

# **A Fractal-based Decision Engine for Teaching & Learning**

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**EDI**2014

A young woman with blonde hair, wearing a blue top, is smiling broadly and looking at a tablet computer. The background is a blurred classroom or office environment with other people and screens.

The world's leading  
learning company



Measurable impact on

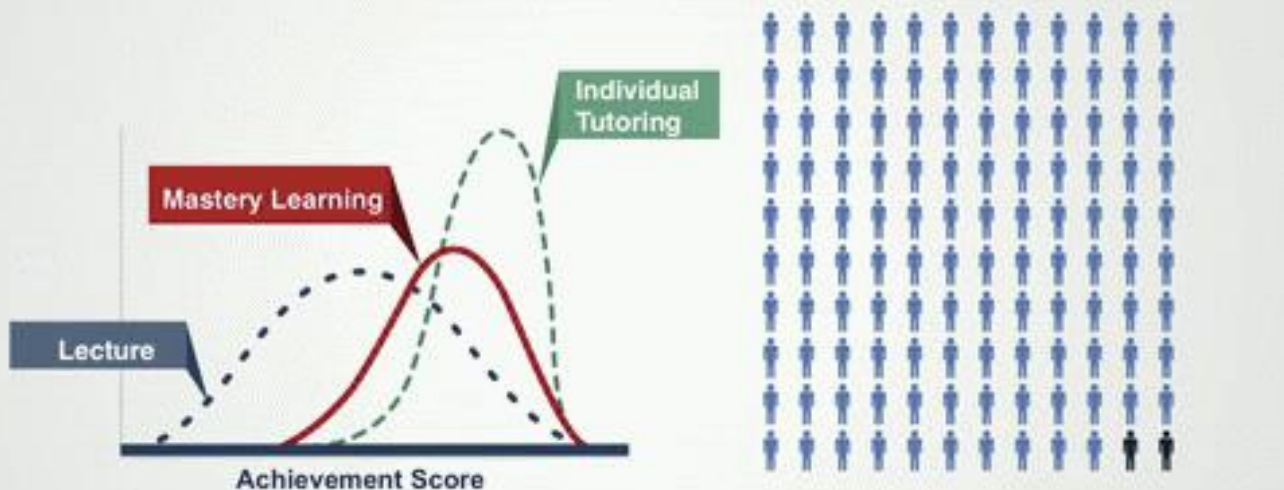
improving lives

through learning

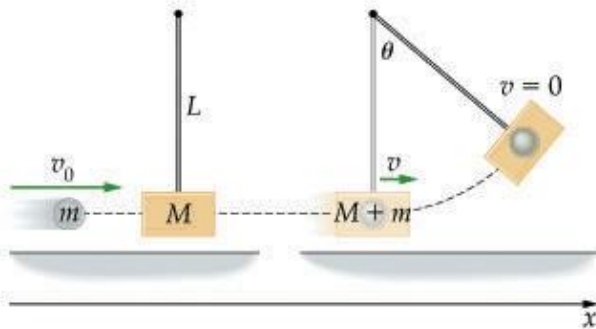


# The Two Sigma Problem

"The 2 Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-One Tutoring." B. Bloom, *Educational Researcher* (1984).



## MasteringEngineering®



Find an expression for  $v_0$ , the initial speed of the fired object.

$\sqrt{\quad}$ 
 $\alpha\beta\gamma$ 
 $\Delta\Sigma\tau$ 

➡
⬅
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$$v_0 = \sqrt{\frac{(m + M)}{m} 2gL(1 - \cos(\theta))}$$

Try Again

submit
hints
my answers
show answer
review part

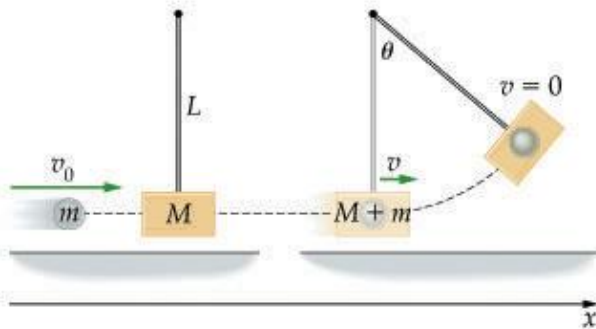
#### Feedback

Close

You set the initial energy of the object equal to the final energy of the object and pendulum. The object collides inelastically with the pendulum, causing energy to be lost in the process. Therefore these energies are not equal.

