Triangle of effective learning

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PPCCLT Workshop on ‘Effective teaching in diverse settings’
July 25, 2023

Predict the outcome

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Consider programming, as taught in many schools today. The teacher explains the syntax and the logic of a program, then asks students to go through the solved examples in the book, and gives a few exercises from the end of the chapter as homework.

In the exam, the students are required to write a program for <u>one of the textbook problems</u>.

Are these students likely to score well in the exam? (80% of the students get 80% marks)

- Yes
- No

Predict the outcome … contd

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The same students are now given a problem that is <u>unfamiliar to them</u> but at the same level as the textbook problems.

They have to write a program, run it for a few test cases and give the output.

Are these students likely to be successful? (80% of the programs run correctly for 80% tests)

- Yes
- No

Discussion

Where are the disconnects? (Note answers here)

Discussion … contd

Your colleague says: I explained my topic well. I gave examples, solved problems, and asked questions. The responses showed that students understood. Then I was shocked to find that they have done miserably in the exams.

What could be some reasons for this?

Some terminology

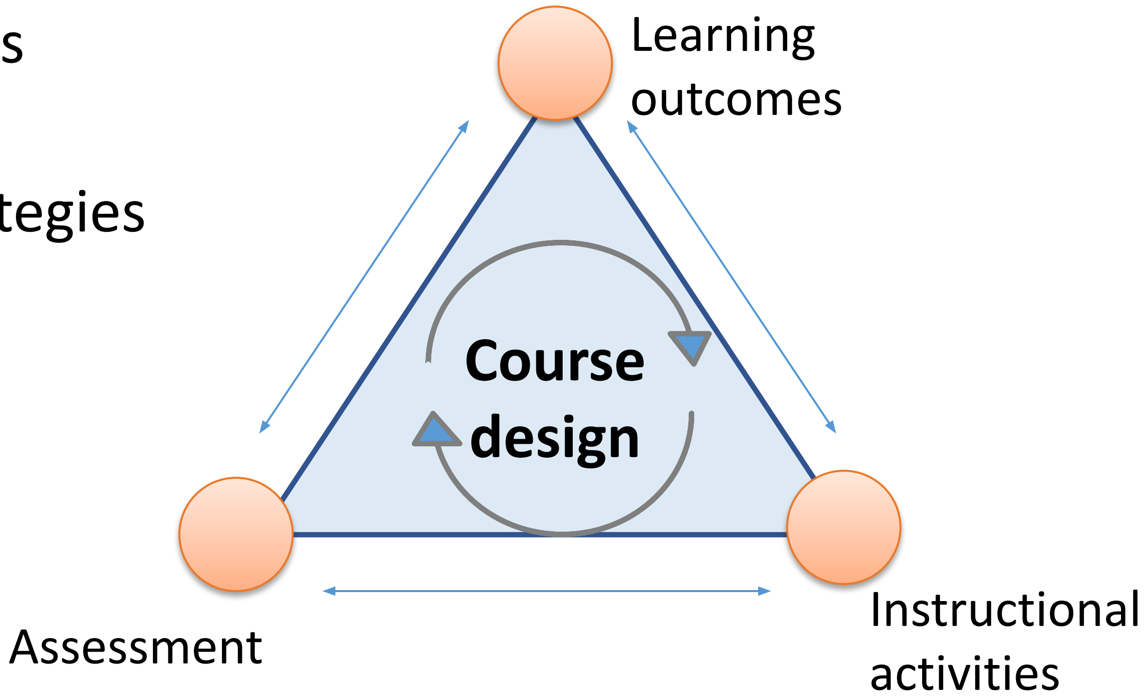
1) What should they be learning? - Can we define it precisely?	Course outcomes/ Learning outcomes
2) What can we do to help them learn it, as defined above?	Instructional strategies
3) Are they learning it? - How do we know that they have learned it, as defined above?	Assessment

Triangle of effective learning

Course learning outcomes

- Guide assessment
- Guide instructional strategies and learning activities

- Ensure alignment



Activity – Write a learning outcome

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- Think of the course you will be teaching in this semester
- Write one learning outcome for this course

The problem with Understand / Know

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I'm teaching a [basic course on computer networks]

Suppose my learning outcome is:

Understand [networking protocols]

What exactly does understand [networking protocols] mean?

