Overview of SoTL in Biomechanics

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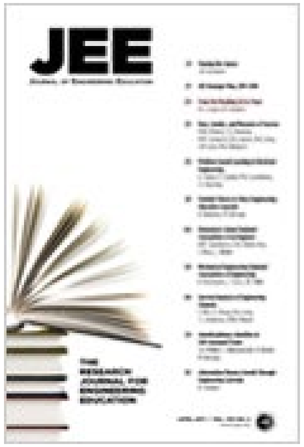
Topics

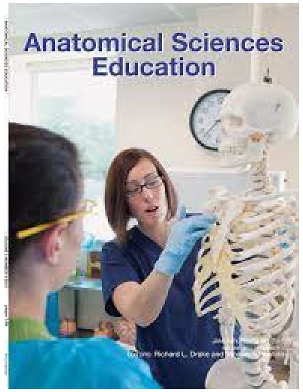
- What is SoTL?
- Physics Education Research (PER) & Active Learning
- Overview of SoTL in Biomechanics

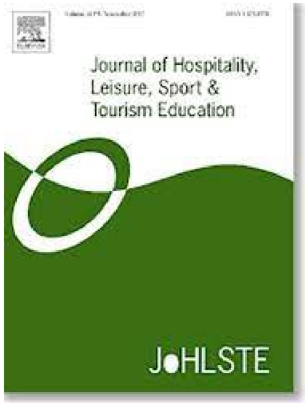
SoTL

- *Scholarship of Teaching & Learning* [SoTL] Boyer (1990) Peer reviewed research on teaching & learning of a specific discipline/field

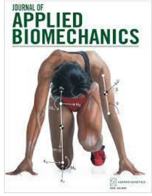


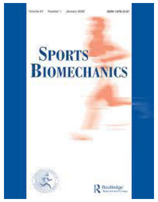
- Extensive SoTL literature in education and other disciplines
  - *Journal of Engineering Education* (ASEE)
  - *Anatomical Sciences Education* (AAA)
  - *Advances in Physiology Education* (APS)
  - *Athletic Training Education Journal* (NATA)
  - *Journal of Physical Therapy Education* (APTA)
  - *Journal Hosp Leis Sport & Tour Education*
  - *CBE Life Sciences Education*





- Biomechanics
  - *JAB*
  - *SB*





Physics Education Research (PER)

- Over four decades of serious research on *learning* of physics concepts—Primarily mechanics concepts because Newtonian mechanics is difficult for most students because of dislike and fear of physics (McDermott, 1991) and misconceptions about motion (Halloun and Hestenes, 1985)
- Large body of robust research documenting typical learning gains and the effect of alternate pedagogies to try and improve learning physics concepts, scientific reasoning, and problem solving (Docktor & Mestre, 2014)
- Doctoral programs in physics education and journals publishing PER

