Comparing a "Flipped" Instructional Model in a Calculus III Course

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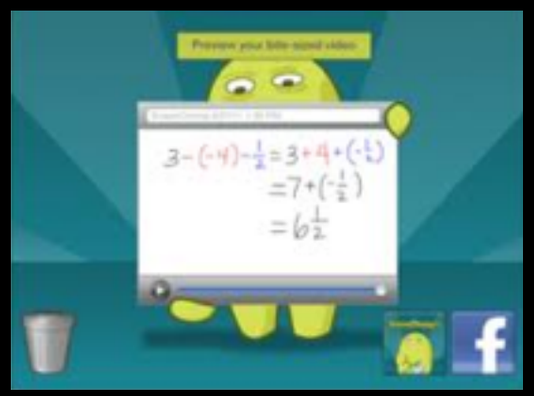
Technology

- In recent years, technology has drastically transformed the educational landscape. In particular, it has expanded the classroom walls.



“Flipping” the classroom

- Lage, Platt, & Tregalia (2000) describe an “inverted” classroom model as: events that typically take place *inside* the classroom now take place *outside* the classroom and vice versa.
- Bergman & Sams (2008) popularized an analogous approach that has come to be known as the “flipped” classroom

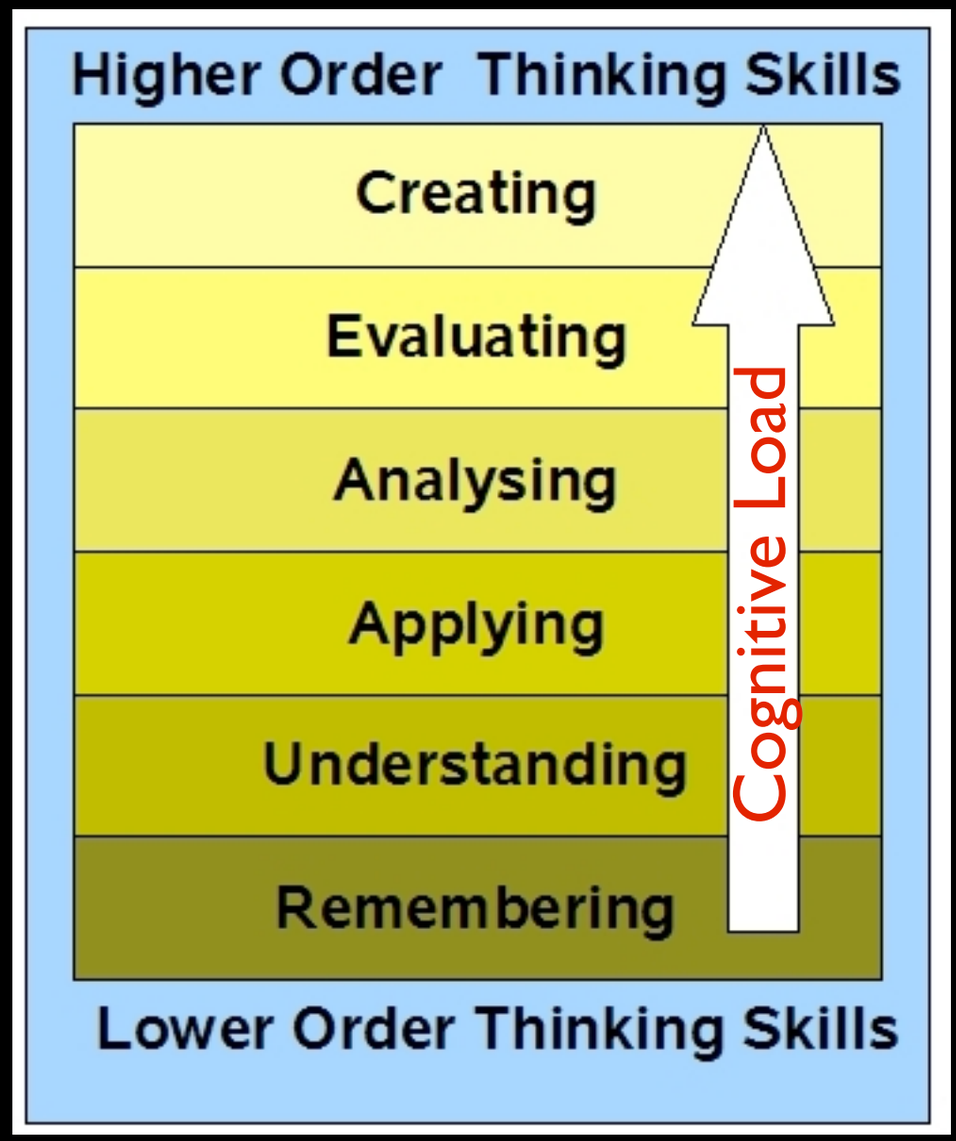
Instruction

Two aspects of instruction are:

1) Transmission of content (e.g., lecture)
2) Assimilation (e.g., practice)

Adaptation of Bloom's Taxonomy

Anderson & Krathwohl (2001)



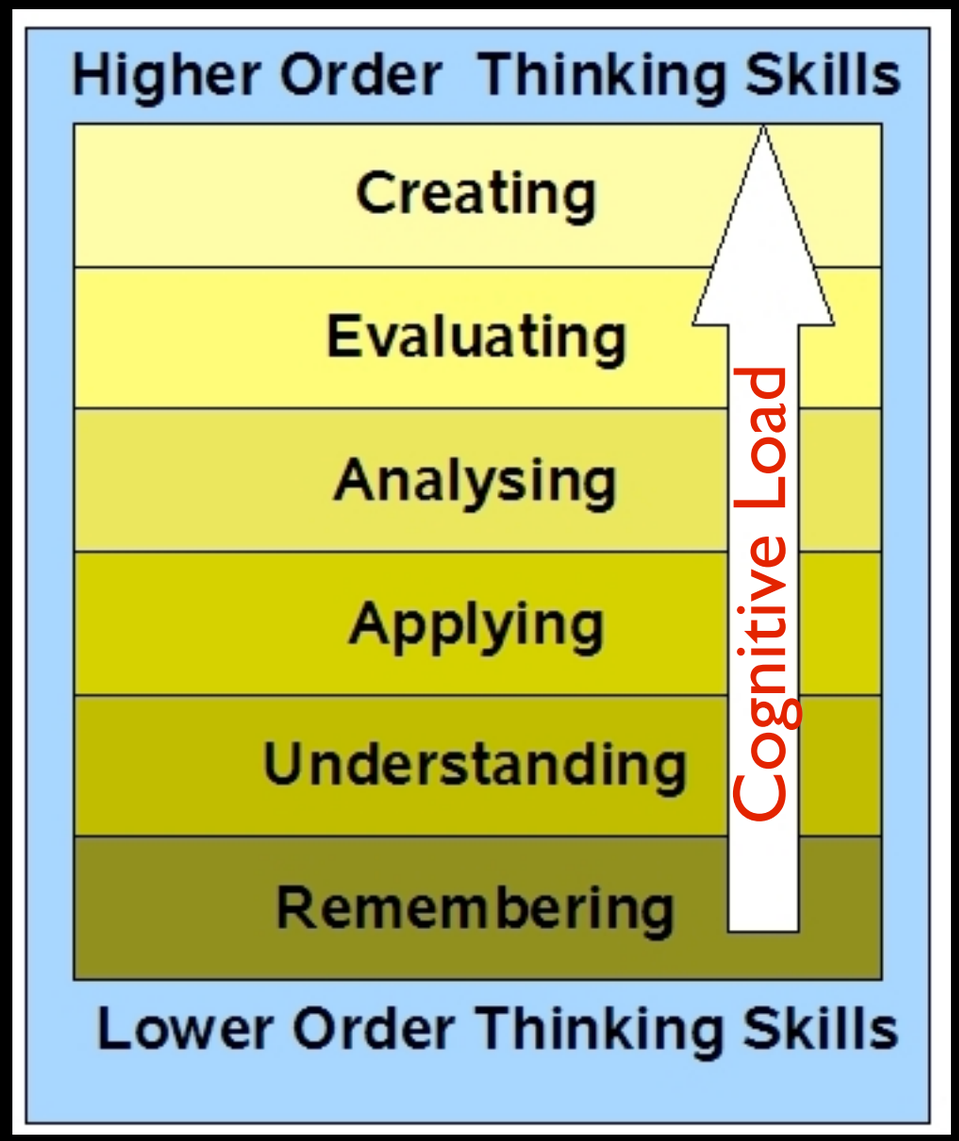
Instruction

Assimilation

Transmission

Adaptation of Bloom's Taxonomy

Anderson & Krathwohl (2001)



