Using skin sensors to measure student engagement in traditional and active learning classrooms

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Why Engagement?

Engagement is “based on the constructivist assumption that learning is influenced by how an individual participates in educationally purposeful activities” (Coates, 2005).

The majority of literature on student engagement directly or indirectly is concerned with improving student learning.

Thus, engagement is an essential part of the learning process

Skin Conductance

Measures Sympathetic activation-increases with excitement or stressors (physical, emotional, cognitive).

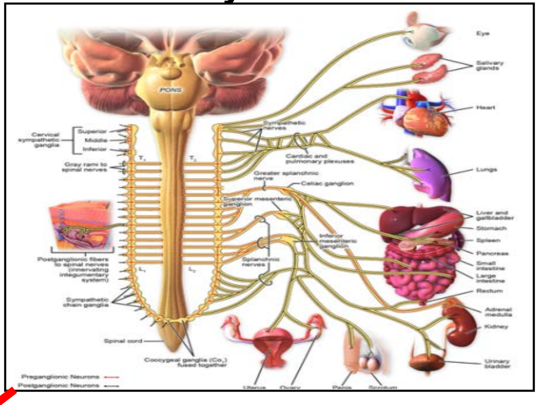
- Proxy for **engagement**

Electodermal Activity (EDA) or Galvanic Skin Response (GSR)

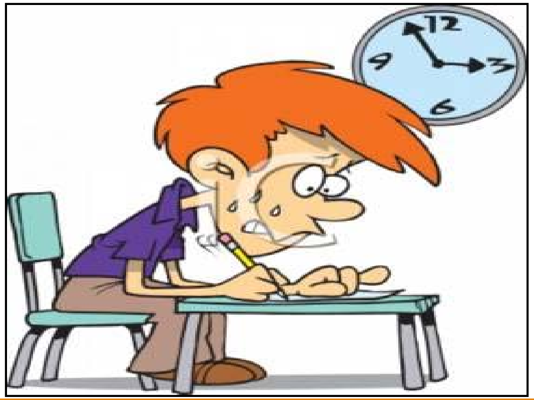
- Captures emotional response
- Non-invasive
- Measured by applying low constant voltage to skin – can not feel it!
- Real time

Arousal/Stimulus

Sympathetic Nervous System



Signal to sweat glands



Change in skin conductance

Benedek & Kaernbach, 2010 ; Dragon et al., 2008; Pecchinenda, 1996; Malmivuo and Plonsey, 1995

Engagement and Skin Conductance

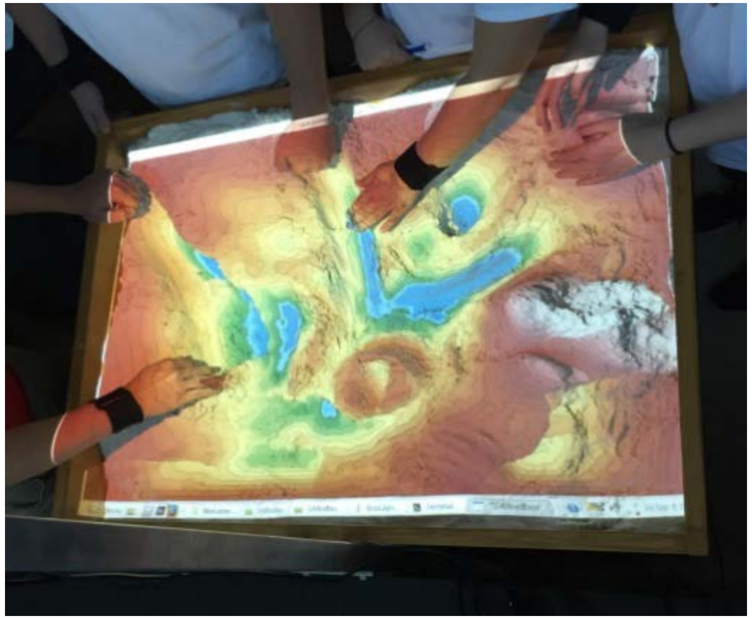
Dimensions of Engagement
Sympathetic Activation

- **Behavioral Engagement**
  Physical Stressors
  Are students involved?
- **Emotional Engagement**
  Emotional Stressors
  Are students interested?
- **Cognitive Engagement**
  Cognitive Stressors
  Are students challenged?

