Quantitative Insights on In-class Creation and Sharing of Knowledge

SLAM

Student Learning and Analytics at Michigan

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Special thanks to…

- Caltech and PCC for iPads
- Helpful Dean/Vice Provost/Provost
- Interested faculty
- Willing students
- An awesome IRB

Today's Outline

1. Background and Approach

Data

   2. Participation Inventory
   3. Behavior in Time
   4. Modes of Learning
   5. Motivation and Outcome

6. Future and Conclusions
7. Supplemental: CSA Outreach

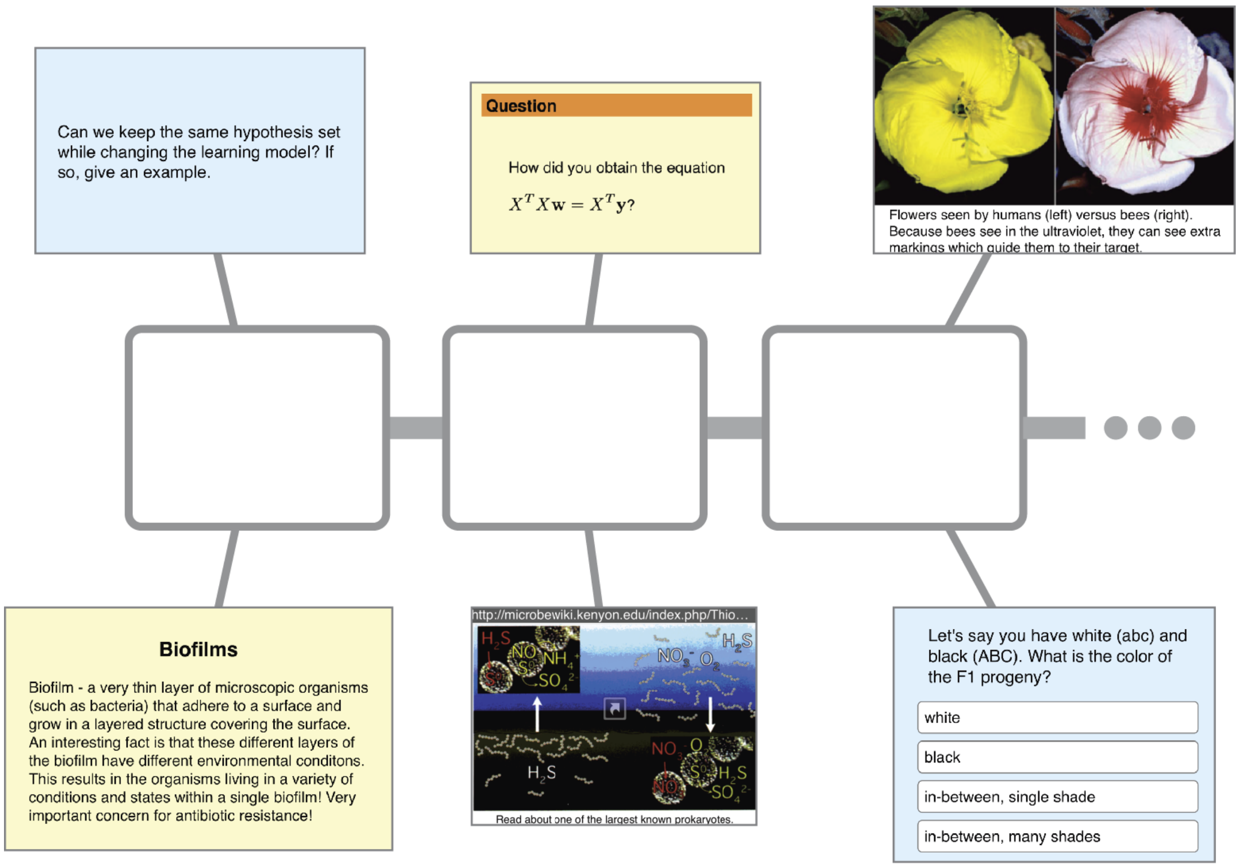
1. Background and Approach

- Context and Goals
- Research Questions
- Tablet-based Collaborative Learning App
- Classes & Kinds of Data

Improving learning & student engagement

Methods that work for students and faculty, and provide new evidence and insights.

SKIES, a collaborative learning application

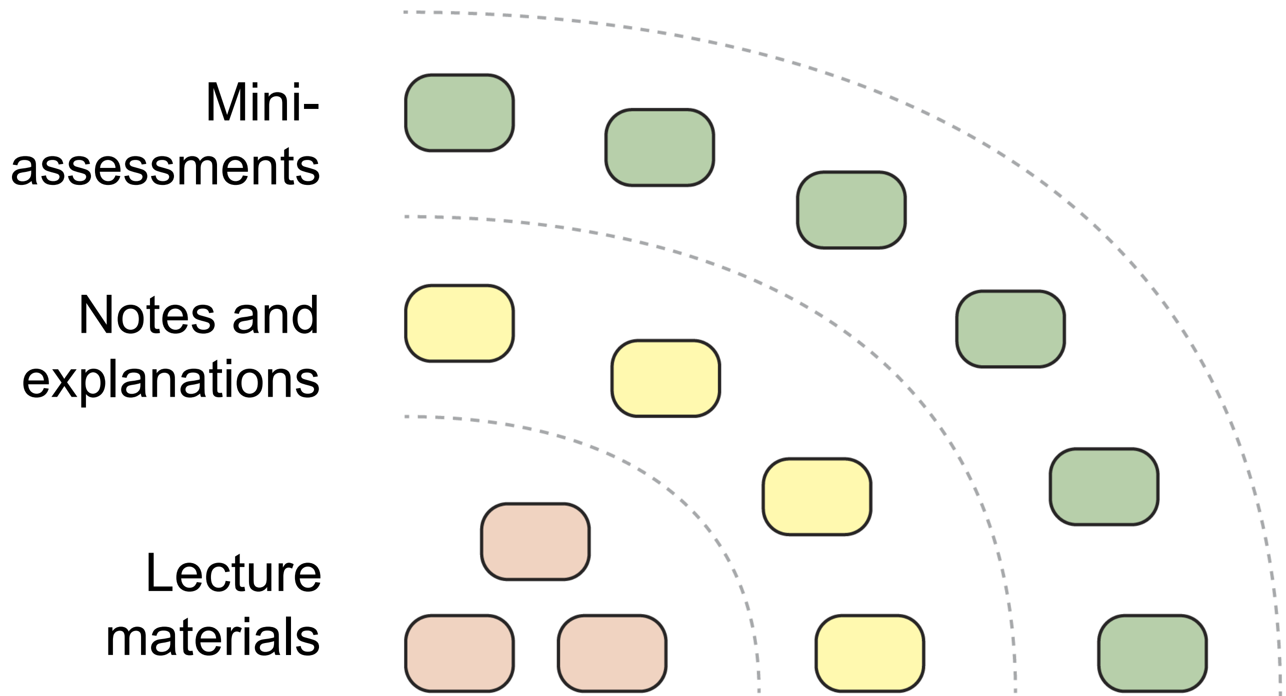


Notes
Questions
Self-quizzes

Equations
Pictures
Web links
Videos

Teachers and students add branches to a class tree

Building cards atop other cards



Many elements ranging from the flexible to the authoritative.

[redacted] – 1 year ago

Repair from a homologous chromosome

b allele serves as a template for repair. It keeps the cell from losing more DNA, but it also changes the original information.

1 of 2

[redacted] 1 year ago

Homologous recombination can create chromosomal instabilities

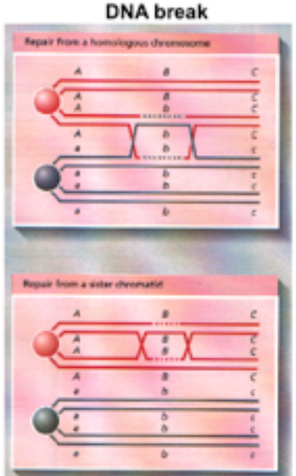
DNA with repetitive elements can become improperly modified as a result of homologous recombination. A linear chromosome with repeated sequences can end up looping back on itself, which upon recombination, can lead to excisions, inversions, and translocations.

2 of 2

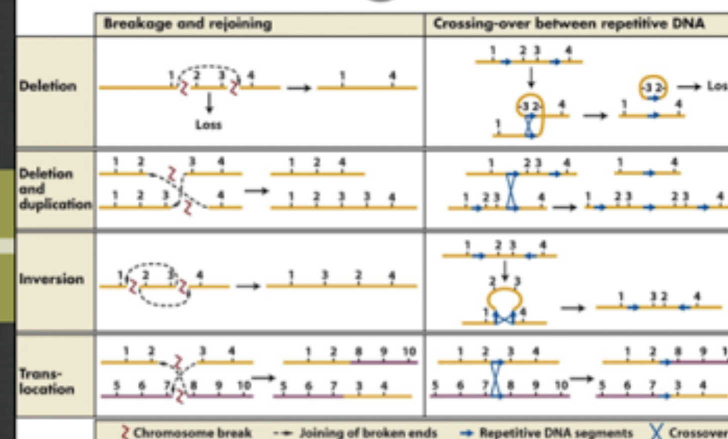
Notes

[redacted] — 1 year ago

Homologous recombination: repair of a double strand DNA break



[redacted] — 1 year ago



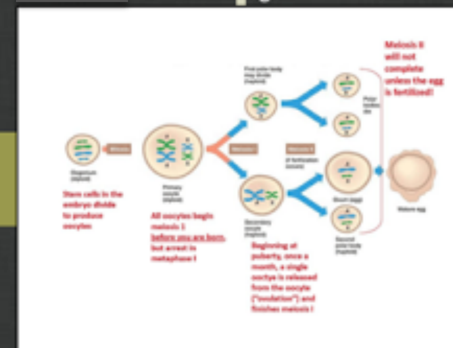
[redacted] – 2 weeks ago

[redacted] 2 weeks ago

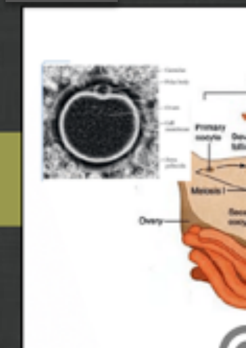

LETTER

Telomerase reactivation reverses tissue degeneration in aged telomerase-deficient mice

[redacted] 2 weeks ago



[redacted] – 2 weeks



[redacted] – 2 weeks ago

http://www.roslin.ed.ac.uk/public-interest/dolly-...

Read about Dolly the sheep and whether she was "born old" in some ways.

[redacted] – 1 week ago

Which cell does not have active telomerase activity?

- Stem cell
- Germ cell
- Somatic cell
- Cancer cell

[redacted] – 1 week ago

Of the approximately two million follicles (immature eggs) that women have at birth how many end up actually maturing properly?

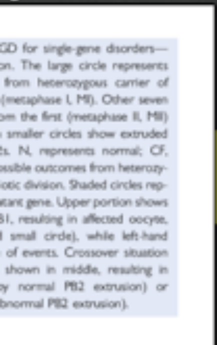
- 4
- 400
- 4000
- 40000

[redacted] – 1 week

how can you lear
present in an egg
destroying it?

Self-quizzes by students

ago



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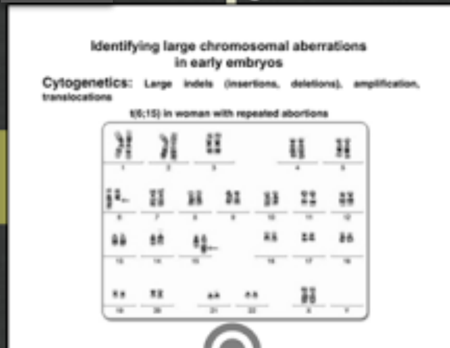

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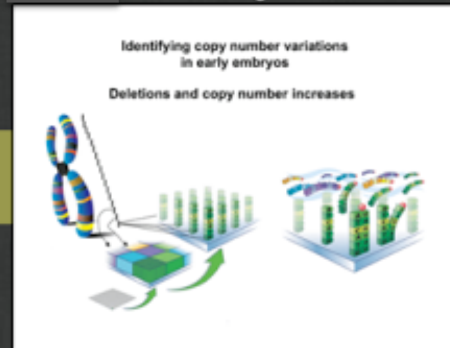

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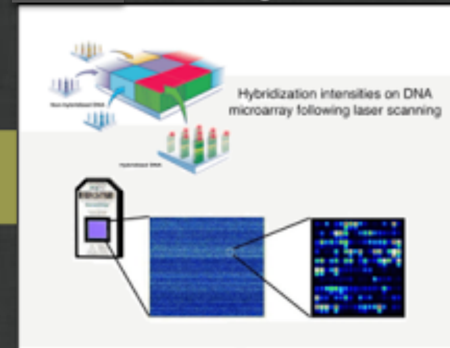


[redacted] — 1 week ago

Only considering the mutation involving chromosomes 6 and 15, what are the chances the offspring will be normal?

?

1 of 4

[redacted] — 1 week ago

Question

how many probes can a microarray hold and how are they made?

[redacted] — 1 week ago

Answer

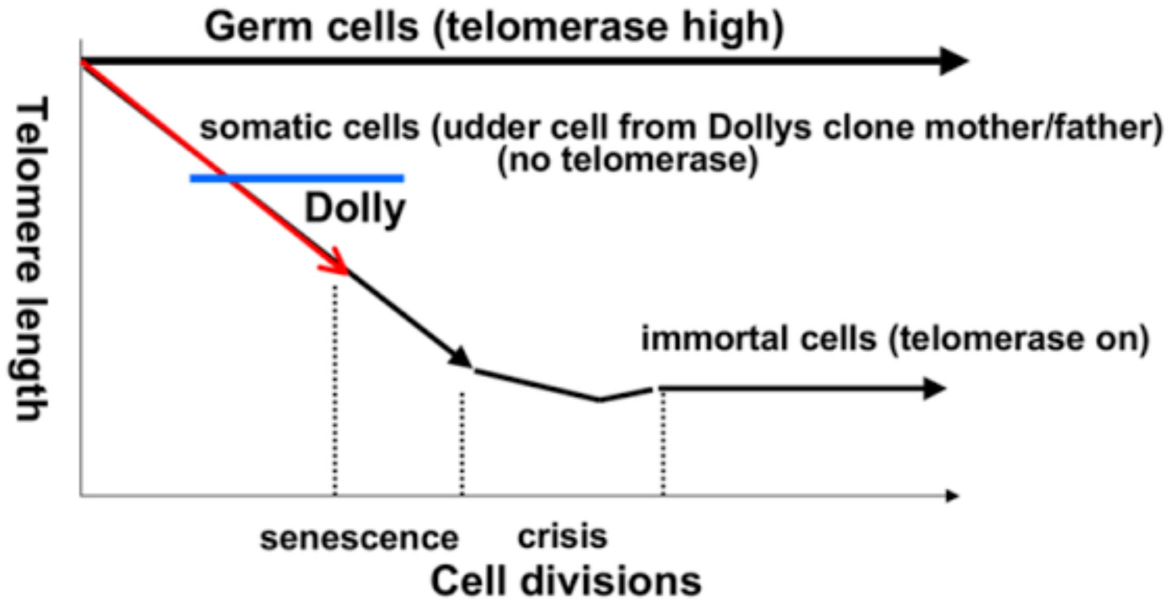
Chips may hold from 10 probes up to 2 million depending on the application. Chips are created by machines that spot the DNA probes into the glass surface.

Discussions

aoneill

Presentation

What is Dolly's age?



Telomere length of cells in Dolly?

- Comparable to that of a six year older control (sheep live to be about 12 normally) Nature 399:316-317

kevinyu

According to the researchers, although Dolly had shorter telomeres, they ...

aoneill

Q/A: What is another way Dolly's genetic material was likely different from that of ...

Card ratings

[redacted] – 1 day ago

Hydrogen as a fuel

Hydrogen plus oxygen combines to form water in an exothermic process:

$$H_2 + \frac{1}{2}O_2 \rightarrow H_2O \quad E = 1.23V$$

Since two electrons are involved in this reaction, there is a net production of 2.46 eV per molecule of water made.