per central
Education research is our focus

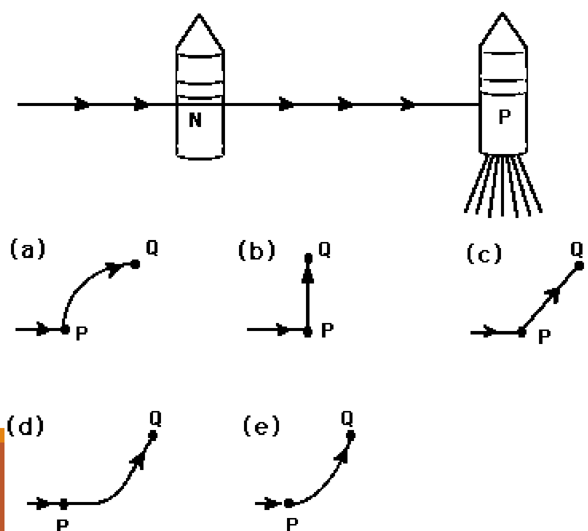
http://www.compadre.org/per/index.cfm

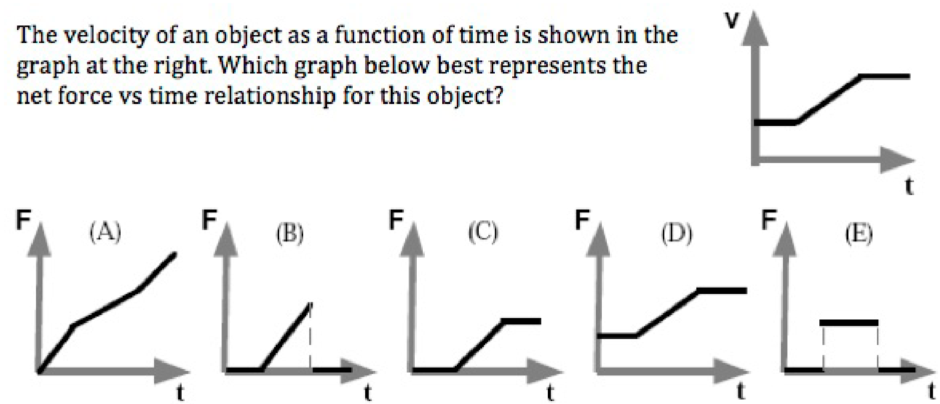
PER Tests of Learning

- Several standardized tests of learning mechanics concepts (pre- and post-testing)—grades [performance measures] ≠ learning
  - Mechanics Diagnostic Test (Halloun & Hestenes 1985)
  - Force Concept Inventory (Hestenes et al 1992)
  - Mechanics Baseline Test (Hestenes & Wells 1992)
  - Force & Motion Conceptual Evaluation (Thornton & Sokoloff 1998)
  - Force, Velocity, and Acceleration Assessment (Rosenblat et al 2011)
- Overall results from 14 different tests have been reviewed by Docktor and Mestre (2014)
- Unbiased measure of learning is the normalized gain score [g = (post-pre)/(max-pre)] (Hake 1998)

PER Tests of Learning

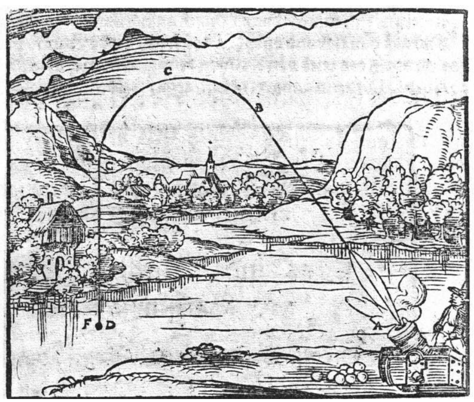
- Research with the FCI and other tests document:
  - Student difficulties with mastering mechanical concepts [g ≈ 0.2] (Hake 1998)
  - Student learning with traditional instruction is independent of the instructor (Halloun & Hestenes 1985). It is more important to influence student attention & interest
  - Difficulties not remediated by solving quantitative word problems (Elby 2001; Demaree et al. 2005; Kim & Pak 2002)





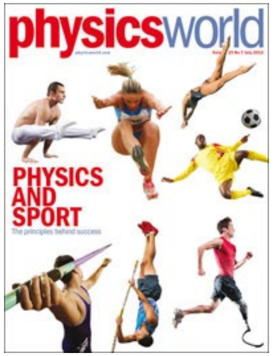
Naïve Conceptions

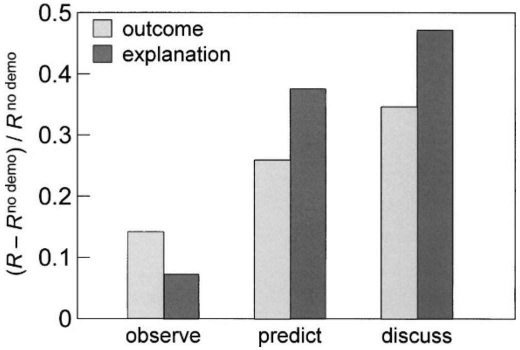
- Misconceptions, pre-instruction conceptions, naïve or intuitive physics (Halloun & Hestenes 1985)
- Newton's Laws of Motion
  - 1^{st} Law: Impetus view of motion—force/power instead of inertia in motion, initial motion
  - 2^{nd} Law: Force equated with motion, lack of differentiation between kinematic quantities $F=d$ not $\Sigma F=ma$
  - 3^{rd} Law: Interpreted as unequal, dominance