Traditional Approach

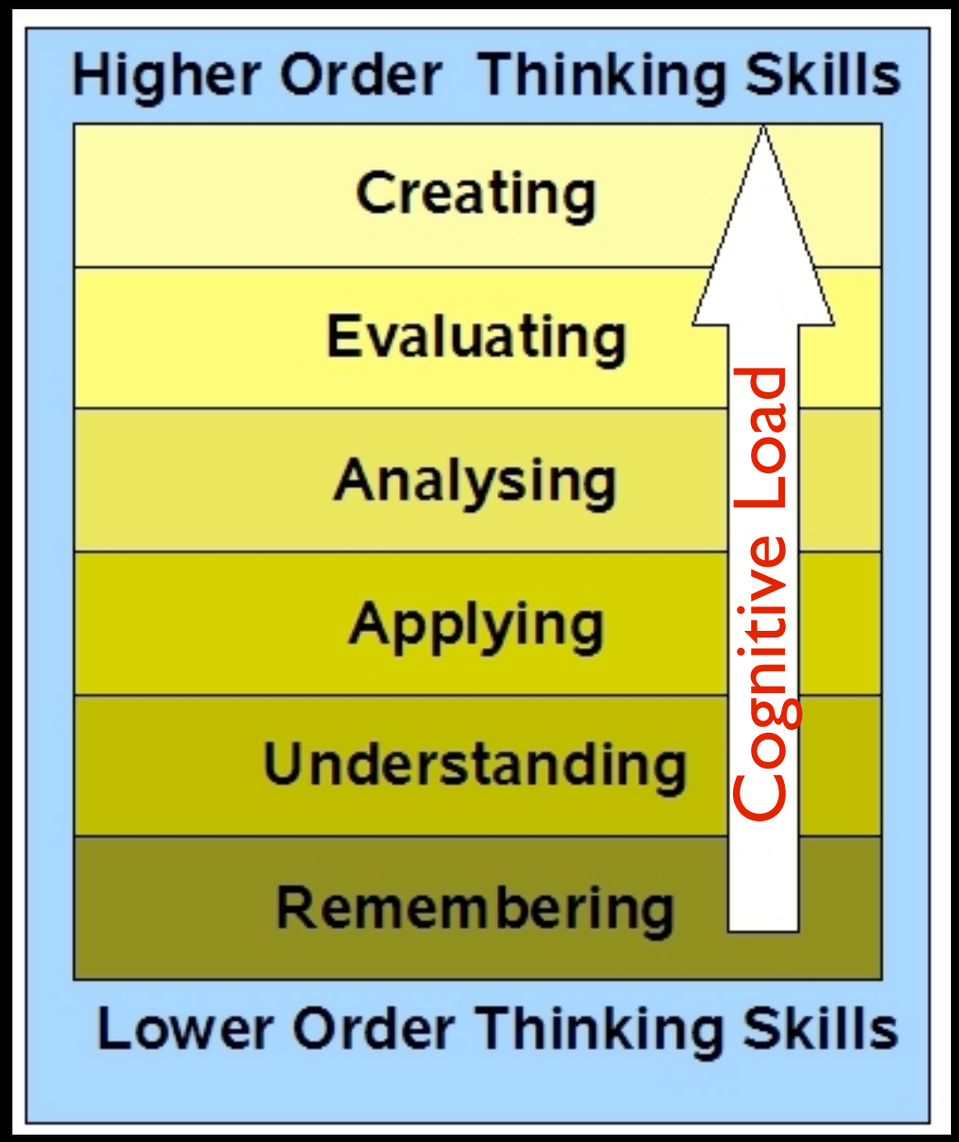
Traditional Approach

Assimilation

Transmission

Adaptation of Bloom's Taxonomy

Anderson & Krathwohl (2001)



Traditional Approach

Traditional Approach Potential Problem

Accessibility of help

Assimilation

Transmission

Adaptation of Bloom's Taxonomy

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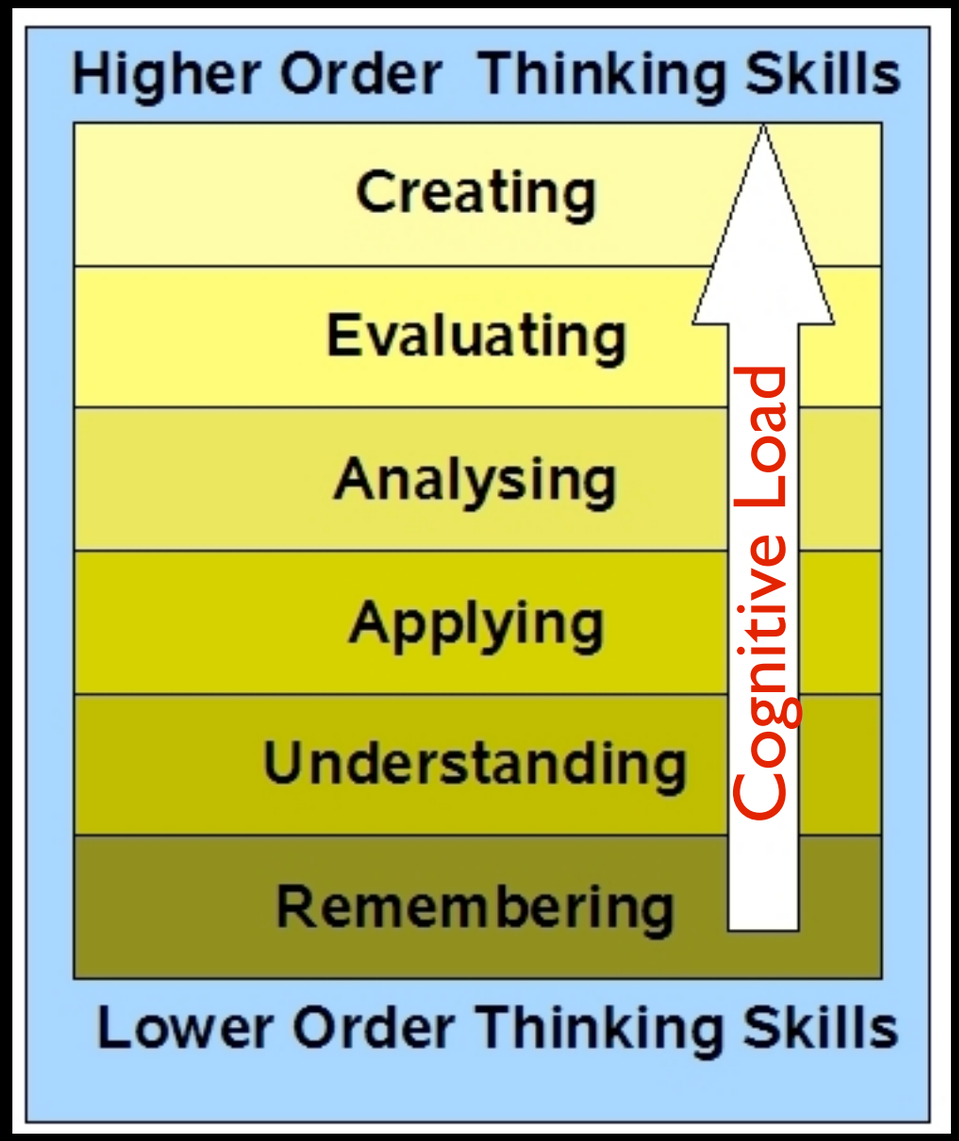

