# What Have We Learned About Teaching and Learning in Sports Science?

Duane Knudson, Ph.D.
Department of Health & Human Performance

TEXAS STATE UNIVERSITY
SAN MARCOS
*The rising STAR of Texas*

# Introduction

- Kinesiology/Exercise Science  is one of the most popular and fastest growing majors in North America
  - Gateway to careers in education & medicine
  - Many students passionate about sport & human movement
- Yet, there is trouble in paradise:
  - Maintaining high standards
  - Concern about amount and retention of ‘learning’
  - Student difficulties in core sciences (biomechanics)
  - Difficulties in critical thinking and application
  - Most teachers and coaches in USA are not interested in biomechanics

AMERICAN COLLEGE of SPORTS MEDICINE

American Kinesiology Association

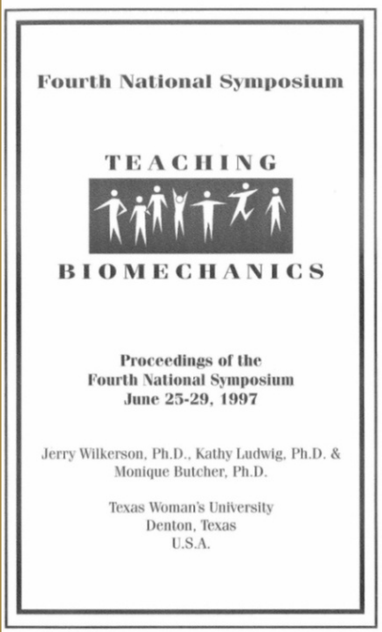
American Alliance for Health, Physical Education, Recreation and Dance

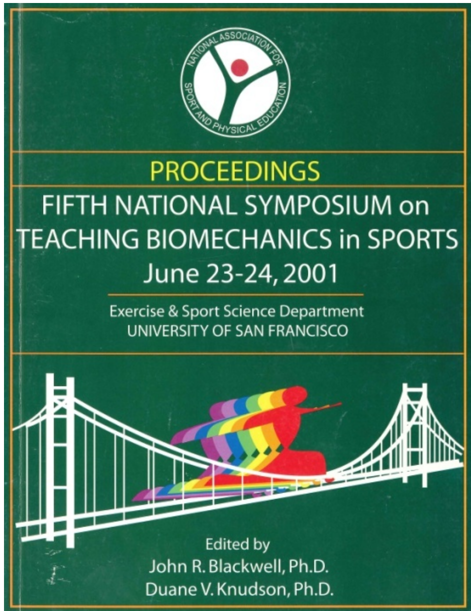
TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

# Topics

- Focus on student difficulties learning important core knowledge in sports science—specifically biomechanics
  - Physics Education Research (PER)
  - Teaching Strategies in Biomechanics
  - Research on Teaching Biomechanics
  - Application in Introductory Biomechanics
  - Future Research

per central
Education research is our focus

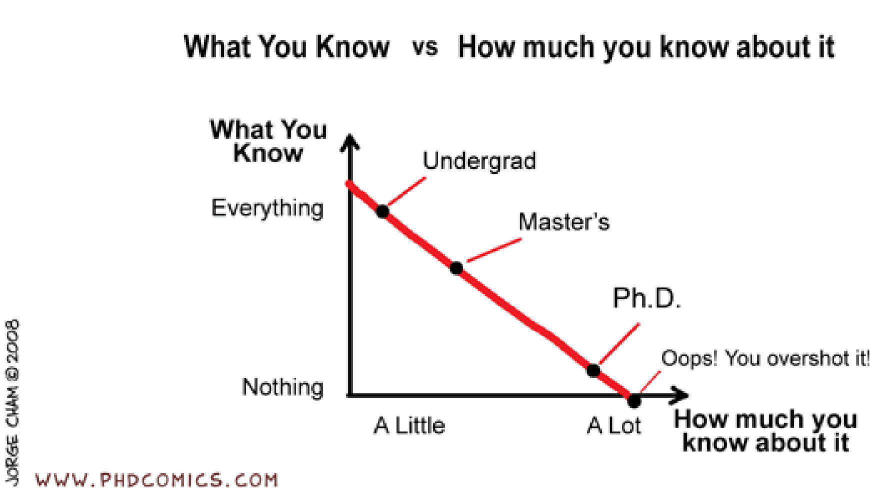



TEXAS STATE UNIVERSITY
SAN MARCOS
The rising STAR of Texas

# Questions

- We know quite a bit about biomechanics and its application, but do we know how to effectively engage most students to help them learn these difficult concepts?
- Do we know enough to substantially improve biomechanics and other sport/exercise science instruction?
- Do we know enough to intelligently extend the research on teaching and learning in sports science?




TEXAS STATE UNIVERSITY SAN MARCOS
*The rising STAR of Texas*

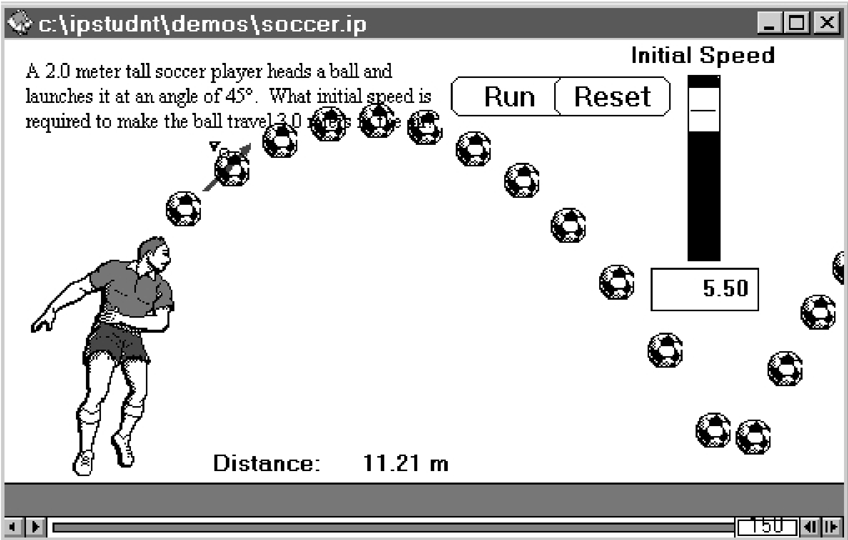
# Physics Education Research (PER)

- *Scholarship of Teaching & Learning* [STL] Boyer (1990)
- Extensive STL literature in education and other disciplines
  - PER - 6 STL journals http://www.compadre.org/per/index.cfm
  - ASEE – *Journal of Engineering Education*
  - AAA – *Anatomical Sciences Education*
  - APS – *Advances in Physiology Education*
  - ATEJ – *Athletic Training Education Journal*
  - JPTE – *Journal of Physical Therapy Education*
- Cyclic ‘crisis’ and ‘reform’ in science education
- Physics this has resulted in over two decades of serious research on learning of physics concepts—mechanics


TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

# PER Contributions

- Focus not on teaching, but what students learn and how they learn—standard tests measuring learning and learning behaviors
- PER reviews
- Naïve conceptions of mechanics
- Epistemology and conceptual change
- Interactive pedagogies



# PER Tests of *Learning*

- Several standardized tests of learning mechanics concepts (pre- and post-testing)
  - Mechanics Diagnostic Test Halloun & Hestenes 1985 *Am J Phys* 53:1043
  - Force Concept Inventory (Hestenes et al 1992 *Phys Teacher* 30:141
  - Mechanics Baseline Test (Hestenes & Wells 1992 *Phys Teacher* 30:159
  - Force & Motion Conceptual Evaluation (Thornton & Sokoloff 1998 *Am J Phys* 35:338)
- Unbiased measure of learning is the normalized gain score [g = (post-pre)/(max-pre)] (Hake 1998 *Am J Phys* 66:64)
- Student learning with traditional instruction is independent of the instructor (Halloun & Hestenes 1985) ASU—more important to influence student attention & interest
- FCI and other tests document student difficulties with mastering mechanical concepts ($g \approx 0.2$)
- Difficulties not remediated by solving quantitative word problems (Kim & Pak 2002 *Am J Phys* 70:759)

TEXAS STATE UNIVERSITY SAN MARCOS

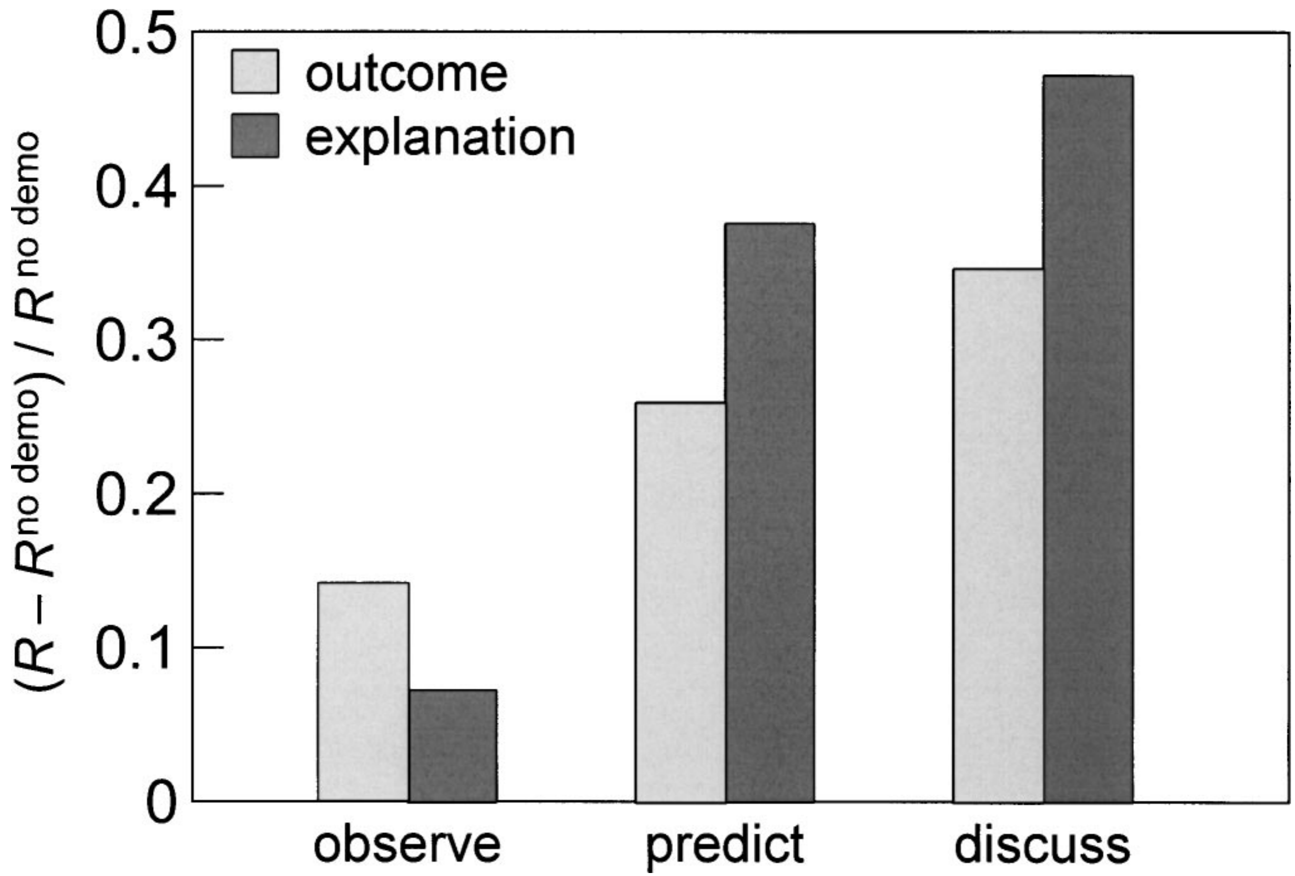
The rising STAR of Texas

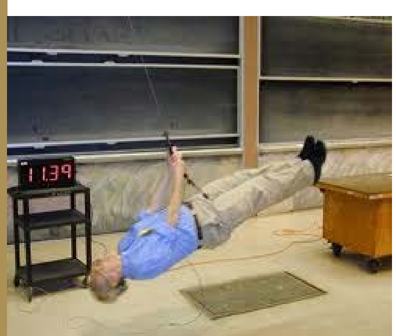
# Classic PER Reviews

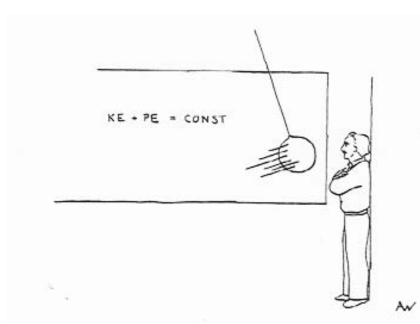
- Physics Education Group U of Washington McDermott 1991 *Am J. Phys* 59:307
  - Integrate concepts, reasoning & representational skills
  - Physics by Inquiry
  - Explicitly link formalism to real world phenomena
  - Explicitly address common difficulties
- IUUP Coleman et al. 1998 *Am J Phys* 66:124
  - Similar learning and decrease in appreciation
  - Storyline & coherence important
  - Universally low student perception of labs
  - Computers can byte
- Redish & Steinberg 1999 *Phys Today* 52:24 Physics Education Research Group U of Maryland
  - What is learned and how to make sense out of student actions
  - Problem solving—concepts and expectations
  - Workshop Physics

TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

# Demonstrations?



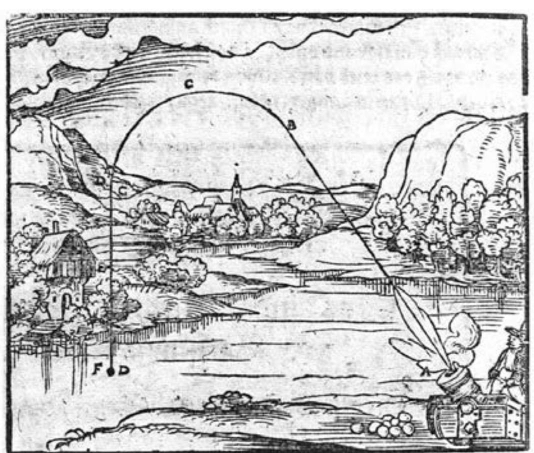



Crouch et al. (2004)

TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

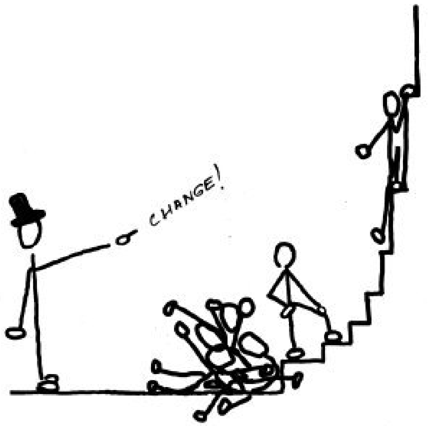
# Naïve Conceptions

- Misconceptions, pre-instruction conceptions, naïve or intuitive physics (Halloun & Hestenes 1985 *Am J Phys* 53:1056)
- 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    Believe F=d, not $\Sigma F=ma$
  - $3^{rd}$ Law: Interpreted as unequal, dominance



# Conceptual Change

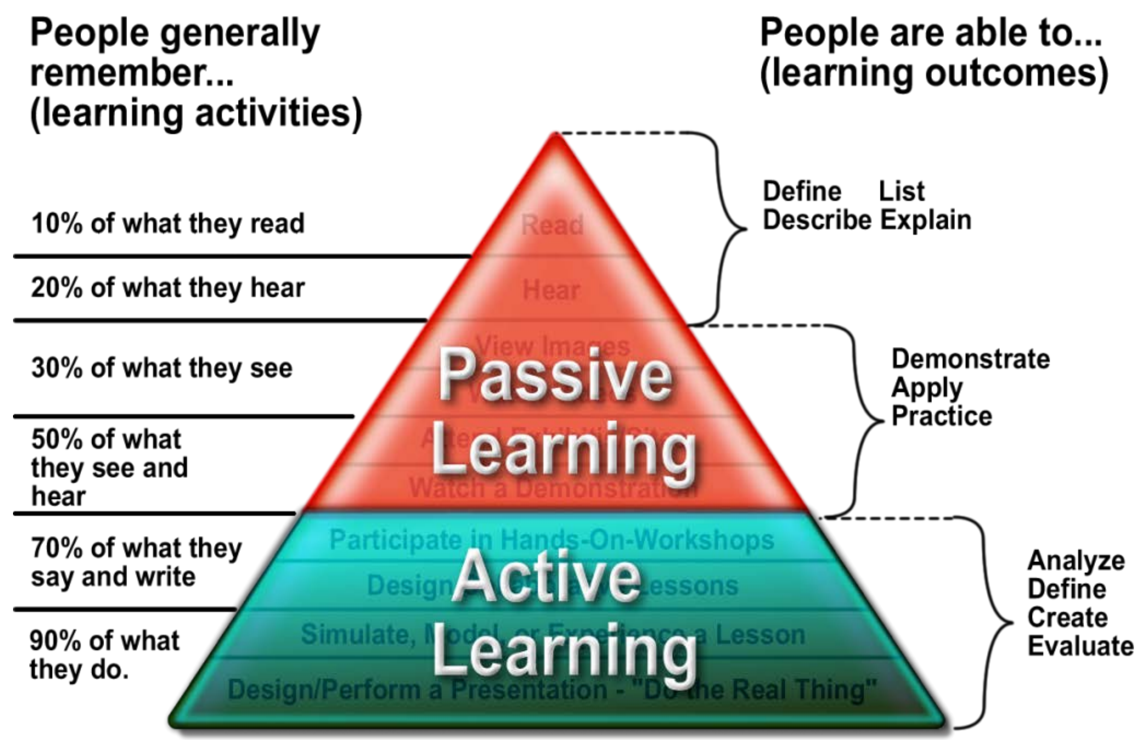
- Change in conceptions about motion is difficult
- Difficult process: new conceptions are unstable and context dependent
- Dependent on epistemology (Elby 2001 *Am J Phys* 69:S554)
- Assimilation to accommodation approaches
  - Integrate
  - Differentiate
  - Exchange
  - Bridge
- Strategies
  - Metacognition—reflection and thinking about learning
  - Concept/Law construction (predict-observ
  - Argumentative essays/discussions
  - Computer simulations
  - Concept substitution




TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

# Interactive Pedagogies

- Interactive engagement, active/discovery learning is more effective than traditional lecture/discussion
- Student-centered teaching in an standards-based world (Deboer 2002 *Sci & Ed* 11:405)

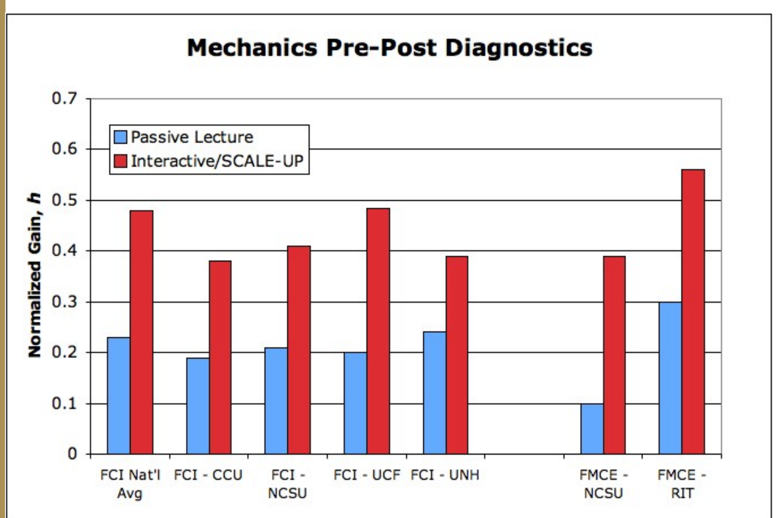



Dale (1969)

TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

# Interactive Engagement

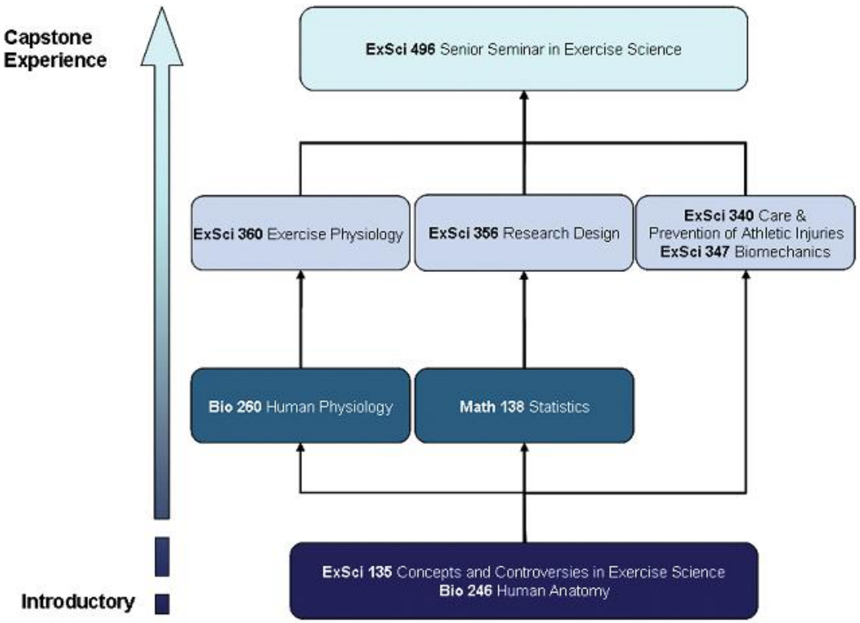
- Students in introductory physics taught with interactive engagement activities doubled learning (g = 44-72%) compared to traditional instruction (g ≈ 20%). Effect observed in numerous studies and with over 10,000 students (Hake 1988 *Am J Phys* 66:64; Hoellwarth & Moelter 2011 *Am J Phys* 79:540)
- These pedagogies can be adapted to large classes—SCALE-UP initiative NC State (Beichner et al 2007)
- Only 48% of university physics teachers currently use at least one research-based instructional strategy (Henderson & Dancy 2009 *Phys Ed Res* 5:020107)




TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

# Interactive Pedagogies

- Investigative instructional design has increased understanding of and confidence in scientific inquiry for exercise science students (Stavrianeas & Stewart 2011 *J Col Sci Teach* 41:92)




Stavrianeas & Stewart (2011)

# Teaching Introductory Biomechanics

- National Guidelines for Undergraduate Biomechanics (NASPE, 2003)
  - *General Anatomy and Math Prerequisites*
  - *9 Neuromuscular System Competencies*
  - *12 Mechanics Competencies*
  - *4 Application Competencies*
  - *Recommendations for faculty, facilities & equipment*

American Alliance for Health, Physical Education, Recreation and Dance

National Association for Sport and Physical Education

TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

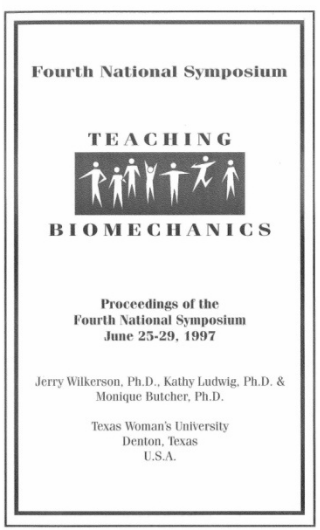
# Teaching Strategies in Introductory Biomechanics

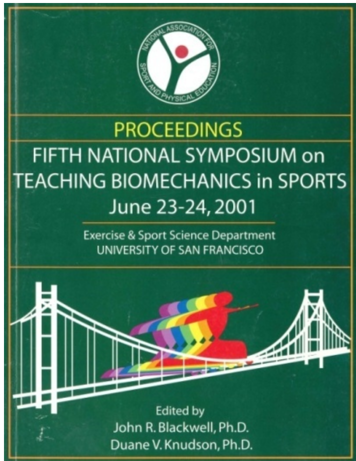
- Teaching introductory biomechanics is a challenging task in most sport & exercise science departments:
  - Complexity of Anatomy
  - Counterintuitive nature of Mechanics
  - Application: Complex system and ecology
- Knudson (2010) reviewed three decades of teaching conferences and peer-reviewed STL papers on biomechanics
- Papers from the five previous teaching conference proceedings were reviewed and classified :
  - Course Concepts/History (CCH)
  - Activity or Laboratory (AOL)
  - Teaching Idea or Pedagogy (TIP)
  - Equipment, Technology or Software (ETS)
  - Scholarship of Teaching & Learning (STL)

TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

# Knudson (2010)

- 162 Teaching Conference Papers
  - 1978: 46
  - 1984: 40
  - 1991: 35
  - 1997: 24
  - 2001: 17
- Most papers were classified as ETS, CCH, or AOL (20-40%)
- Smaller percentages of papers in TIP and STL (0-20%)



# Knudson (2010)

Types of Teaching Conference Papers
(percent)

| Year | CCH | ETS | AOL | TIP | STL |
|---|---|---|---|---|---|
| 1978 | 28 | 35 | 15 | 22 | 0 |
| 1984 | 28 | 15 | 25 | 10 | 0 |
| 1991 | 26 | 34 | 17 | 14 | 9 |
| 1997 | 21 | 42 | 25 | 8 | 1 |
| 2001 | 29 | 29 | 18 | 6 | 18 |

TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

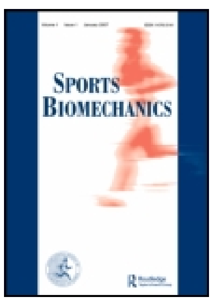
# Knudson (2010)

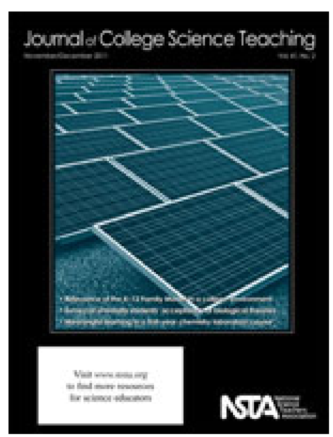
- STL in Teaching Conference Papers
  - 1991
    - Skill Analysis (Dedeyn 1991; Knudson et al. 1991)
    - CAI (McPherson & Guthrie, 1991)
  - 1997
    - 74% mastery of NASPE standards (Bird et al. 1997)
    - 10% improvement with hands-on EMG (McGee et al. 1997)
  - 2001
    - 70% mastery of Newton's Laws as measured by the Force Concept Inventory (Coleman 2001)
- 6th Teaching Conference (2010) No STL Papers
- ASB 2011
  - Two active learning papers: Riskowski, Nuckley

TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

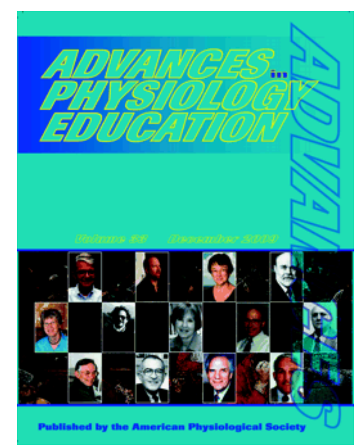
# Knudson (2010)

- Over 20 journal articles on teaching and learning in biomechanics since 1980
  - Standardized Tests
  - Factors Associated with Learning Biomechanics Concepts
  - Biomedical Engineering
  - Exercise & Sport Science



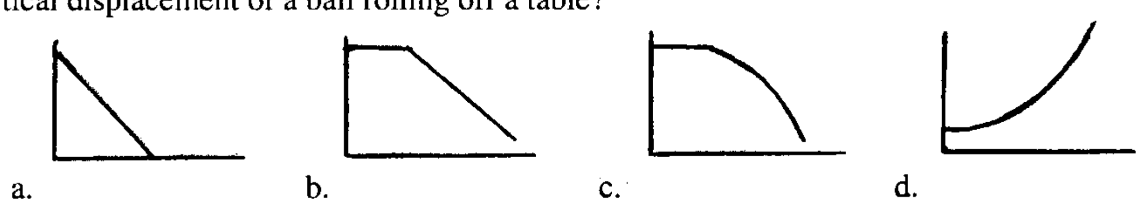




# Tests of Biomechanical Concepts

- Biomechanics Concept Inventory (Knudson et al. 2003) based on FCI and NASPE (2003) guidelines for introductory biomechanics
- 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)

____ 5. Which of the following displacement-time graphs most accurately represents the vertical displacement of a ball rolling off a table?



# Factors Related to Learning

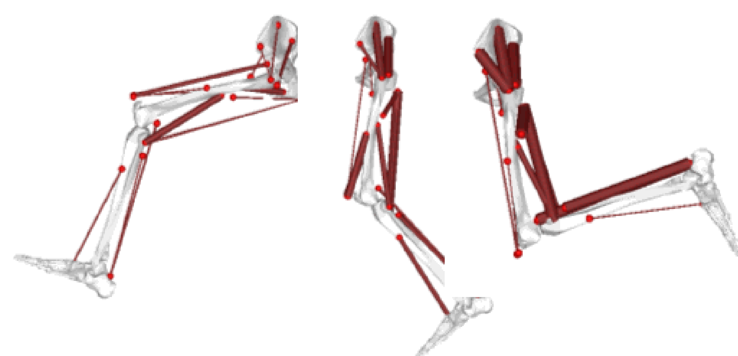
- Course and instructor variables weakly associated with normalized gain in biomechanical concepts (Knudson et al. 2009)
  - Credit hours ($r^2$ = 2.3%), but lab doubles learning!
  - Mean annul expenditures ($r$ = -0.18, $r^2$ = 3.2%)!
- Student characteristics and behaviors more strongly associated ($r^2$ =14-40%) with normalized gain (Hsieh & Knudson 2008; Hsieh et al. 2010)
  - GPA & student interest
  - GPA, student interest, & perceived application

TEXAS STATE UNIVERSITY SAN MARCOS

*The rising STAR of Texas*

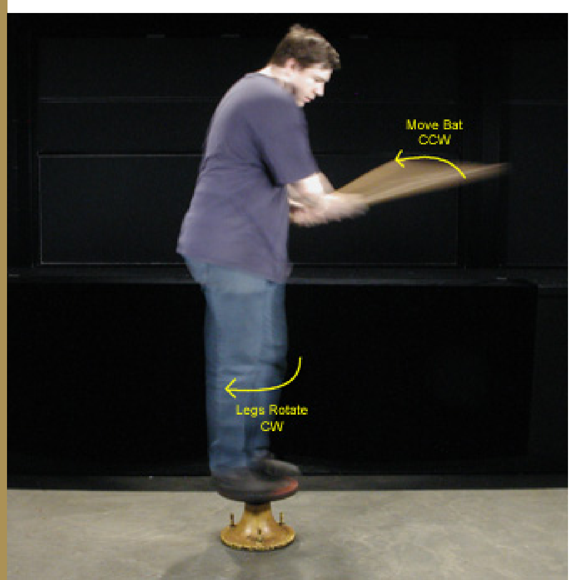
# Biomedical Engineering

- Computer-assisted or active learning strategies studied with mixed results on learning improvement
  - Nonsignificant (Duncan & Lyons 2008; Roselli & Brophy 2006; Washington et al. 1999)
  - Significant (Pandy et al. 2004 *J Eng Ed* 93:211)
- Difficult to get beyond the novelty/wow factor in simulations/visualizations (Chandler 2009 *Comp Hum Beh* 25:389)

# Exercise and Sport Science

- Instructional technology (Carlton et al. 1999; Chow et al. 2000; Kirtley & Smith, 2001; Miller 1997; Nicol & Liebscher, 1983)
- Lab activities (Di Carlo et al. 1998 *Am J Physiol* 275:S59)




# Is this pedagogical knowledge being applied in biomechanics?

- Four North American surveys of introductory biomechanics instructors and courses
- Most recent: Garceau et al. (2011)
  - Web-based survey of 165 North American biomechanics faculty
  - Questions on course instruction and beliefs about teaching/learning

**Marquette University**
**Educational Policy and Leadership**
**Biomechanics Pedagogy Research Project**

**Survey of Undergraduate *Introductory Biomechanics* Faculty**

Please consider completing the following survey if you believe it pertains to your teaching in the last five years. It should take approximately twenty minutes for you to complete the survey. The purpose of this research is to identify the current teaching practices of North American university faculty teaching Introductory Biomechanics (a.k.a. Kinesiology) in departments of exercise science, HPER, Kinesiology, etc. Your responses are strictly anonymous and your participation is completely voluntary. By completing the survey, you are giving your permission to the research to use your anonymous responses for use at professional meetings and in research publications. Thank you for your participation!