BASED ON FREDRICKS, BLUMENFELD AND PARIS (2004, 62-63), DRAWING ON BLOOM (1956) AND MALMIVUO AND PLONSEY (1995)

Applications of skin sensors in geosciences

Student engagement with AR Sandbox



Soltis et al., JGE, in revision

Active learning in undergraduate classrooms

McNeal et al., JGE, 2014
McNeal et al., in prep

Communicating climate change through music & movies

Maudlin et al., in prep
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Research Goal and Question

Goal: To utilize and validate skin sensors as a meaningful measurement tool for student engagement in large undergraduate STEM classrooms

Research question:

- What are students' engagement, affect and cognitive learning outcomes during different teaching modalities (active learning vs traditional learning) in the undergraduate biology classroom?

Experimental Design

One active learning introductory biology section and one traditional introductory section taught by same instructor

Pre-post assessments (N=138, 168):
Conceptual knowledge (Intro Bio)
(modified from Shi et al., 2010; Wick et al., 2013)
Biology self-efficacy (Balwin et al., 1998)
Biology sense of belonging
(Good et al., 2012)

Skin Sensors (N= 71, 65):
Worn by 15+ students in each of 5 courses for both the active learning and teaching treatment

COPUS Observations (N=5, 5):
5 classes were observed in each active learning and traditional teaching treatments
(Smith et al., 2013)

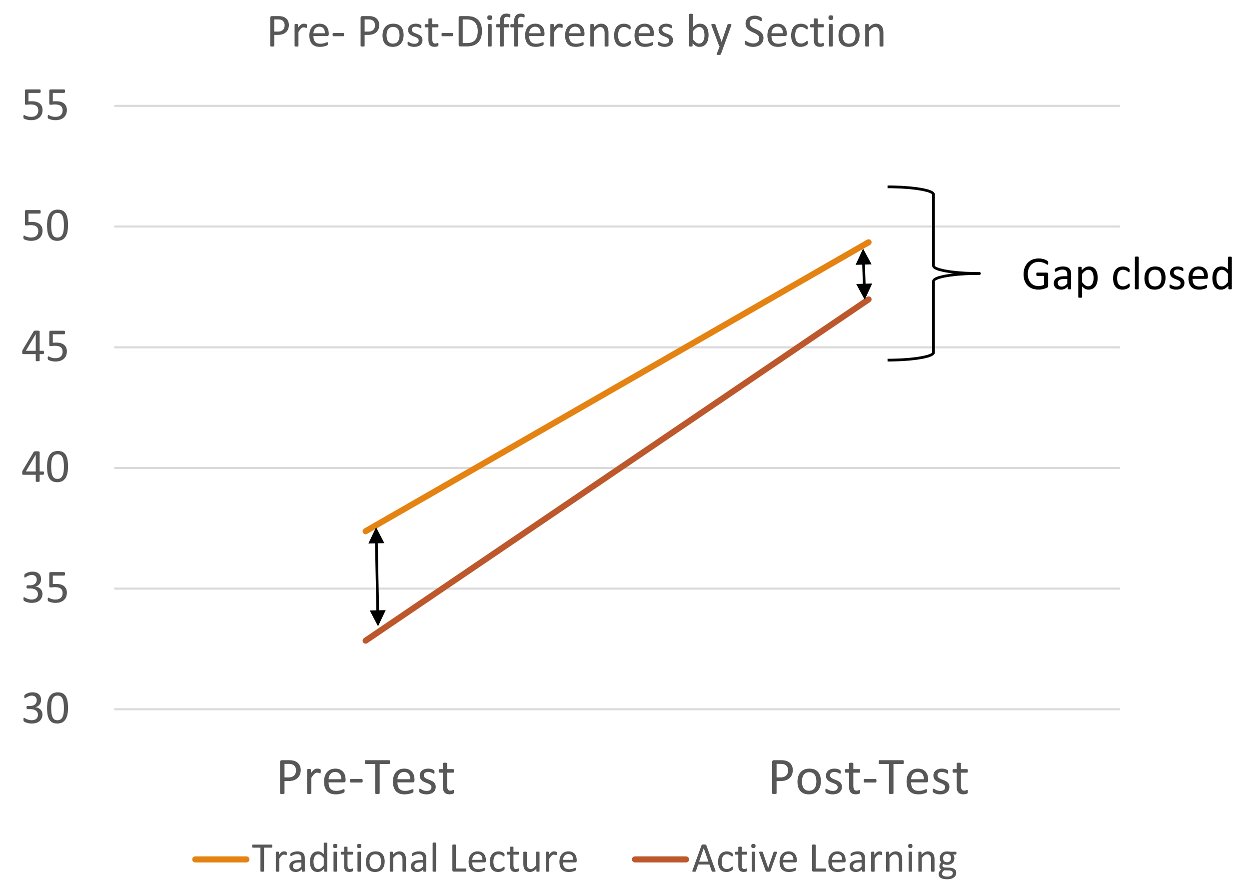
In class self-reflection engagement forms (N=71, 65):
Students that wore skin sensors completed forms after each of the five classes in both treatments