2 of 2

[redacted] – 1 day ago

Hydrogen may be an ideal energy storage device

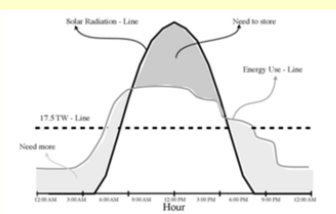
$$2H^+ + 2e^- \rightarrow H_2 \quad E° = 0$$

$$2H^+ + 2e^- + \frac{1}{2}O_2 \rightarrow H_2O \quad E° = 1.23V$$

$$H_2 + \frac{1}{2}O_2 \rightarrow H_2O \quad E° = 1.23V$$

[redacted] 1 day ago

Solar needs to be coupled to energy storage



Because people like to work before sunrise and after sunset, there will be periods where there isn't enough sunlight available to provide energy.

Thus we need a way to store solar energy for later.

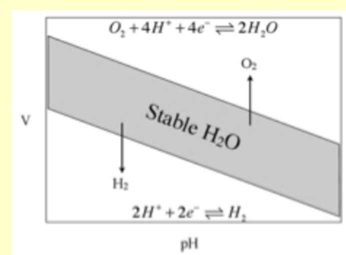
[redacted] – 1 day ago

Why does higher voltage make it less favorable to generate O_2, but more favorable to generate H_2?

?

[redacted] – 1 day ago

Pourbaix diagram



Using the Nerst equations derived previously, we can plot out the regions where O_2 and H_2 are spontaneously generated, as a function of applied voltage and pH.

[redacted] – 1 day ago

Answer

It absolutely can, and this is a major research effort at Caltech (Lewis, Gray, Roberts, Agapie, Goddard, Miller, Peters, etc.)

[redacted] – 1 day ago

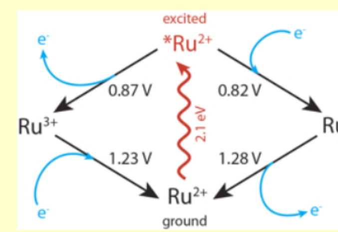
Question

Is this similar to the process of electron transfer that occurs in photosynthesis? Could electron carriers or enzymes that are used in photosynthesis be adapted for this process?

1 of 2

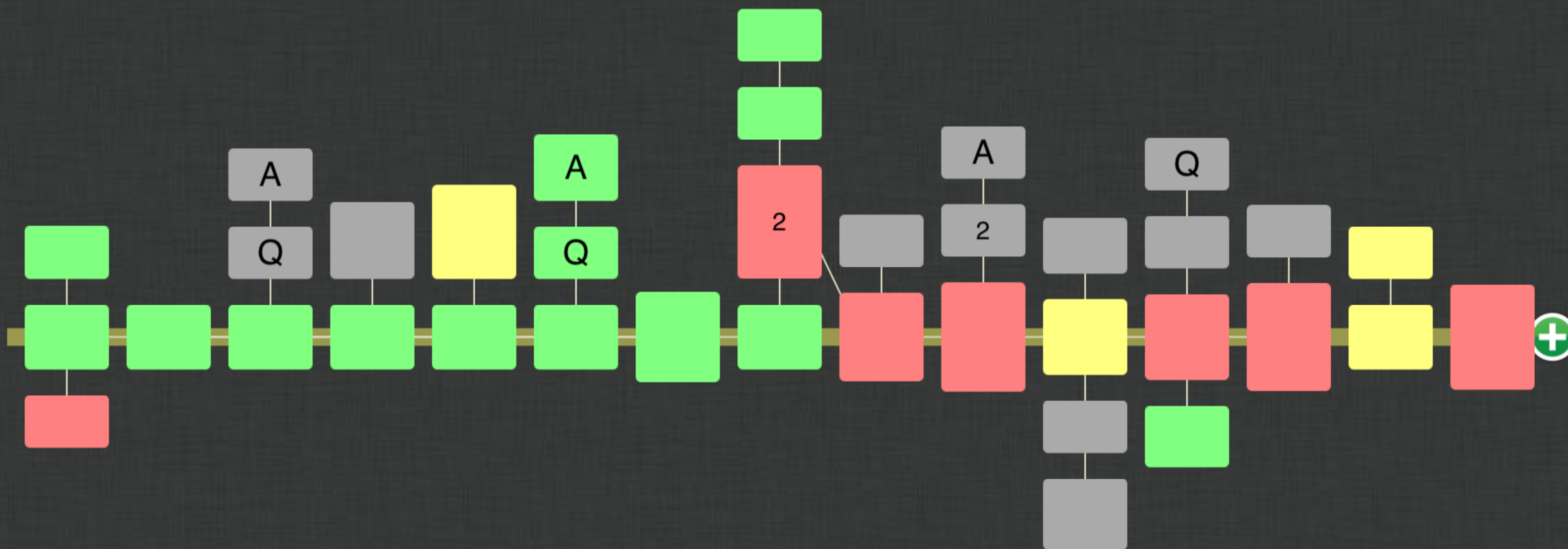
[redacted] – 1 day ago

Coupling light to fuel production



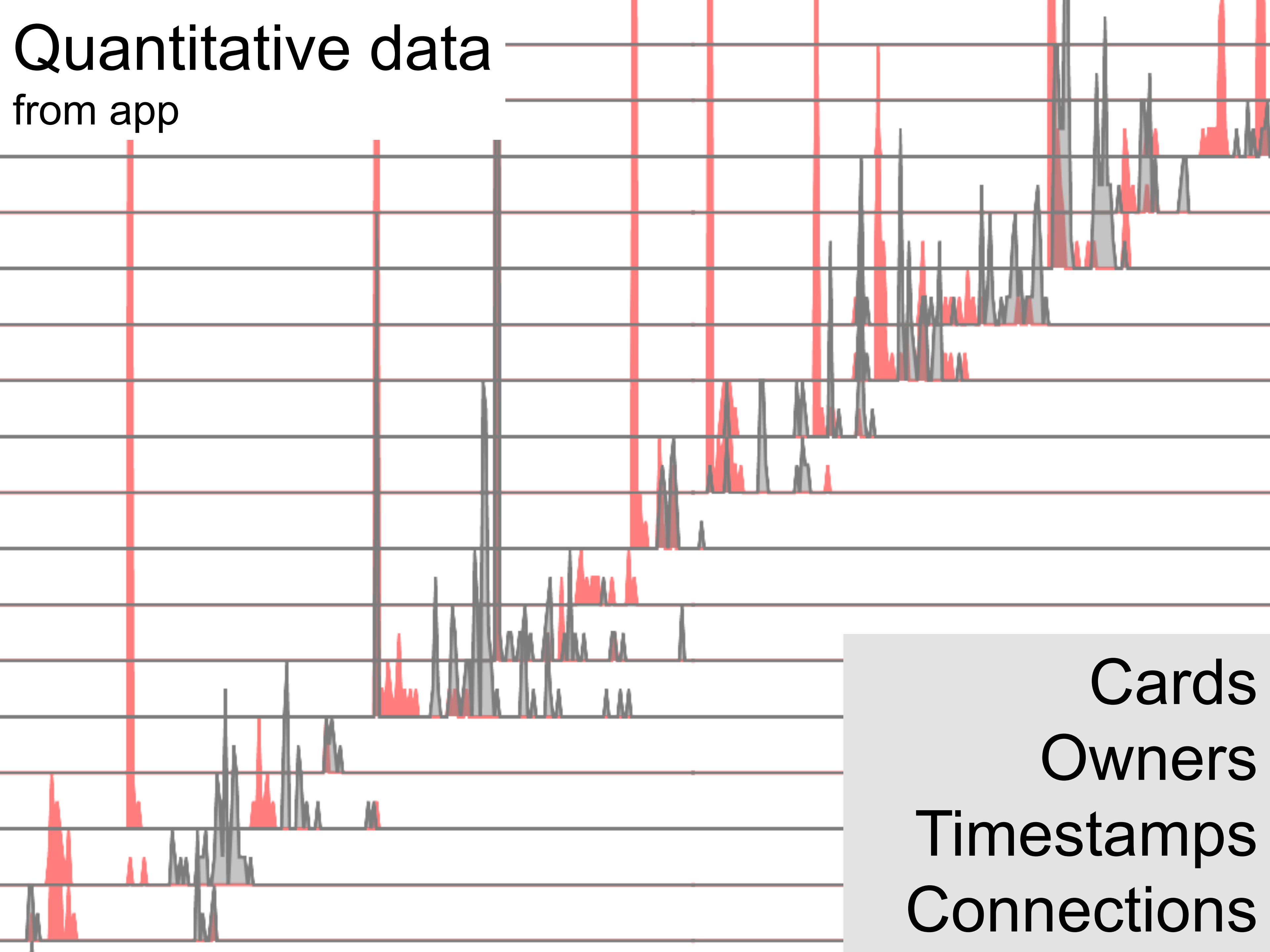
When Ru^{2+} is excited by light, it becomes an active species which can either donate or accept an electron to become lower in energy. The electron can then hop back on/off to recreate Ru^{2+}.

We can couple this oxidation/reduction to the electrolysis half-reactions. The 0.87 V reduction potential is strong enough to produce H_2, but the 0.82 V oxidation potential is too weak to produce O_2.



Card ratings

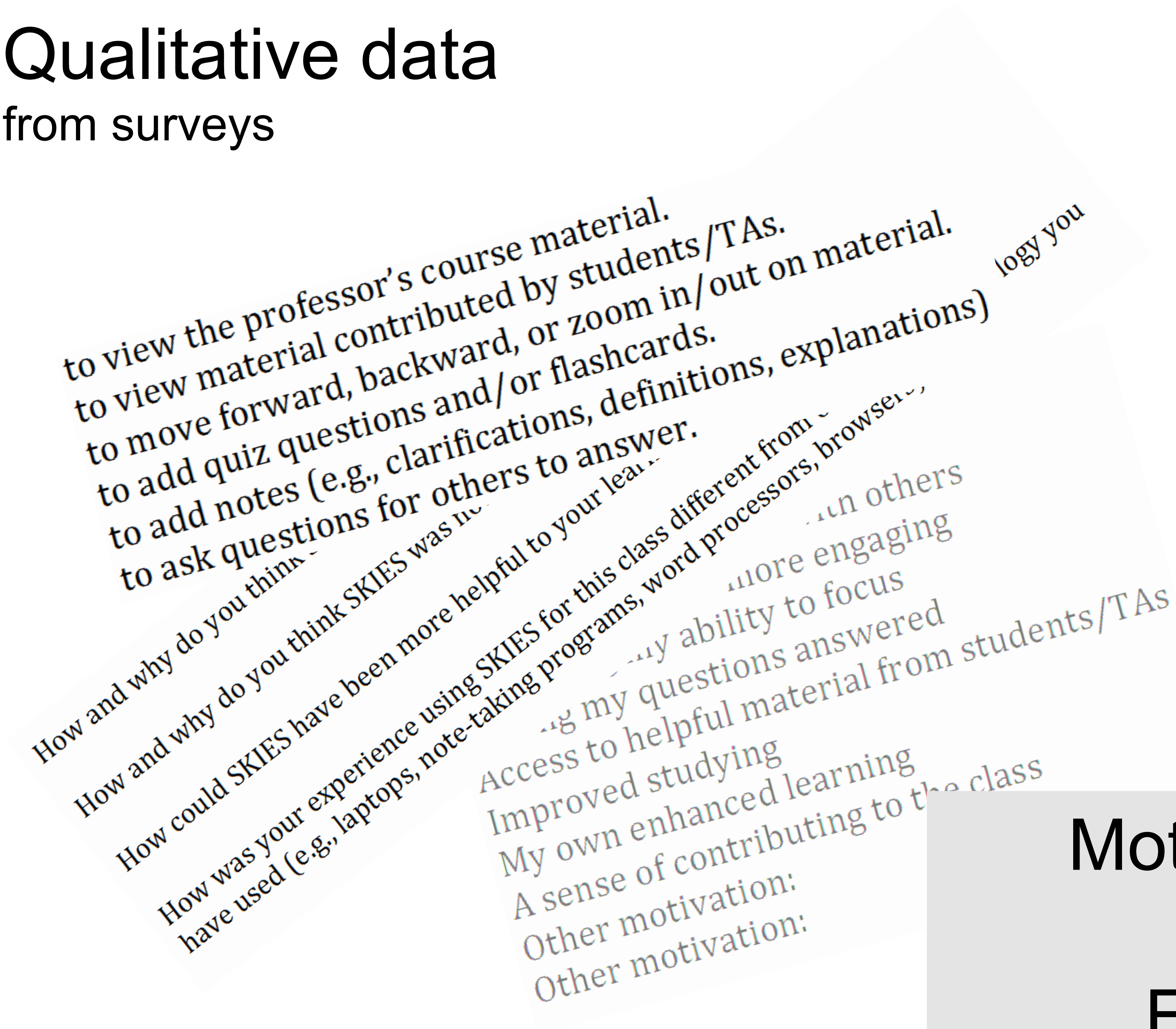
Quantitative data
from app



Cards
Owners
Timestamps
Connections

Qualitative data

from surveys

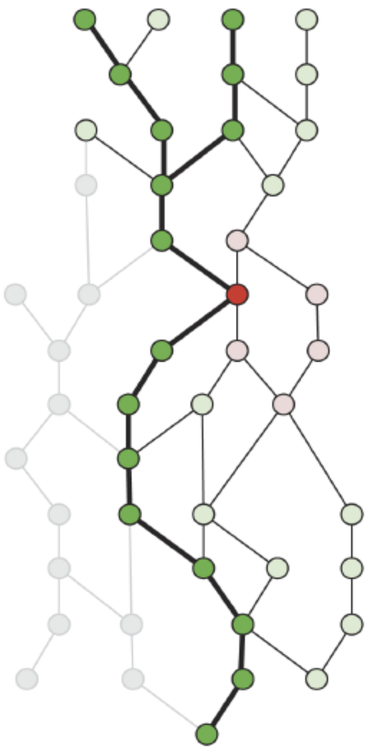


Motivation

Usage

Efficacy

Answer questions about classroom active learning



How do students choose to participate?

How can we quantify in-class engagement?

What motivates students? Faculty?

App provides a durable record of learning in the classroom

Research Questions

- What are the **observable patterns of real-time student engagement** during class, under open (student choice) and directed conditions, for individual students and group behaviors?

- What **types and levels of complexity are present in student engagement** during class, both self-reported and independently observed?

- What **relationships** exist **between student engagement, student learning, student motivation, and faculty experience** adopting active learning methods?

Administrative and technology logistics

Research & coordination

Programming & teaching support

100 iPads

Provost's Innovation in Education Fund (Caltech), Bechtel Foundation (Caltech), CTE Funding (PCC)

Caltech →

Genetics

Chemistry

+ 3 others

Pasadena City College →

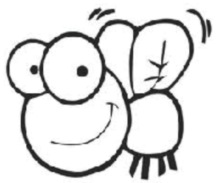
Calculus

+ 6 others

This talk: two classes at Caltech and one at Pasadena City College

Degree of structure & change to existing instruction

↓



Genetics

Low

35 students

Chemistry

Medium

53 students

Calculus

High

45 students

Solar chemistry

Ch 3X

Student — 1 week ago

Question

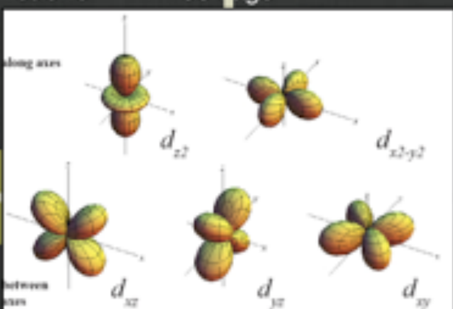
why would the other d orbitals not get destabilized in a tetrahedral structure (esp the x2-y2 one)

Teacher — 1 week ago

Which levels would be destabilized if the ligands bound in tetrahedral fashion?

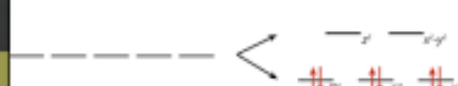
?

Teacher — 1 week ago



d orbitals can be classified into those whose lobes lie along the xyz axes, and those whose lobes lie in-between the xyz axes.

Teacher — 1 week ago



Ligands at octahedral positions destabilize the d_z^2 and $d_{x^2-y^2}$ orbitals, breaking the degeneracy of d orbitals in the free atom.

