Technology-Enhanced Formative Assessment Increases Efficacy of the Homework Review Process

Dr. Kim Kelly,
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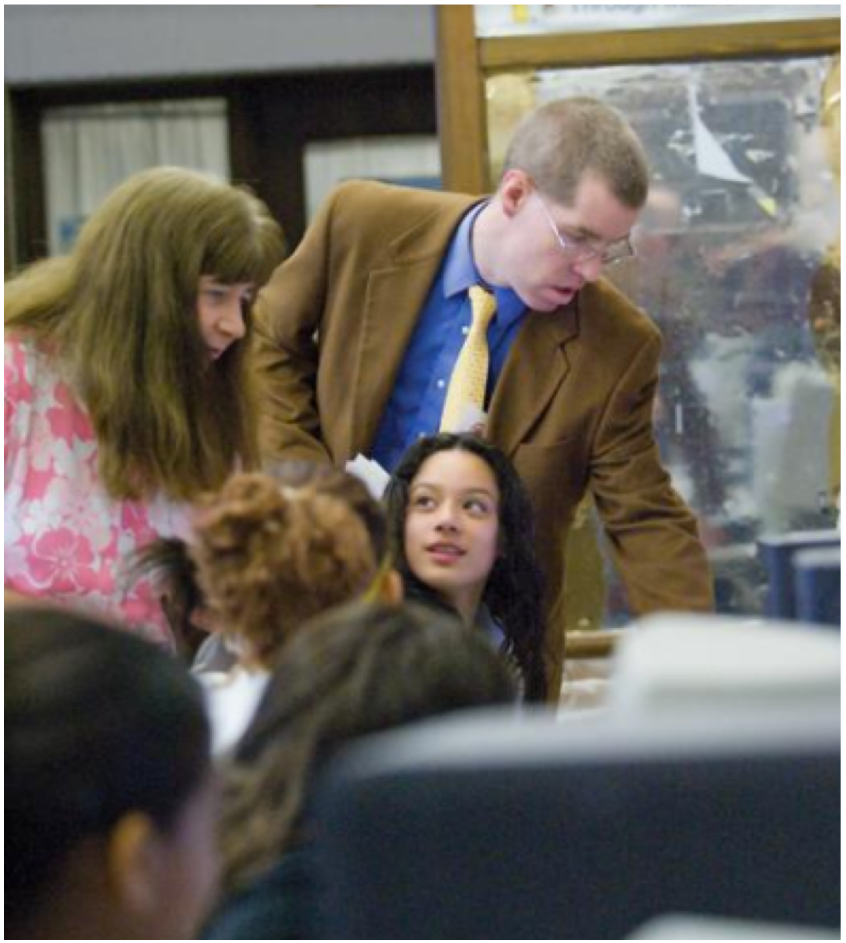
WPI

Who are we?



Dr. Neil Heffernan

- The William Smith Dean's Professor of Computer Science
- Director, Learning Sciences & Technologies Graduate Program
- Over 100 Peer-Reviewed Studies
- Nearly two dozen Peer-Reviewed Randomized Controlled Experiments

Who are we?

Dr. Kim Kelly

- 7th Grade Math Teacher, Leominster Public Schools
- PhD Learning Sciences & Technologies
- Conducts Randomized Controlled Trials in the classroom

Does it have to be one or the other?

VS

Technology Enhanced Formative Assessment

A research-based platform for enabling formative assessment and skill development.

