The effects on instructor workload of implementing active teaching methods to improve student enthusiasm and performance

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What is active teaching?

- Any method of teaching that does not include the instructor lecturing for without student involvement.
  - - Richard Felder, ASEE-NETI coordinator

- I personally include "calling for volunteers" and "cold-calling students" traditional teaching as well.

  - Group discussions
  - Video presentations
  - Modeling demonstrations
  - Peer problem solving
  - Flipped classrooms
  - Design based learning

What are some problems that you would have to overcome to implement active teaching?

- Prep time
- Lost lecture time/can't cover as much material
- Difficult to get students to perform engineering solutions before lecturing/providing examples
- Student resistance to new styles
- Instructor lack of knowledge on active teaching

Background – Personal experience

Cory Mettler

- 10 years of teaching experience
  - Has always attempted to increase class participation by asking for volunteers at the board, attempting to facilitate class discussions, regularly providing Q/A time, etc.
  - Rarely been satisfied with the participation level achieved with the exception of a few outspoken students.
  - Always tentative about implementing a different teaching style due to the workload that undertaking would create.
- Returned to teaching fulltime in Fall 2013 and was assigned a number of new preps.
  - Decided this was a good time to implement an active teaching style.
  - Also decided to track the results to determine whether to continue using these techniques in the future.

Background – Personal Experience

Nathan Ziegler

- Ph.D. in Educational Psychology, with emphasis on cognition, critical thinking, ESL, and teaching practices.
- Background and expertise in Qualitative research.
  - Conducting classroom observations,
  - Interviewing students,
  - Researching communicative behaviors
- 10 years of experience teaching graduate, undergraduate, high school, and grade school level students in U.S., S. Korea, and China.

Background

- This study was implemented on 2 spring courses
  - All students involved took the fall prerequisite from me

	Traditional Lecture (Fall 2013)	Active Teaching (Spring 2014)
Sophomore-level	EE220: Circuits I Previously Taught: 9 semesters	EE222: Circuits & Machines Previously Taught: 3 semesters
Junior-level	EE320: Electronics I Previously Taught: 0 semesters	EE321: Electronics II Previously Taught: 0 semesters

Active Teaching Methods Used - Small Group Discussions

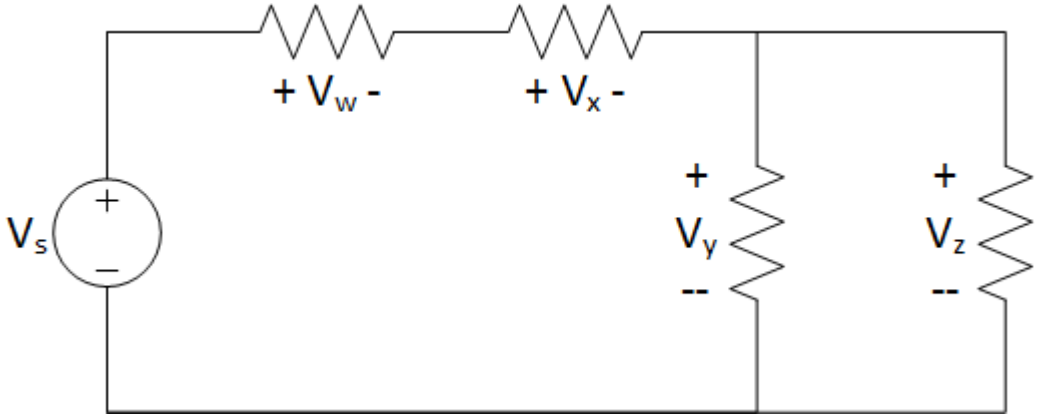
- Small Group Discussions
  - Have the students form groups and discuss, tell them they have 10s-30s.
    - Have them guess at a definition
    - Create a list for a specific category
    - Create a list of questions
  - This takes only slightly longer than cold-calling, why
    - Usually takes majority students a few seconds to work up the guts to answer
  - Works better than traditional polling/questioning
    - Every student has the opportunity to answer!
    - Students have a chance to think – addresses students who have a 'reflective' style of learning.
    - Students can rely on partner's answers – this reduces embarrassment

Active Teaching Methods Used - Thinking aloud Peer Problem Solving (TAPPS)

- Same groups
- Partner A
  - is the faculty member who has been at SDSU the shortest amount of time
  - Walk through the following problem and explain each step to your partner
- Partner B
  - Actively listen
  - Challenge if statements are incorrect or ambiguous
  - Help determine correct answer if Partner A gets stuck