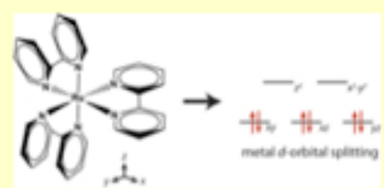
Student — 1 week ago

Energy Splitting due to d-orbital Interference

The molecule has so many electrons near each other that the electron orbitals interact with each other and change their energies.
d-electrons all fall into xy, xz, and yz orbitals (the lower energy d-orbitals).

Teacher — 1 week ago

Electronic states of Ru(bpy)2



Normally the d orbitals of Ru have the same energy (are degenerate).

However, when the *bpy* ligands bind, they do so in an octahedral fashion, e.g. along the x, y, and z axes. This causes the energy of the $d_{x^2-y^2}$ and d_{z^2} orbitals to be pushed upward. The 6 electrons of Ru^{2+} end up occupying the d_{xy}, d_{yz}, and d_{xz} orbitals.

Student — 1 week

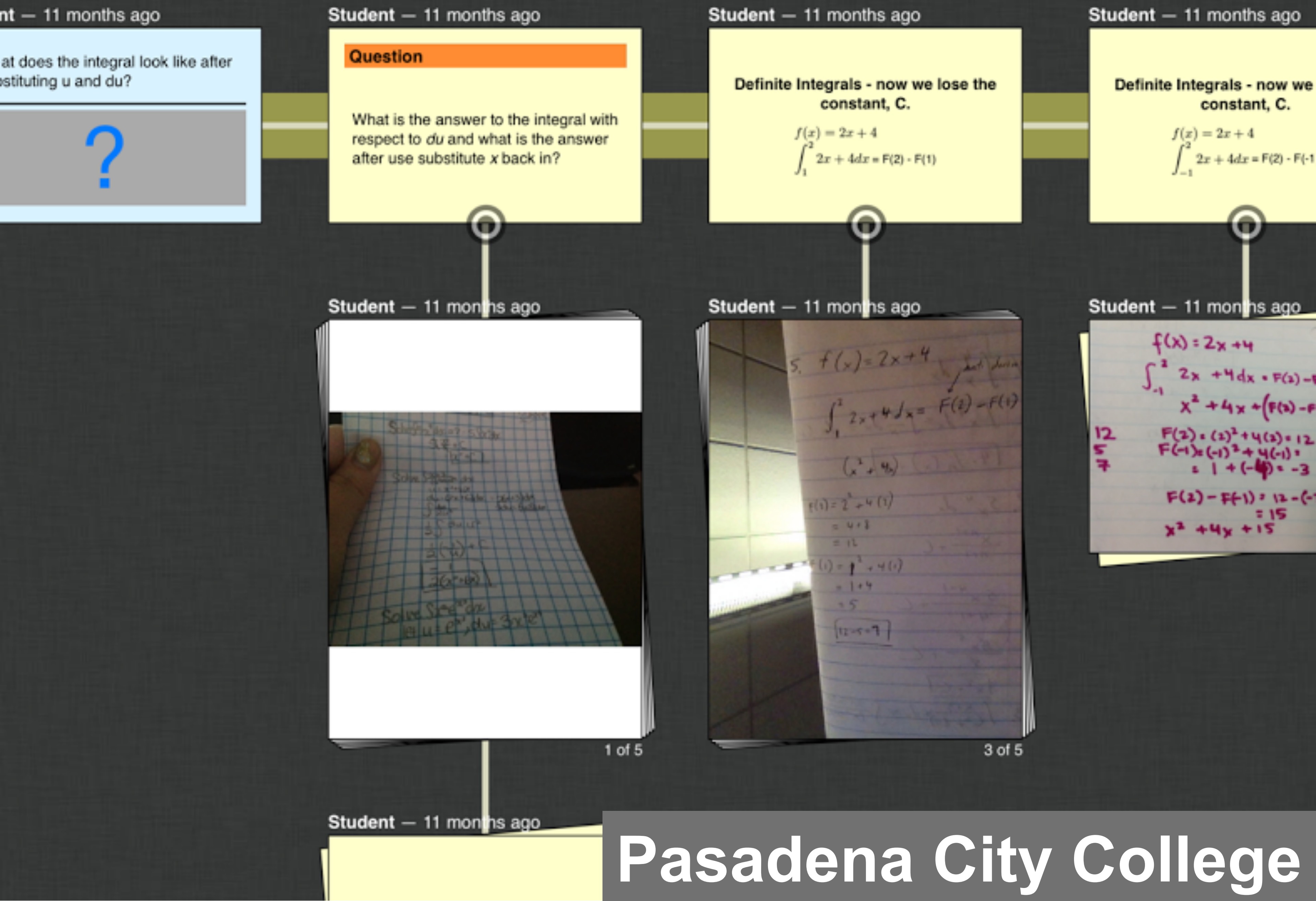
What is it called if the electron imme down to lower ene photons?

Teacher — 1 week

Electronic excit

Light of 400 nm can exci metal to the π^* orbital of

The splitting between d that the π^* orbital energy

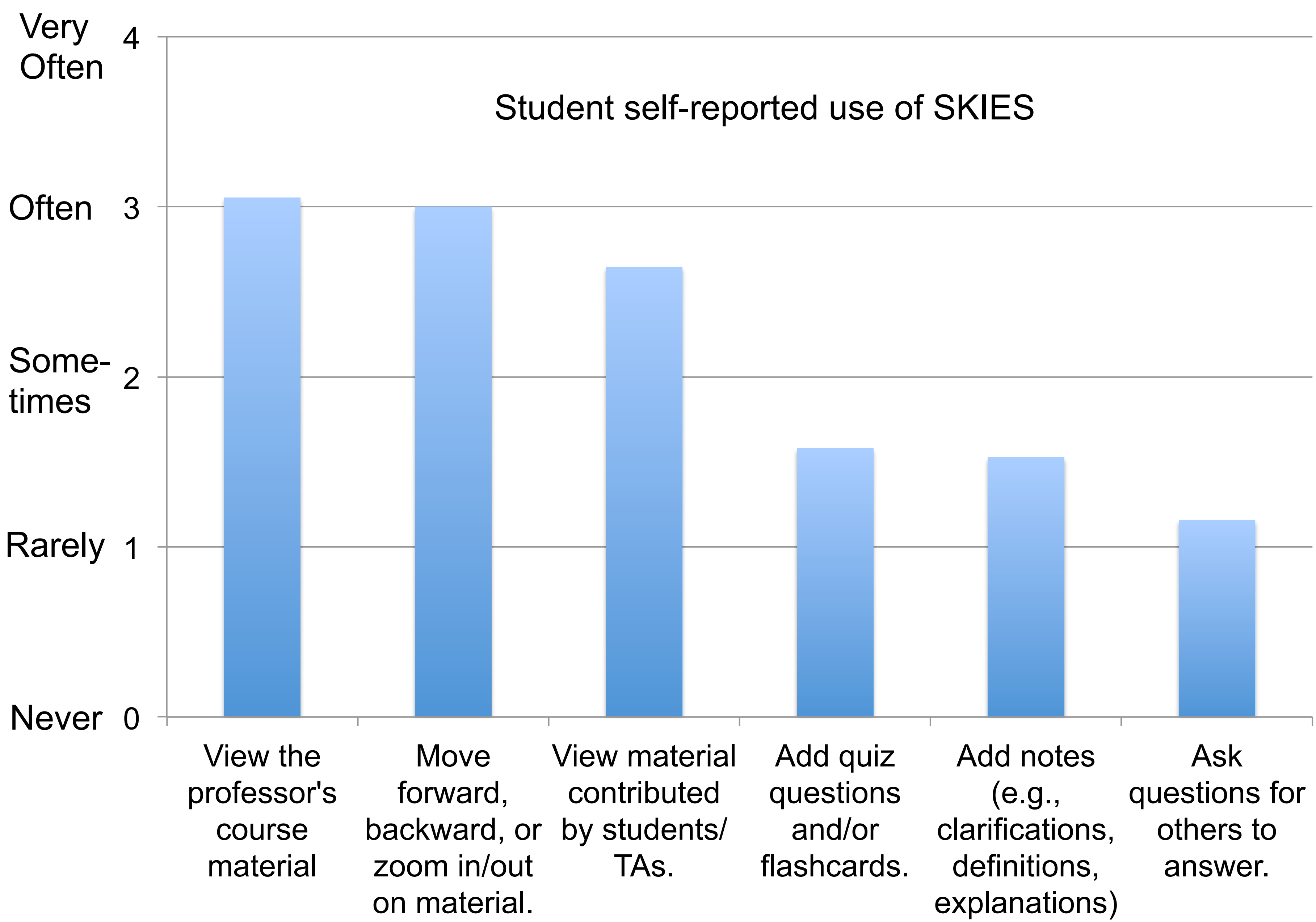


Pasadena City College

2. Participation Inventory

- Counting Cards
- Self report vs. App data
- Student, TA, and Faculty contributions

Counting cards



Student self-reported use of SKIES
Very Often 4
Often 3
Some-times 2
Rarely 1
Never 0
View the professor's course material
Move forward, backward, or zoom in/out on material.
View material contributed by students/ TAs.
Add quiz questions and/or flashcards.
Add notes (e.g., clarifications, definitions, explanations)
Ask questions for others to answer.

In genetics, how many cards were added?

Slides for 14 lectures	**834**
Added year 1	843
+ added year 2	1036
= Total added	**1879**

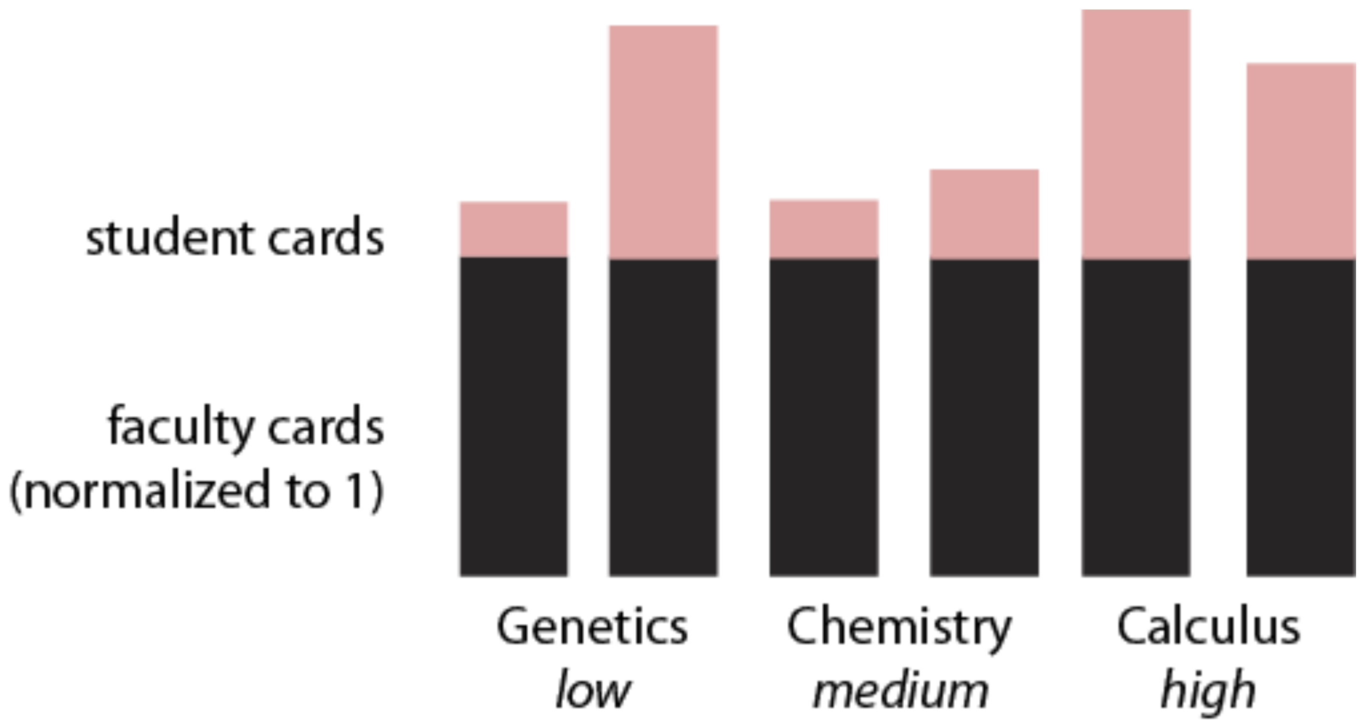
>2.2 additions, quiz questions, papers etc. per slide

In genetics, who makes cards?

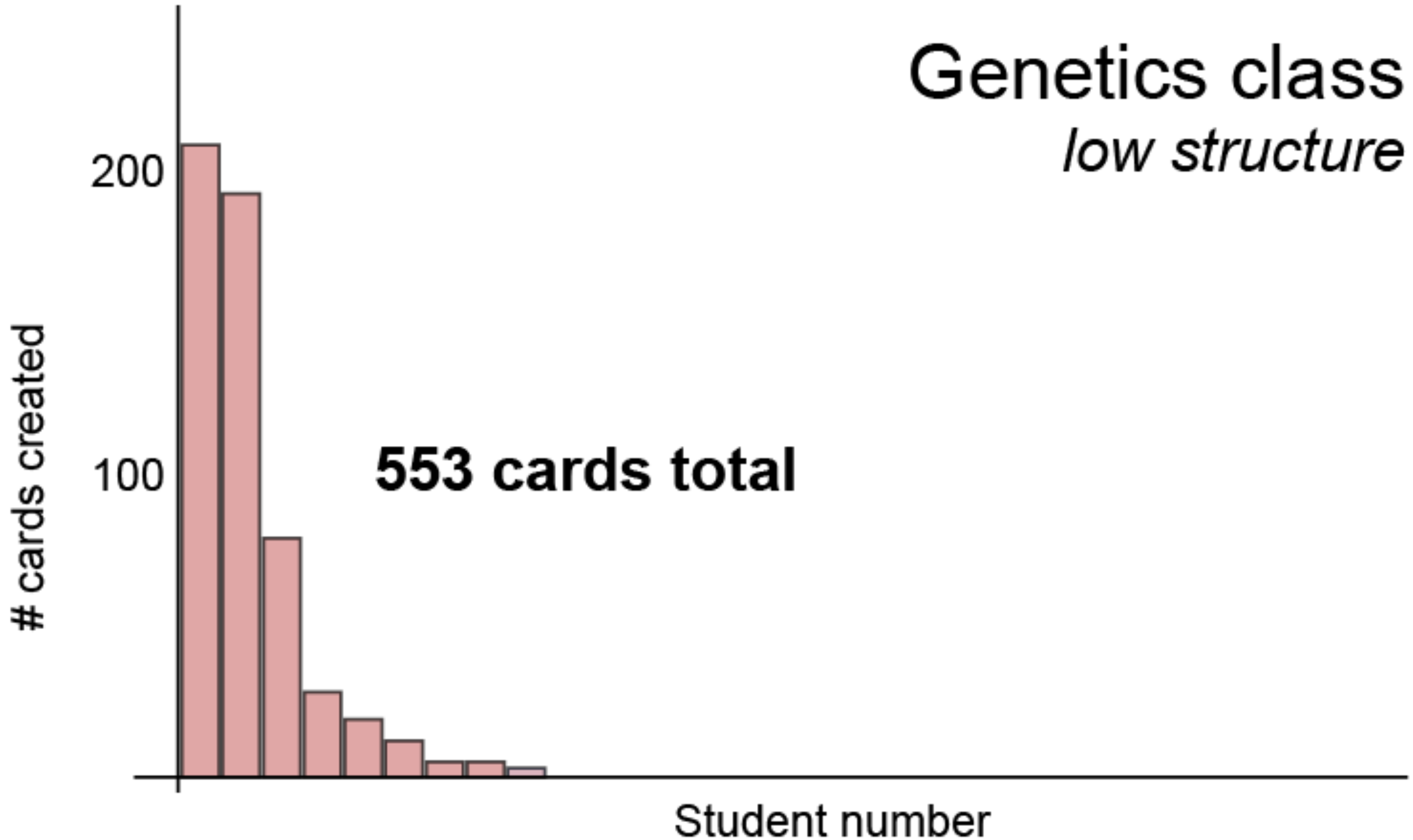
	Year 1	Year 2
TAs	**696**	430
Students	147	**606**
Total	**843**	**1063**