# Answer-Specific Feedback

## MasteringEngineering®



Hint 1. How to approach the problem

Open

Hint 2. Determine which physical laws and principles apply

Open

Which of the following physical laws or principles can best be used to analyze the collision between the object and the pendulum bob? Which can best be used to analyze the resulting swing?

- Newton's first law
- Newton's second law
- Newton's third law
- Conservation of mechanical energy
- Conservation of momentum

Try Again

submit

my answers

show answer

review part

Feedback

Close

Mechanical energy is conserved in elastic collisions, but there is another conservation law that applies to any collision.

Hint 3. Describe the collision

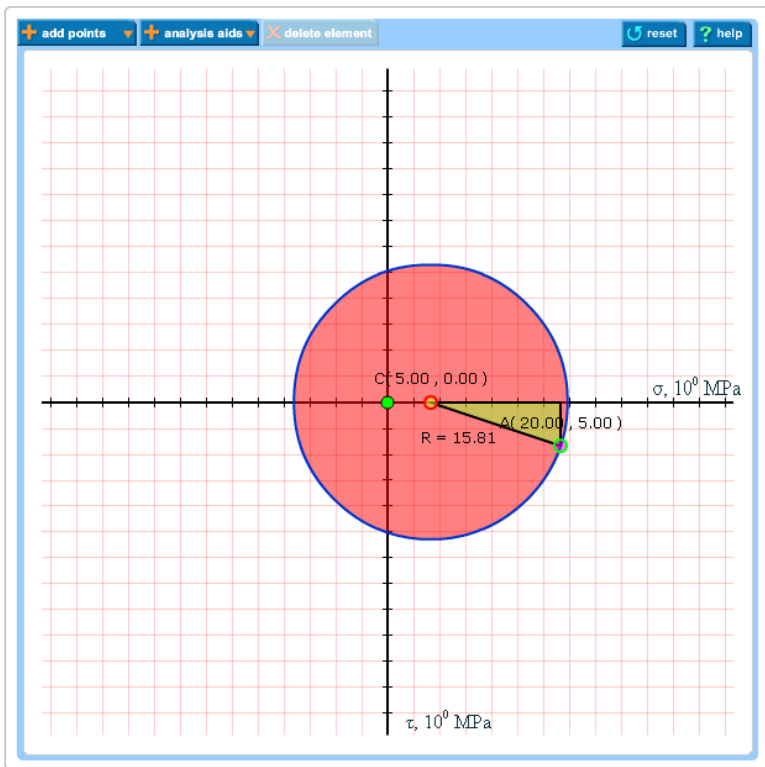
Open

Hint 4. Describe the swing

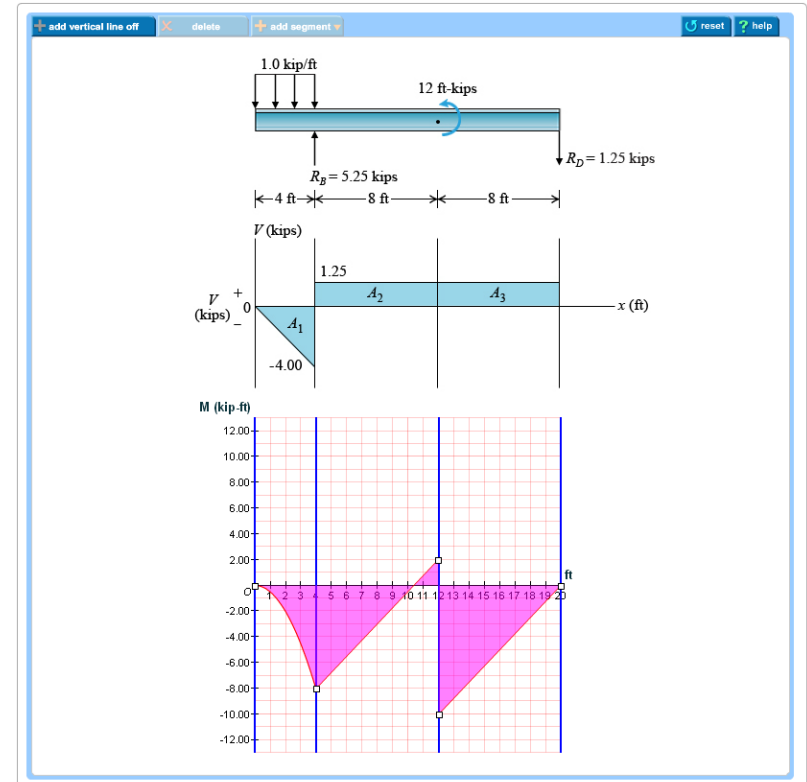
Open

# Socratic Hints

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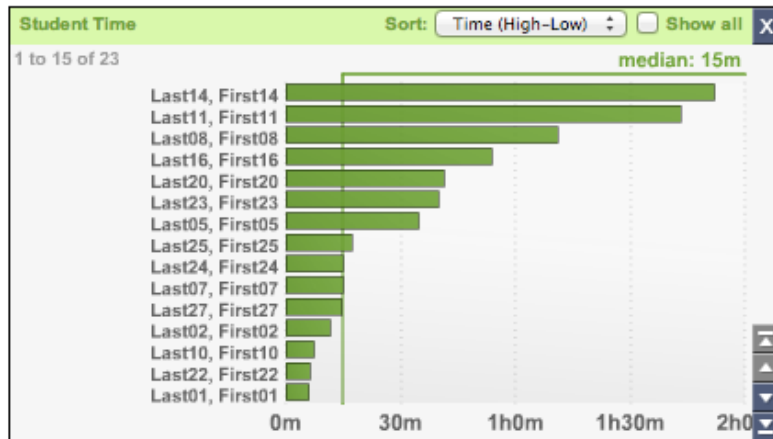