Pre-Post Content Knowledge

Section		Pre-Test (%)	Post-Test (%)	Difference (%)
Traditional Lecture	Mean	37.38	49.35	**11.97**
	N	138	138	138
	Standard Deviation	10.45	12.29	12.72
Active Learning	Mean	32.84	46.98	**14.15**
	N	168	168	168
	Standard Deviation	10.13	11.95	12.67

Pre-Post Content Knowledge

- Students in the traditional lecture course started the semester with significantly higher pre-test scores
  $t(304)= 3.851, p<.01$
- By the end of the semester, there was no longer a significant difference between scores in the traditional lecture and active learning course
  $t(304)= 1.700, p=.09$
- The increase in points in the active learning class from pre to post was significantly higher than the traditional lecture
  $t(305)=-1.974, p=.049, d=.227$



Methods- Skin Conductance

October 16, traditional teaching (50 mins)

Percent Change= $\frac{Average\ skin\ conductance\ during\ class - Average\ skin\ conductance\ during\ 10\ minute\ benchamark}{Average\ skin\ conductance\ during\ 10\ minute\ benchamark}$

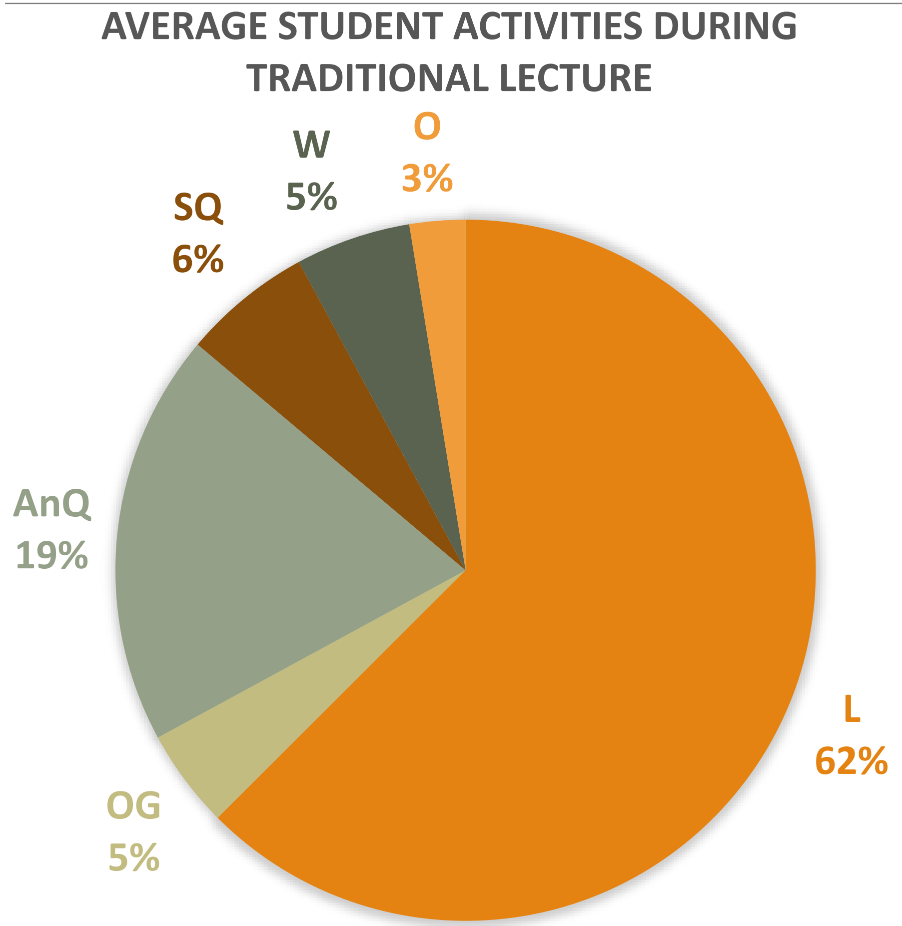
October 17, active classroom (80 mins)