Students contributed more cards than TAs by Year 2

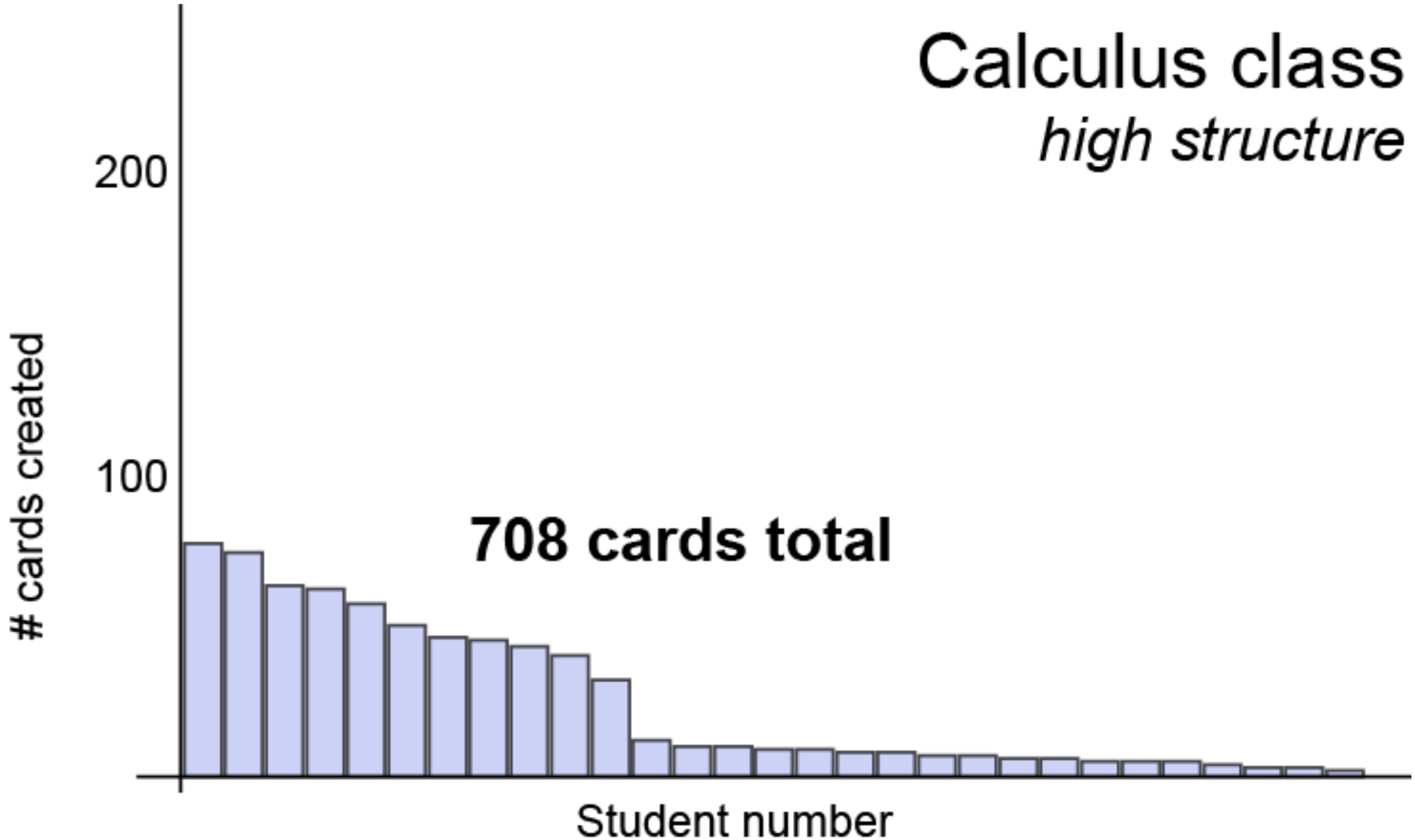
Class structure affects student participation



Students add many cards in the low and high structure extremes

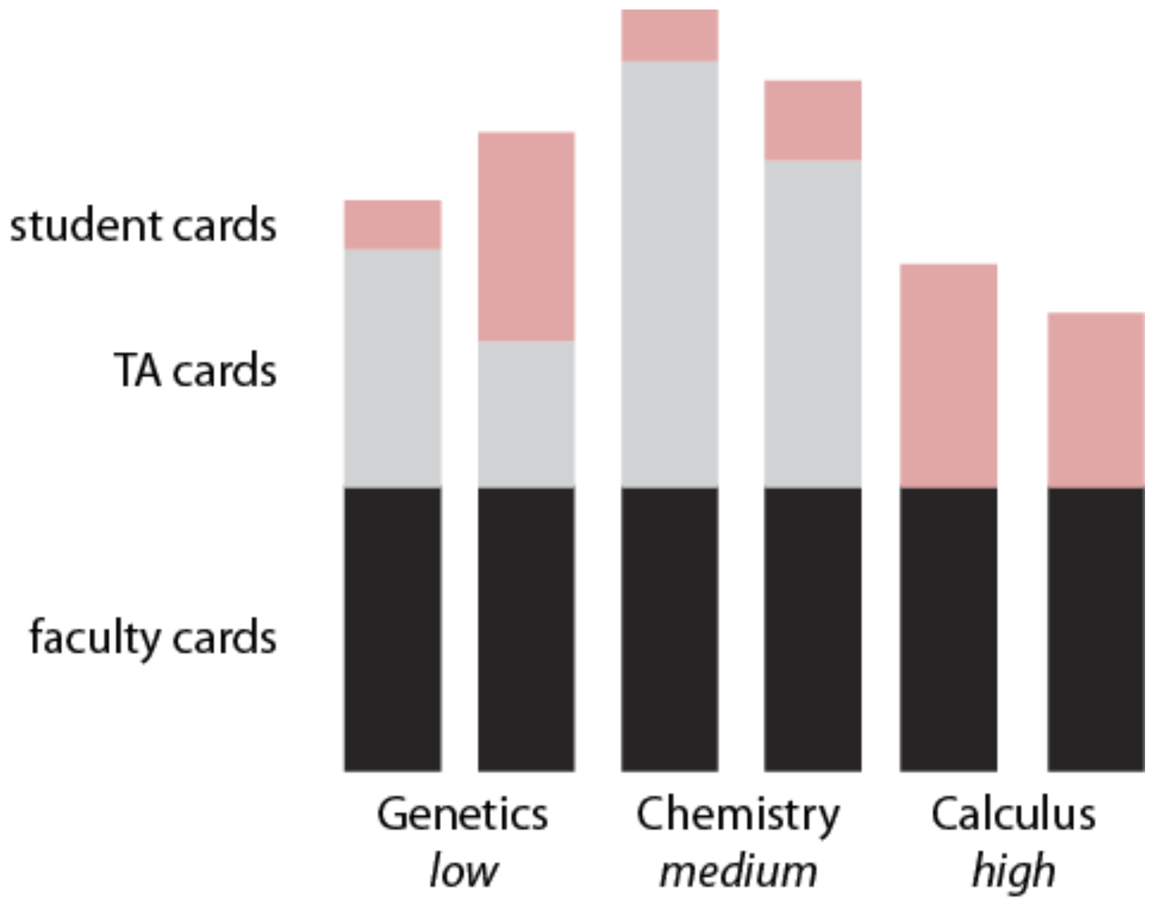


In the low structure class, a few students add most of the cards



In the high structure class, many students add a few cards

Contributions from teaching assistants



TAs were particularly active in the medium structure class

Student participation: Conclusions

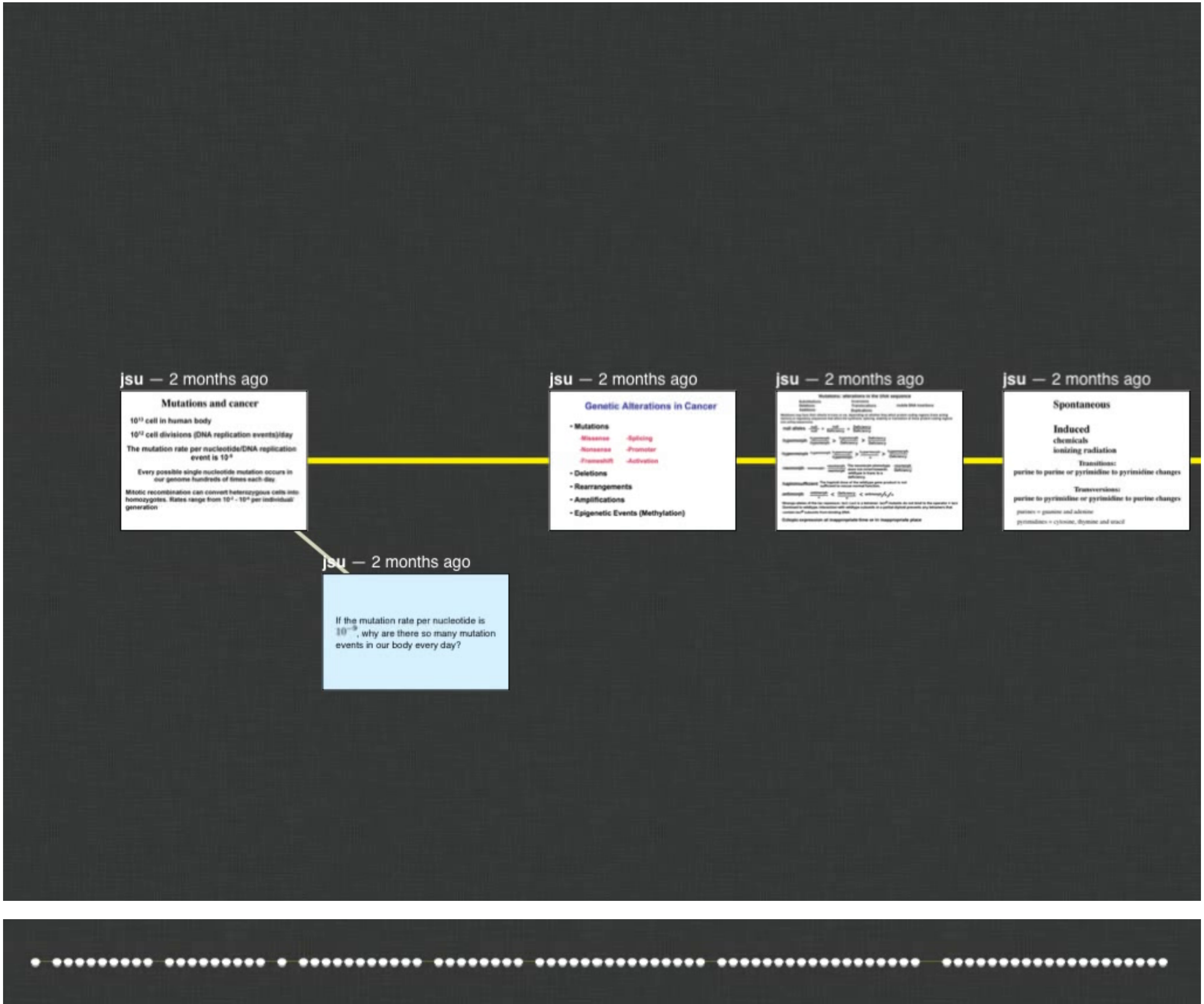
The most participation came from classes with **low** or **high** degrees of structured tablet use.

In the **low** structure case, a subset of students became very active teachers/contributors.

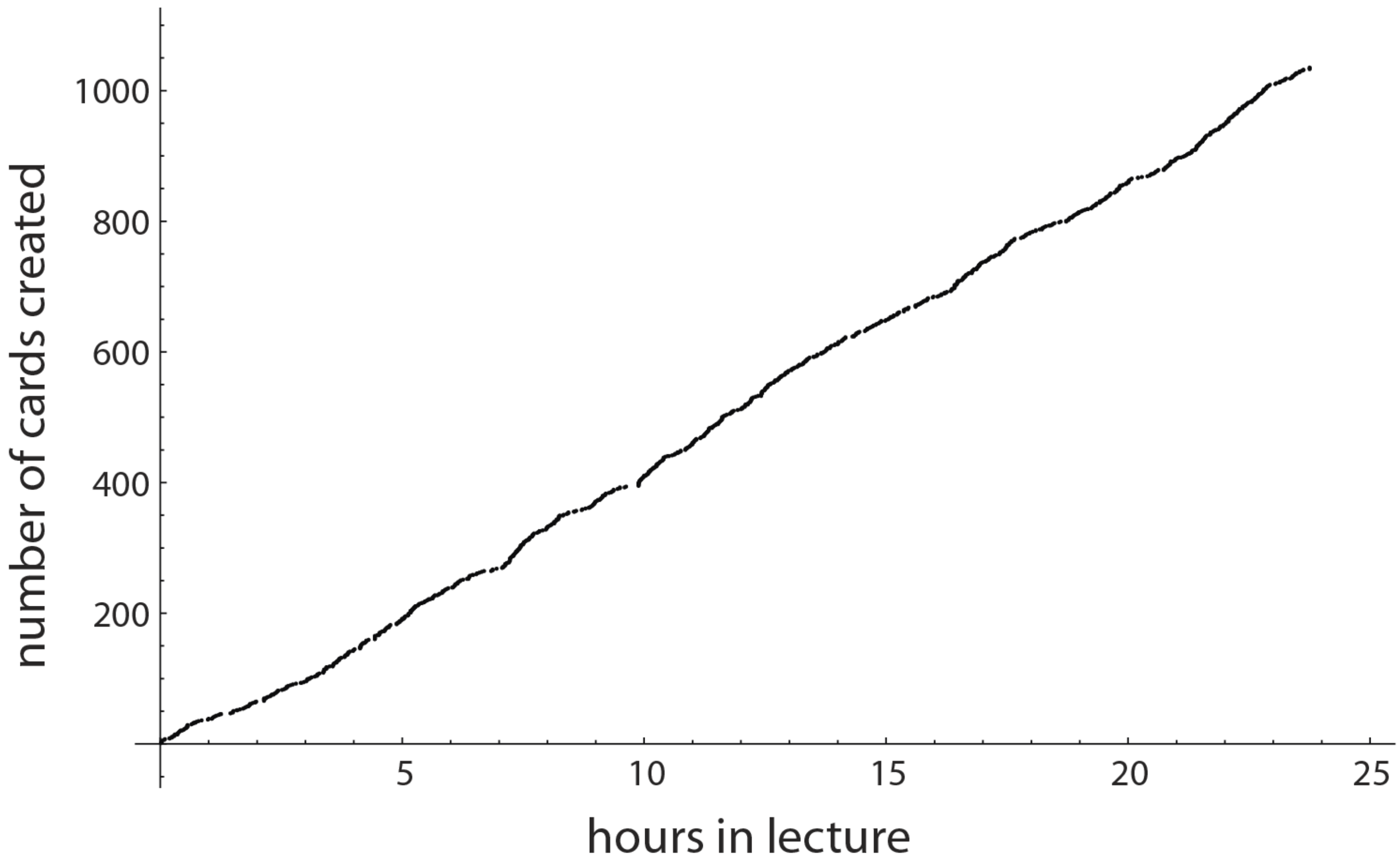
In the **high** structure case, a broader range of students contributed more uniformly.