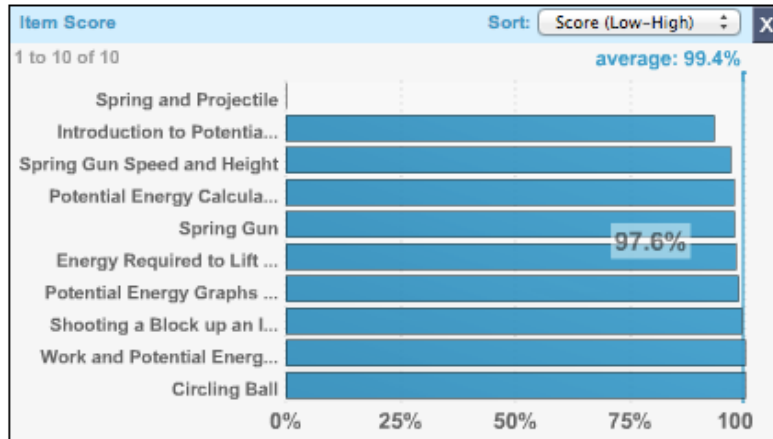


Submit [Hints](#) [My Answers](#) [Give Up](#) [Review Part](#)

# Auto-scored Answer types



# MasteringEngineering®



ANSWER:

$$\text{height} = \frac{H}{4}$$

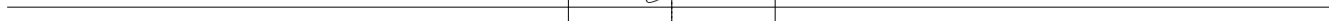
Answer Stats:	Students	% Correct	% Unfinished	% Req'd Solution	Wrong/student	Hints/student
Overall	7046	94.7%	2.8%	2.4%	0.8	0.6
MPDEMOGRADES	25	96%	4%	0%	0.8	0.2

### Wrong Answers for MPDEMOGRADES

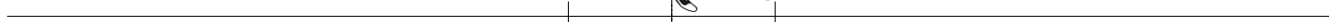
% Wrong	Answer	Response
10%	$\frac{k \left( \left( \frac{x_0}{2} \right)^2 \right)}{2mg}$	The correct answer does not depend on the variables: x_0, k, m
10%	0.5H	Gravitational potential energy varies linearly with height, but the spring's potential energy varies quadratically with the amount of compression or extension.
5%	$\frac{.125k(x_0)^2}{mg}$	The correct answer does not depend on the variables and functions: x_0, k(), m
5%	$\frac{4H}{g}$	Your answer is off by a multiplicative factor.