Key PER Results

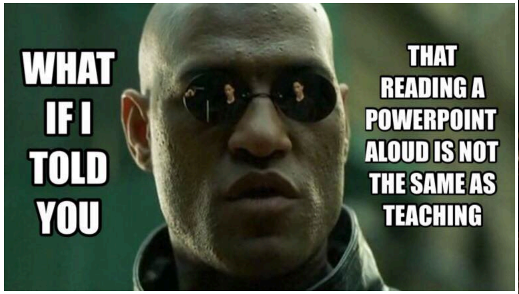
- IUPP (Coleman et al. 1998)
  - Similar learning and decrease in appreciation across instructor
  - Universally low student perception of labs
  - Computers/electronic technology can byte 
- Demonstrations do not improve learning mechanical concepts (Crouch et al. 2004)
- Students interact superficially with simulations/interactive multimedia unless: program is well-designed and *students taught to use* this kind of learning (Yeo et al. 2004)



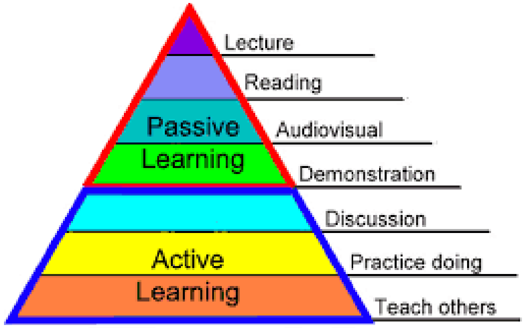


Crouch et al. (2004)

Key PER Results

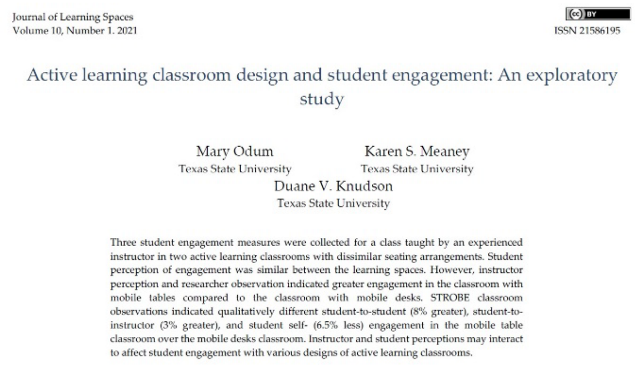


- Students in introductory physics taught with interactive engagement activities (aka: Active Learning or AL) doubled learning (g = 44-72%) compared to traditional instruction (g ≈ 20%). Effect observed in numerous studies and with over 10,000 students and other disciplines (Beichner et al. 2007; Freeman et al. 2014; Hake 1998; Hoellwarth & Moelter 2011)
- AL is an interactive and engaging process for students that may be implemented through the employment of strategies that involve metacognition, discussion, group work, formative assessment, practicing core competencies, live-action visuals, conceptual class design, worksheets, and/or games (Driessen et al. 2020)
- Some of AL benefits may be from greater forgetting with traditional lecture (Franklin et al. 2014)



Active Learning in PER

- Affirmed decades of education/SoTL research that AL is more effective than traditional lecture/discussion and can be scaled-up for large classes (Beichner et al. 2007)
  - Physics-by-Inquiry
  - Workshop Physics
  - Studio Physics
  - Student-Centered Active Learning Environment: SCALE-UP
  - Technology-Enabled Active Learning: TEAL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Active learning classroom design and student engagement: An exploratory study