3. Behavior in Time

- In-class time lapse
- Learning Curve
- Waiting Time

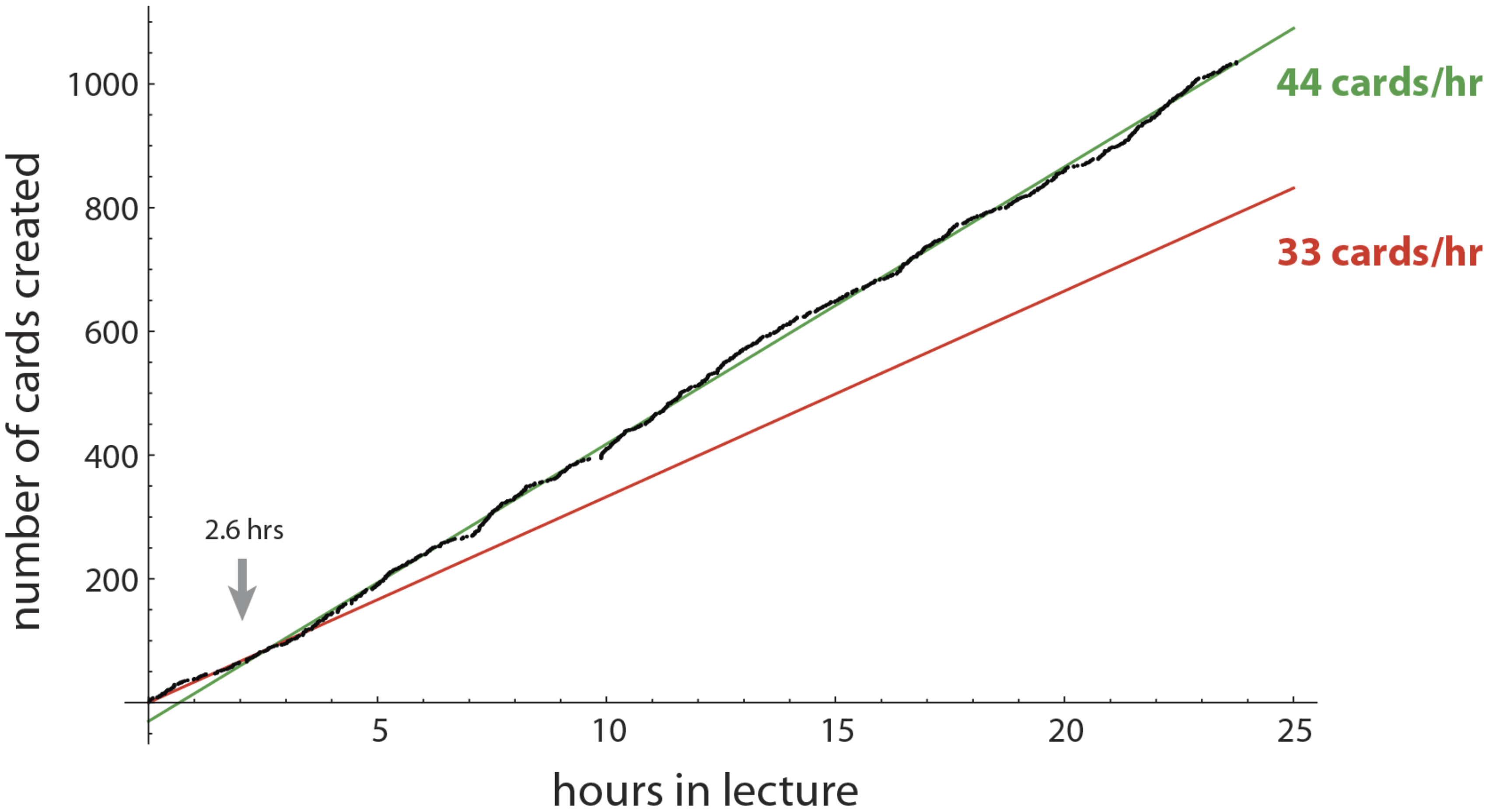

jsu — 2 months ago
Mutations and cancer
cell in human body
cell divisions (DNA replication events)/day
The mutation rate per nucleotide/DNA replication event is
Every possible single nucleotide mutation occurs in our genome hundreds of times each day
jsu — 2 months ago
If the mutation rate per nucleotide is 10^{-9}, why are there so many mutation events in our body every day?
jsu — 2 months ago
Genetic Alterations in Cancer
• Mutations
-Missense
-Splicing
-Nonsense
-Promoter
-Frameshift
-Activation
• Deletions
• Rearrangements
• Amplifications
• Epigenetic Events (Methylation)
jsu — 2 months ago
jsu — 2 months ago
Spontaneous
Induced
chemicals
ionizing radiation
Transitions:
purine to purine or pyrimidine to pyrimidine changes
Transversions:
purine to pyrimidine or pyrimidine to purine changes
purines = guanine and adenine
pyrimidines = cytosine, thymine and uracil

Card creation over time: IC1 Genetics



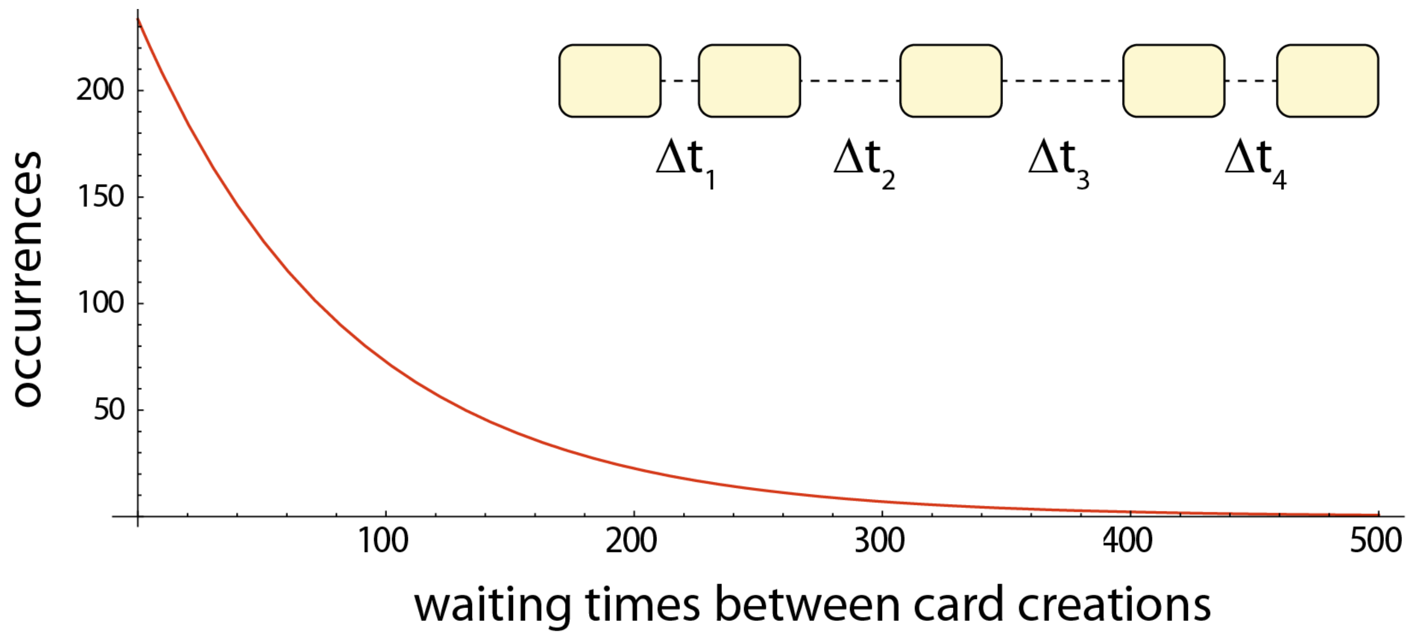
Students + TAs make cards steadily over the term

Card creation over time: IC1 Genetics



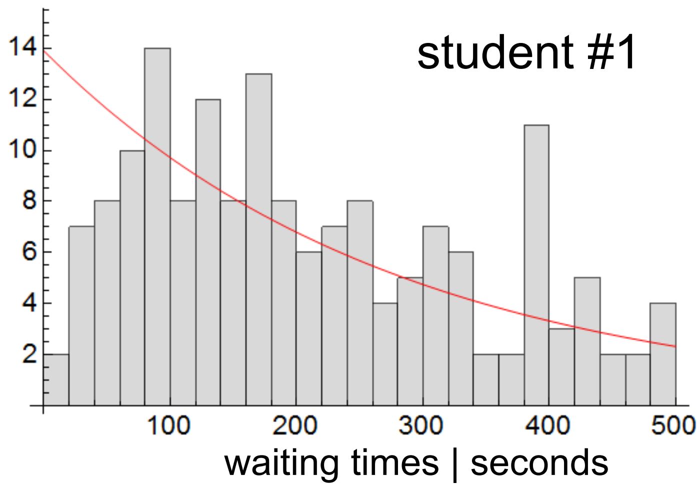
After an initial learning curve, rises to a steady-state 44 cards/hr

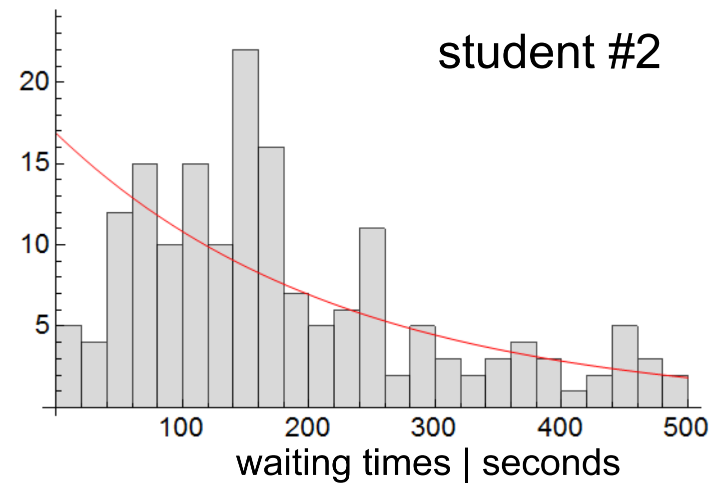
Card creation by a "model student"

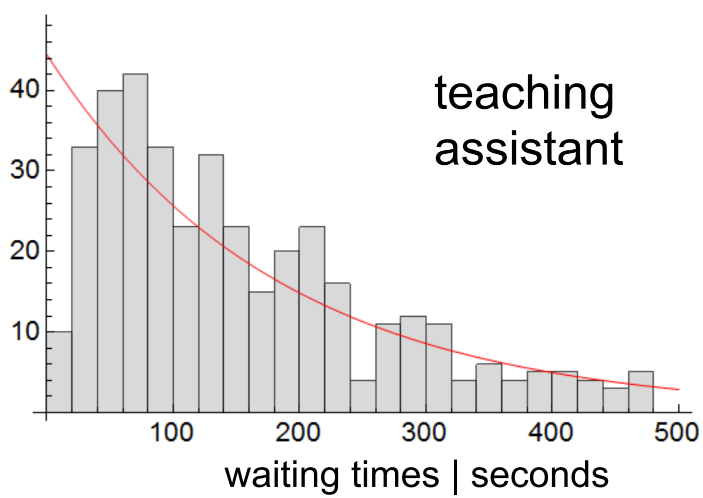


Exponential distribution if inspired to create at a constant rate

Individuals are not model students though

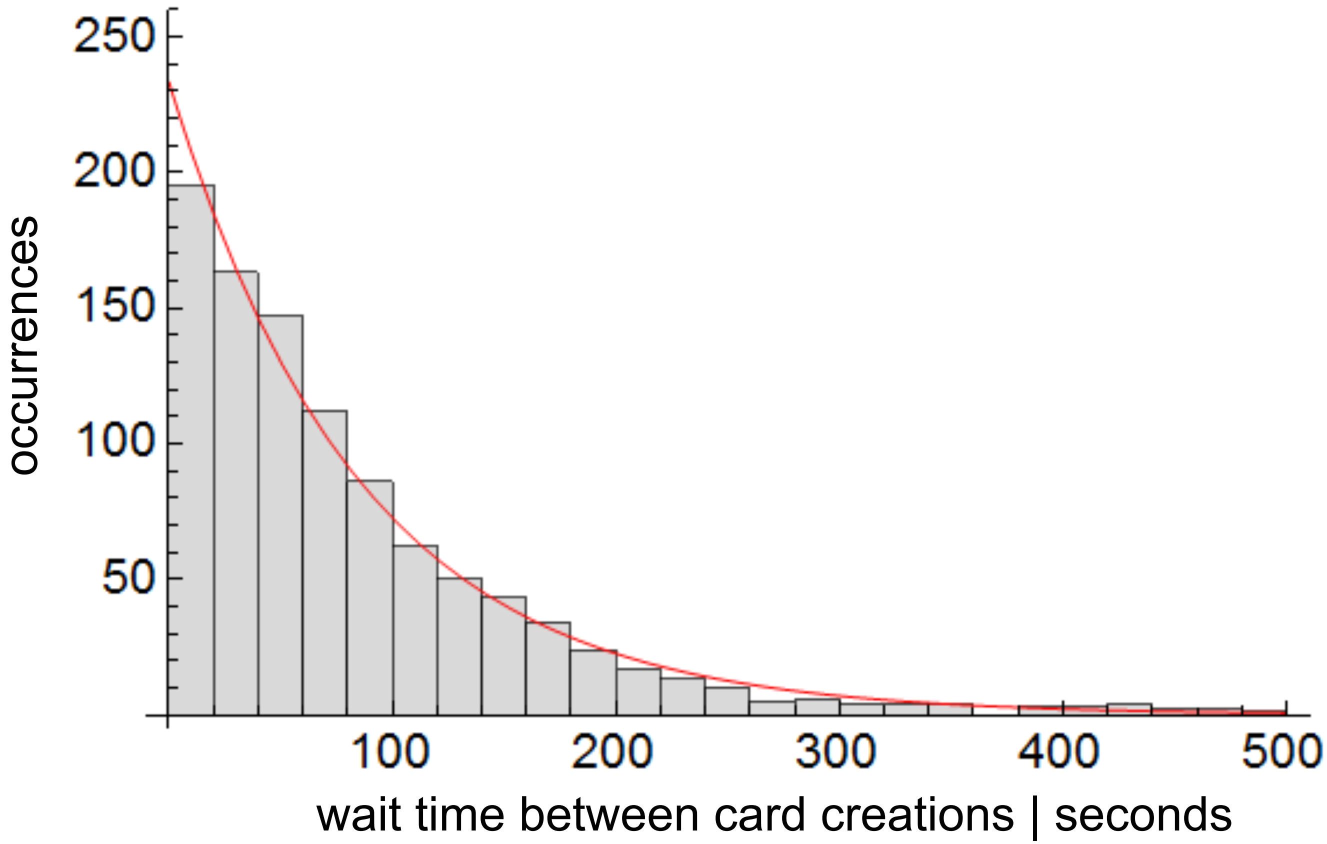






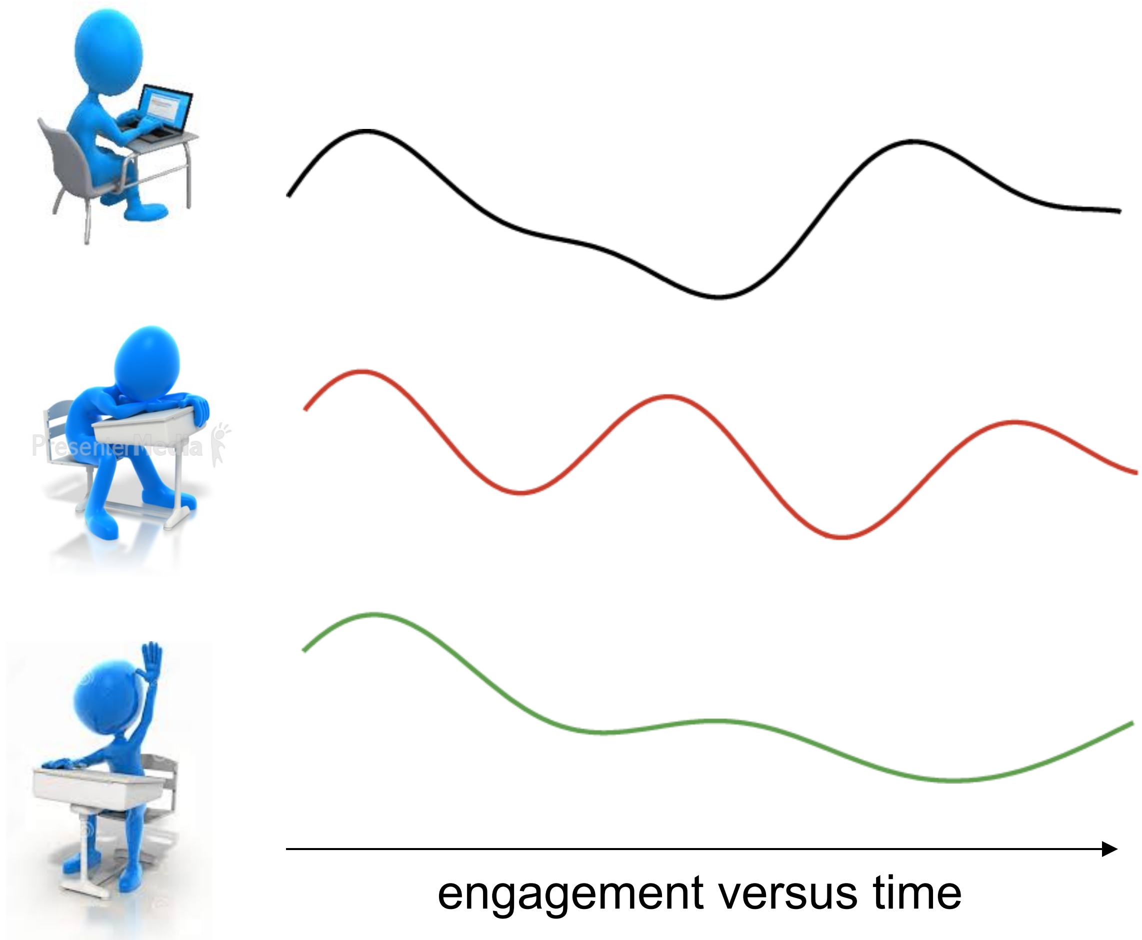
Creation rate observed to flag right after making a card

Collectively, though, the class acts as a model student



Taken together, the class is attentive and creating constantly

Principle of collaborative learning



Palm-Khintchine theorem; superposition of non-Poisson processes

Sharing combines attention spans, to everyone's benefit

Behavior in Time: Conclusions

Attention span ebbs and flows add up: collectively, class may behave like an "ideal student."