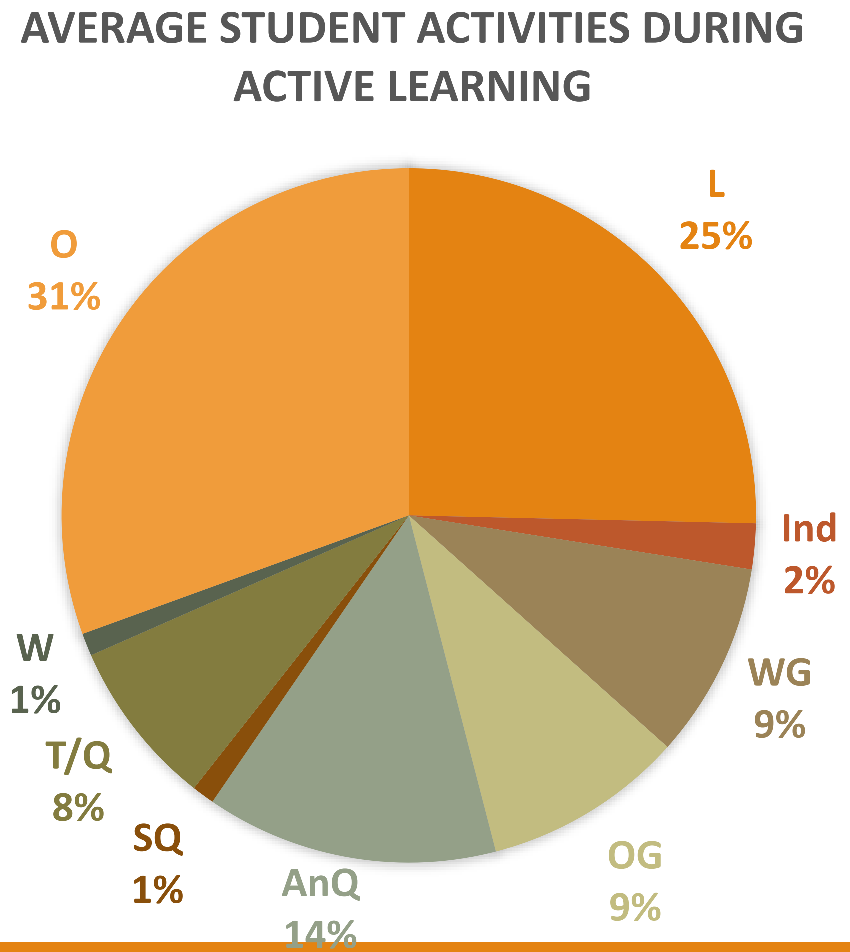
Engagement

Section	N	Mean % Change in Engagement	Standard Deviation
Traditional Lecture	71	-1.23	58.08
Active Learning	65	10.56	45.92