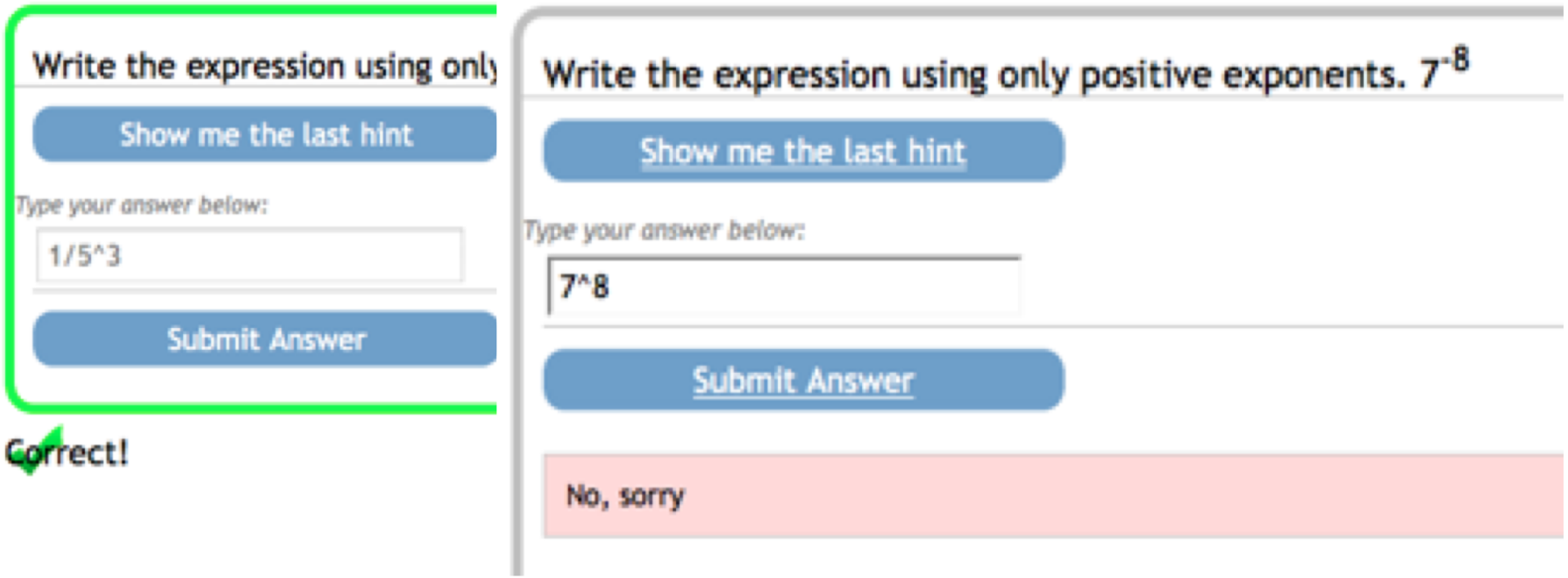
- Students get immediate feedback, hints, guided practice
- Teachers can see how students are doing homework
- Teachers can change homework review to adapt to students' needs

Overview:
Technology Enhanced Formative Assessment

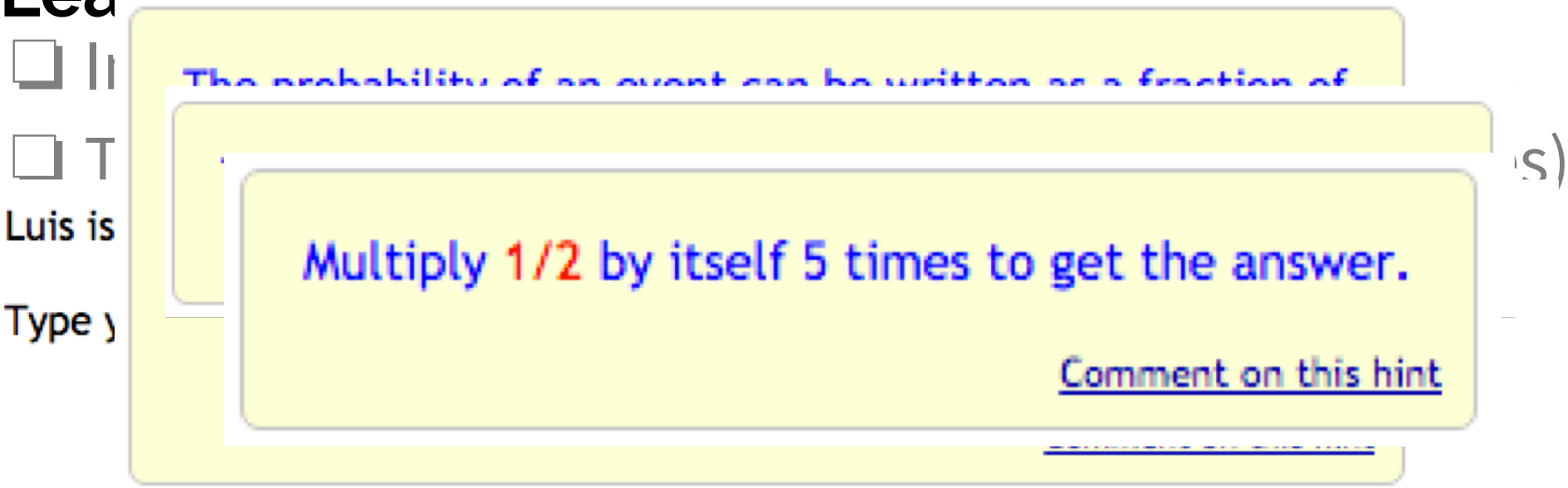
- Features that Enhance Student Learning
- Tales From the Classroom- Randomized Controlled Trial
  - Impact of homework on student learning
  - Impact of homework review process on student learning
  - Student Survey
- Replication (at scale)
- Why Technology Isn't Enough
  - Refusing Feedback- Randomized Controlled Trial
  - Hint Overuse- Randomized Controlled Trial
- Improved Homework Review Process