Example: Basic circuit analysis

- Given this circuit use KVL to find V_X



Def: The sum of voltage around a complete path sums to:

Label KVL path:

$V_S + V_w + V_x + V_y + V_z = 0$

$-V_S + V_w + V_x + V_y = 0$

$V_x = -V_S - V_w - V_y - V_z$

$V_x = V_S - V_w - V_y$

Active Teaching Methods Used - Thinking aloud Peer Problem Solving (TAPPS)

- Choose partner A and B – it saves time
- Use problems you already planned to use as examples, just don't work the problem yourself
- On some TAPPS provide the correct answer, particularly if it is a tricky problem
  - Don't cover the correct answer, it forces the ALL students to put effort into the problem
  - Do ask if there was problems, address the problems as a class, this is what you are hoping for – it is the best learning opportunity you can create!
- On some TAPPS provide an incorrect solution, but choose a mistake that you know your students will historically make.
  - I have started to ALWAYS tell them that there IS a mistake
  - I always cover the correct solution

- Forces ALL students to work your example
- Students can typically complete the example faster than you can (they can read faster than you can speak and write)
- Allows students to make the exact mistake you KNOW they will make on homework, but do so in a learning environment where they can get immediate feedback.

Active Teaching Methods Used - Individual Sketch

- Usually very similar to Small Group Discussions, but student work on question individual.
- I usually applied this to review, where I am sure the majority of the class *should* know the answer
- Benefits are much the same as SGD
  - However, it is an opportunity for students to build some self-confidence

Study objectives
- Outcomes to be analyzed

1. Preparation time for an Active Teaching lecture should not require more than 15 minutes more than a similar Traditional Teaching lecture
2. The amount of course material covered must not decrease from previous semesters
3. Student mastery of course material should improve
4. Student enjoyment of (and enthusiasm for) course material should increase.

Outcome #1 – Preparation time should not increase by more than 15 minutes

Class	Semesters taught	Num of Lectures	Req Prep per lecture in 2013/14 (min)	Total Prep Time in 2013/14 (hr)	Increased time to prep (min)
EE220	9	30	18.8	9.4	6.4
EE222	3	32	25.2	13.4	
EE320	0	24	137.3	54.9	13.4
EE321	0	22	150.7	55.3	

- EE220 vs EE222
  - Increase of prep time was due only to the time it took to Copy/Paste existing examples from personal notes to class notes and to add in some mistakes in TAPPS examples
- EE320 vs EE321
  - Increase of prep time was partly due to being less familiar with course material, some due to formatting TAPPS. Also, time was spent researching common mistakes to include in TAPPS exercises.
- Future: I expect the increase of prep time to be a 1 time increase – subsequent course offerings should require less prep effort

Outcome #2 – Amount of course material should remain the same

EE222: Circuits and Machines topics	
2013	2014
Sinusoidal Steady State	Sinusoidal Steady State
Phasors and Impedance	Phasors and Impedance
Complex and Apparent Power	Complex and Apparent Power
3phase circuits	3phase circuits
Magnetically coupled circuits	Magnetically coupled circuits
Transformers	Transformers
S-domain circuit analysis	S-domain circuit analysis
DC motors and generators	DC motors and generators
Induction Motors	Induction Motors
- - - -	Elect to Mech system conversions

EE321: Electronics II topics	
2013	2014
Frequency response of transistors	Frequency response of transistors
Integrated Circuit transistor designs	Integrated Circuit transistor designs
Current sources	Current sources
Differential amplifiers	Differential amplifiers
Active loads	Active loads
- - - -	Feedback
CMOS OpAmps	CMOS OpAmps
Logic Inverters and Gates	Logic Inverters and Gates
Memory Circuits	Memory Circuits
- - - -	Oscillators

- Results – the amount of material actually increased in both classes from the previous course offering
- Hypothesis – this may be due to the fact that students were learning the material better and I was required to repeat and review less

Outcome #3 – Students' mastery of the material should increase

- Method 1: Some material was still taught using TL and some using AT. Some test questions were designed to specifically target topics from each lecture. ATx was designed to be the same difficulty level, have the same amount of class time dedicated, and have the same amount of homework assigned as TLx.
  - It was expected that students would score better on the ATx problems than they did on the TLx problems

- Method 2: Since this group of students took the pre-req course from the same instructor in the fall as their respective classes in the spring, a comparison of the pre-req course final grade was made to the spring course final grade.
  - It was expected that the class average would remain the same between the fall and spring courses. This is because the spring course material is the second-level material and is more challenging. Typically, there is a decrease in average.