Luke R. Garceau
Marquette University
Milwaukee, WI, USA

Duane V. Knudson, Ph.D.
Texas State University
San Marcos, TX, USA

TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

# Garceau et al. 2011a,b

- Survey of instructional techniques used by North American biomechanics faculty
- Active learning strategies (n=94 of 165) during lecture
  - Group problem solving 22%
  - None 19%
  - Lab experiments 14%
  - Group projects 13%
  - Implements 13%
  - Student demonstration 9%
  - Teacher demonstration 9%
  - Active exercise 7%
  - Motion analysis task 6%
  - Student response system 5%
  - Small groups 5%


TEXAS STATE UNIVERSITY SAN MARCOS

The rising STAR of Texas

# Garceau et al. 2011a,b

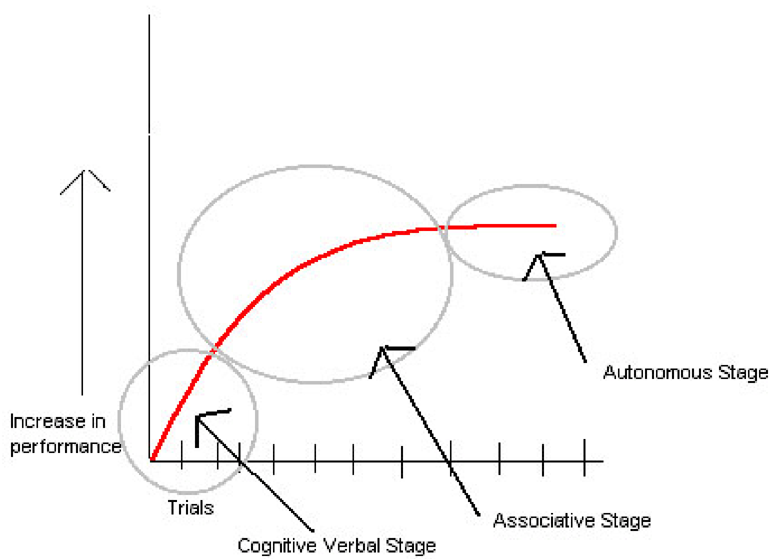
- Assessment strategies (n=99 of 165 respondents) in exams

| Type | Percent Use | Percentage of exam |
|---|---|---|
| Multiple Choice | 78 | 42 |
| Quant Problem | 97 | 41 |
| Short Ans/Essay | 66 | 22 |
| Qual Problem | 60 | 20 |
| Fill Blank | 32 | 15 |
| True/False | 44 | 15 |
| Matching | 20 | 11 |

# Garceau et al. 2011a,b

- Greatest challenges (n=93 of 165 respondents)

| Type | Percentage |
|---|---|
| Math difficulty | 60 |
| Physics difficulty | 27 |
| Lack of time | 22 |
| Student differences | 20 |
| Student apathy | 18 |
| Too many students | 16 |
| Poor general preparation | 14 |
| Difficulty finding application | 12 |
| Limited lab space | 12 |
| Complex instrumentation | 10 |
| Equipment limitations | 10 |




TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

# Garceau et al. 2011a,b

- Changes if you had unlimited time and money(n=70 of 165 respondents)

| Type | Percentage |
|---|---|
| Obtain equipment | 40 |
| Put equipment in instruction | 31 |
| Add prerequisites | 20 |
| Increase lab size | 19 |
| Add lab to class | 17 |
| Change course structure | 14 |
| Get lab | 14 |
| Increase lab length | 10 |
| Increase student lab projects | 10 |
| Fewer students per lab | 9 |

TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

# Application

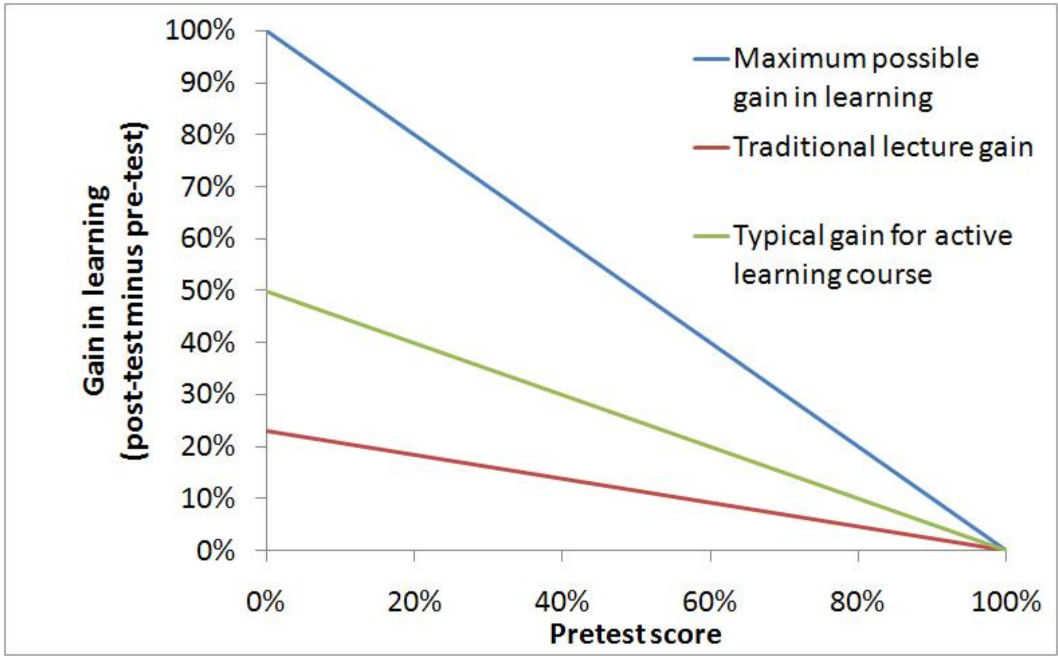
- Bain (2004) *What the best college teachers do*. Cambridge: Harvard Univ Press
  - Knowledge is constructed, not received
  - Mental models change slowly
  - Questions are critical (link student and disciplinary)
  - Caring/motivation is crucial

Bain (2004)


