Making meaning in large lectures via clickers

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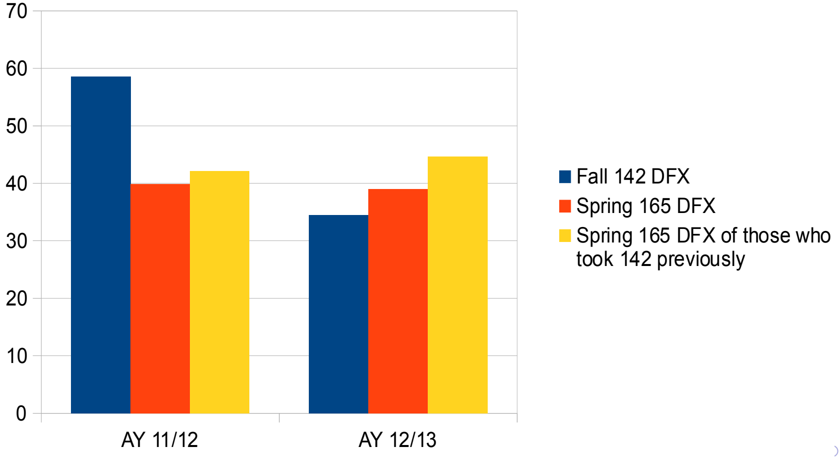
Structure of Precalculus at ISU: Fall 2011- Fall 2012

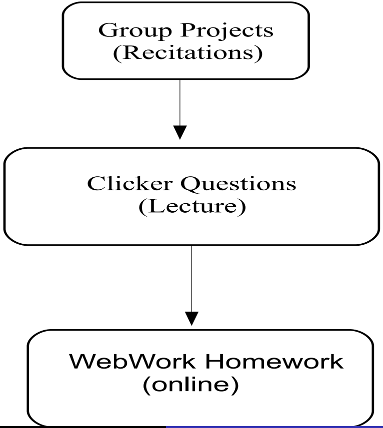
- Three courses:
  - MATH 140: College Algebra (3 credits)
  - MATH 141: Trigonometry (2 credits)
  - MATH 142: Trigonometry and Analytic Geometry (3 credits)
- Primarily taught in large lecture sections (200+)
- 142 taken by students seeking entrance to Calculus I (MATH 165)


70
60
50
40
30
20
10
0
AY 11/12
AY 12/13
Fall 142 DFX
Spring 165 DFX
Spring 165 DFX of those who took 142 previously

Changes made Fall 2013

- New course: MATH 143X “Preparation for Calculus" introduced.
  - Pathways materials developed by researchers at Arizona State University.
  - Pre and post-testing with Precalculus Concept Assessment test.
  - Inquiry-Based Learning approach adapted to large lecture with recitations.
  - Clickers and WebWork homework.

143 Learning Flow



What are clickers and how do they work? Let's watch a short video demonstration.

Clicker Administration in MATH 143

- Turningpoint clicker system
- 3 - 5 questions per class
- Each asked twice: once individual work only, then discussion
- Students shown correct answer and distribution of responses after second attempt
- Countdown timer
- 4 points for each response, 8 points for each correct response (6000 total semester points)
- 10% of grade.

Some effects of clickers

- Dramatically improved attendance (80% - 90% vs. 50% - 60%)
- Anonymity
- Increased student engagement
- Key: whether a student learns from a clicker depends on participation only.

Some questions

- Can clickers help students in a large lecture construct meanings of essential precalculus concepts such as constant rate of change, function, exponential growth, etc. ?
- What are characteristics of clicker questions that are effective in encouraging meaning-making? Are there response patterns that indicate a question is effective?

Kinds of clicker questions

Let's look at a resource from Iowa State's Center for Excellence in Learning and Teaching about the different kinds of clicker questions. Then let's look at some of the clickers developed for Pathways.