Technology-Enhanced Formative Assessment Features that Enhance Student Learning

- ❑ Immediate Correctness Feedback



Technology-Enhanced Formative Assessment Features that Enhance Student Learning



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Features t **rning**

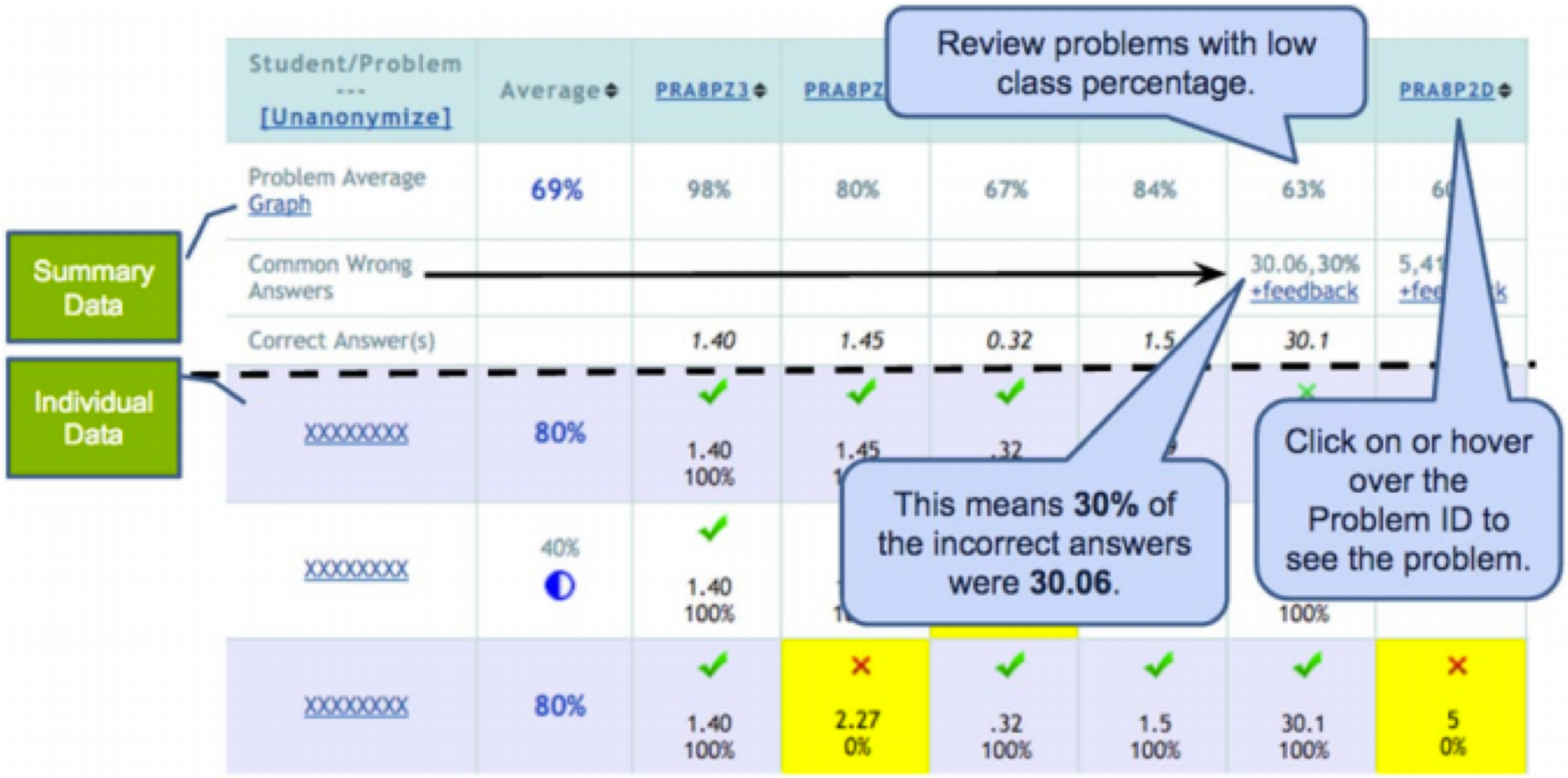
- ❑ Immedia
- ❑ Tutoring ds examples)
- ❑ Student F