# Diagnostic Analytics

# A Simple Model of Student Behavior



✗ - Incorrect answer is a step to the left

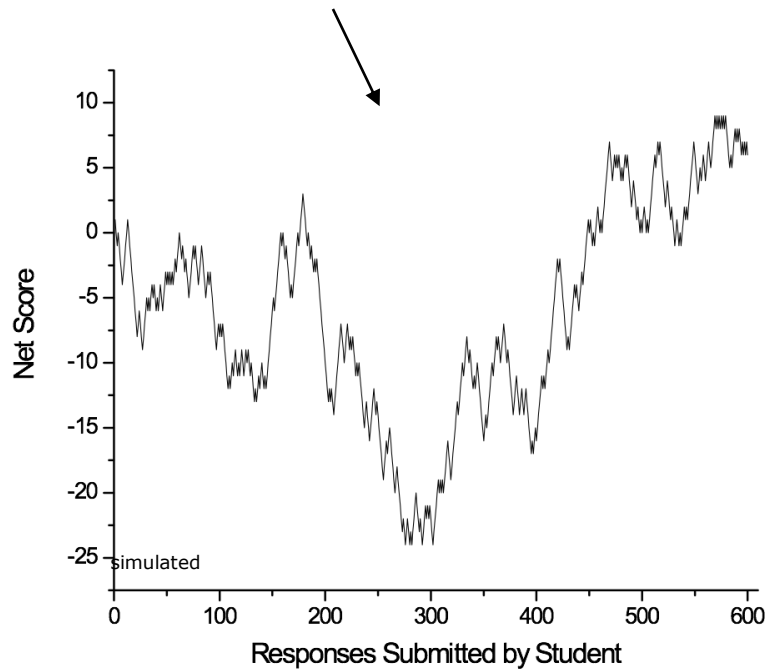


✓ - Correct answer is a step to the right

Net Score = # steps to the right - # steps to the left

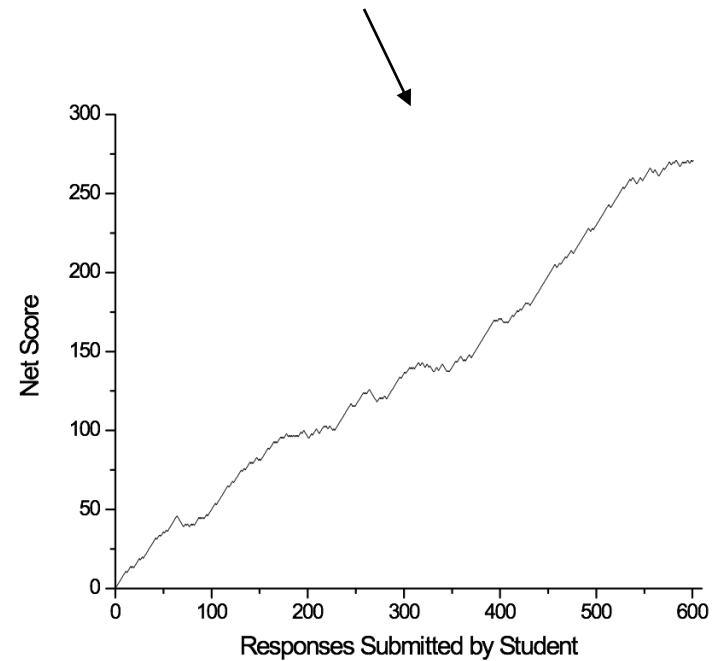
# Distinguishing Response Patterns

A student showing  