This may shift instructional views of "engagement":
the class may be engaged,
just not all equally at the same time.

4. Modes of Learning

- Types of Contributions
- Cognitive Complexity of Contributions
- Complementarity and Knock-on Effect
- Wait Time for Different Complexities

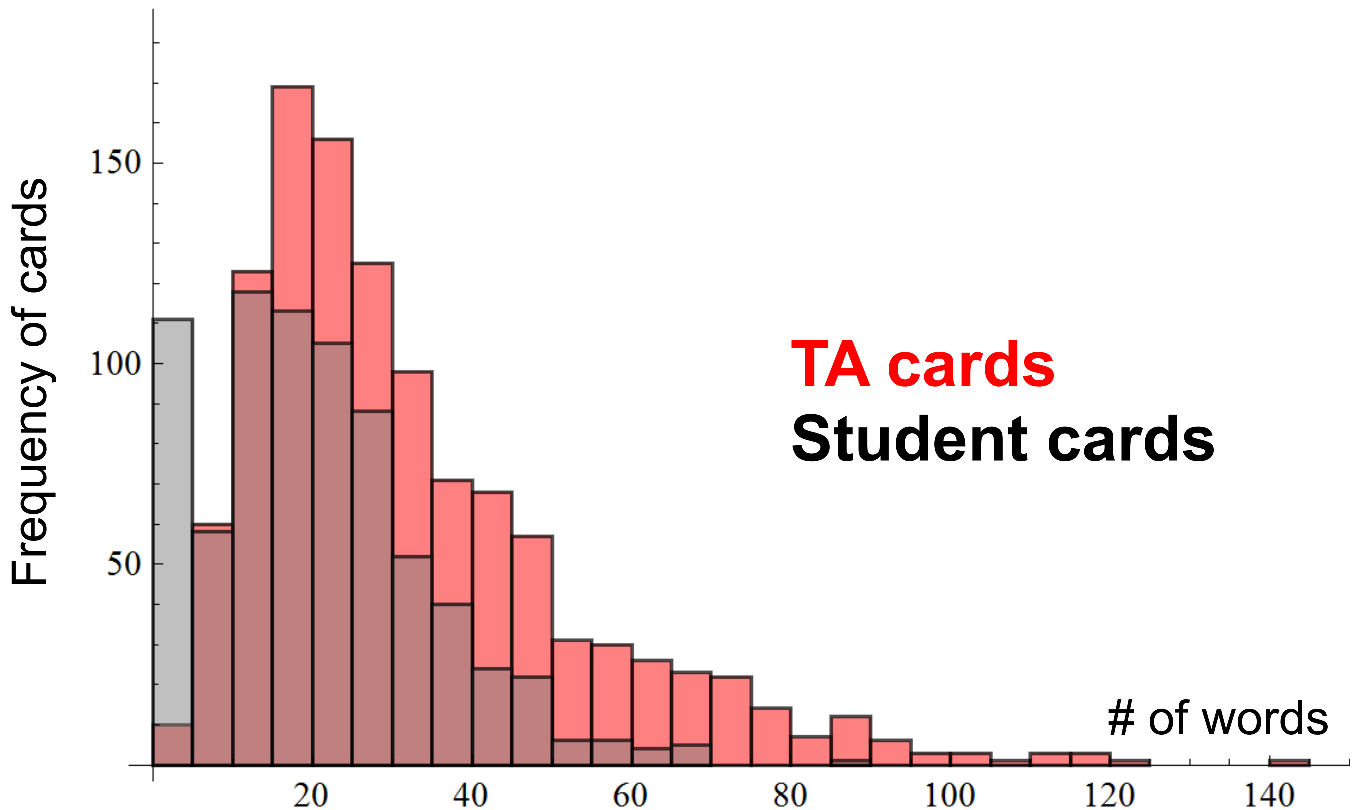
Detailed analysis of Genetics

What kinds of cards are made?

	information	assessment
TAs	497	**629**
Students	**645**	108
Total	**1142**	**737**

TAs like to make questions; students like to make notes.

How many words are in each card?

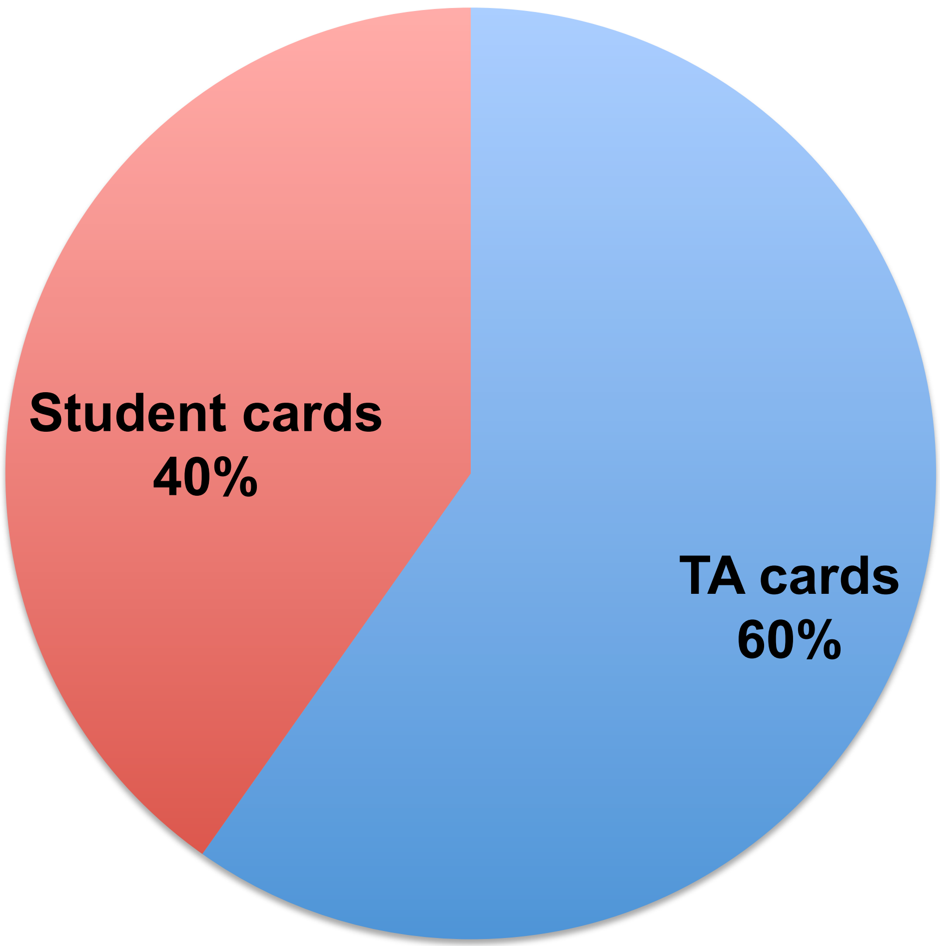


TAs are more verbose than students (~32 vs 20 words per card)

Genetics Coded Card Set
838 Cards, Lectures 1 thru 8 (out of 14)

Code	Type	Examples
N-F	Note—Fact	*Definitions, terms, short factual materials*
N-S	Note—Summary, Synthesis	*Boiling down, bringing together, connecting material*
N-I	Note—Insight	*Elaborating, clarifying, interpreting, concluding*
Q-R	Question—Recall	*Self/peer quiz asking simple facts, definitions, information*
Q-T	Question—Thinking	*Self/peer quiz asking complex question requiring thought*
Q-O	Question—Other	*Open-ended questions, answers to other students' questions*
O	Other	*Supplemental and related material from outside sources; "Human Interest" tangents, stories, humor, etc.*

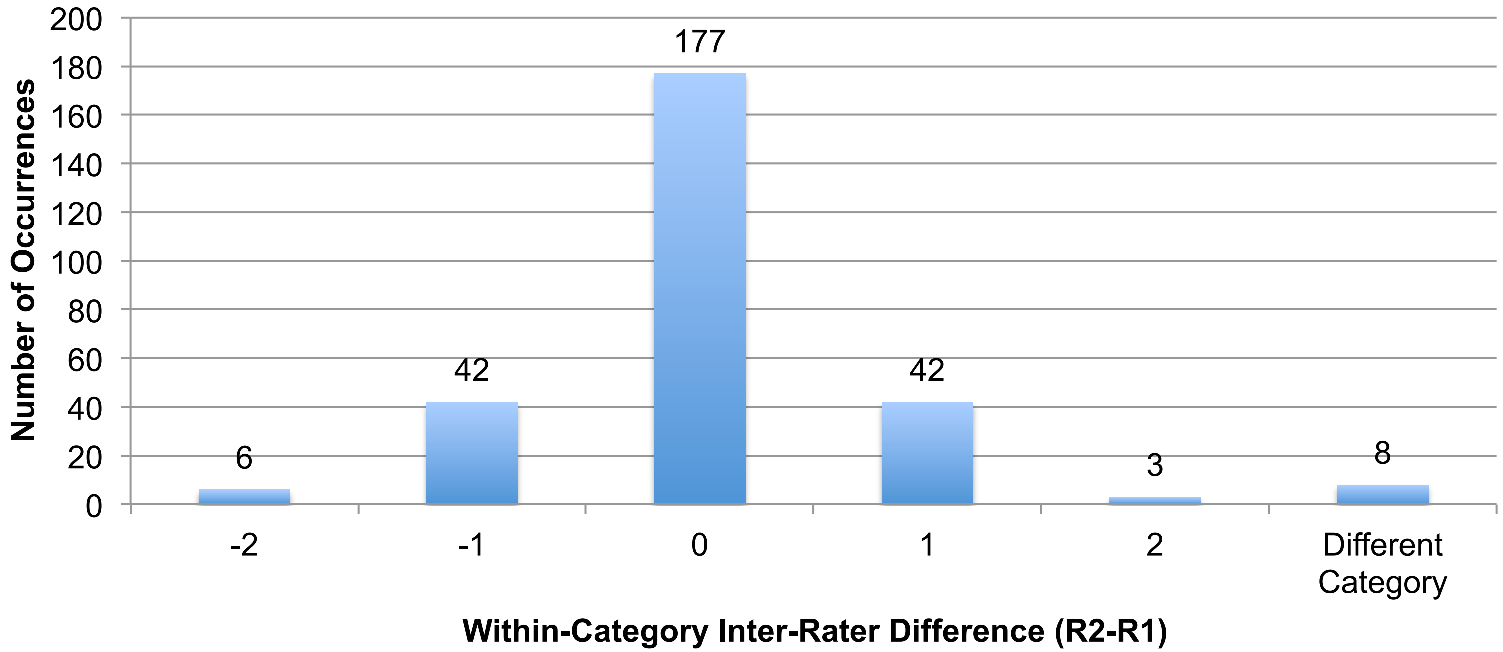
Who made cards in the coded set?



Coded cards were made by students & TAs in the same proportion as all genetics class cards.