Bloom's taxonomy - for writing specific outcomes

Level	Description	Action verbs
Create	Combine parts to make (new) whole, creative behaviours, propose plans	design, combine, devise, modify
Evaluate	Judge value based on criteria, decision making	assess, conclude, contrast, evaluate
Analyze	Separate whole into parts until structure of whole and relationship between parts is clear	analyze, infer examine, dissect
Apply	Use knowledge in a new situation. Involves rules, methods, laws, principles	Apply, calculate, solve, predict
Understand	Grasp meaning, explain, interpret, translate, paraphrase	describe, explain, give example
Recall	Recognize, recall facts	define, identify

More details

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See the PPCCLT channel on YouTube;

Learning objectives - https://www.youtube.com/watch?v=Os5rY2faig8

Activity – Write an assessment question

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- Refine the learning outcome that you wrote earlier (if reqd).
- Think of a question that you could ask to determine if students have “learnt”, i.e., achieved the learning outcome.

Key point

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Assessment should be aligned with outcomes

==> Use Bloom's taxonomy as a framework for Assessment

* Typically higher levels encompass lower levels.

Reflection Spot – what do you excel at?

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- Think of one activity that you excel at doing.

(Note: Activity could be academics or your hobby)

- Think about why you are so good at this activity
  - Write down top 3 reasons for your mastery in this activity

Discussion - Excellence

Think of one activity that you feel you excel at doing.

Think about why you are so good at this activity.

Let me guess - One of your top 3 reasons is likely to be:

Practice or Experience

Discussion - Excellence

Do you feel that you could have gained such mastery by listening to lectures on the topic?

Point to keep in mind:
As learners, we develop mastery through practice (doing activities, rather than simply listening to lectures, or watching demos).

So,
As teachers, we must ensure that we provide our students with practice – sufficient and timely opportunities.

How to provide sufficient and timely practice?

One way – Active learning techniques.

- Students go beyond listening, writing notes, executing prescribed procedures.
- Students asked to ‘figure things out’ *during class.*

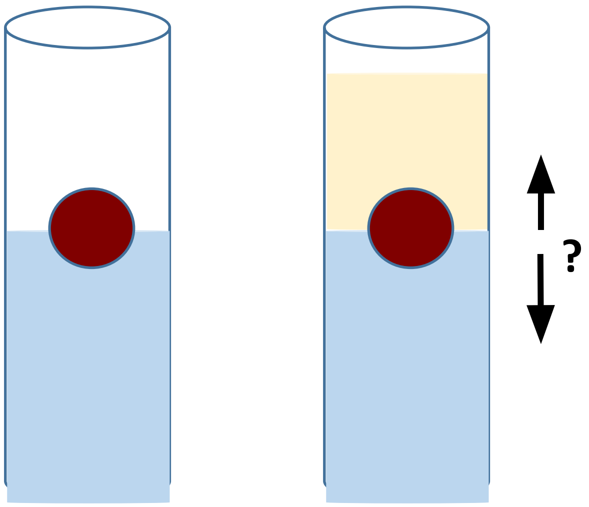
Needs attitude shift of teacher:

- from content-oriented to learning-oriented.
- from “How well am I lecturing?” to “How well are they learning?”

Vote individually

An object floats in water but sinks in oil. When it floats in water it is exactly halfway submerged. If we slowly pour oil on top until the oil completely covers the object, does the object:

1) Move up
2) Stay in place
3) Move down

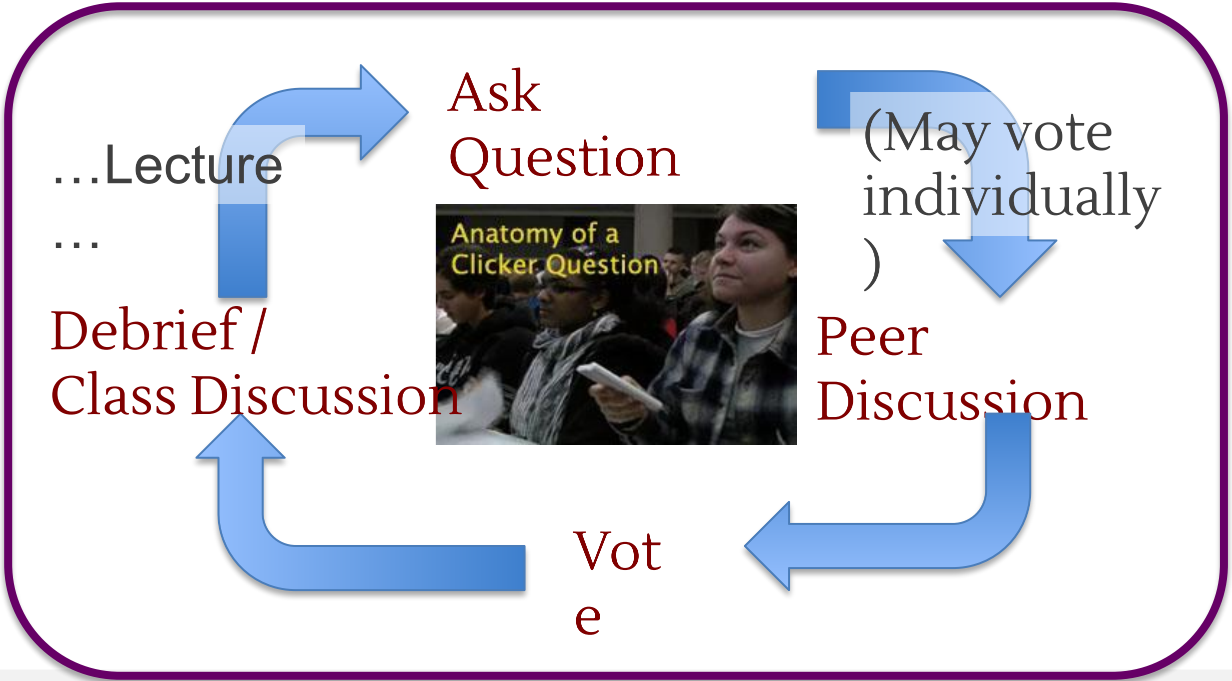


Discuss with your neighbor and Converge

Then Vote again

Peer Instruction (PI) technique

- Download the *PI-activity-constructor* resource sheet from:
  - Download from www.et.iitb.ac.in/TeachingResources.html



PI – another example

What is the output of the code shown below?

```
int main() {
int a = 1; b = 2; c = 3;
int *p, *q;

    p = &a; q = &b;
    c = *p; p = q;
    *p = 13;

cout << a << b << c;
}
```

Options are:

1) a=1, b=2, c=3
2) a= 1, b=13, c=1
3) a=1, b=2, c=1

PI – An example with visualizations

Observe Phase

TEACHER:

- Play viz upto the point the stimulus is shown.
- PAUSE before result. Don't show rest of viz yet.

STUDENTS:

Observe first part of viz

Predict Phase

TEACHER:

- Ask students to make prediction: "What will happen if …"

STUDENTS:

- **Make prediction – write, vote, discuss w each other**

Will the balloon move?

A) Yes, to the left
B) Yes, to the right
C) No

Check Phase

TEACHER:

- Shows rest of viz, which has result

STUDENTS:

- Check their prediction by watching the result in viz

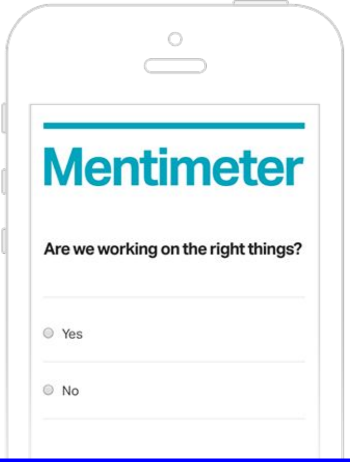
Show rest of movie

Link to video: http://paer.rutgers.edu/pt3/experiment.php?topicid=13&exptid=121

Peer-Instruction implementation

https://youtu.be/wont2v_LZ1E
https://cwsei.ubc.ca/resources/instructor/prs

Crouch, C. H., & Mazur, E. (2001).
Peer instruction: Ten years of experience and results. *American journal of physics*, *69*(9), 970-977.



www.mentimeter.com

Predict the engagement

Imagine a 90-minute class in a large auditorium with fixed seats.