random walk behavior



Fractal Dimension = 1.94

A student not showing  
random walk behavior



Fractal Dimension = 1.60

# Distinguishing Response Patterns

Straight line

Plane

1 ← **Fractal Dimension** → 2

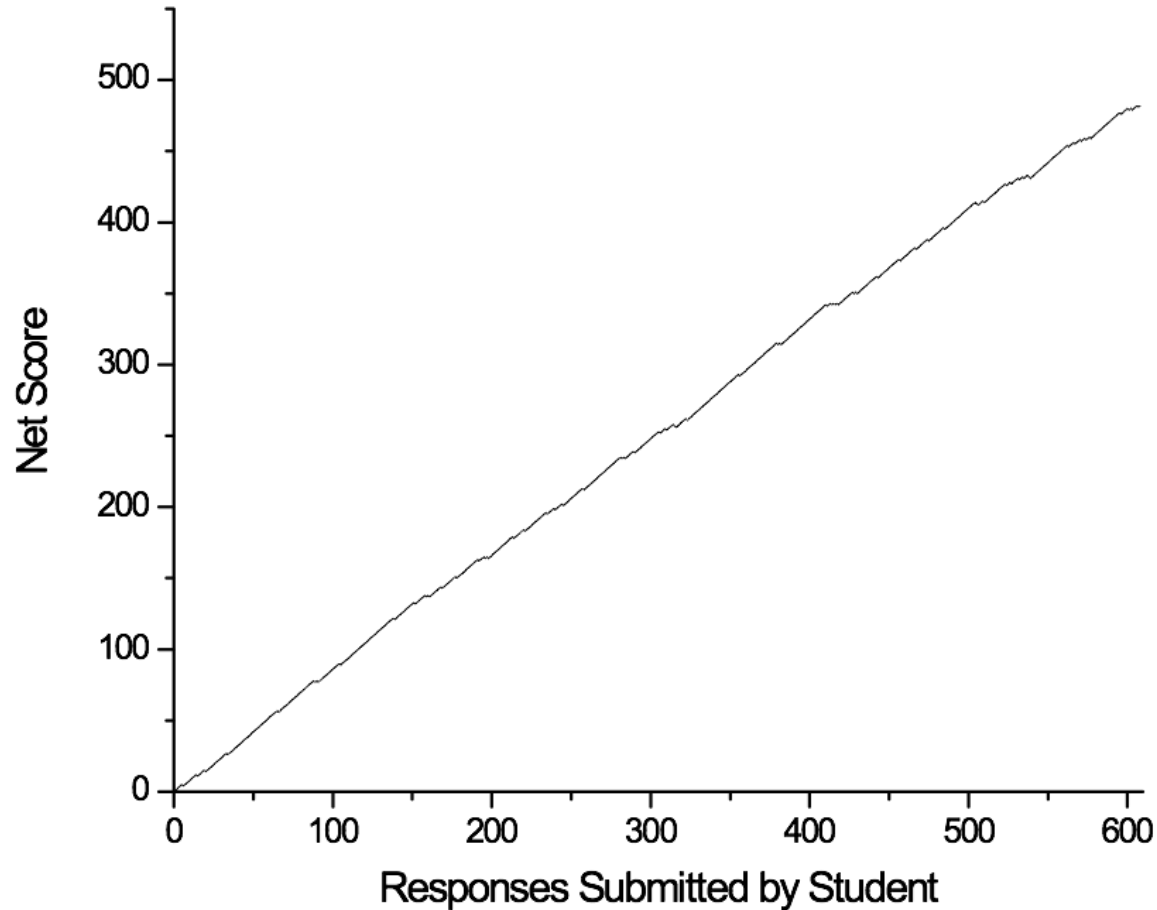
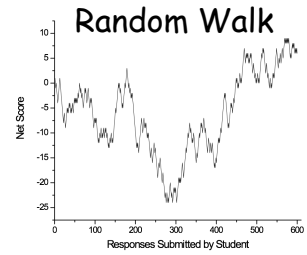
Less irregularity in the response pattern  
i.e., Persistent behavior

