How Teaching and Learning Research Transformed My Teaching

Tin Tin Su & Michelle Smith
MCD Biology

The SEI End of Year Event, 2010

A little history……

Assistant Professor 1998-2005
Associate Professor 2005-present

Teaching
3 years (99-01)  Experimental Embryology
   (Critical Thinking) ~15 students
3 years (02-05)  Principles of Genetics
   Major requirement ~160 students
1 year (06-07)   Experimental Embryology

2008 Spring  Principles of Genetics ~360 students
Prior evidence that peer discussion is useful for learning

Mazur, 1997

Students answer a clicker question individually

Students talk to neighbors and answer the same question again after discussion

These data cannot rule out this hypothesis:

*students click in the answer most strongly supported by those around them without learning anything*

Assessing learning from peer discussion

Students answer a clicker question individually (Q1).

Students talk to neighbors and answer Q1 after discussion (Q1_AD).

Students answer a different question individually (Q2). Q2 is asking about the same concept as Q1.
Sample Q1/Q1\textsubscript{AD}

Wild-type female
\begin{align*}
b^+ b, g^+ g
\end{align*}

Black, green eye male
\begin{align*}
b b, g g
\end{align*}

Offspring:
\begin{align*}
& 36 \text{ wild-type} & 15 \text{ gray, green eyes} \\
& 36 \text{ black, green eyes} & 13 \text{ black, white eyes}
\end{align*}

100 total fish

What is the recombination frequency between the \textit{black} and \textit{green} genes?

A. 0.15  \\
B. 0.13  \\
C. 0.28  \\
D. 0.51  \\
E. 0.72

\begin{itemize}
\item \(b^+\) = mutant version of black
\item \(b\) = normal version of black
\item \(g^+\) = mutant version of green
\item \(g\) = normal version of green
\item Normal dominant over mutant for both
\end{itemize}

Sample Q2

Wild-type female
\begin{align*}
c^+ c, pr^+ pr
\end{align*}

Curly wings, purple eyes
\begin{align*}
c c, pr pr
\end{align*}

\textbf{Offspring:}
\begin{align*}
& 155 \text{ Wild-type} & 330 \text{ normal wings, purple eyes} \\
& 165 \text{ curly wings, purple eyes} & 350 \text{ curly wings, normal eyes}
\end{align*}

\textbf{1,000 total flies}

What is the recombination frequency between \textit{curly} and \textit{purple} genes?

A. 0.16  \\
B. 0.32  \\
C. 0.49  \\
D. 0.52  \\
E. 0.68

\begin{itemize}
\item \(c^+\) = mutant version of \textit{curly}
\item \(c\) = normal version of \textit{curly}
\item \(pr^+\) = mutant version of \textit{purple}
\item \(pr\) = normal version of \textit{purple}
\item Normal dominant over mutant for both
\end{itemize}
Evidence that students are learning during peer discussion

Students answer a clicker question individually (Q1).

Students talk to neighbors and answer Q1 again (Q1\textsubscript{AD} for Q1 “After Discussion”).

Students answer a different question individually (Q2). Q2 is asking about the same concept as Q1.

The histograms are displayed for the first time and the answers to Q1/Q1\textsubscript{AD} and Q2 are explained to students.

n = 350 students

Further evidence that peer discussion helps

- Almost all students who answered Q1 correctly also answered Q1\textsubscript{AD} and Q2 correctly

- On average, students who corrected their initial response on Q1 were much more likely to answer Q2 correctly than students who did not correct their initial response
Conclusion: Most Students Learn from Peer Discussion

But how??

Transmissionist view: the stronger students explain the correct reasoning to the weaker students, who therefore now understand it.

Constructivist view: in the process of actively discussing and defending different points of view, students arrive at a correct understanding by themselves.

Support for constructivist learning during peer discussion

More students can correctly answer a new question (Q2) after discussion, even when the questions are difficult.
Student surveys support the constructivist explanation

When I discuss clicker questions with my neighbors, having someone in the group who knows the correct answer is necessary in order to make the discussion productive (agree/disagree, n=328 responding).

47% of students disagreed.