TEXAS STATE UNIVERSITY
SAN MARCOS
*The rising STAR of Texas*

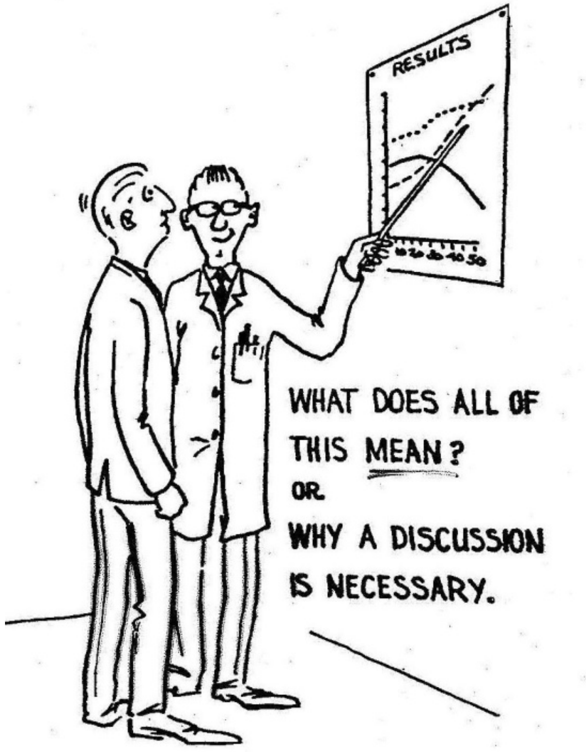
# Application

- Interactive Engagement, Active/Discovery Learning is more effective than traditional lecture/discussion
- Emphasize depth over breadth
- Listen to student experience and understanding
- Link student interest/application with discipline questions
- Three main Strategies to help students construct knowledge
  - Analogy/Metaphor
  - Categorization
  - Embodiment



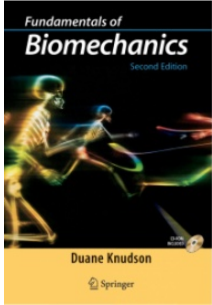

TEXAS STATE UNIVERSITY SAN MARCOS
*The rising STAR of Texas*

# Teaching Introductory Biomechanics




TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

# Knudson (2007) Lab Activities



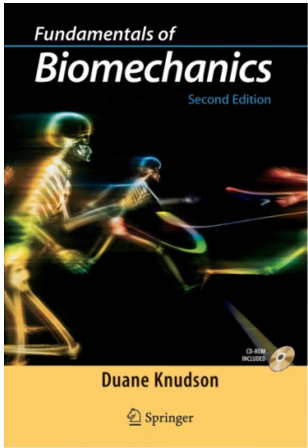

- Qualitative/quantitative analysis of ROM
- Functional anatomy? (Knudson, 2001)
- Muscle actions and the SSC
- Velocity in sprinting
- Accuracy of throwing speed measurements
- Segmental contributions to ball speed (Knudson, 1997)
- Top gun kinetics (Abraham, 1991)
- Impulse-momentum and water balloons (McGinnis et al. 1991)
- Angular kinetics of exercise
- Magnus effect in baseball pitching (Knudson, 1997)
- Qualitative analyses
  - PE: lead-up activity
  - Coaching: skill levels
  - Strength & Conditioning: training
  - Sports Medicine/Rehab: gait

TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

# Principles of Biomechanics

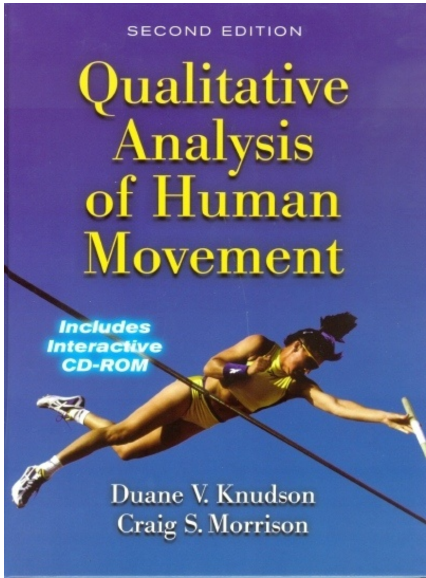
- The nine principles I use are based on the work of Norman (1975) and Hudson (1995)

| | |
|---|---|
| Balance | Optimal projection |
| Coordination | Range of motion |
| Force-motion | Segmental interaction |
| Force-time | Spin |
| Inertia | |




TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

Qualitative analysis is “the systematic observation and introspective judgment of the quality of human movement for the purpose of providing the most appropriate intervention to improve performance.”