(an increase in net score at one instance is more likely to be followed by an increase at a future instance)

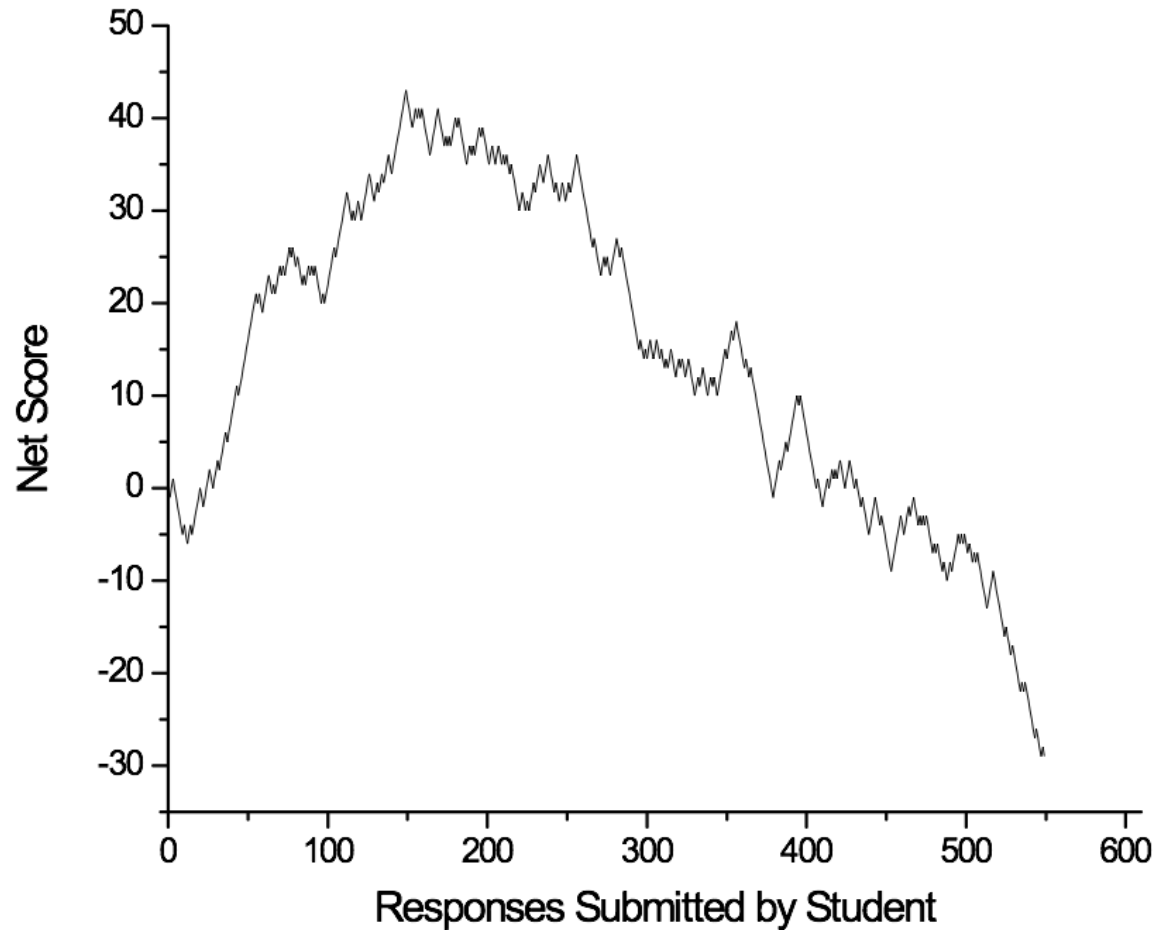
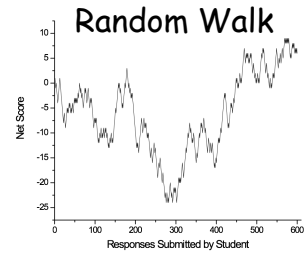
High irregularity in the response pattern  
i.e., Anti-Persistent behavior