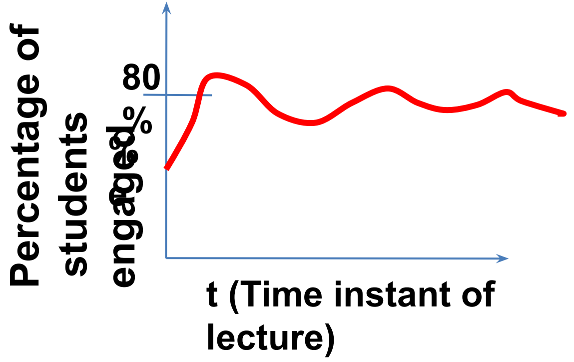
Think (individually):

- Predict the percentage of students who may be showing "engaged" behaviour (with the content of the lecture), at various instants of time.
- Draw a graph of engagement versus time. [~1 min]

Sustain the engagement

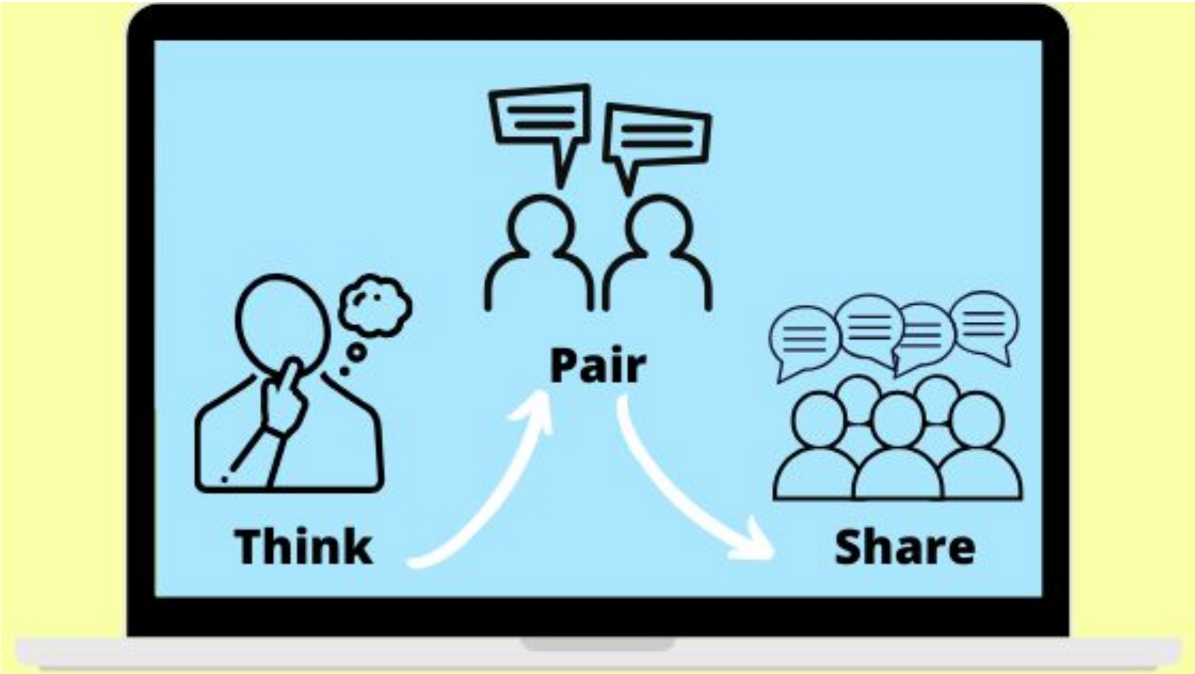
Pair (with your neighbour):

- Together, come up with two techniques that could be used to convert your graph into something that looks like the figure shown. [~2 min]



Think-Pair-Share (TPS) technique

- Download the *TPS-activity-constructor* resource sheet from:
  - Download from www.et.iitb.ac.in/TeachingResources.html



TPS implementation and example

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- **T** (Think): Teacher poses a specific question about the topic. Students "think" and write their own individual answer.
  - Example: How will you sort a given set of numbers?