Problem	My Answer	My Classmates' Average
PRABNCSP	✓ 3/5 100%	58%
PRABNCSP	✗ 1 1/4 0%	61%
PRABNCSQ	✓ 9/7 100%	65%
PRABNCSQ	✗ 30/7 0%	80%
PRABNCSR	✓ 9/2 100%	80%
PRABNCSR	✗ 27/2 0%	82%
PRABNCSS	✓ 6/7 100%	90%
PRABNCST	✓ OK 100%	100%

Technology-Enhanced Formative Assessment

Features to Enhance Student Learning

- ❑ Immediate Correctness Feedback
- ❑ Tutoring (hints, scaffolds, videos, words examples)
- ❑ Student Reports
- ❑ Teacher Reports


Review problems with low class percentage.
Summary Data
Individual Data
Student/Problem --- [Unanonymize]
Average
PRA8PZ3
PRA8PZ
PRA8P2D
Problem Average Graph
69%
98%
80%
67%
84%
63%
Common Wrong Answers
30.06,30% +feedback
Correct Answer(s)
1.40
1.45
0.32
1.5
30.1
XXXXXXX
80%
1.40 100%
1.45
.32
40%
1.40 100%
100%
XXXXXXX
80%
1.40 100%
2.27 0%
.32 100%
1.5 100%
30.1 100%
5 0%
This means 30% of the incorrect answers were 30.06.
Click on or hover over the Problem ID to see the problem.

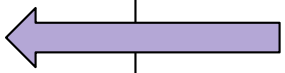
Web-Based Homework
Randomized Controlled Trial

Traditional Homework	Web-Based Homework
No Feedback	Immediate Correctness Feedback
Teacher review based on **student questions**	Teacher review based on **data from item report**

Kim Kelly, Neil Heffernan, Cristina Heffernan, Susan Goldman, James Pellegrino, Deena Soffer Goldstein (2013). Estimating the Effect of Web-Based Homework. In Lane, Yacef, Motow & Pavlik (Eds) The Artificial Intelligence in Education Conference. Springer-Verlag. pp. 824-827.

Web-Based Homework Study Design

Day 1	Pre-Test
	Lesson
	Homework
Day 2	Post-Test 1
	Homework Review
Day 3	Post-Test 2



Post-Test 1 Results

TH	WBH	P-Value	Effect Size
58% (27)	69% (21)	0.046*	0.52

Web-Based Homework Study Design

Day 1	Pre-Test
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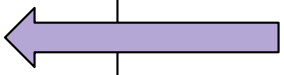


Homework Review Process

Traditional Homework:

Relies on student prompted questions

Inconsistent review in each class

Limited student engagement

Students missed critical focus areas

Homework Review

Web-Based Homework:

Relies on teacher use of item report

Focused on common wrong answers

Students were engaged regardless of homework performance or completion

Consistent review in every class

Web-Based Homework Study Design

Day 1	Pre-Test
	Lesson
	Homework
Day 2	Post-Test 1
	Homework Review
Day 3	Post-Test 2

Post-Test 2 Results

	TH	WBH	P-Value	Effect Size
Post Test 1	58% (27)	69% (21)	0.046*	0.52
Post Test 2	68% (26)	81% (22)	0.018*	0.56

Web-Based Homework Learning Gains

Web-Based Homework

PRAHE5Y	PRAHE5Z	PRAHE52
27%	61%	84%
1/9^ ,56%	1/5^ ,58% +fee ack	
1/3^10	*1/5^3*	*1/16^2*
✗ Hint requested 0%	✗ 1/5^13 0%	✓ 1/16^2 100%
✗ 1/9^10 0%	✗ 1/25^3 0%	✓ 1/16^2 100%
✗ 1/3^6 0%	✓ 1/5^3 100%	✓ 1/16^2 100%

Traditional Homework

PRAHE5Y	PRAHE5Z	PRAHE52
61%	61%	66%
1/9^10,46%	1/25^3,46% +feedback	1/256^2,63%
1/3^10	*1/5^3*	*1/16^2*
✓ 1/3^10 100%	✓ 1/5^3 100%	✓ 1/16^2 100%
✓ 1/3^10 100%	✗ 1/5^13 0%	✓ 1/16^2 100%
✗ 3^11 0%	✗ 5^3 0%	✗ 16^2 0%

Delayed versus Immediate Feedback: Randomized Controlled Trial

Within Subject Design (n = 61)

Condition	Mean	Standard Deviation
Immediate Feedback	67%	26
Delayed Feedback	55%	32

(t(60)=2.501, p=0.015) The effect size is 0.37 with a 95% confidence interval of 0.05 to 0.77.