- ❑ Within subjects tests revealed that there was **significant decrease** in skin conductance in the **traditional lecture** class with medium effect size (p=.04, d=.51)
- ❑ In the active learning class there was no within subject differences between the benchmark and during class (p>0.05)
- ❑ **Self-reported** engagement was **significantly higher in the active learning** class (p=.016, d=.520)
- ❑ There is a **significant negative correlation** between the times student spent **listening** and their percent change in skin conductance (p=.031, Pearson corr.=-0.161)
- ❑ There is a **significant positive correlation** to time spent **working in groups** and skin conductance (p=.043, Pearson corr.=0.148)

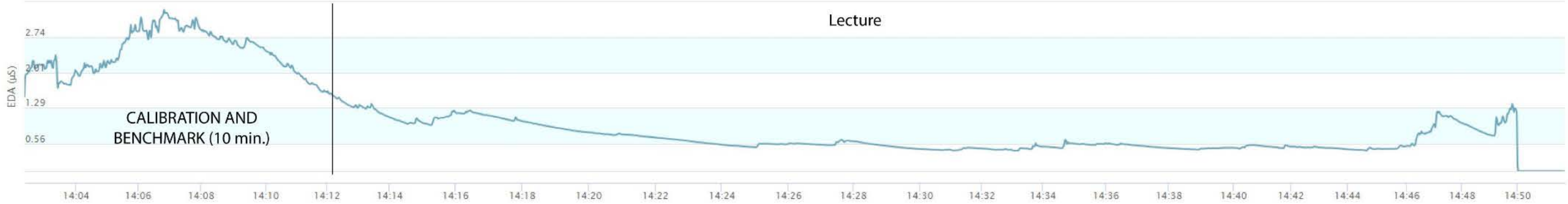
COPUS Results: Student Activities





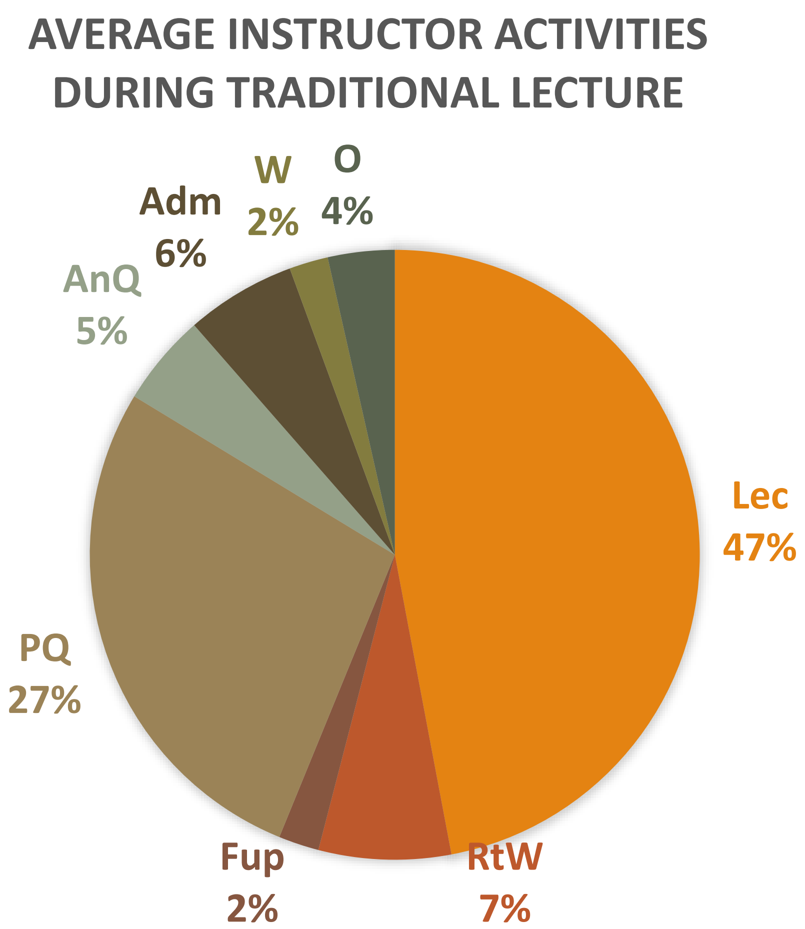
Skin Conductance – Comparison to COPUS activities