- **P** (Pair): Teacher gives a task related to the one in previous phase. Students “pair” with a neighbor to perform the task.
  - Example: Discuss pros-cons of each others’ sorting solutions.

- **S** (Share): Students share their thinking (or solution) with the class. Teacher facilitates a discussion on the topic.
  - Example: Discussion on different types of sorting algorithms.

TPS - Another example

"Design a taxi scheduling service for an airport as follows:

(i) When a driver arrives, his ID is entered in an array

(ii) When a customer arrives the earliest waiting driver is assigned

Think: What structures and variables are required?

Pair: Come up with the pseudo-code for the functions required.

Share: : Discussion of pros-cons of your solutions and others.

More details

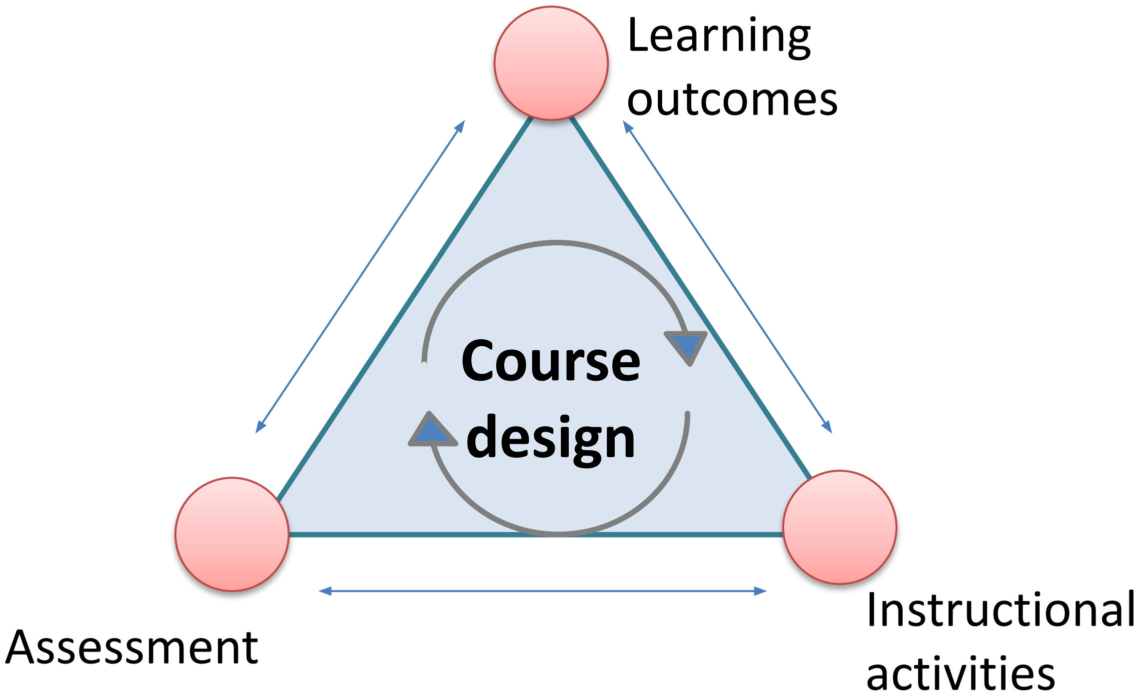
See the PPCCLT channel on YouTube;

- Active learning - https://www.youtube.com/watch?v=4zhogedayxw

- Peer-instruction - https://www.youtube.com/watch?v=n-ZNAjgtf-Q
- Think-Pair-Share - https://www.youtube.com/watch?v=Kbcci0rRo18