Outcome #3, Method 1 – EE222 Results

	Test Question	Possible points	Class average
AT1	Determine the current produced in this circuit and predict how it will change if the frequency is reduced	6	61.1%
AT2	Find the apparent power from this 3phase source, use the power triangle to describe pf correction	40	76.9%
AT3	Draw a model of this circuit that accounts for the mutual coupling	10	83.3%
AT4	Reflect the load and/or source over the ideal transformers	15	72.0%
AT5	Write the system of equations for this circuit with initial conditions using S-domain analysis to determine the mesh currents	20	85.3%
AT6	Determine the induced voltage on this DC motor	10	96.4%
AT7	Translate this ME model to an EE equivalent	30	56.2%
	Average AT test score		74.1%
TL1	Draw a phasor diagram of the signals at 60Hz and explain how it changes at 50Hz	8	38.2%
TL2	Determine the RMS value of a sawtooth wave and find the resistance that draw the max power from this circuit	30	45.7%
TL3	Write the KVL equation for the mutually coupled model	10	75.3%
TL4	Analyze the currents in the ideal transformer circuit	10	68.0%
TL5	Solve the system of equations using Cramer's Rule	10	64.7%
TL6	Determine the induced current on this DC motor	10	90.0%
TL7	Determine the speed and torque of this DC motor	40	47.7%
	Average TL test score		55.6%

Outcome #3, Method 1 – EE321 Results

	Test Question	Possible points	Class average
AT1	Determine W/L of this MOSFET current source	10	85.3%
AT2	Design a MOSFET current steering circuit	20	95.8%
AT3	Determine the required drain resistance and offset voltage for this differential amplifier	25	80.2%
AT4	Implement this logic statement	25	56.7%
	Average AT test score		77.4%
TL1	Determine VSD for this MOSFET current source	10	77.5%
TL2	Design a BJT current steering circuit	10	60.8%
TL3	Determine the W/L ratio and common mode gain for this differential amplifier	25	71.8%
TL4	Size the transistors for this logic gate	25	55.0%
	Average TL test score		65.0%

- Nearly 100% of student scored better on the AT question than that related TL question nearly 100% of the time!
- The difference between the two decreased as the semester went on.
  - Hypothesis: I believe that initially students put more emphasis on the topics taught by AT than by TL
  - If this is true, it is yet another justification to implement AT!

Outcome #3 – Method 2 – Results

Class #1	Grade #1	Class #2	Grade #2	Difference
EE320-Fall2013	78.8%	EE321-Spring2014	80.1%	1.3%
EE220-Fall2013	91.7%	EE222-Spring2014	85.9%	- 5.8%
EE220-2011&2012	82.4%	EE222-2012&2013	73.2%	- 9.2%

- EE321: As expected, the grades remained constant, suggesting students mastered more challenging material to the same level as the pre-req material.
- EE222: Unfortunately, the Sp14 grades decreased from Fa13. However, they decreased less than 2011/2012 and 2012/2013 classes did. Also, it should be noted that the Fa13 class had the highest ever class average.

Outcome #4 – Student enthusiasm for course material should increase

- Very tough to directly assess!
  - I partnered with Nathan Ziegler particularly to help address this issue.
- Assumption:
  - Students who are more engaged in course material are more likely to have a high-level of enthusiasm.

Outcome #4 - Methods

- Method 1: Instructor based observations

Activity:					
Class participation during activity:	1	2	3	4	5 Y/N
Class participation after reconvening:	1	2	3	4	5 Y/N

1. No class participation
2. Participation by only a small core group of commonly active students
3. Participation by more than 50% of students
4. Participation by more than 90% of students
5. Activity resulted in extended discussion (yes or no)

- Method 2: Student polls

- Method 3: Independent research observations

Outcome #4 - Method 1 Results

- TAPPS/SGD
  - Reached level 4

  (>90% class engagement)
  - 79.3% in EE222
  - 88.1% in EE320
- Cold Calls
  - Limited to levels 1&2

  (Core group participation only)
  - 100% in EE222
  - 90.0% in EE320

EE222 Activities		1	2	3	4	5
Small groups	During	0	0	5	17	3
	After	0	1	5	14	3
TAPPS	During	0	0	1	6	1
	After	0	0	1	3	4
Ind. Sketch	During	0	1	2	1	0
	After	0	0	3	1	1
Cold Calls	During	5	6	0	0	2
EE321 activities		1	2	3	4	5
Small groups	During	0	0	5	25	2
	After	0	1	7	11	9
TAPPS	During	0	0	0	12	0
	After	1	0	2	5	3
Ind. Sketch	During	0	0	1	1	0
	After	0	0	2	0	0
Cold Calls	During	8	10	1	1	2