Clicker development process

- Identify key conclusions for each investigation covered.
- Link each question to one or more key conclusion.
- Spread out question writing: no more than two a day.
- Developed from:
  - Conversations with students
  - Student responses in recitations
  - Adapt from WebWork problems
- Revise according to data collected on student responses/refine distractors

Question (Clicker Question # 1)

Which of the following statements best explains why $a^b a^c = a^{b+c}$?

1. *Because that's the rule.*
2. *That's what I was taught in high school.*
3. *It's not true! $a^b a^c = a^{bc}$*
4. *If you multiply a by itself b times, and then multiply it by itself c times, and then multiply those products together, you have multiplied a by itself a total of $b + c$ times.*

Question (Question # 7)

Which of the following is a quantity in the wire animation?

1. *The wire on the spool.*
2. *The length of the wire on the spool.*
3. *The amount of wire on the spool.*
4. *All of the above.*

Question (Clicker Question # 10)

Consider the information about a burning candle in the following graph. As the number of hours the candle has been burning increases from 3 hours to 6 hours what is the change in the height of the candle (in inches)?

1. $15 - 8$
2. $8 + 15$
3. 8×15
4. $8 - 15$

Question (Clicker Question #17)

Suppose the point (1,5) is on a line that has a constant rate of change of -1.1. Use this information to determine the value of y when the value of x is -2.5.

1. *1.15*
2. *8.85*
3. *3.85*
4. *-3.85*

Question (Clicker Question #18)

A driver who is driving at a constant speed on I-80 crosses into Iowa from Nebraska. She passes milepost 34 at 3:21p.m. and milepost 110 at 4:05p.m.. Let t = the number of minutes since 3p.m.. Let d = the distance she has driven from the Iowa border at t minutes after 3p.m.. Which of the following equations expresses t in terms of d?

1. $t = (44/76)d + \frac{100}{76}$
2. $t = (44/76)(d - 34) + 21$
3. $t = (44/76)(d - 110) + 65$
4. *All of the above.*
5. *None of the above.*

Question (Clicker Question # 27)

Suppose $f(m) =$ the population of Ames, Iowa m months after January 1, 2012. Which of the following best describes the meaning of $f(m+3)$?

1. $f(m) + 3$
2. $f(m) + f(3)$
3. *Three more than the population of Ames m months after January 1, 2012.*
4. *None of the above.*

Question (Clicker Question # 32)

Define a function f that determines the area of a circle from its circumference, C.

1. $f(x) = \frac{C^2}{4\pi}$
2. $f(C) = \frac{C^2}{4}$
3. $f(C) = \frac{C^2}{2\pi}$
4. $f(C) = \pi C^2$
5. *None of the above.*

Question (Clicker Question # 33)

Define a function f that determines the perimeter of the square when given the length of the diagonal, d.

1. $f(d) = 4d/\sqrt{2}$
2. $f(x) = \sqrt{d/2}$
3. $f(d) = 4\sqrt{d}$
4. $f(x) = 4\sqrt{d}$
5. *(3) and (4)*

Question (Clicker Question # 35)

Five people who work in the same office building show up to work on March 1 with the same cold virus. Each day, the number of people who are sick triples. Which of the following is true?

1. *The number of infected people in the building increases by 15 every day.*
2. *The number of infected people in the building after t days is* $5 + 3t$
3. *The number of infected people in the building after t days is* 5×3^t
4. *(1) and (3)*
5. *(1), (2), and (3)*

Question (Clicker Question # 37)

Suppose g is the function in the previous question. Let $R = g(k)$. *Which of the following is constant?*

1. $\frac{\Delta R}{\Delta k}$
2. $\frac{g(k+1)}{g(k)}$
3. $g(k+1) - g(k)$
4. *None of the above.*

Question (Clicker Question # 42)

Six years ago it was estimated that 1,250 wild turkey lived in a wildlife park. Today's estimate of the number of wild turkey in this park is 955. Assume that an exponential decay pattern continues for the wild turkey population in this park. What is the annual percent rate of decline for this six year time period? (Round to nearest 100th.)