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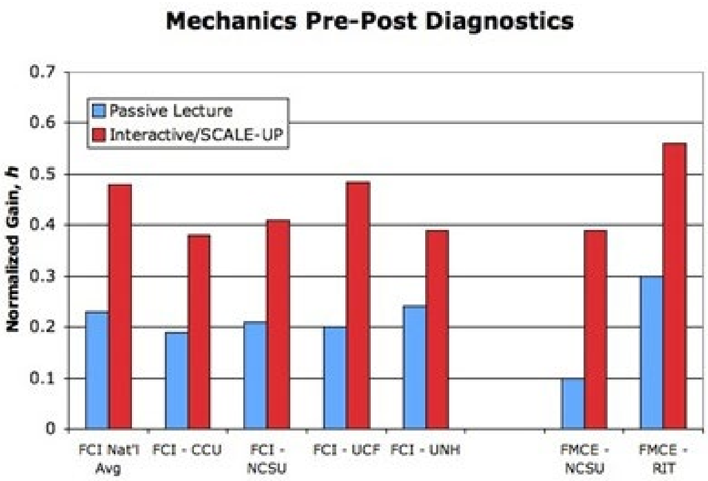
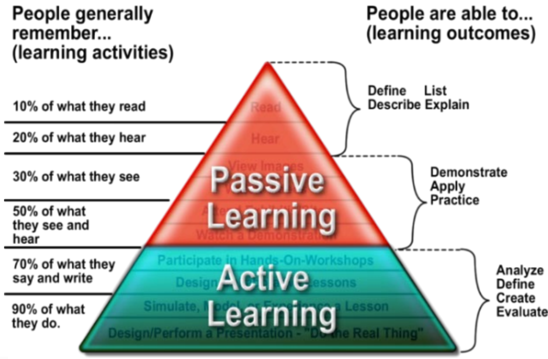
Three student engagement measures were collected for a class taught by an experienced instructor in two active learning classrooms with dissimilar seating arrangements. Student perception of engagement was similar between the learning spaces. However, instructor perception and researcher observation indicated greater engagement in the classroom with mobile tables compared to the classroom with mobile desks. STROBE classroom observations indicated qualitatively different student-to-student (8% greater), student-to-instructor (3% greater), and student self- (6.5% less) engagement in the mobile table classroom over the mobile desks classroom. Instructor and student perceptions may interact to affect student engagement with various designs of active learning classrooms.



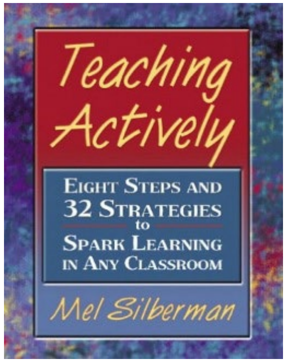
Beichner et al. (2007)

Active Learning



Dale (1969)

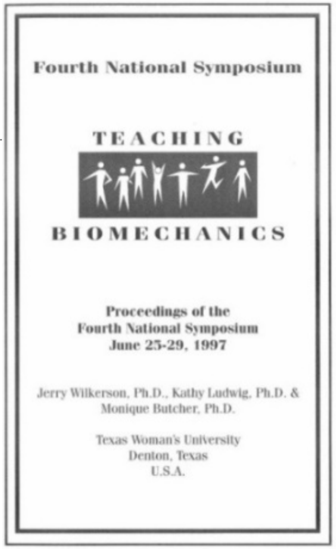
- Now many books on AL
- Bain (2004) *What the best college teachers do.* Cambridge: Harvard University Press
  - Knowledge is constructed, not received
  - Mental models change slowly
  - Questions are critical
    - Listen to student experience and thinking (gauge)
    - Link student interest and disciplinary concepts (engage)
  - Caring/motivation is crucial
  - Emphasize depth over breadth



- Is AL used by physics & biomechanics faculty?
  - Only 48% of university physics teachers currently use *at least one* research-based instructional strategy (Henderson & Dancy 2009)
  - Similar low percentage of biomechanics instructors report usage of active learning strategies. About 50% of biomechanics instructors think they utilize AL strategies, but only about 10% to 41% likely do (Garceau et al. 2012; Breen & Knudson, 2022)

Biomechanics Teaching → SoTL

- Six North American teaching conferences since 1978
  - Concern about amount and retention of ‘learning’
  - Student difficulties in core Newtonian Laws & concepts
  - Difficulties in critical thinking and application
  - National Guidelines and Standards for the course
  - 0-18% of papers report SoTL (Knudson, 2010)


Fourth National Symposium

TEACHING

BIOMECHANICS

Proceedings of the
Fourth National Symposium
June 25-29, 1997

Jerry Wilkerson, Ph.D., Kathy Ludwig, Ph.D. &
Monique Butcher, Ph.D.