“Flipped” Approach

“Flipped” Approach Potential Solution

Accessibility of help

Assimilation

Transmission

Adaptation of Bloom’s Taxonomy

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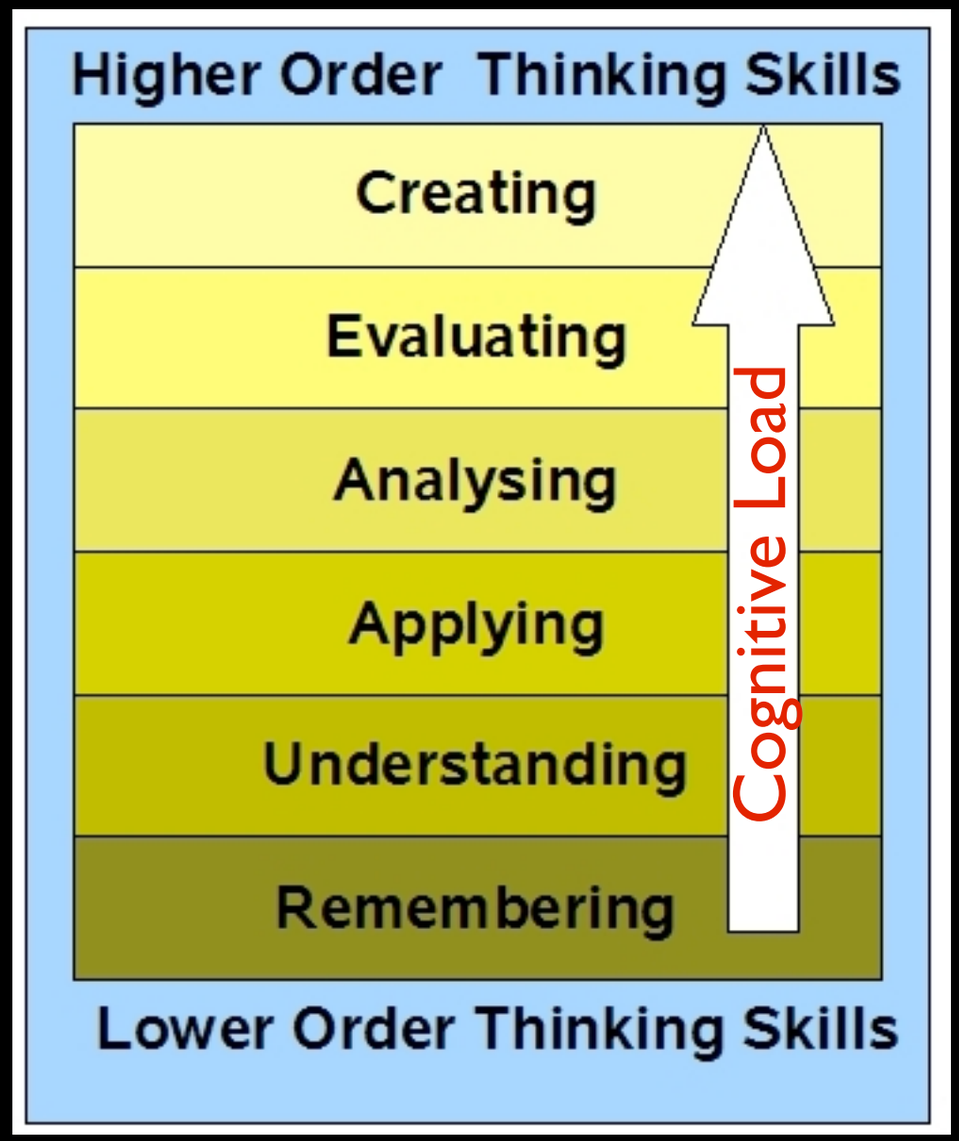
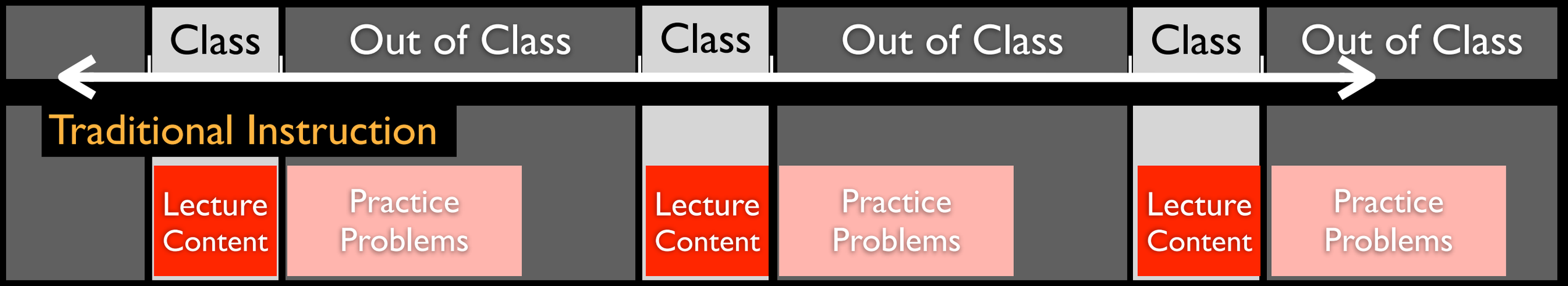
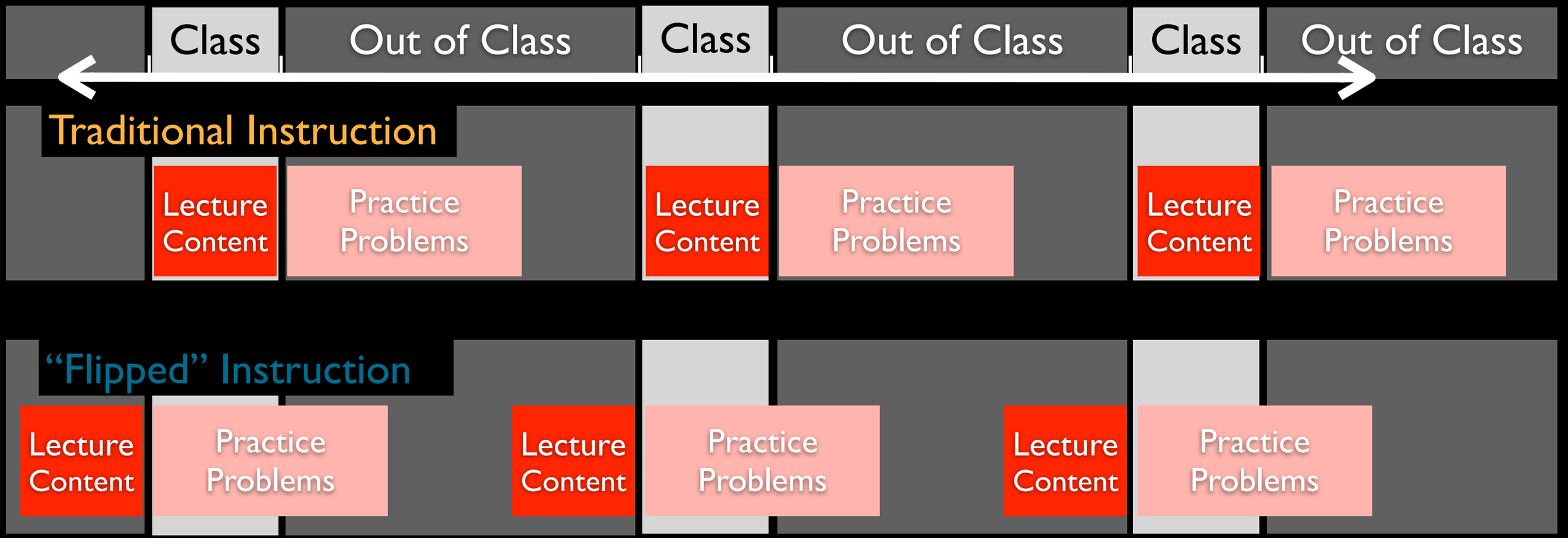


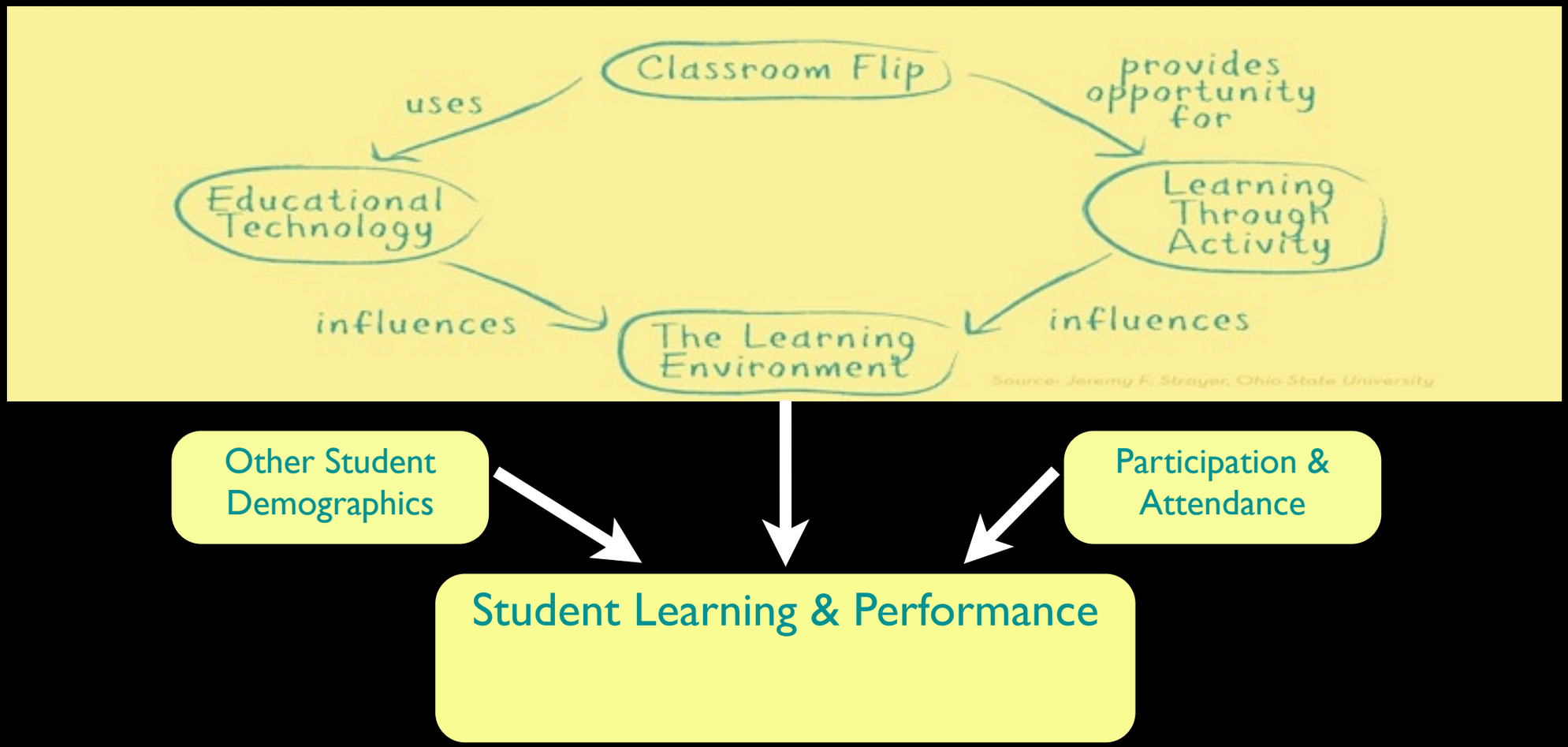
Instructional Models



Instructional Models



Theoretical Model



Theoretical Model

Procedural questions: those that primarily require carrying out a standard mathematical procedure or algorithm (e.g., calculate the partial derivative of a function)

Conceptual questions: those that primarily require explanation/generalization of mathematical concepts or application of procedures in non-standard settings (e.g., interpret the partial derivative of T=f(x,y,z) with respect to z)

Other Research

- While the theoretical idea of "flipping" the classroom is compelling, there is actually very little conclusive research about its impact on student performance
- From Bergman & Sams (2008)
  -Chemistry class
  -2006-2007, traditional
  -2007-2008, flipped
  -Same tests

Checking the Results

Exam	2006–07	2007–08
Unit 2	78.7%	78.7%
Unit 3	84.5%	86.8%
Unit 4	81.6%	80.7%
Unit 5	N/A	N/A
Sem 1	67.9%	66.2%
Unit 6	75.1%	74.1%
Unit 7	89.0%	81.2%
Unit 8	N/A	N/A
Final	73.9%	71.7%