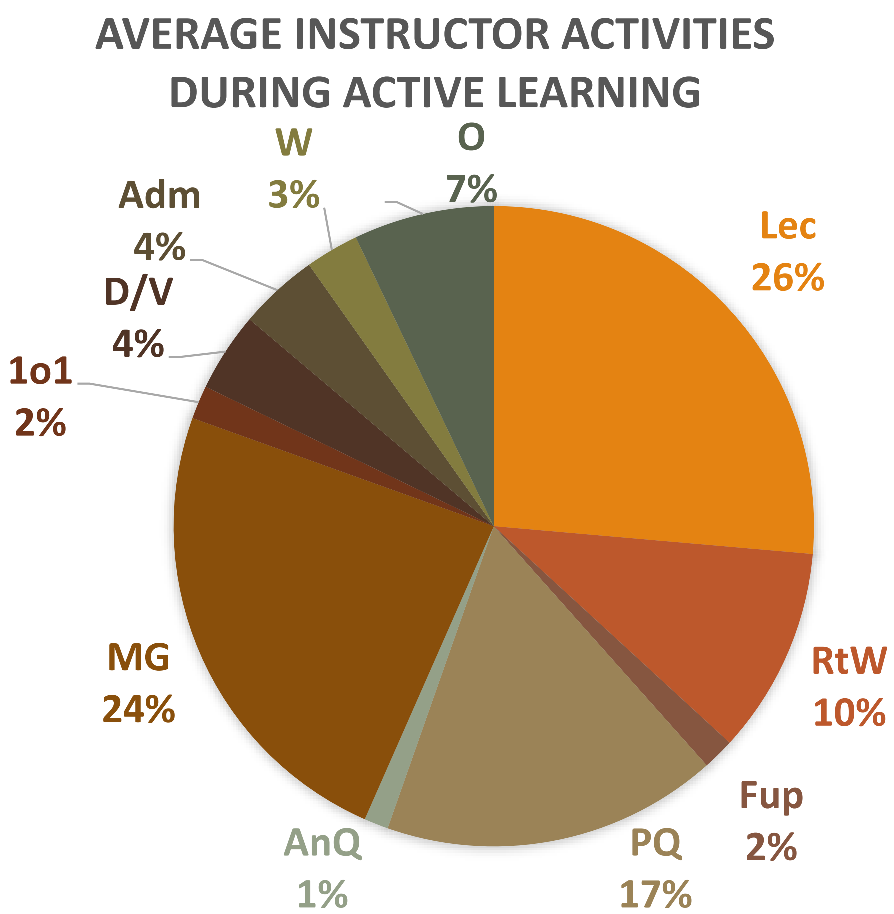
November 13, traditional teaching (50 min.)



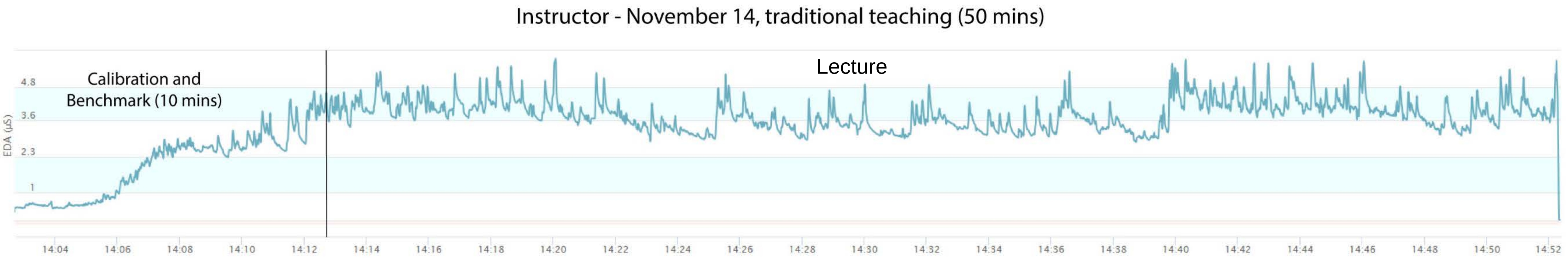
November 14, active classroom (80 min.)