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- Abraham et al. *(*2018) Guidelines for Undergraduate Biomechanics https://www.shapeamerica.org/uploads/pdfs/2018/guidelines/Guidelines-for-UG-Biomechanics.pdf

- Reviews of teaching and SoTL in biomechanics, engineering & physics (Knudson, 2010, 2013, 2016)

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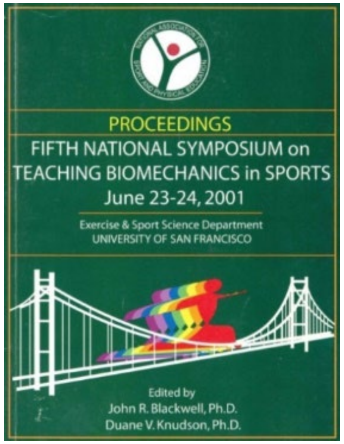
Guidance Document

Guidelines for Undergraduate Biomechanics

Biomechanics SoTL

- Early SoTL in Teaching Conferences (Dedeyn 1991; Knudson et al. 1991; Bird et al. 1997; McGee et al. 1997; Coleman, 2001)
- Early call to peers to adopt AL strategies/exercises to improve learning of biomechanics concepts (Smith & McCabe 2001)

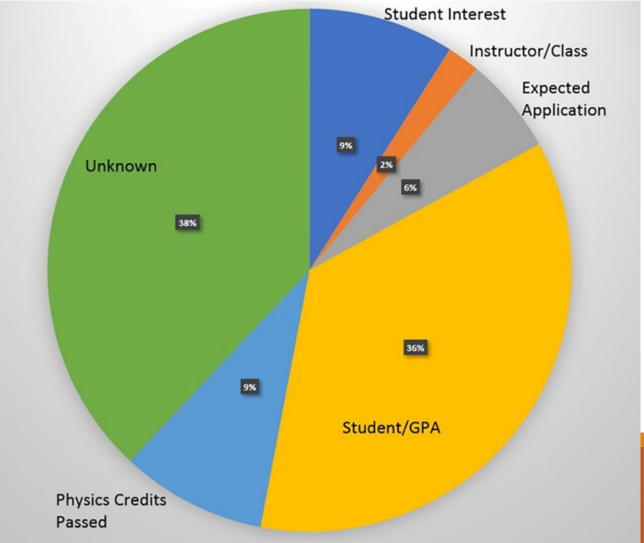


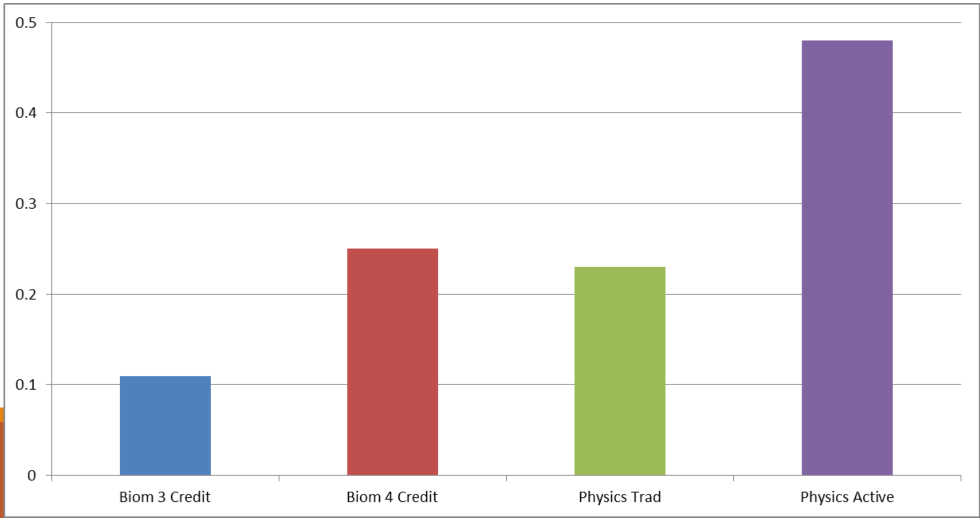
Test of Introductory Biomechanics Concepts