Other Research

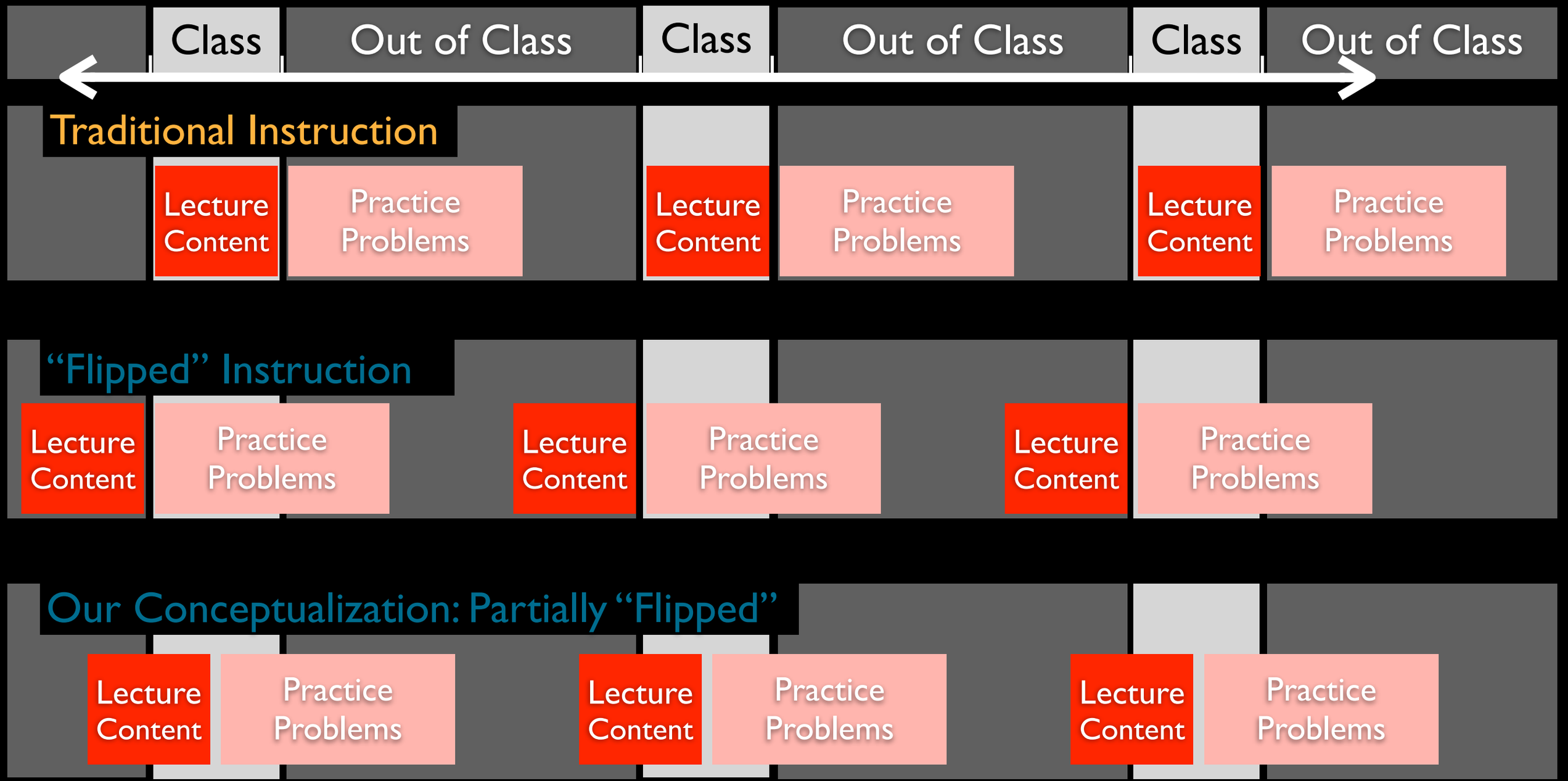
- Gannod, Burge, & Helmick (2008), in an undergraduate software engineering course, used pre- and post-testing to demonstrate that students did learn using a flipped approach. No control group.
- Los Altos school district, using Khan Academy, showed some improvements for 7th graders on state test scores; suggestive, but not conclusive.
- Deslauriers, Schelew & Wieman (2011), in two large enrollment physics courses, demonstrated large gains for students in one class from just one week of "flipped" instruction. Not entire course.

Research Questions

Does "flipping" the instructional delivery in an undergraduate Calculus III course:

- Impact students' overall performance, or their performance on procedural or conceptual mathematics problems (compared to a more traditional delivery that covers the same content)?
- Impact students' opinions and perceptions about the course regarding in-class and out-of-class interactions with the content and the professor?

Partially "Flipped" Model



Conceptualization

In-Class

Out of-Class

	Traditional	Flipped	
Content	Lecture (primarily writes notes on board, minimal student interaction)	Procedural Lecture Content ~20 min. instructor video	Cover Same Lecture Notes
		Conceptual Lecture Content (whole-class/small group discussions, using additional lecture notes or HW problems)	
Practice	Homework Problems	Some HW problems Turned into class activities	Assign Same HW Problems
		Rest of HW problems	

Goal: Make the process of "flipping" as simple as possible

Example of "Flipping" a HW problem

- HW problem:

Calculate $\frac{dz}{dt}$ if $z = \sin A \cos B$

$A = t + s$

$B = t^2 - s^2$

Example of "Flipping" a HW problem

- HW problem "Flipped":

With a partner, one of you calculate $\frac{\partial z}{\partial A}$, the other calculate $\frac{\partial z}{\partial B}$

$$z = \sin A \cos B$$
$$A = t + s$$
$$B = t^2 - s^2$$

Discuss the meaning of each partial derivative.
Together, calculate $\frac{dz}{dt}$.

Reflection Question:
1. What happens if A or B is just a function of S (e.g $A = s$)?
2. Why do you think: $\frac{dz}{dt} = \frac{dz}{dA}\frac{dA}{dt} + \frac{dz}{dB}\frac{dB}{dt}$?

Methodology

Fall 2012. Two Calculus III courses. Two Instructors.

	Class A, Instructor A N=41	Class B, Instructor B N=39
1st third	Traditional	Traditional
Students' performance was similar when both professors used a traditional instructional model		
2nd third	Traditional	Flipped
3rd third	Traditional	Flipped

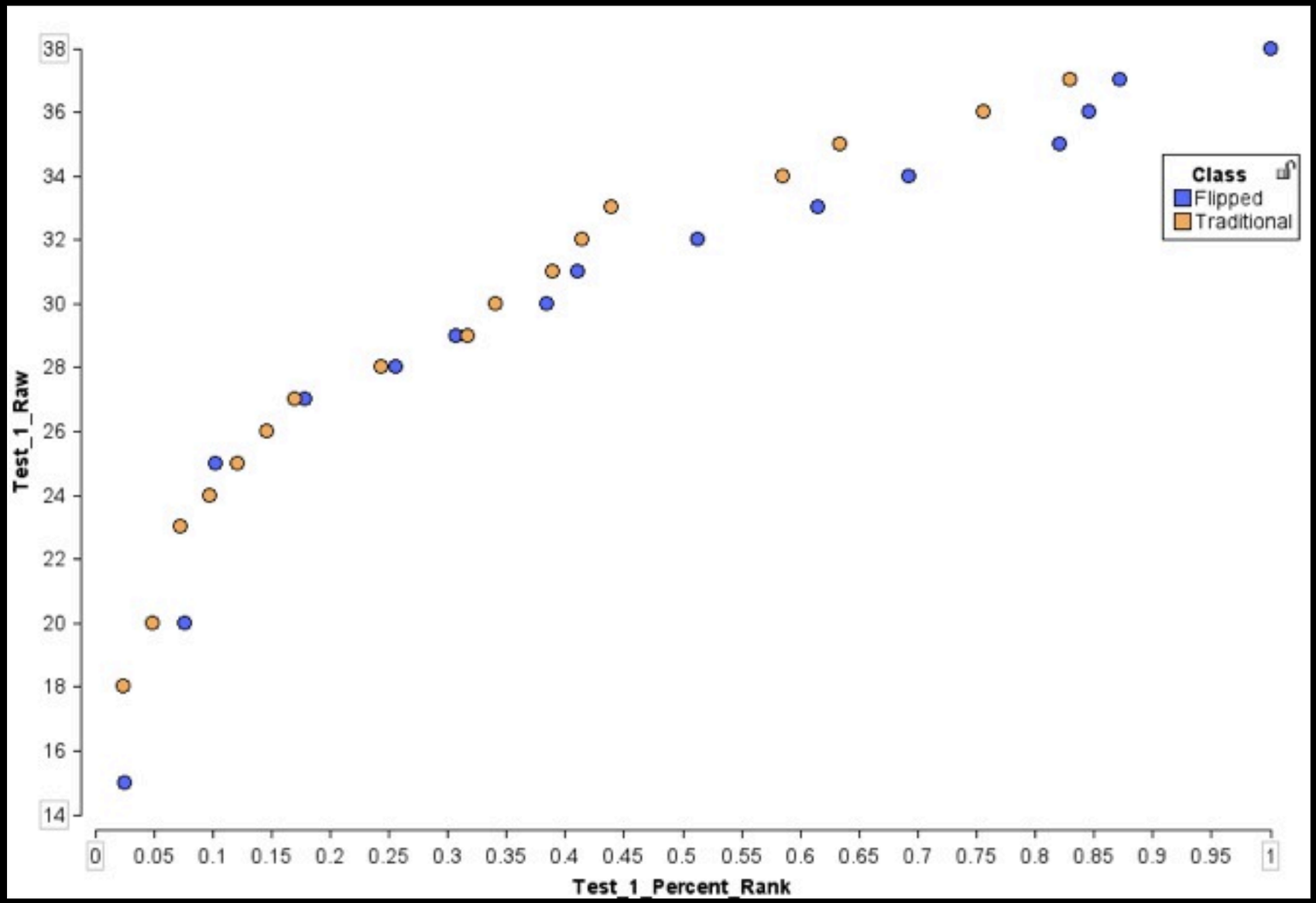
NOTE: Demographic backgrounds of both classes of students were similar along: Gender, Age, Ethnicity, Major, Class, Calculus II grades, SAT Math Scores

Measures

	Traditional		Flipped
Exams	•Professors collaborated to write each Exam •Professors gave the same Exam •Professors split the grading, so that one professor graded the same questions for both sections •Questions were determined to be more procedural or conceptual; sub-scores for each category were calculated		
Participation	Attendance HW completion		Attendance HW completion Blog post about video