- In depth questions
  - AT regularly resulted in level 5 discussion (29.2% and 44.4%)
  - Cold call *rarely* resulted in level 5 discussion (18.1% and 10.0%)

Outcome #4 - Method 2 Results

- Student were asked to write minute papers three times during the semester to address their thoughts on Active Teaching techniques
  - Students were exposed to test results to show their mastery difference after each test
- The amount of students who responded positively increased each time until 100% acceptance was reached in both classes
- On the last minute paper student were asked to comment on the amount of AT
  - 31% and 50% were satisfied
  - 69% and 50% requested more next year
  - 0% requested less

	Minute Paper #1	Minute Paper #2	Minute Paper #3
EE222	68.7%	81.3%	100%
EE321	70.0%	70%	100%

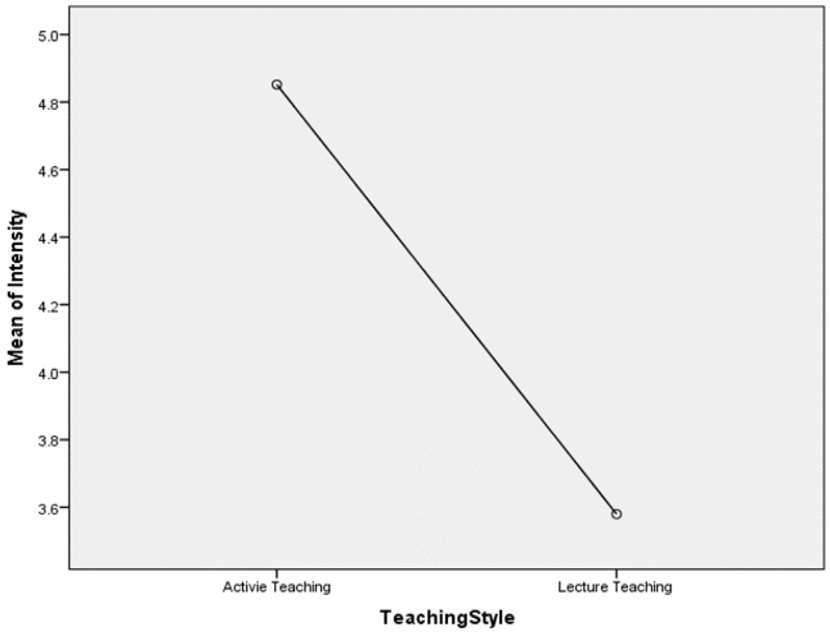
Outcome #4 - Method 3 results

- Significant correlation between **Eye Brow Raising** and **Perceived High Intensity Enthusiasm** (Chi-square=12.911; $p < .05$).
  - Suggests internal consistency with observations of participants.
- Significant correlation between **Teaching Style and Expression** (Pearson=.138; $p < .05$), and **Teaching Style** and **Intensity of Expression** (Pearson=-.435; $p < .01$).
- Significant relationship between **Higher Levels of Enthusiasm** and **AT** ($F=69.370$; $p < .01$).

Outcome #4
- Method 3 results

Table 1. Frequency of Teaching Style, Expression, and Intensity of Expression

Intensity			TeachingStyle: Active Teaching	TeachingStyle: Traditional Lecture	Total
Low	Expression	Enthusiasm	2	3	5
	Total		2	3	5
Fairly Low	Expression	Enthusiasm	4	29	33
	Total		4	29	33
Medium	Expression	Enthusiasm	26	43	69
		Bored	2	6	8
	Total		28	49	77
Fairly High	Expression	Enthusiasm	13	18	31
	Total		13	18	31
High	Expression	Enthusiasm	49	18	67
		Bored	0	2	2
		Frustration	1	0	1
	Total		50	20	70
Very High	Expression	Enthusiasm	65	9	74
		Bored	0	10	10
	Total		65	19	84



Conclusion and Discussion

- Outcome #1: Inconsequential increase in preparation time for AT.
- Outcome #2: More material was covered compared to previous terms.
- Outcome #3: Students learn more with the AT style.
- Outcome #4: Students showed higher levels of enthusiasm during AT than TL, suggesting higher engagement, motivation and efficacy.

Even a minimal amount of effort dedicated to introducing low intensity AT methods has a profound effect on student learning.

Questions?