- Biomechanics Concept Inventory [BCI] based on FCI and national course guidelines for introductory biomechanics (Knudson et al. 2003)
- BCI is a 24-question test with national normative data from over 300 students from 11 universities
- Research using the BCI and subsequent versions (Knudson, 2004, 2006) were consistent with Force Concept Inventory results in introductory physics instruction: ($g \approx 0.2$)
- BCI test scores not likely biased by preferred learning style (Hsieh et al. 2012)

Factors Related to Learning Biomechanics

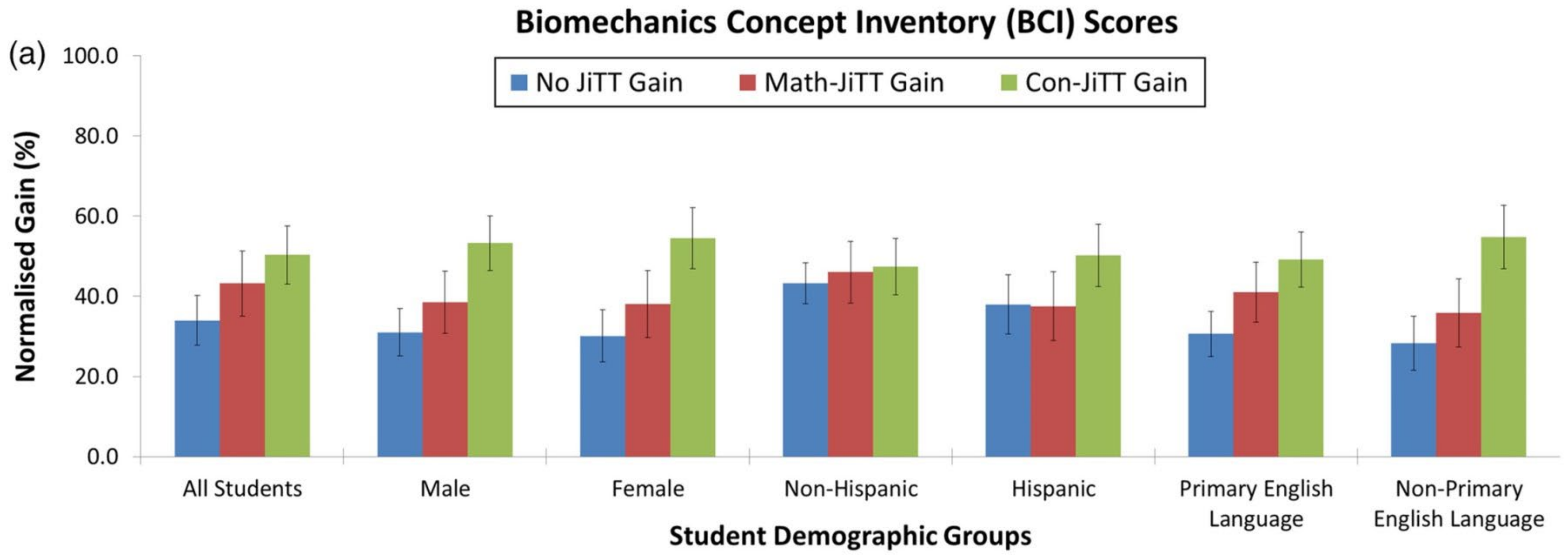
- Course and instructor variables are weakly associated with normalized gain in biomechanical concepts (Knudson et al. 2009)
  - Credit hours (r^2 = 2.3%), but lab doubles learning!
  - Mean annual expenditures on lab (r = -0.18, r^2 = 3.2%)!
- Student characteristics and behaviors more strongly associated (r^2 =14-40%) with normalized gain (Hsieh & Knudson 2008; Hsieh et al. 2012)
  - GPA & student interest
  - GPA, student interest, & perceived application