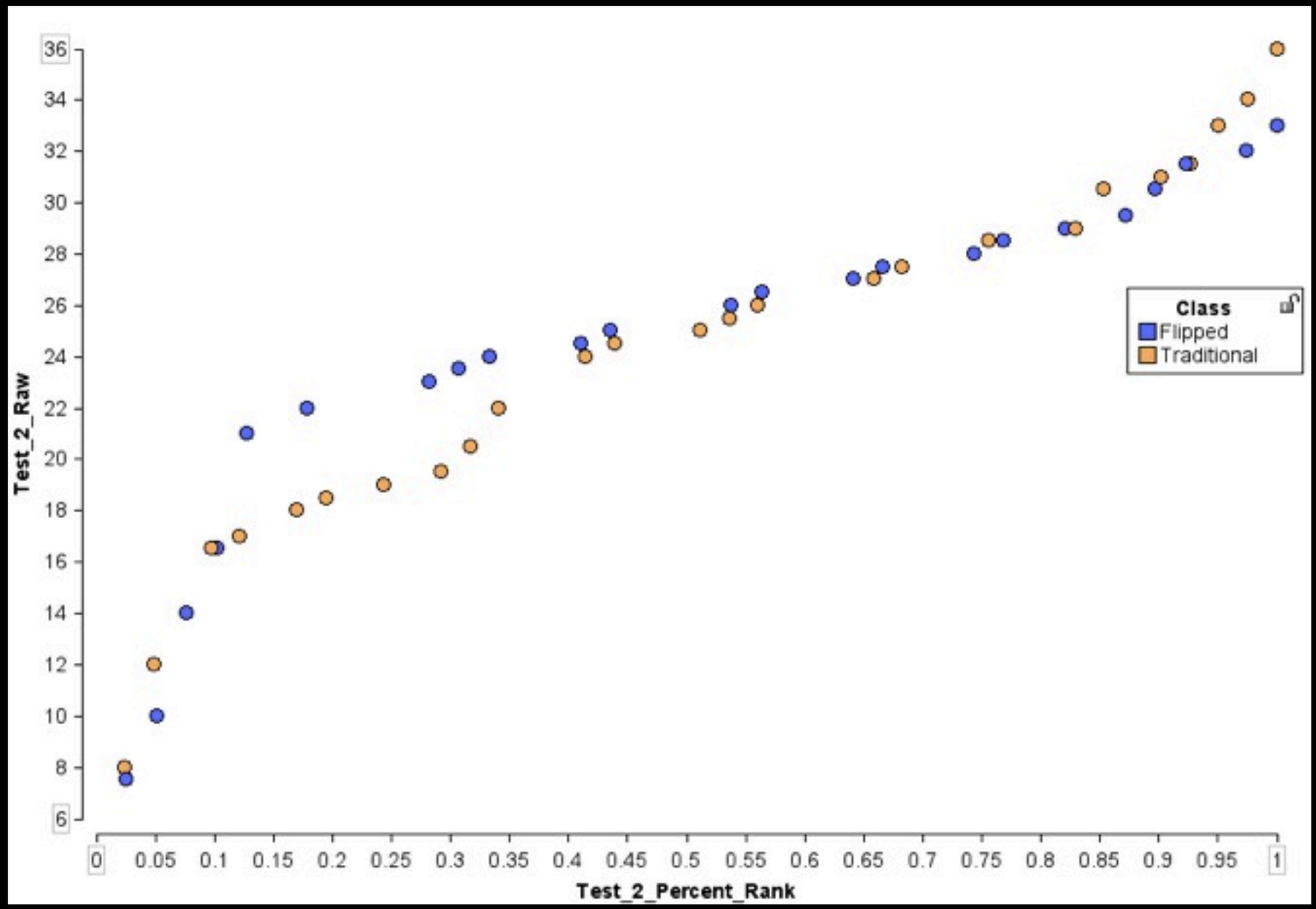
Exam Findings

- Test 1 Scores



Exam Findings

- Test 2 Scores



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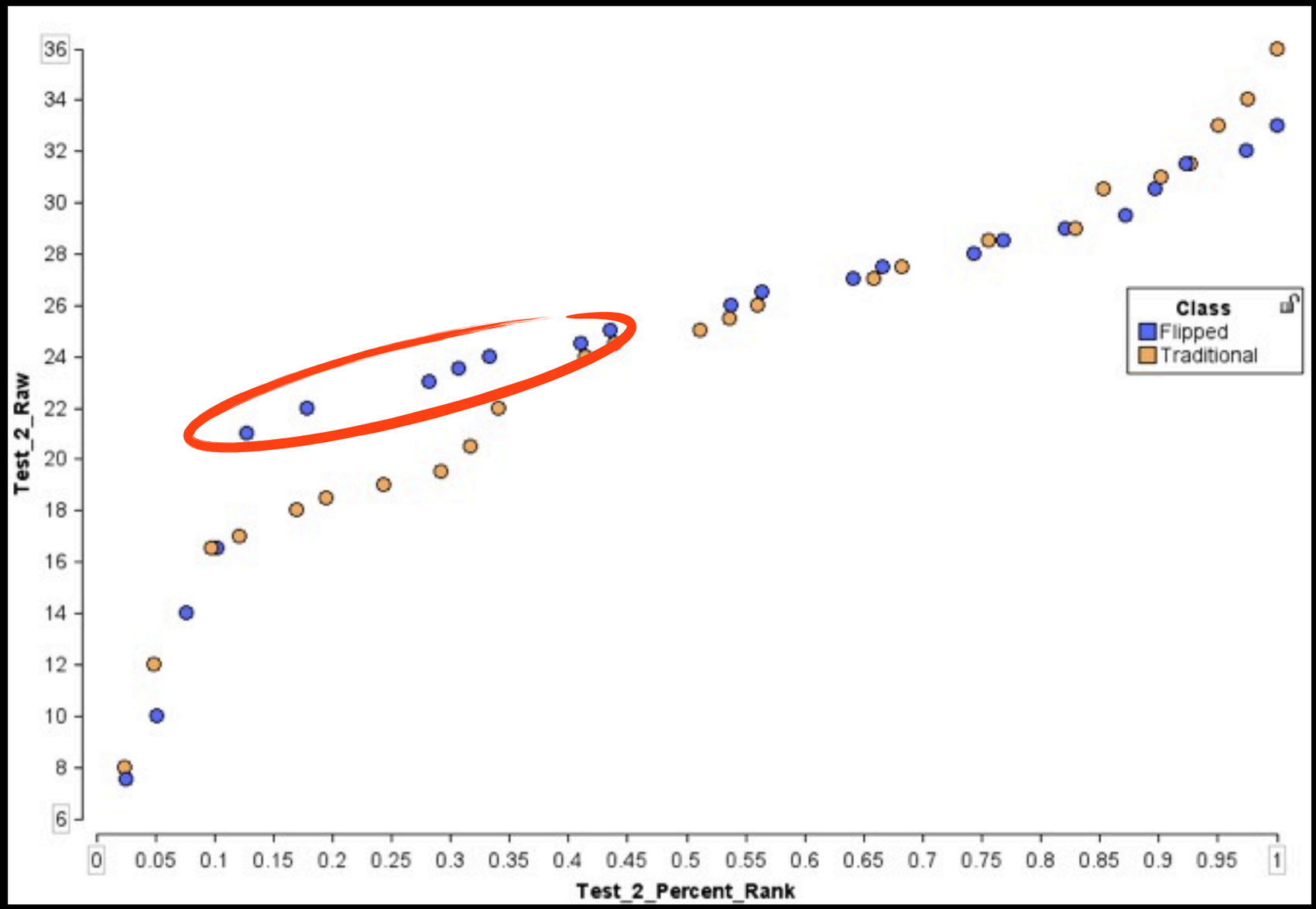