1. *-0.0439*
2. *95.61*
3. *4.39*
4. *-4.39*
5. *3.9%*

Question (Bonus Question #2)

The number of fruit flies in an experiment t days after the start of the experiment is given by $f(t) = 237(2.25)^t$. *Let* $g(s) =$ *the number of fruit flies s weeks after the start of the experiment. Which of the following best approximates* $g(s)$*?*

1. $g(s) = 237(291.93)^s$
2. $g(s) = 237^7(2.25)^{7s}$
3. $g(s) = 237(1.12)^s$
4. $g(s) = 237(2.25)^{7t}$
5. *(1) and (4)*

Question (Clicker Question #43)

Suppose a savings account pays 8% APR interest compounded monthly. What is the 13-month growth factor for the account?

1. $\left(1+\frac{0.08}{13}\right)^{13}$
2. $\left(1+\frac{0.08}{12}\right)^{12}$
3. $\left(1+\frac{0.08}{12}\right)^{13}$
4. $(1+0.08)^{13}$

Question (Bonus Question # 1 (M4I8&9 Sec A))

\$10,000 is invested in an account and grows by a factor of 1.2 every year. Set up an equation to solve for when the value of the investment is \$80,000.

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1. $80,000 = 10,000(1.2)^t$
2. $80,000 = 10,000e^{1.2t}$
3. $80,000 = 10,000(0.2)^t$
4. $80,000 = 10,000 \times 1.2 \times t$
5. $\log_{1.2}(8)$

Question (Clicker Question # 51 (Carroll College))

Imagine that you are skydiving. The graph of your speed as a function of time from the time you jumped out of the plane to the time you achieved terminal velocity is

1. *increasing and concave up*
2. *decreasing and concave up*
3. *increasing and concave down*
4. *decreasing and concave down*

Question (Clicker Question # 52)

Let $f(x) = \frac{2}{7-x}$. Which of the following best describes what happens to $f(x)$ as x approaches 7 from the right?

1. *$f(x)$ decreases and gets very close to 0.*
2. $2/0$
3. *$f(x)$ increases and gets very very large.*
4. *$f(x)$ decreases and gets very very negative.*

Question (Clicker Question #59)

In the following picture,P is $-2/3$ radius lengths above the horizontal diameter of the circle. What is the length of the line segment PQ in inches?

1. $-2/3$
2. $2/3$
3. $-20/3$
4. $20/3$
5. $2/30$
6. $-2/30$

Question (Clicker Question #60)

A water wheel placed in the ocean so that the water's surface bisects the wheel. The radius of the wheel is 6 meters. A bucket is placed on the wheel at sea level in the 3 o'clock position. The wheel turns counterclockwise, and the bucket travels 17 meters around the circumference of the wheel. Use sin *to find an expression for the altitude of the bucket (in meters) at this point in time).*

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1. $\sin(17/6)$
2. $\sin(17)$
3. $6\sin(17/6)$
4. $6\sin(17)$

Fall 2013 Precalculus Data

- PCA gains in Fall MATH 143: 8/25 to 15/25
- DFX in Fall MATH 143 = 26.8%
- DFX in Spring 165 of Fall MATH 143 students 2% lower than class as a whole, 8% lower than those who took MATH 142
- Study by Kliemann, Stephenson, et. al. indicates success in calculus strongly improved.

Spring 2014 Data

- PCA gains in 143 approximately 6/25
- DFX in MATH 143 $\approx$ 50%

Fall 2014 Data

- MATH 143 PCA gains $\approx$ 6.5/25
- MATH 143 DFX $\approx$ 20%

Future directions

- Categorize clickers according to PCA items
- Collate data so far on clickers
- Study relationship between clicker data and PCA gains
  - Does participation matter more than correctness?
  - What response patterns correlate with learning gains?
- Write more clickers