Active Learning in Biomechanics

- Conceptual Just-in-time teaching (JiTT) significantly (30-40%) increased learning of biomechanics concepts in all students (Riskowski, 2015). Conceptual JiTT outperformed mathematical JiTT

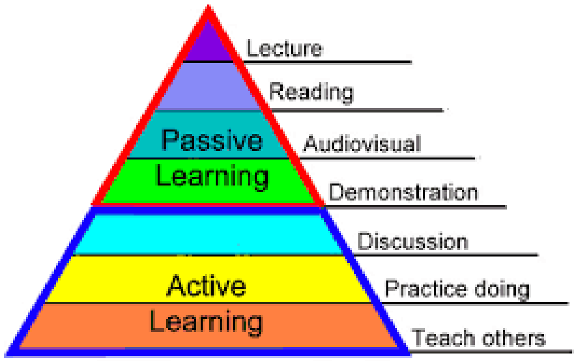


Active Learning in Biomechanics

- Low-tech AL experiences effective in increasing BCI scores over level reported for 3-credit traditional lecture instruction (Knudson 2019, 2020; Knudson & Wallace, 2021; Wallace et al. 2020) and are also effective in online formats (Wallace & Knudson 2020)
- Biomechanics students opting to participate in two quiz opportunities to practice a day (TOPday) showed greater interest, enthusiasm, and test performance (Tanck et al. 2014)
- Using gait analysis projects, students perceive greater autonomy and engagement (Low, 2015)
- Problem-based learning in biomechanics (Clyne & Billiar, 2016; Wallace et al. 2020)

Active Learning Examples

- Many AL strategies have been studied in SoTL (see review of *utility* and efficacy by McConnell et al. 2017 *J Geosci Ed*)



  - *Concept maps*
  - Interactive demonstrations (H_o Demo/Activity)
  - *Peer instruction*
  - Jigsaw
  - *Think-Pair-Share*
  - Case studies
  - Writing test questions & answers
  - Student projects or peer instruction
  - Learn-before-lecture (Moravec et al. 2010)
  - JiTT (Riskowski, 2015)
  - *Minute papers*
  - *Lectorial*
  - Teaching with models
  - Role playing
  - Gallery walks

Opportunity

- Correcting student mechanical misconceptions is difficult and not easily resolved by lecture, demonstrations, or multimedia
- SoTL research confirms that learning biomechanical concepts is difficult for most students and generalizing to application is even harder
- SoTL research on learning biomechanical concepts is important to the future of sports biomechanics
  - Improve application by clinicians, coaches and teachers
  - Inspire future scholars to pursue advanced training in sports biomechanics
- Integrate *Carefully crafted* active learning strategies based on student interests and professional application are likely to improve learning
- Need more SoTL research in biomechanics using AL strategies

Selected References

Breen & Knudson (2022) Revision in review

Hsieh & Knudson (2008) *Sports Biomech 7*:398

Hsieh & Knudson (2018) *Sports Biomech 17*:361

Heieh et al. (2012) *Journal of College Science Teaching 41:*83

Knudson (2016). *ISBS-Conf Proc Archive* https://ojs.ub.uni-konstanz.de/cpa/article/view/6817

Knudson (2019) *Sports Biomech* https://doi.org/10.1080/14763141.2019.1682650

Knudson (2020) *Sports Biomech* https://doi.org/10.1080/14763141.2020.1810306

Knudson (2022) *Bibliography of Biomechanics Teaching and Learning Resources*. ASB Teaching Repository. http://asbteachingrepository.herokuapp.com/

Knudson et al (2009) *Percept Mot Skills 108*:499

Knudson et al. (2003) *Sports Biomech* 2:267

Knudson & Wallace (2021) *Sports Biomech 20:458*

Wallace & Knudson (2020) *Sports Biomech* https://doi.org/10.1080/14763141.2020.1830163

Wallace et al. (2020) *J Hosp Leis Sport Tour Ed 27:*100258