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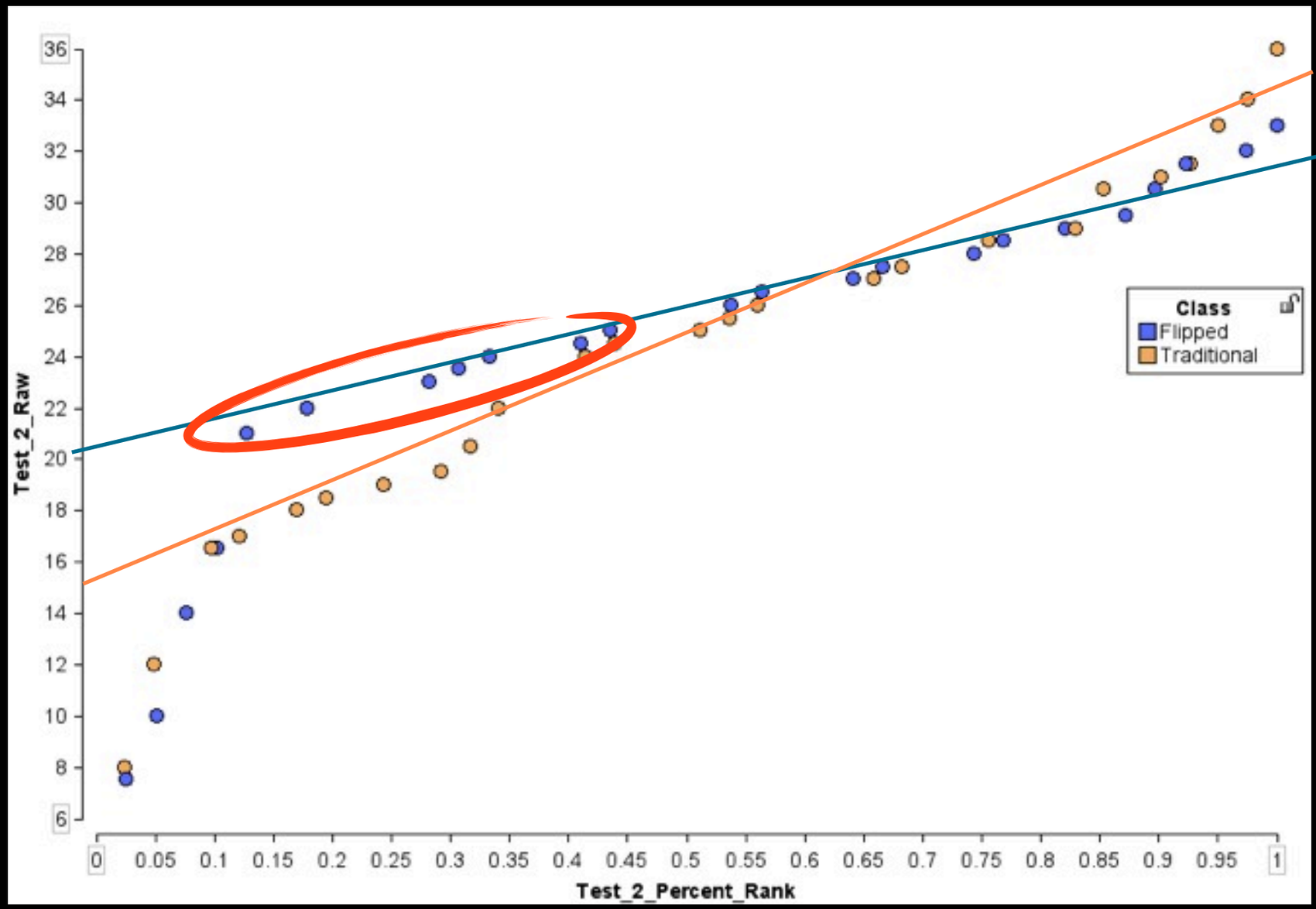
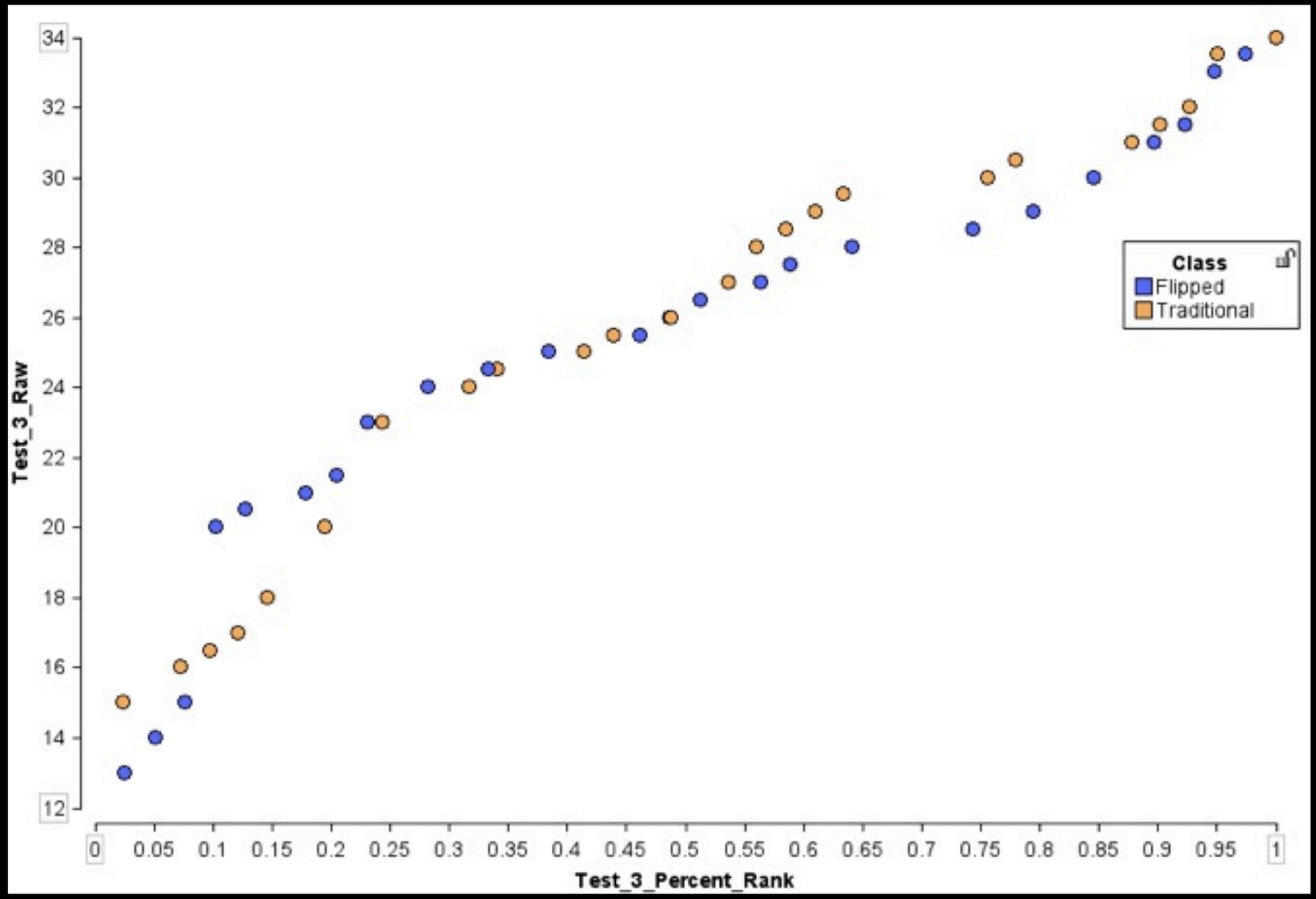