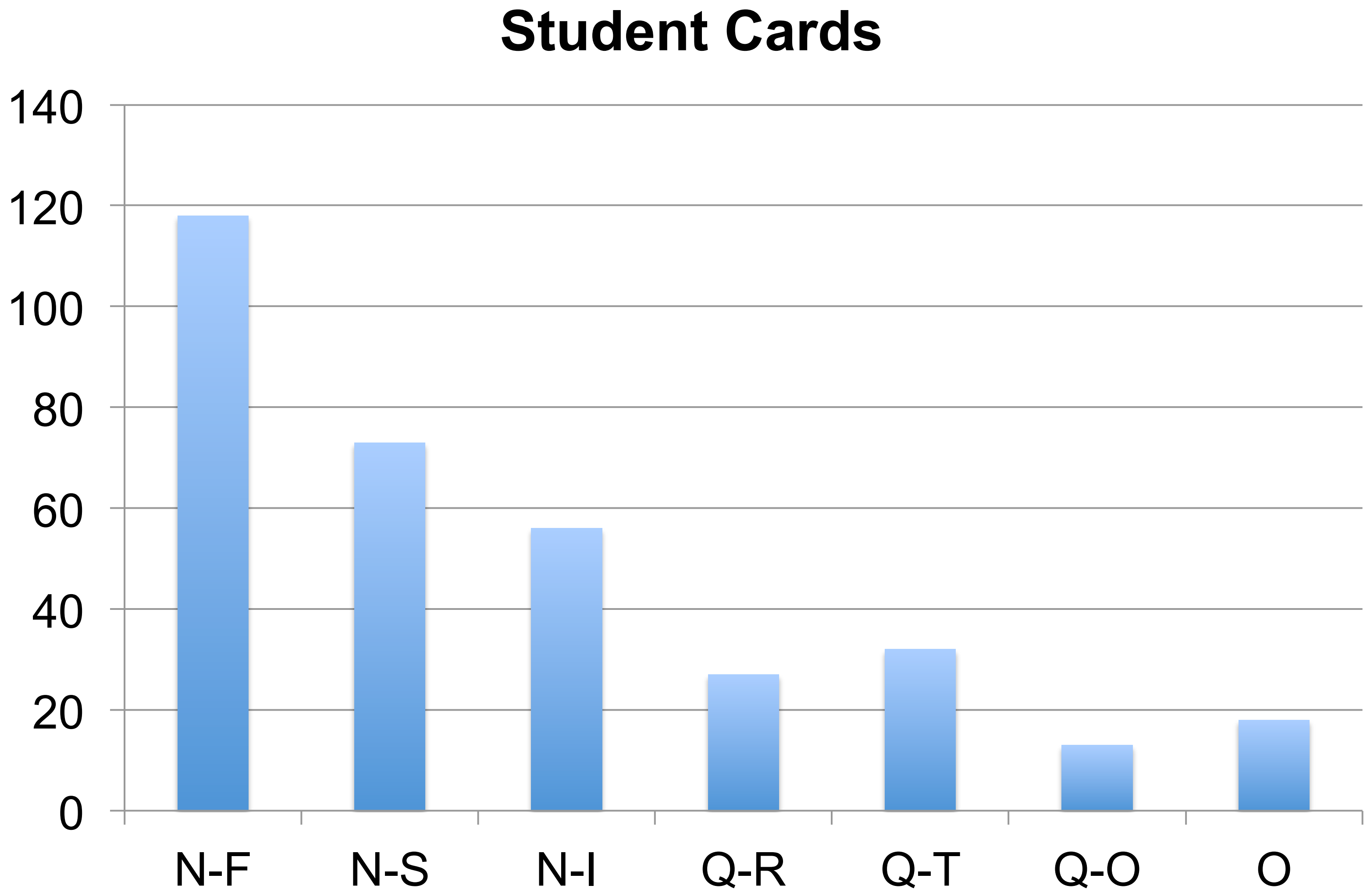
Inter-rater Reliability

- Twice-coded 1/3 of coded set



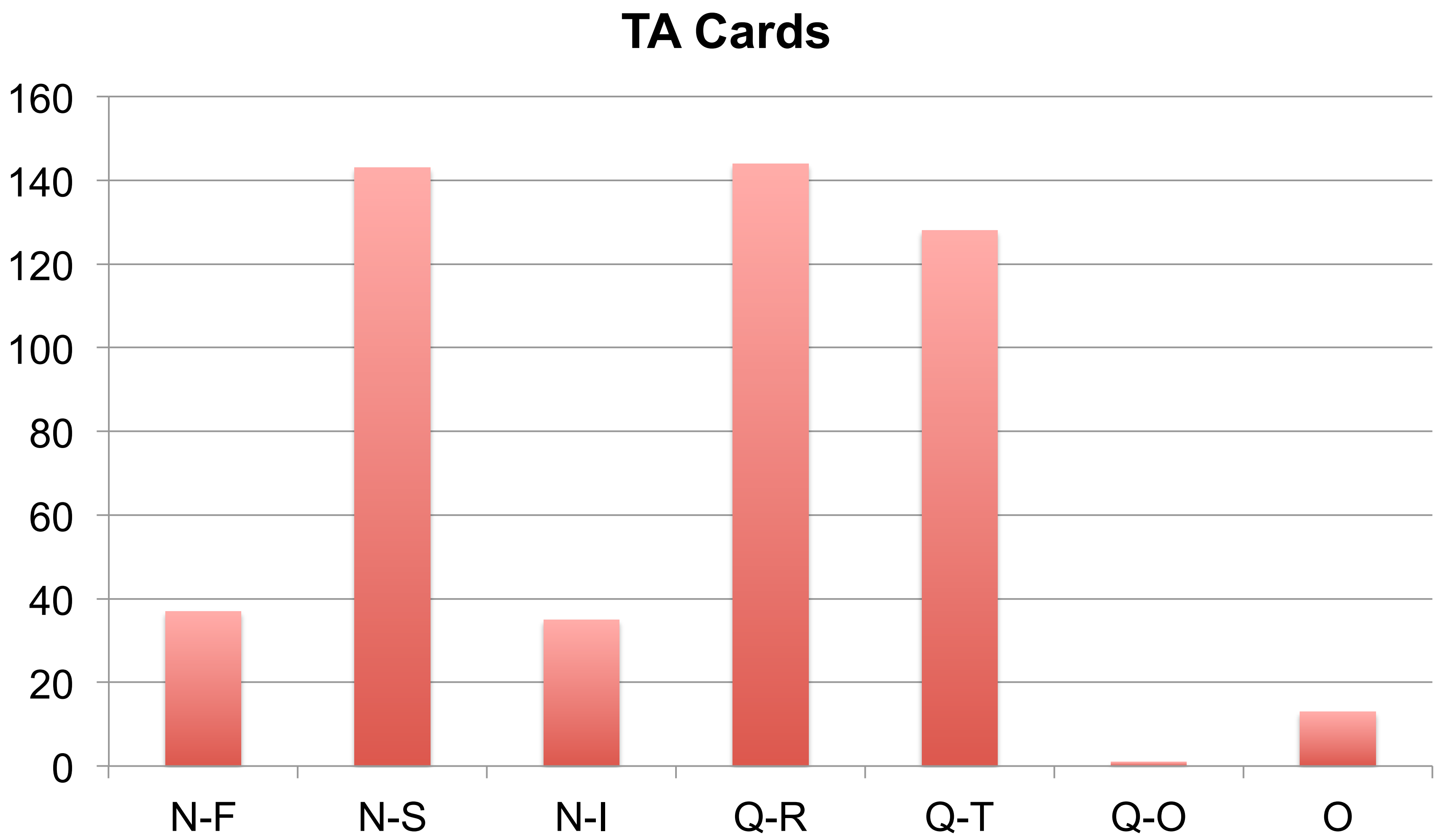
- Cohen's Kappa = **0.53** (moderate)
- Pearson's r = 0.92; 0.99 for within-category

How do students actively engage in card-making?



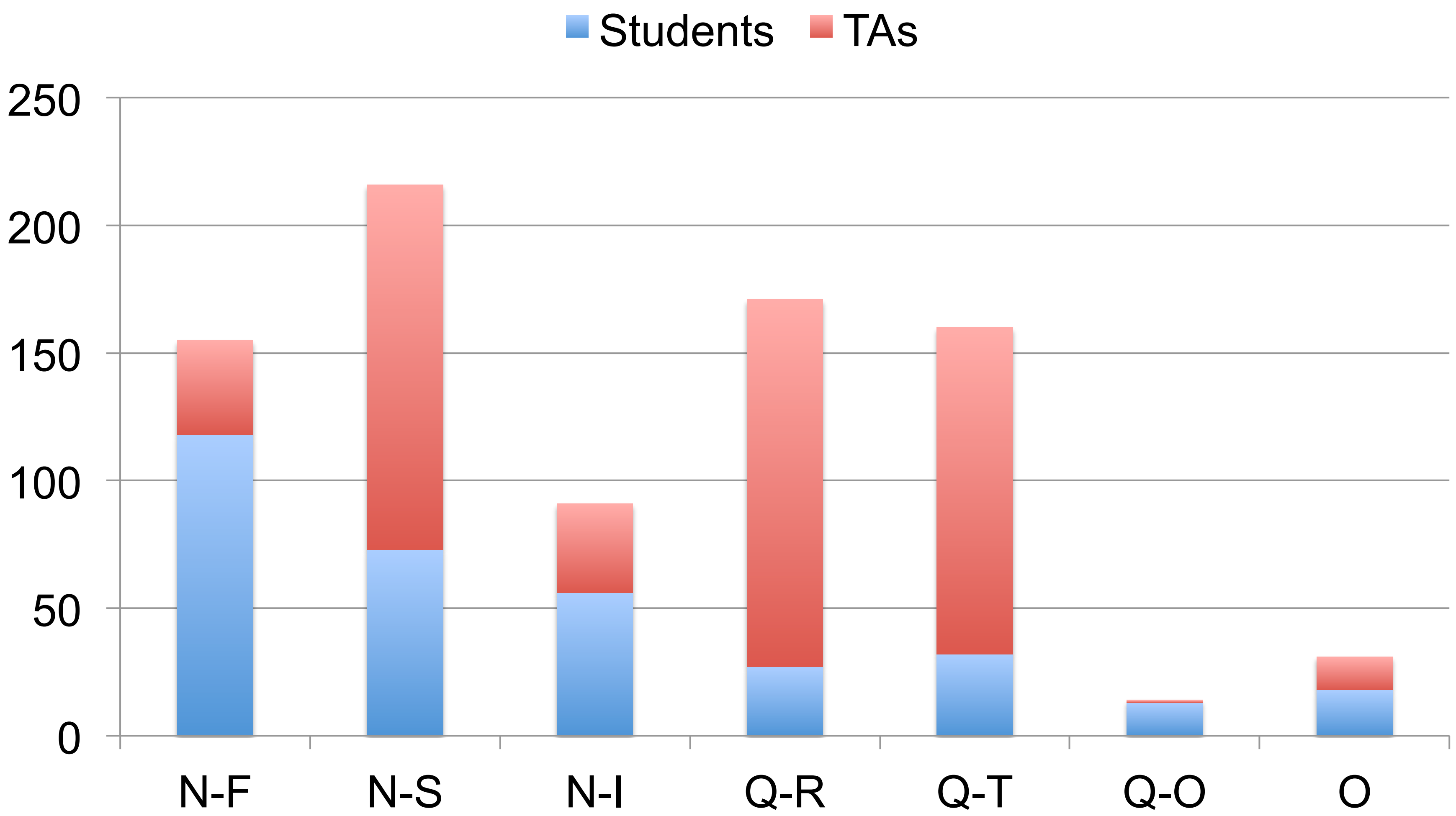
Students lean toward notes and facts.

How does TA card-making differ?



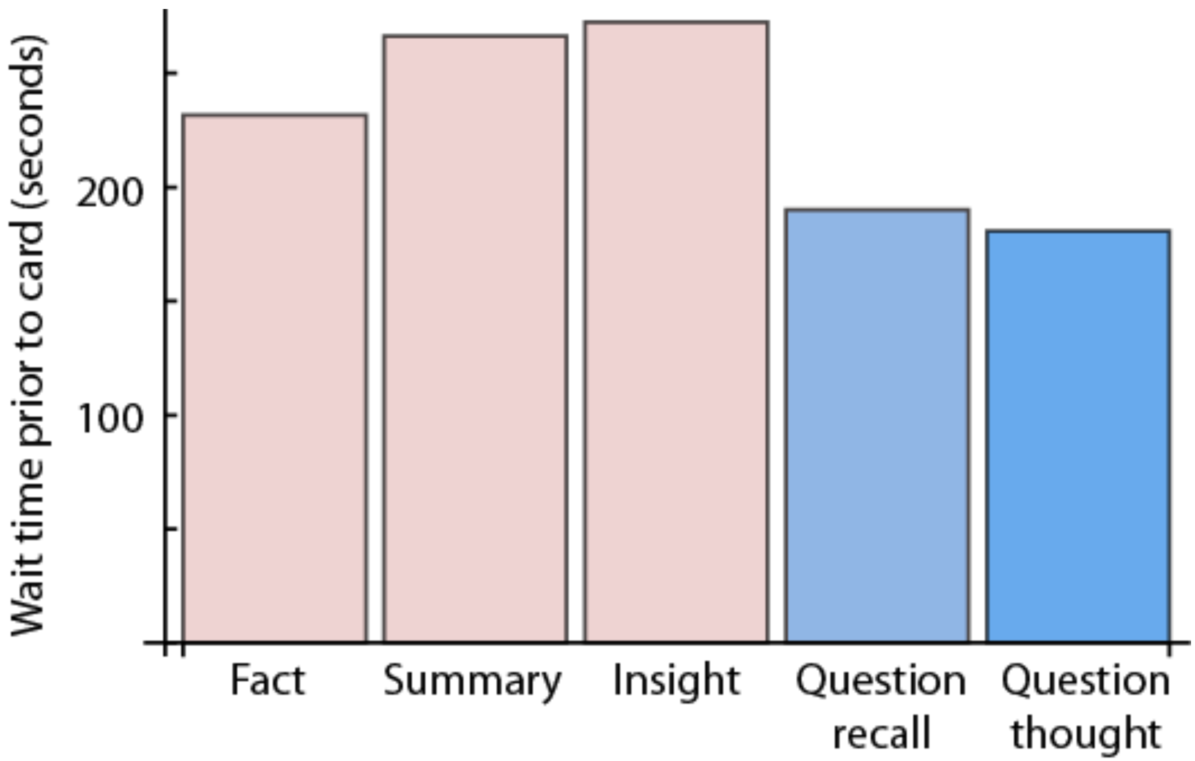
TAs add more complex notes and substantially more questions.

Overall, how does the student/TA collaboration look?

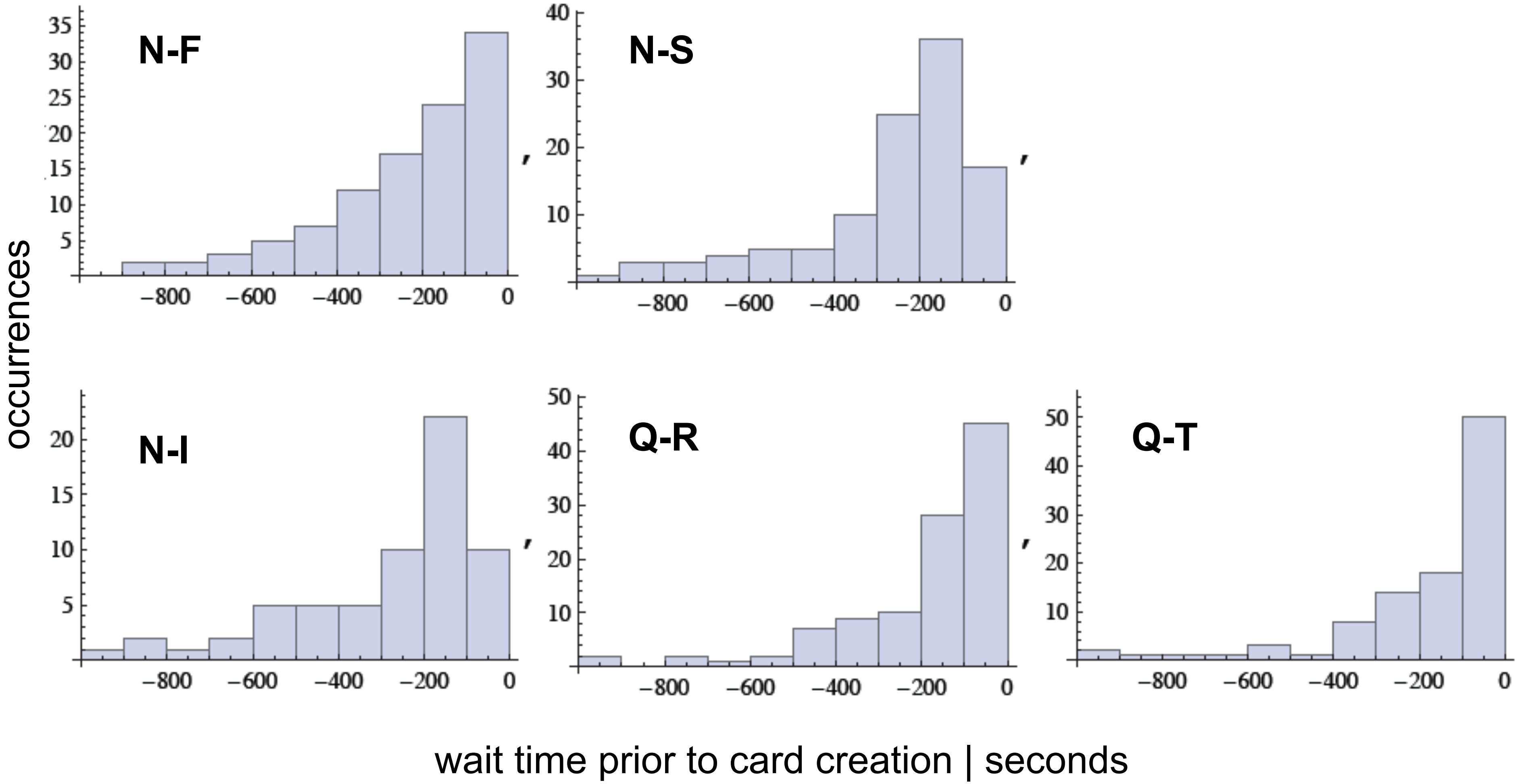


Students and TAs together create a varied set of learning resources.

Some cards take longer to make than others



Shorter wait times associated with question type cards



occurrences
N-F
N-S
N-I
Q-R
Q-T
wait time prior to card creation | seconds

Complexity and Modes of Engagement

Students and TA contributions differ in type and cognitive complexity

It takes students longer to do more complex tasks

The overall result is rich and complementary

"Knock-on effect" of increasing overall engagement

Consider & Contribute:

How does classroom teaching change when it is visibly collaborative?

5. Motivation and Outcomes

- Student motivation
- Faculty self-report
- Student learning
- Student self-report

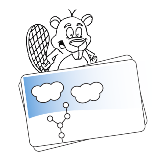
Encouragement and in-class rewards

"Reading is a good way to learn; teaching is a great way to learn. We encourage everyone to contribute flashcards to the class tree (and any other kind of card as well).

Top contributors will be recognized at the end of each lecture."

– e-mail to students

Various incentives provided to encourage participation



Su-Kam Intelligent Education Systems and Caltech thank

a wonderful student

FOR OUTSTANDING CONTRIBUTIONS TO THE BI 122 CLASS TREE

Julius Su, SKIES | Bruce Hay, Caltech

Why do students report using SKIES?

Self-reported as most important

1. Access to helpful material from students/TAs
2. My own enhanced learning
3. Improved studying
4. Making class time more engaging
5. Enhancing my ability to focus

More intrinsic

Self-reported as least important:

6. Having my questions answered
7. A sense of contributing to the class
8. In-class rewards
9. Recognition by the professor
10. A sense of competition with others

More extrinsic

Students say intrinsic motivations are most important

Faculty outcomes (self-reported)

SKIES was a **great benefit to my class**…This activity by the students may have **helped to draw people out** a bit since it provided a **forum in which to shape the class and participate** rather than just sit and absorb.