“Often when talking through the questions the group can figure out the questions without originally knowing the answer, and the answer almost sticks better that way because we talked through it instead of just hearing the answer.”

“Discussion is productive when people do not know the answers because you explore all the options and eliminate the ones you know can’t be correct.”

Why Peer Discussion Improves Student Performance on In-Class Concept Questions

When students answer an in-class concept question individually using clickers, discuss it with their neighbors, and then revote on the same question, the percentage of correct answers typically increases. This outcome could result from gains in understanding during discussion, or simply from peer influence of knowledgeable students on their neighbors. To distinguish between these alternatives in an undergraduate genetics course, we followed the above exercise with a second, similar (isomorphic) question on the same concept that students answered individually. Our results indicate that peer discussion enhances understanding, even when none of the students in a discussion group originally knows the correct answer.

Is peer discussion equivalent to instructor explanation? Compared student performance after

• peer discussion
• instructor explanation
• a combination of both

See poster by Knight, Krauter, Wood & Smith
Combo > peer = instructor
The combination method results in the largest normalized learning gain

See poster by Knight, Krauter, Wood & Smith

* = How much performance increased/possible increase

\[ g = \frac{100 \cdot (\text{post} - \text{pre})}{100 - \text{pre}} \]

*significantly higher (repeated measures ANOVA, \( p < 0.05 \) in all cases)

How much do students retain from in-class discussion/questions?

What if Q2 is 2 classes later rather than right away

Study conducted by Michelle Smith and Tin Tin Su in the Fall 2009 Genetics
Testing for retention

Students answer a clicker question individually (Q1).

Students talk to neighbors and answer Q1 again (Q1\textsubscript{AD} for Q1 “After Discussion”).

At least two classes later

Students answer a different question individually (Q2). Q2 is asking about the same concept as Q1.

Last day of class

Randomly chosen Q2 questions were asked again (students did not know this was coming)

All means are significantly different ($p<0.05$) from each other except “Q1 after discussion” and “Q2 end of course”

n= 151 students
Conclusions so far

• Students are retaining conceptual understanding two classes later and at the end of the semester

• The best predictor for how students perform at the end of the course is how they do on the retention question two classes later

Much more data analysis underway….
Retention clicker questions may help students monitor their own learning

"It is easy to answer them right after covering the material, but it is not so easy a few days later."

"Made me think about stuff we had already covered, instead of letting me forget it until the night before the test."

"Makes sure that I am retaining the information and not just letting it pass through my brain. Gives me a good idea of what I need to work harder on."

SURVEY: It was useful for my learning to answer the retention clicker questions

Future directions:

finish data analysis on retention experiment
test which learning method leads to highest retention

Using clickers in Critical Thinking....
Experimental Embryology S2010: Testing whether students read assigned papers

Cooperation of Mtmr8 with PI3K Regulates Actin Filament Modeling and Muscle Development in Zebrafish

Jie Mei, Zhi Li, Jian-Fang Gui

Q. Do the clicker questions increase your motivation to read the paper before class?

“Oh yes, I would still read the papers in other classes but for this class I highlight key things and keep the paper open while the presentation is going on so I can keep track of what is going on”

“Yes, it influences my grade, also it gives me a deadline. Otherwise I would put off reading the paper or probably not even do it. Because of clicker questions I know I have to read the paper the night before”

[Interviews with students to get feedback on using clickers in Embryology]

 Couldn’t I do this with a quiz??
Testing what students learned from paper presentations

Experimental Embryology S2010

If we didn’t have clicker questions then 2-3 people would dominate the conversation and Tin Tin might think because they understand what is going on, we all understand it.”

“Clickers give people a voice even if it is not a verbal one. It lets the whole class contribute to the conversation”

“Clickers force students to answer and discuss, you avoid that blank stare after the instructor asks if you have any questions, they get students thinking and their brains moving. And that will get them to start talking”
MCDB graduate core F2009

How I teach differently now

• More peer interaction in classes from intro to graduate core

• Bringing research from lab to classroom

• I am more engaged because I want to know the results

• Plan to use retention questions in the future to help students on track

• I am forced to avoid monologues
Thanks to

Michelle Smith

I would not be here without her

SEI folks in MCDB and CU Boulder