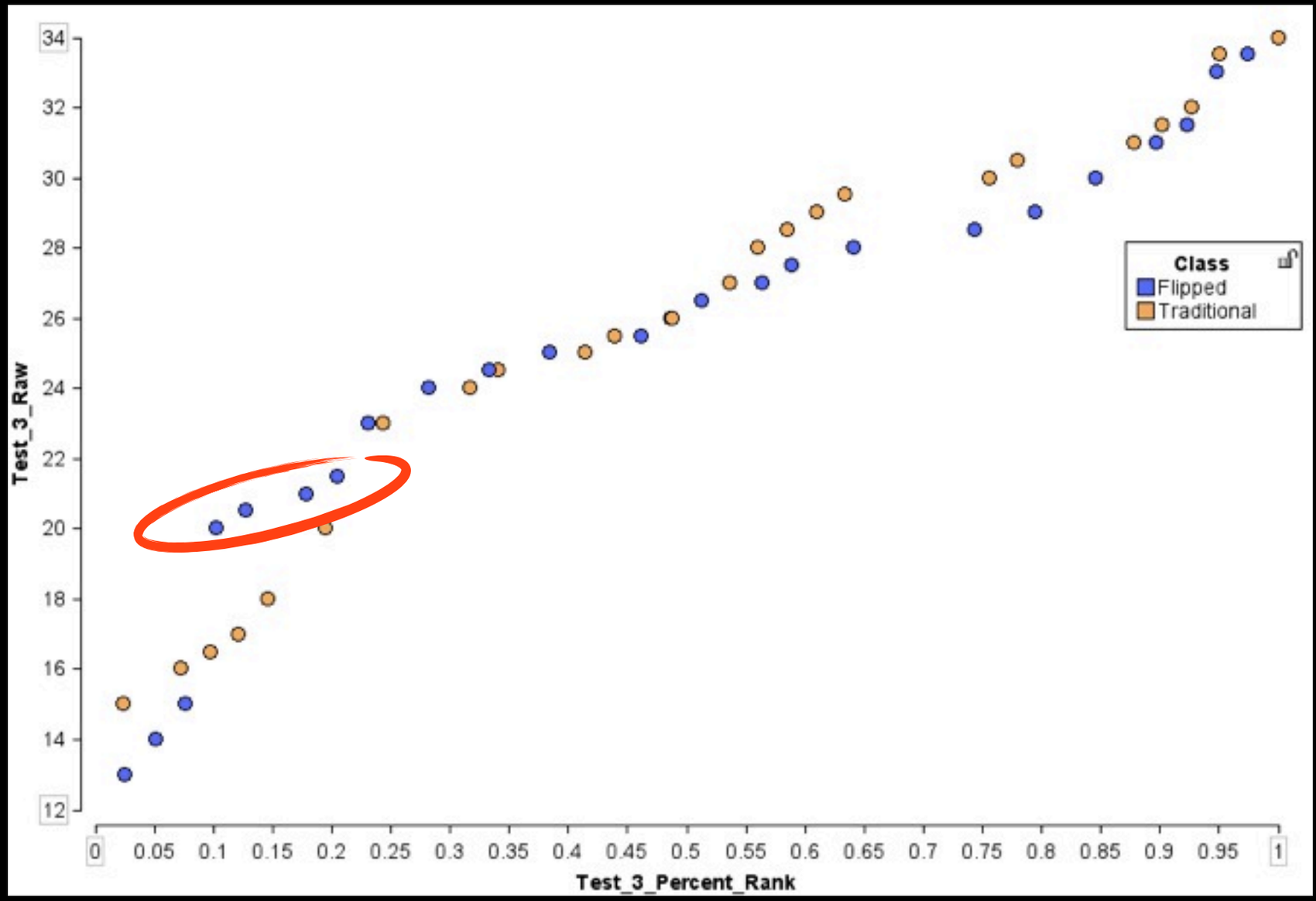
Exam Findings

- Test 3 Scores



Exam Findings

- Test 3 Scores



Exam Findings

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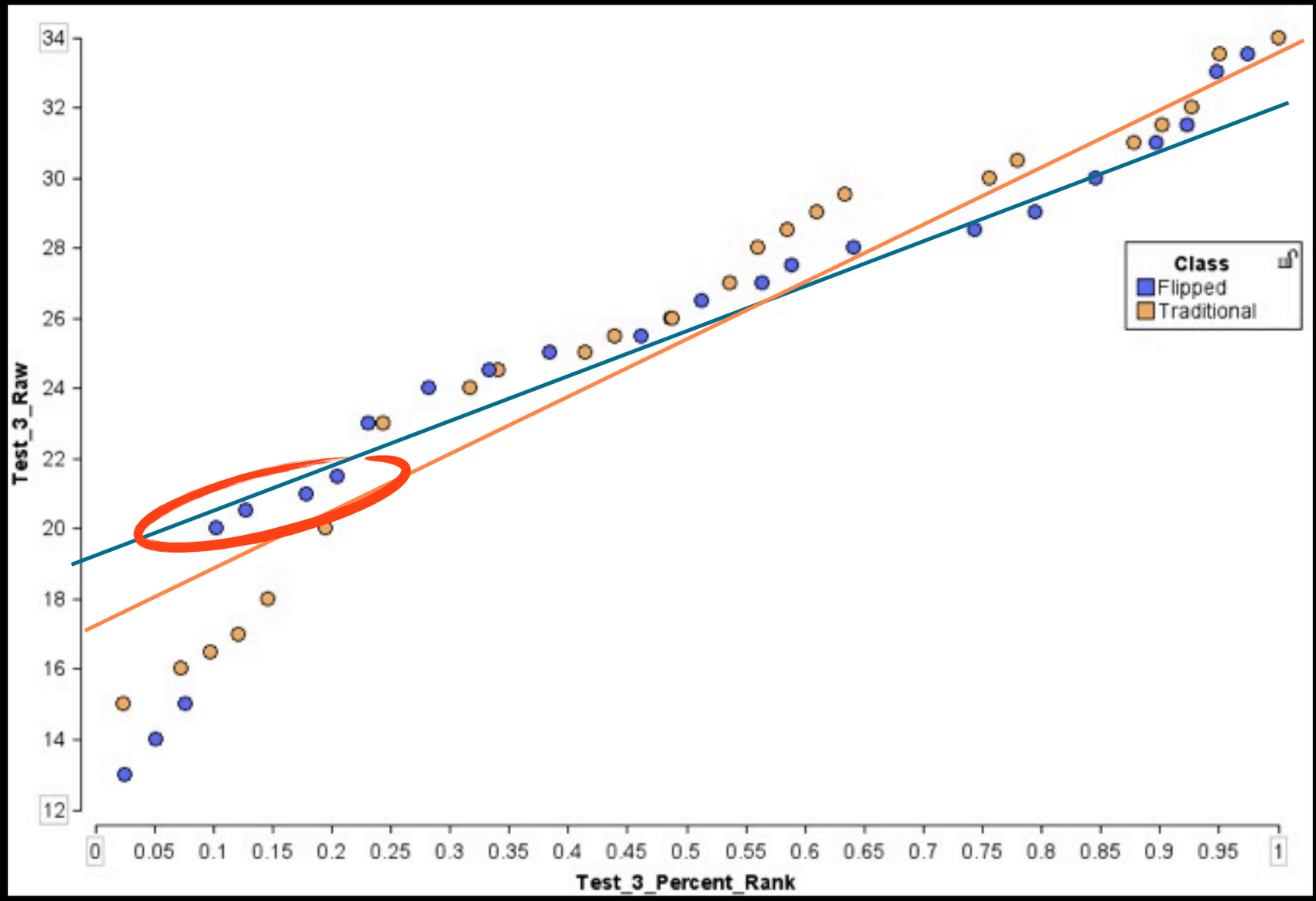
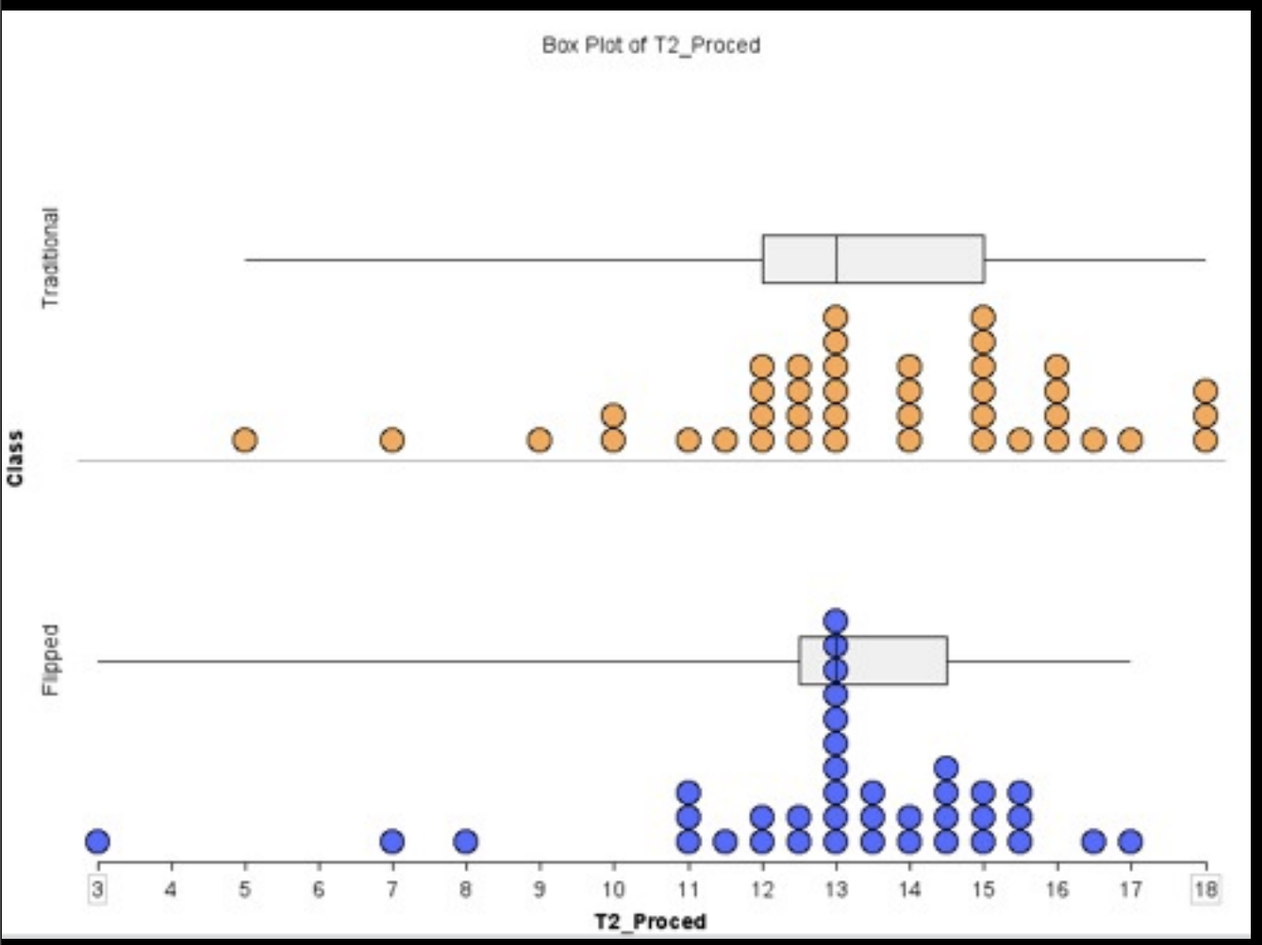
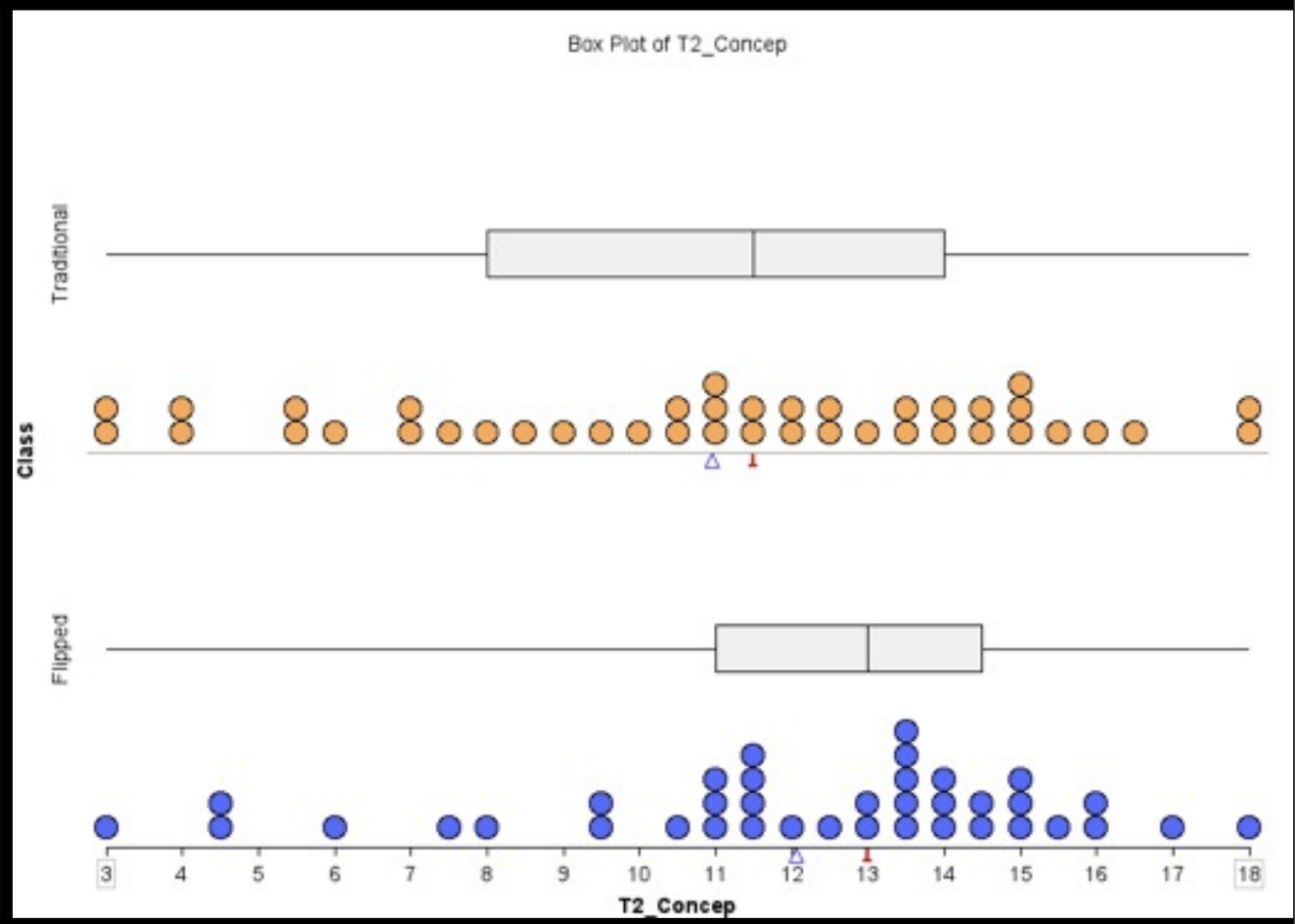