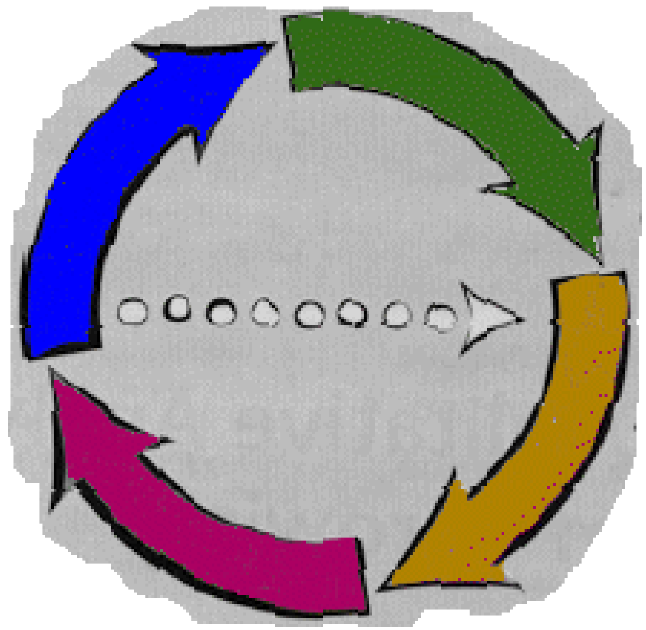



TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

# Four Task Model of QA

Preparation

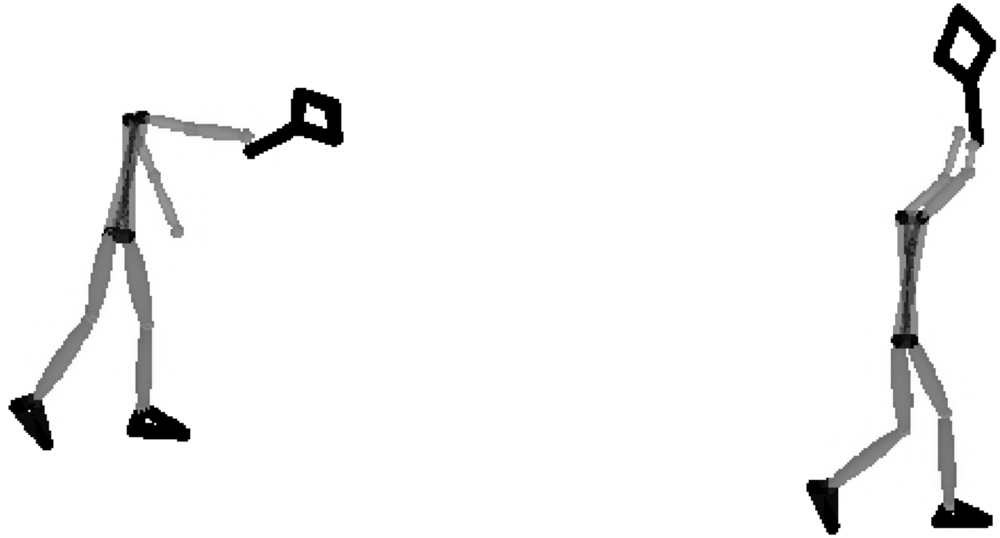
Intervention



Observation

Evaluation/Diagnosis

**Knudson & Morrison (1997)**



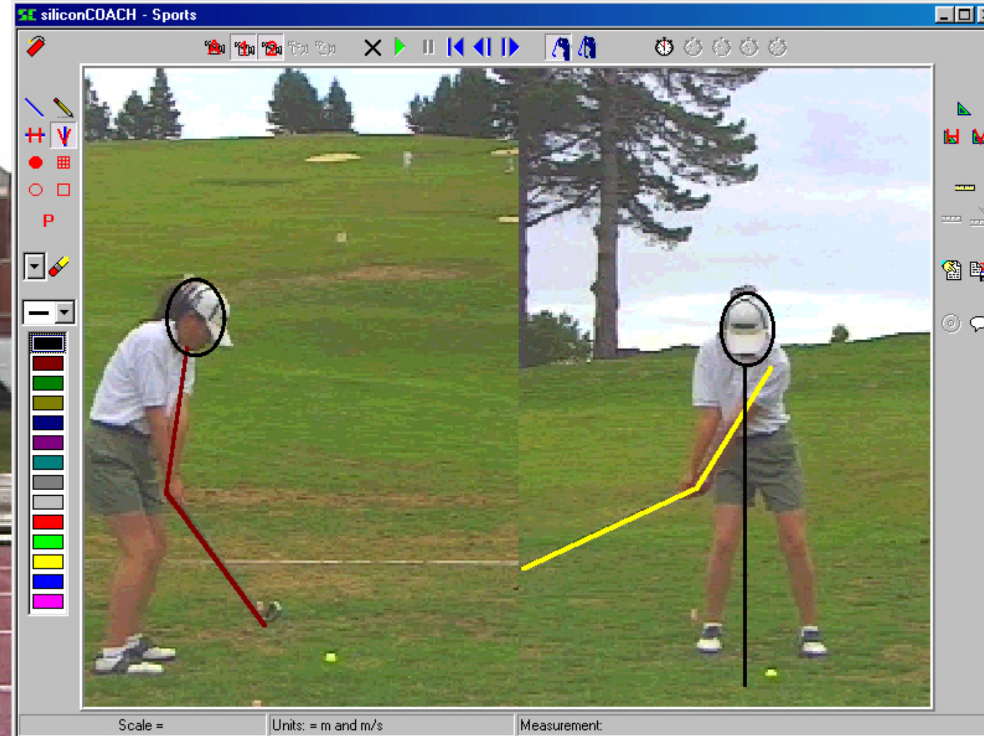
Ordinal Scale:

| | | |
|---|---|---|
| Inadequate | Within the Desirable Range | Excessive |

Visual-Analog Scale:

Too little ROM ________________________________ Too much ROM

Knudson (2000)

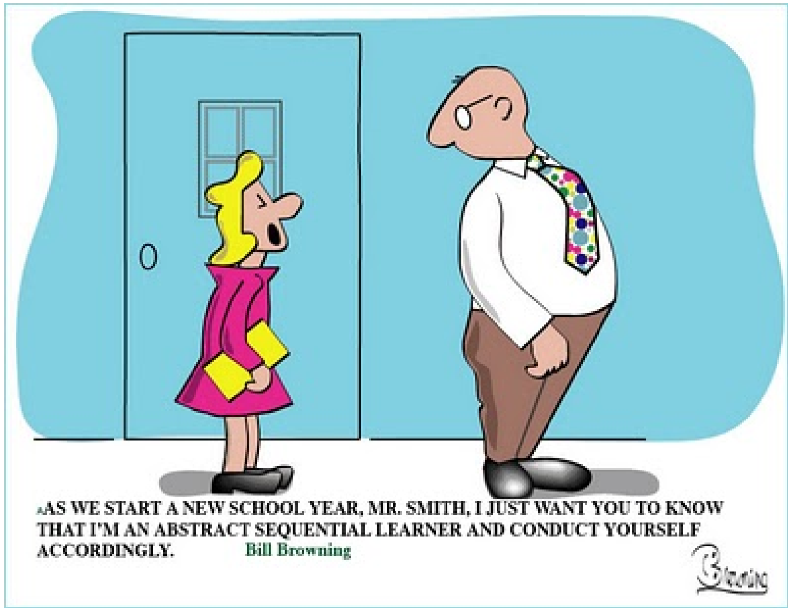


Volley Analysis using siliconCOACH

TEXAS STATE UNIVERSITY
SAN MARCOS
*The rising STAR of Texas*

# Future Research

- Continued support of STL in biomechanics and other exercise sciences
- Refining measures of learning biomechanical and exercsie science concepts
- Documenting variables related to learning these concepts
- Prospective STL studies of carefully crafted active learning strategies based on variables significantly associated with learning biomechanical concepts




TEXAS STATE UNIVERSITY
SAN MARCOS
*The rising STAR of Texas*

# Thank You

- Julie Abendroth-Smith
- Rafael Bahamonde
- Jeff Bauer
- Michael Bird
- John Blackwell
- Mike Bohne
- John Chow
- Bill Ebben
- Luke Garceau
- Jackie Hudson
- Chentu Hsieh
- Peter McGinnis
- Melissa Mache
- Guillermo Noffal
- Jeremy Smith
- Scott Strohmeyer

TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas

# References


- Garceau et al. 2011a *Proc 29th Conf ISBS* 29:951
- Garceau et al. 2011b Submitted
- Hsieh & Knudson 2008 *Sports Biomech* 7:398
- Hsieh et al. 2012*Sports Biomech*
- Hsieh et al. 2012 *J Coll Sci Teaching*
- Knudson 2010 *Proc 28th Conf ISBS* 28:678
- Knudson 2007 *Sports Biomech* 6:108
- Knudson 2007 *Fund of Biomech* 2nd ed. Springer
- Knudson 2007 *Percept Mot Skills* 103:81
- Knudson et al. 1991 *Teach Kine & Biomech in Sports* pp. 17
- Knudson et al. 2009 *Percept Mot Skills* 108:499
- Knudson et al. 2003 *Sports Biomech* 2:267
- NASPE 2003 Guidelines for undergraduate biomechanics http://www.aahperd.org/naspe/publications/teachingTools/upload/Guidelines-for-Undergraduate-Biomechanics-2003.pdf


TEXAS STATE UNIVERSITY SAN MARCOS
The rising STAR of Texas