One other thing about this class that made it **remarkable was the number of questions** the students asked. Sometimes it was difficult to make it through the lectures, there was so much querying going on. SKIES is likely to be a part of it, **allowing students to quickly go back through the slides and links.**

SKIES also helps in a more general way in that it provides a way to get them…**comfortable in the idea that they are a part of creating [the class].** This then makes them generally **more engaged & inquisitive**.

Faculty outcomes (self-reported)

The one other data point we have is just how well the students did overall. Here I am a bit embarrassed and shocked. The **average grade this year was astonishingly!!!!!!!!!!!!! higher than in all previous years I have taught the course**. It really was quite a change.

Usually this is **considered one of the hardest required … courses** because it focuses on tricky problem solving. It normally serves as a bit of a weed out course.

Average GPA (learning) jumped with SKIES

Problem sets, exams + <u>extra credit problems to boost score</u>

2009 Ave = 85

2010 Ave = 88

2011 Ave = 86

Average GPA (learning) jumped with SKIES

Problem sets, exams + <u>extra credit problems to boost score</u>

2009 Ave = 85

2010 Ave = 88

2011 Ave = 86

+SKIES 2012 Ave = 98.2

Average GPA (learning) jumped with SKIES

Problem sets, exams + <u>extra credit problems to boost score</u>

2009 Ave = 85

2010 Ave = 88

2011 Ave = 86

+SKIES 2012 Ave = 98.2

+SKIES 2013 Ave = 89.6 Extra credit eliminated

Self-reports of how SKIES helped learning

SKIES was very engaging and allowed me to remain more focused in class.

SKIES was very helpful for supplementing the lecture slides. Often, it is difficult to pick up on what material is being presented in the slides, and the cards were very helpful for figuring out what material we learned.

It was helpful to be able to manipulate the notes during lecture, I could go back and check things

Interactiveness helped a lot. made it fun.

Writing things/typing things down is a good way of repetition of material, especially material heard audibly. It strengthens learning in that manner.

6. Conclusions and Future Directions

Conclusions

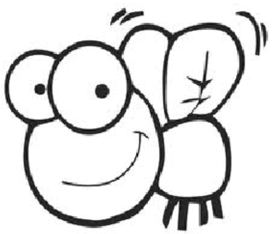
- SKIES-based active and engaged learning benefits student learning and faculty teaching practices.
- Actionable analytics emerge from real-time student behavior available as a result of SKIES.
- Benefits are evident across a range of use cases; SKIES is a gateway drug for teaching transformation.

6. Conclusions and Future Directions

Now under investigation

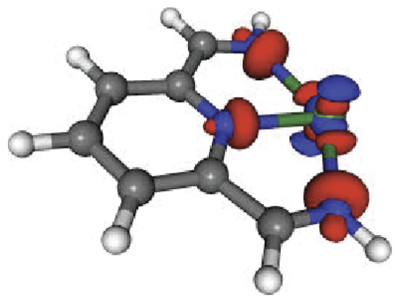
- Self-efficacy with respect to technology, content, general student experience.
- Role of teaching assistants in changing teaching practices.
- Role of immediate access to learning analytics: Faculty, TAs, Students.
- Synthesis of learning analytics data: e.g., weekly engagement report with recommendations.

Spread at Caltech: 3 classes in Year 1 (2012)



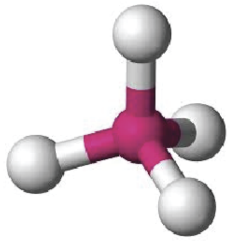
Genetics

Bi 122



Computational chemistry

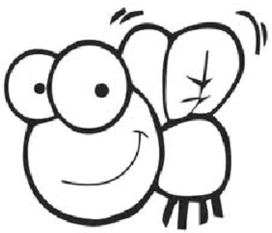
Ch 121



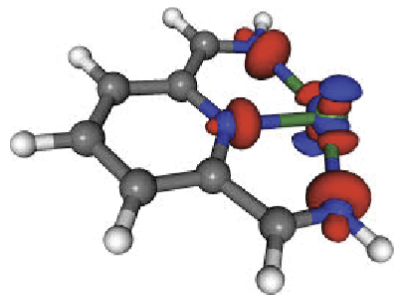
Theoretical chemistry

Ch 120

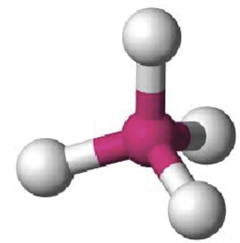
Spread at Caltech: 5 classes in Year 2 (2013)



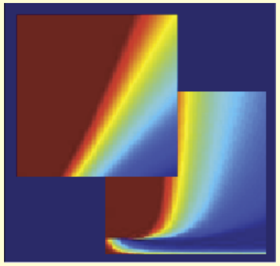
Genetics
Bi 122



Computational chemistry
Ch 121



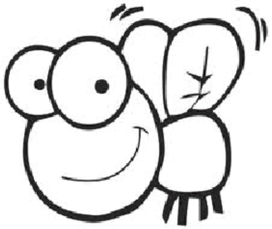
Theoretical chemistry
Ch 120



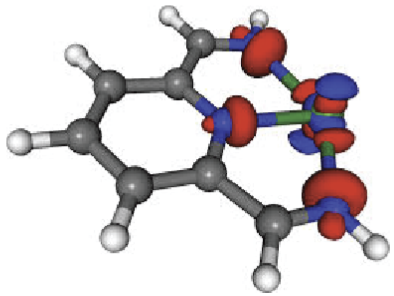
Machine learning
In-class part of flipped MOOC
(>200,000 students)
CS 156

Solar lab chemistry
Ch 3X

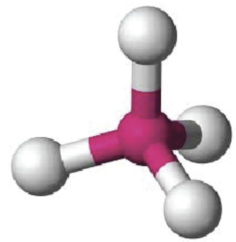
Proposed at Caltech: 9 classes in Year 3 (2014)



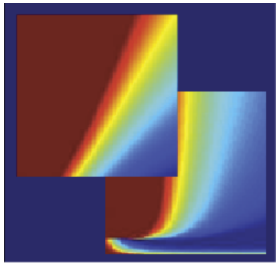
Genetics
Bi 122



Computational chemistry
Ch 121



Theoretical chemistry
Ch 120

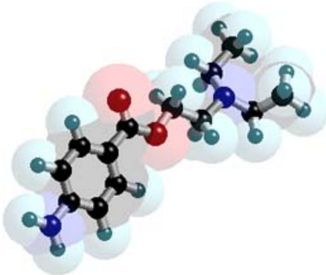


Machine learning
CS 156

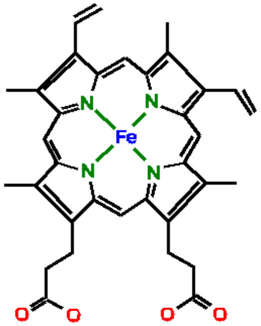
Solar lab chemistry
Ch 3X

Freshman lab chemistry
Ch 3A

Digital ventures
EE 150



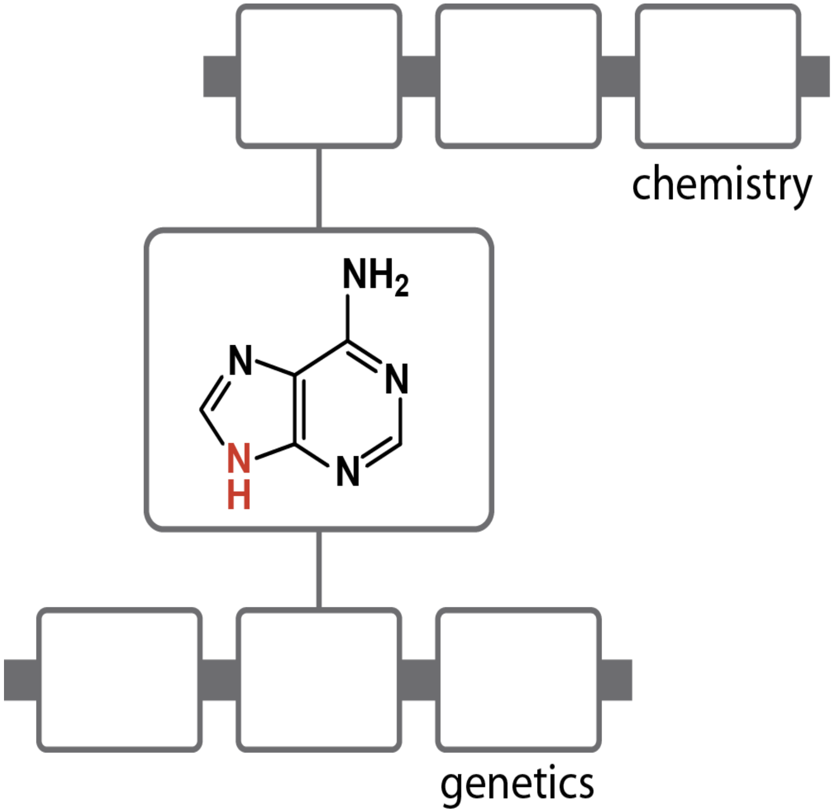
Orgo/Physical chemistry
Ch 1

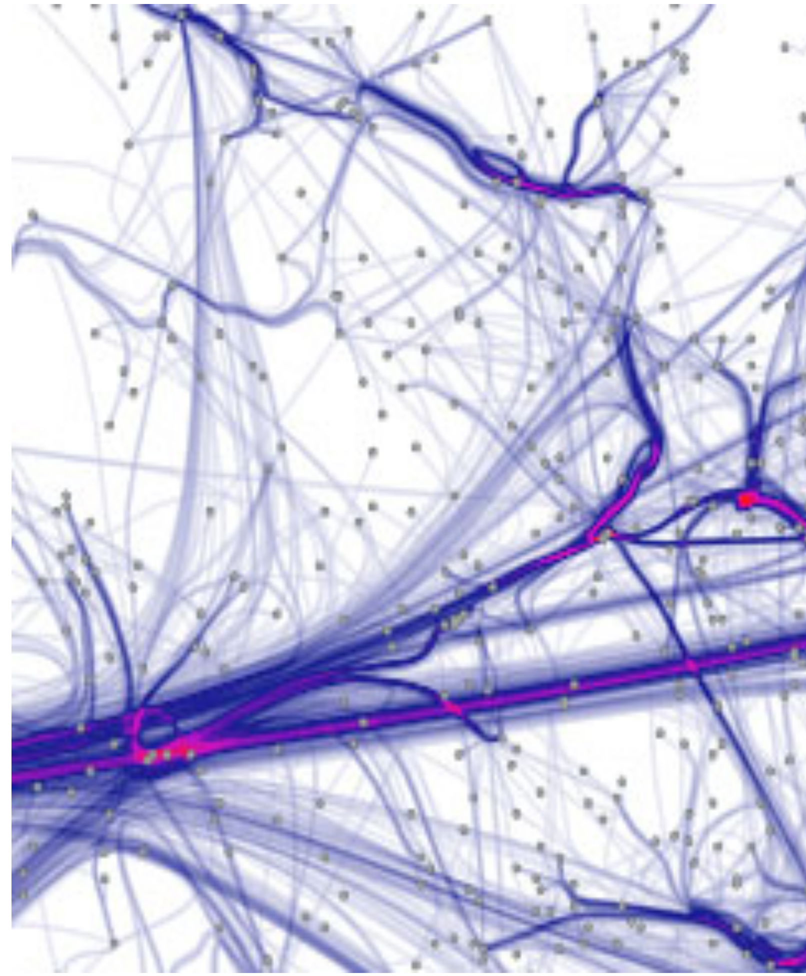


Inorganic chemistry
Ch 102

The next step

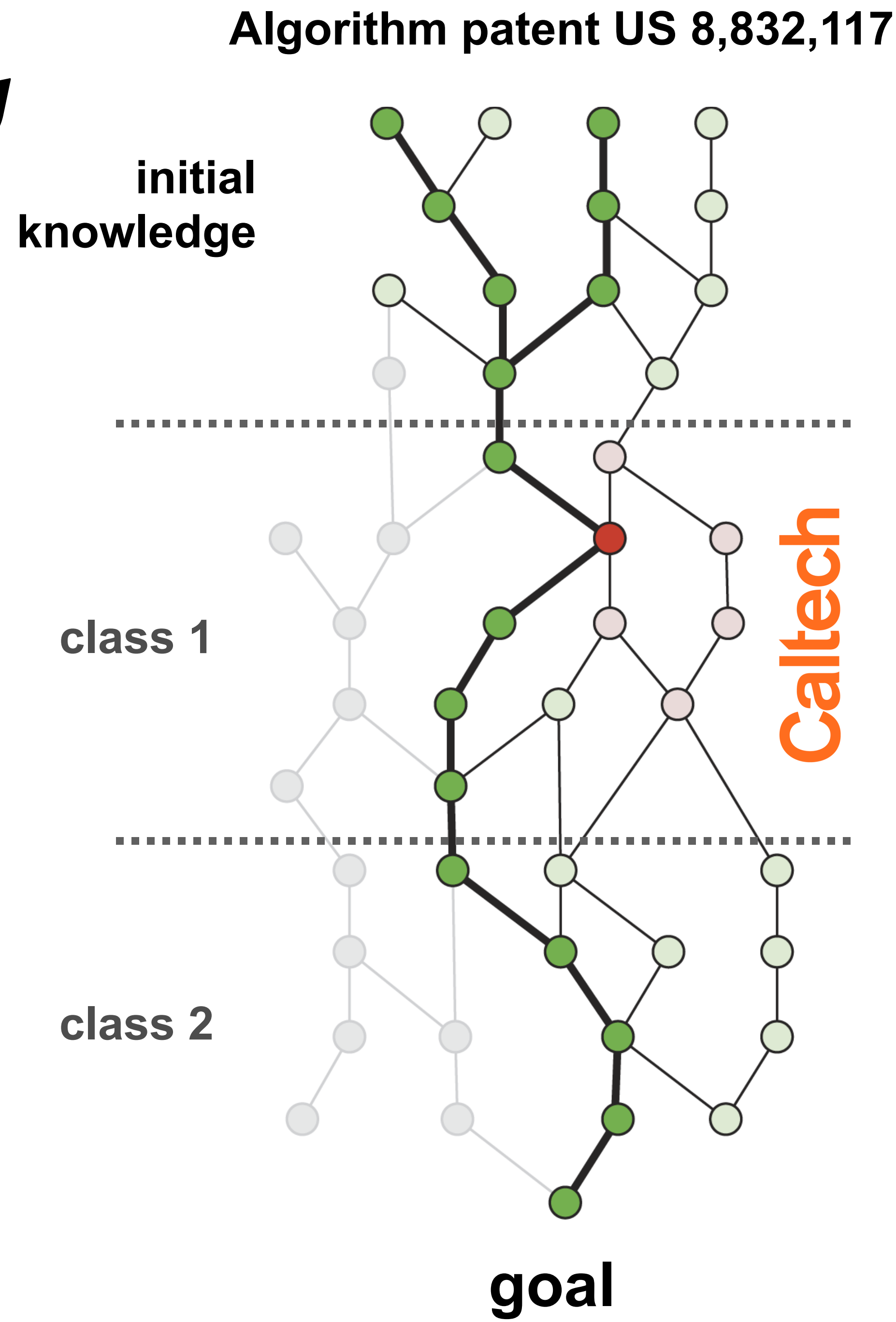
Interlinking Caltech courses across levels & disciplines





Connecting it all into a large-scale knowledge graph

A GPS for learning



What you **know**
What you **don't know**
What you **want to know**

Traverse real or virtual classrooms on the way to goals & aspirations

Democratizing teaching, research, and exploration

… to achieve an impact far disproportionate to our size.

6. Conclusions and Future Directions

Ultimate objectives

- Break down silos, interlinking material across core classes; and ultimately between universities, schools, and other organizations.
- Use detailed engagement and micro-assessment data on a global knowledge graph to create personalized learning paths.
- Learning paths guide students through classes and online resources to distant learning goals and aspirations.