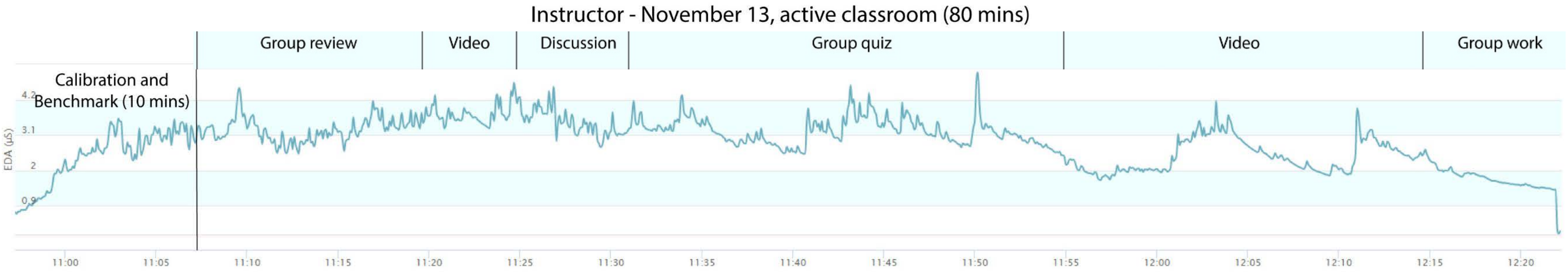
COPUS Results: Instructor Activities





Skin Conductance - Instructor





Conclusions

- The two classes started the semester with significantly different pre-test scores; however by the end of the semester the **active learning class closed that gap and** the net increase in points in the active learning class was significantly higher
- On average, **active learning** classes showed an **increase in skin conductance**, while traditional **lecture** classes showed a significant **decrease** in skin conductance
- Skin conductance was significantly **positively correlated with time spent working in groups and negatively correlated with time spent listening**
- There was no significant difference in affect or attitudes towards biology between the two sections or within subjects
- **Instructor engagement** appears to **decrease with some aspects of active learning**, however their time interacting with students increases and their time spent on activities that allow for more in class reflection and refinement also increases

Implications and Next Steps

- ❑ **Real-time, useful measure** = confidence through data triangulation (e.g., COPUS, student response forms, pre-post tests).
- ❑ **Evidence** = Could such evidence about student engagement help to convince faculty and students of the learning benefits of active learning approaches?
- ❑ **Alternatives** = Other biometric approaches, such as heart rate may offer similar benefits to skin conductance at more affordable rates (e.g., fitbits) but data extraction and analysis will still be complex = need automation and algorithm for large scale implementation
- ❑ **Future** = Could smart classrooms of the future utilize wearable technology to inform both students and teachers of the collective "pulse" of the class, allowing for "just-in-time" modifications to occur?
- ❑ ***Next steps: "NO WHERE TO HIDE IN ACTIVE LEARNING CLASSROOMS?"***
  - ❑ *Analyze courses for engagement based on where students sit in the large lecture hall (e.g., Does seating location affect student engagement? Is there a mediation effect with active learning engaging students regardless of their seating position in class?)*
  - ❑ *Further examine instructor engagement during various teaching modalities (e.g., how does engagement changes allow for variability in teaching approaches to occur?)*

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Acknowledgements

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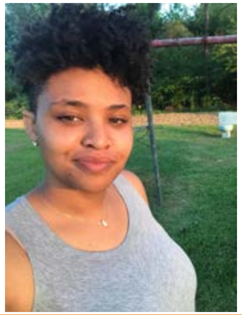


THANK
YOU


ANY
QUESTIONS?