Exam Findings

- Procedural and Conceptual Problems Test 2





Exam Findings

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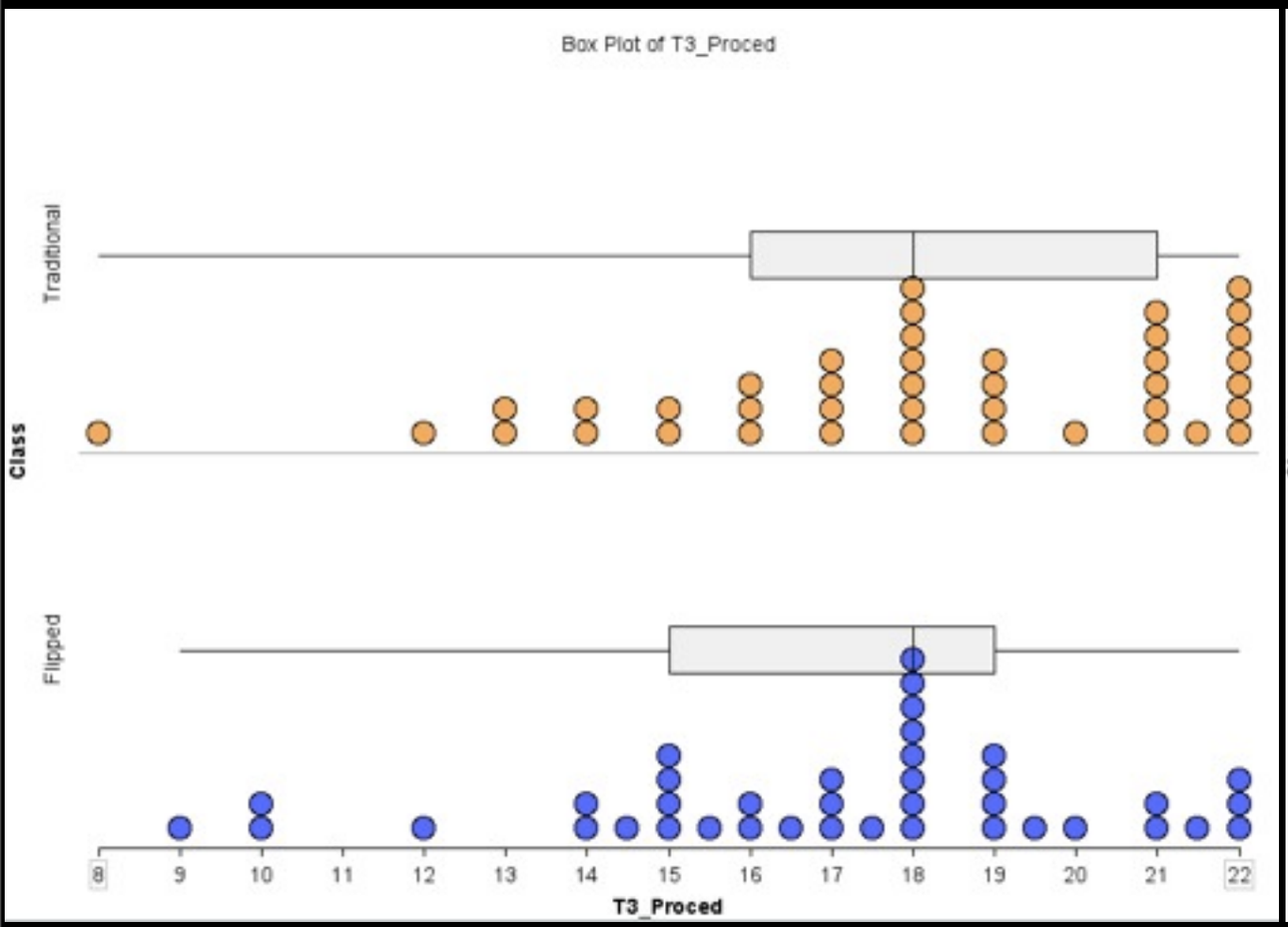

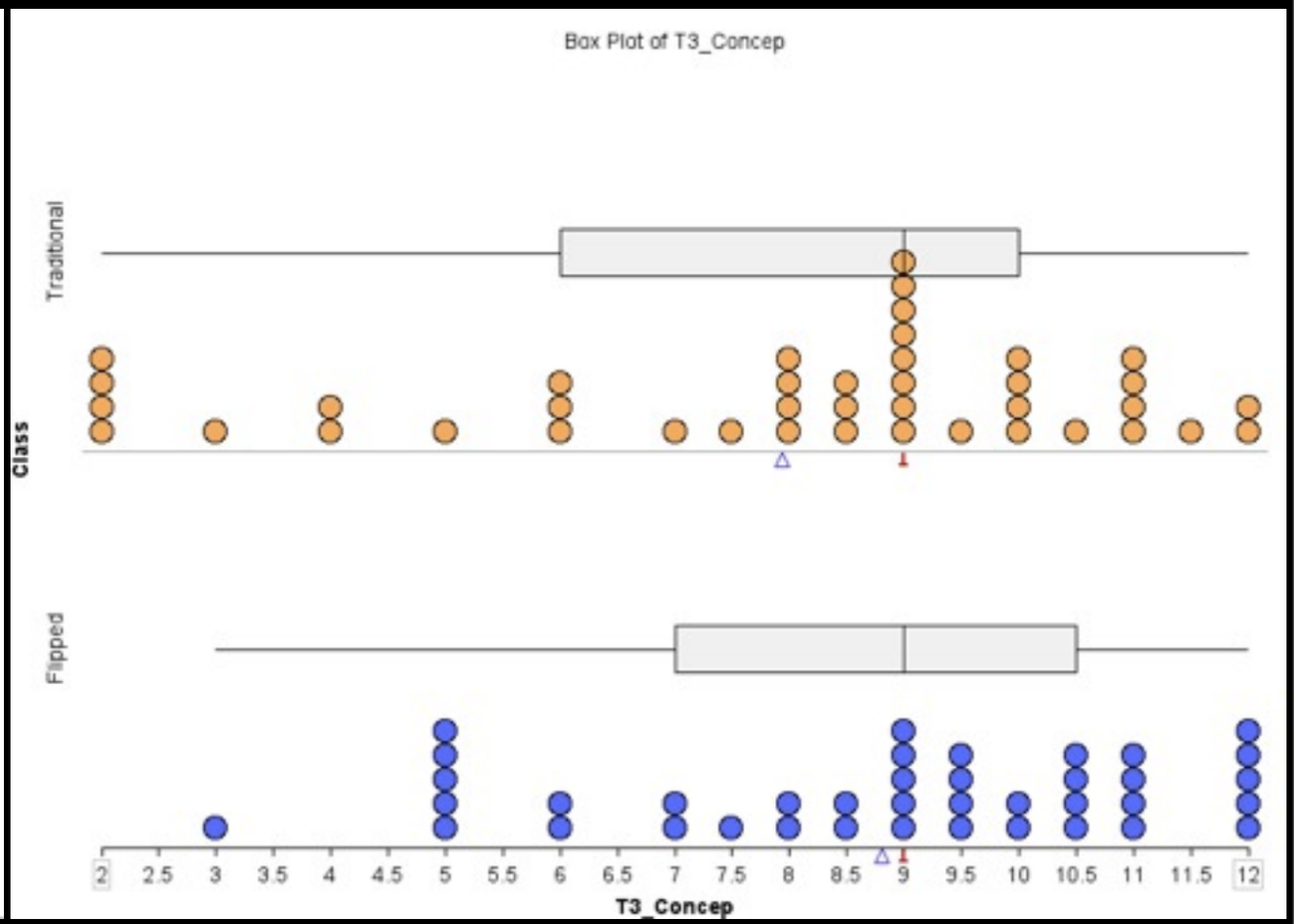

Exam Findings

- RQ1: Based on the findings, there was no statistically significant differences between the two groups overall.
- However, the effect of "flipping" instruction seems to be potentially promising for: 1) lower-achieving students; and potentially impactful for: 2) performance on more conceptual problems.
- There were no significant differences or visual trends between classes that depended on students' Gender, Age, Ethnicity, Major, Class, Calculus II grades, SAT Math Scores, or **Participation**

Survey Findings

TIME SPENT OUTSIDE OF CLASS

- Based on the results from 3 survey questions, there were no differences in students perception of time spent outside of class.
  - **Q4:** Compared to other math courses, I spent about the same amount of time outside of class completing assignments and studying.
  - **Q12:** The work required for this course outside of class was more demanding than I am accustomed to doing for other courses.
  - **Q31:** In a typical week, how many hours outside of class did you devote to this course?

Survey Findings

COURSE SATISFACTION/PREFERENCE

- Traditional students reported the traditional method as more effective use of class time
  - **Q3:** Our class stays busy and doesn't waste time
  - **Q14:** The time during class was used effectively for learning the course material
- Overall, flipped students' responses about satisfaction with the course were much more varied.

Limitations

- Implementation of "Flip" may have some limitations
  - Video creation
  - Facilitating in-class problems & discussions
- Consistency between Courses
  - Interpretation/Emphasis on Notes
  - Reviews for exams
- Sample
  - Different professors & students
  - Size

Conclusions

- Overall, despite small sample, and not enough statistical power to infer significant differences, the findings indicate some potential hypotheses worth exploring related to low-performing students and conceptual problems.
- Currently, implementing a second iteration of the study

Discussion

- Any thoughts about the characterization of the partially "flipped" model?
- Any thoughts about the experimental design for isolating the impact that Traditional vs. Flipped instructional delivery (of same content) has on student performance?
- Any other suggestions? Questions? Comments?