Triangle of effective learning

Ensure alignment



Thank you

www.et.iitb.ac.in

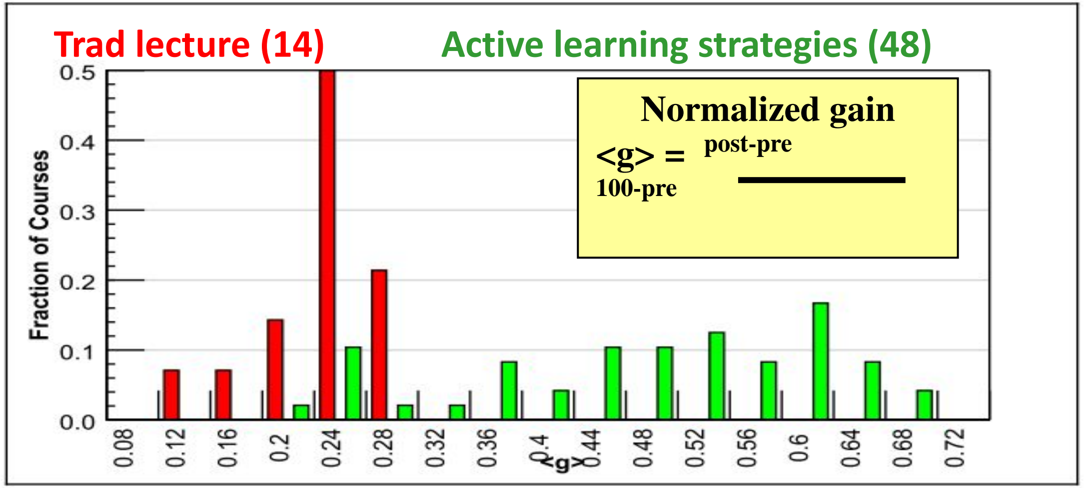
Why interactive lectures may not be enough

- Students don’t pay utmost attention throughout the lecture.
- Students *think* that they understand because they can follow the lecture.
  - They are not confronted with their misconceptions immediately.
- Difficult to ensure that all students in the class participate actively.
  - Students with high motivation / achievement levels drive the pace.
  - Students with low achievement levels get left behind.
- Students may have a barrier to responding directly to the instructor.
  - Shy students don’t ask questions, or give answer, even if they have one.
  - Forcing all students to respond tends to be counter-productive.

Evidence for active learning – 1

Comparative study of 62 Physics courses (1998)

- 6542 students
- Variety of institutions: high school, college, university
- Test of conceptual reasoning – Force Concept Inventory
- Pre-post, semester long



IMPLICATION

Desirable to explicitly incorporate active learning strategies in our teaching-learning.

RESULTS:

- Maximum gain from lecture courses was 0.28
  - Many instructors had high scores on teaching evaluations
- Gain from active-learning courses had a wide range: 0.23-0.7
  - AL courses had gains 2-3 times greater than lectures

R. Hake, "Interactive-engagement versus traditional methods: A six-thousand student survey of mechanics test data for introductory physics courses" Am. J. Phys., **66** (1998)

Evidence for active learning – 2

PNAS

Active learning increases student performance in science, engineering, and mathematics

Scott Freeman[a,1], Sarah L. Eddy[a], Miles McDonough[a], Michelle K. Smith[b], Nnadozie Okoroafor[a], Hannah Jordt[a], and Mary Pat Wenderoth[a]

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Edited* by Bruce Alberts, University of California, San Francisco, CA, and approved April 15, 2014 (received for review October 8, 2013)

To test the hypothesis that lecturing maximizes learning and course performance, we metaanalyzed 225 studies that reported data on examination scores or failure rates when comparing student 225 studies in the published and unpublished literature. The active learning interventions varied widely in intensity and implementation, and included approaches as diverse as occasional group

Meta-analysis of 225 studies (2014)

Proc. Natl. Acad. Sc, 111(23), 2014

- Exam performance: higher by 0.47 standard deviations in active learning courses– ~ 1/2 letter grade average increase.
- Failure rates : 33.8% in traditional classes vs 21.8% in active learning courses
- Results hold across STEM disciplines, majors and non-majors, lower- and upper-division courses.

Evidence for active learning – 3

Effect of Think-Pair-Share in a Large CS1 Class: 83% Sustained Engagement

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https://dl.acm.org/doi/pdf/10.1145/2493394.2493408

Think-Pair-Share in a Large CS1 Class: Does Learning Really Happen?

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https://dl.acm.org/doi/pdf/10.1145/2591708.2591739