Kehrer, P., Kelly, K. & Heffernan, N. (2013). Does Immediate Feedback While Doing Homework Improve Learning. In Boonthum-Denecke, Youngblood(Eds) *Proceedings of the Twenty-Sixth International Florida Artificial Intelligence Research Society Conference*, FLAIRS 2013, St. Pete Beach, Florida. May 22-24, 2013. AAAI Press 2013. p 542-545.

Student Survey Results

86% of students preferred ASSISTments to paper and pencil homework.

66% of students thought homework in ASSISTments takes longer than paper and pencil (they are wrong!)

44% of students reported feeling frustrated when using ASSISTments for homework

73% of students said their time was better spent using ASSISTments for homework than traditional homework

What do students like about ASSISTments?

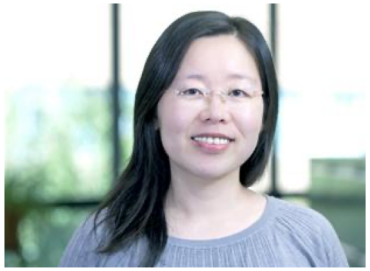
You can redo your answer if you get it wrong and learn from your mistakes.

Being able to try again.

That if you get stuck on a problem that it will give you the answer.

How it tells you immediately if you are right or wrong.

I like how I know if I'm right or wrong. This helps because often times when I get things wrong I just go back to my work and I see what I’m doing wrong which helps me when doing other problems.



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Online Mathematics Homework Increases Student Achievement

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In a randomized field trial with 2,850 seventh-grade mathematics students, we evaluated whether an educational technology intervention increased mathematics learning. Assigning homework is common yet sometimes controversial. Building on prior research on formative assessment and adaptive teaching, we predicted that combining an online homework tool with teacher training could increase learning. The online tool ASSISTments (a) provides timely feedback and hints to students as they do homework and (b) gives teachers timely, organized information about students' work. To test this prediction, we analyzed data from 43 schools that participated in a random assignment experiment in Maine, a state that provides every seventh-grade student with a laptop to take home. Results showed that the intervention significantly increased student scores on an end-of-the-year standardized mathematics assessment as compared with a control group that continued with existing homework practices. Students with low prior mathematics achievement benefited most. The intervention has potential for wider adoption.

Keywords: *computers and learning, effect size, evaluation, experimental design, hierarchical linear modeling, homework, mathematics education, technology*

Not All Students Want Help

For tonight's homework, you have a choice!!!
Would you like to complete the assignment WITHOUT feedback? This means you will not be told if you are right or wrong. You can just enter your answers and move on.
OR
Would you like to complete the assignment WITH feedback? This means you will be told if you are right or wrong and can correct your incorrect mistakes.

Select one:

- I do NOT want feedback.
- I DO want feedback.

Submit Answer

Baseline Data:
46% Requested Feedback
54% Did Not Want Feedback

Show answer

Requesting Feedback Randomized Controlled Trial: Intervention

In an attempt to encourage students to request feedback, students were shown a video where Dr. Heffernan, as an authority figure, presented the students' data on a post-test.

Requesting Feedback: Results

Condition	No First, Yes Second	Yes First, No Second
Control	n=5	n=3
Experimental	n=4	n=3

Survey: Why don't you want feedback?

- "because i dont like to get feedback and just do the problem without feeling nervous that i am going to get it wrong."
- "i do not choose feed back because i get frustrated when i get the answers wrong and i just want to pull my hair out"
- "because im ready to be right on my own"
- "it makes me frustrated when i keep getting the answer wrong"
- "I chose to not use feedback because sometimes when I use the feedback I get aggravated if I get the question wrong. It only tell me what I did wrong, unless I choose to use a hint. Which then means I will get the question even more wrong. It makes me not want to do my work and makes me more and more aggravated"
- "I choose not to get feed back because I dont want to have to keep fixing my mistakes. This way is easyier then having to do it over again and simply get it done."

STOP Abusing Hint Overuse

WAIT! Did you actually read the hints? I bet if you go back and look at the hints you will be able to answer this question on your own without asking for another hint. Go back and read through all of the hints and try answering the question on your own!

Improved Homework Review Process

- Identify Common Wrong Answer
  - Error Analysis
- Identify class weaknesses
  - Use as “Do Now” in class
  - Re-teach
- Identify student weaknesses
  - Re-teach
  - Assign additional Practice
  - Form groups
- Skip Review if unnecessary

Benefits in the Classroom

- ALL students can engage in the review
- Saves time
- Target Students
- Target Content
- Provides more time for and higher quality instruction

QUESTIONS

Comparison to other programs

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