(an increase in net score at one instance is more likely to be followed by a decrease at a future instance)

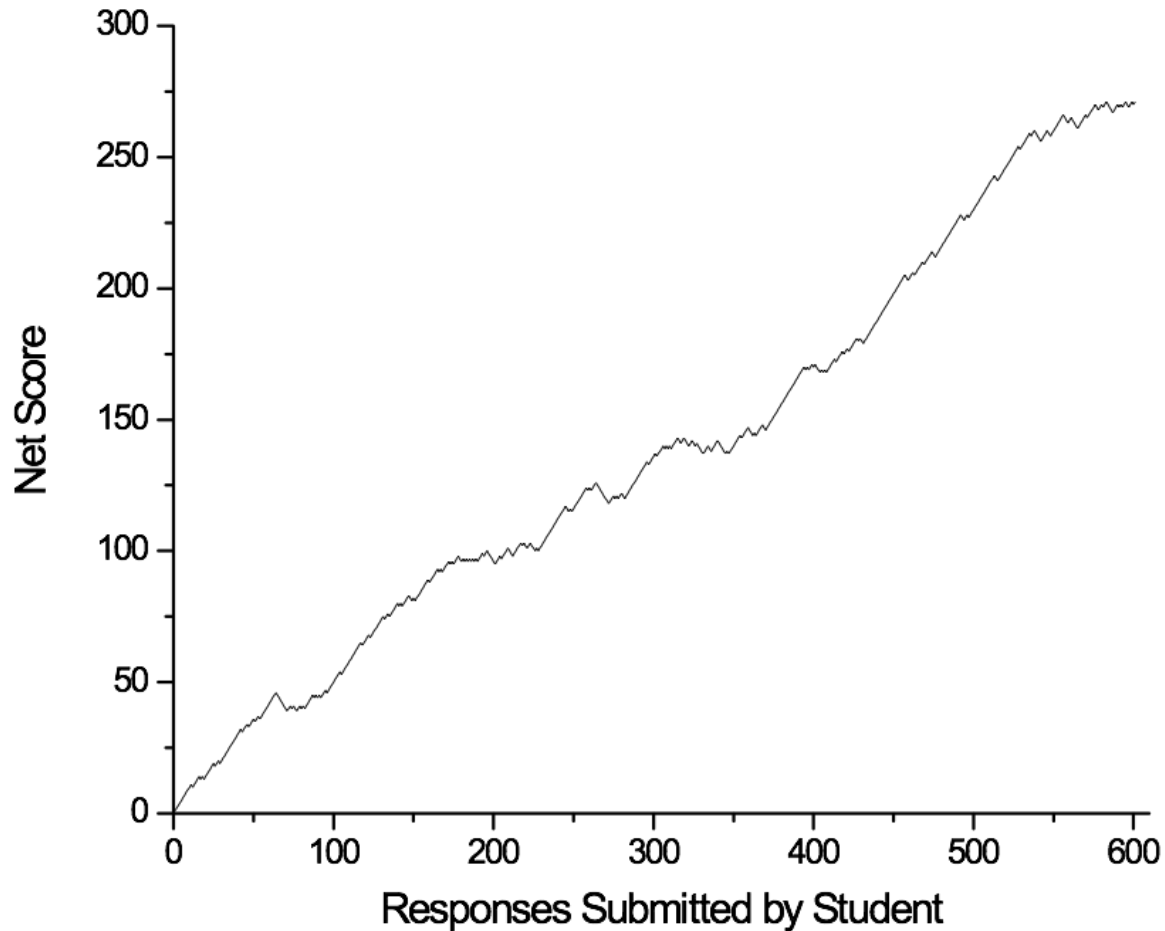
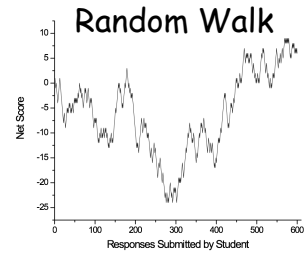
# A student with fractal dimension 1.32



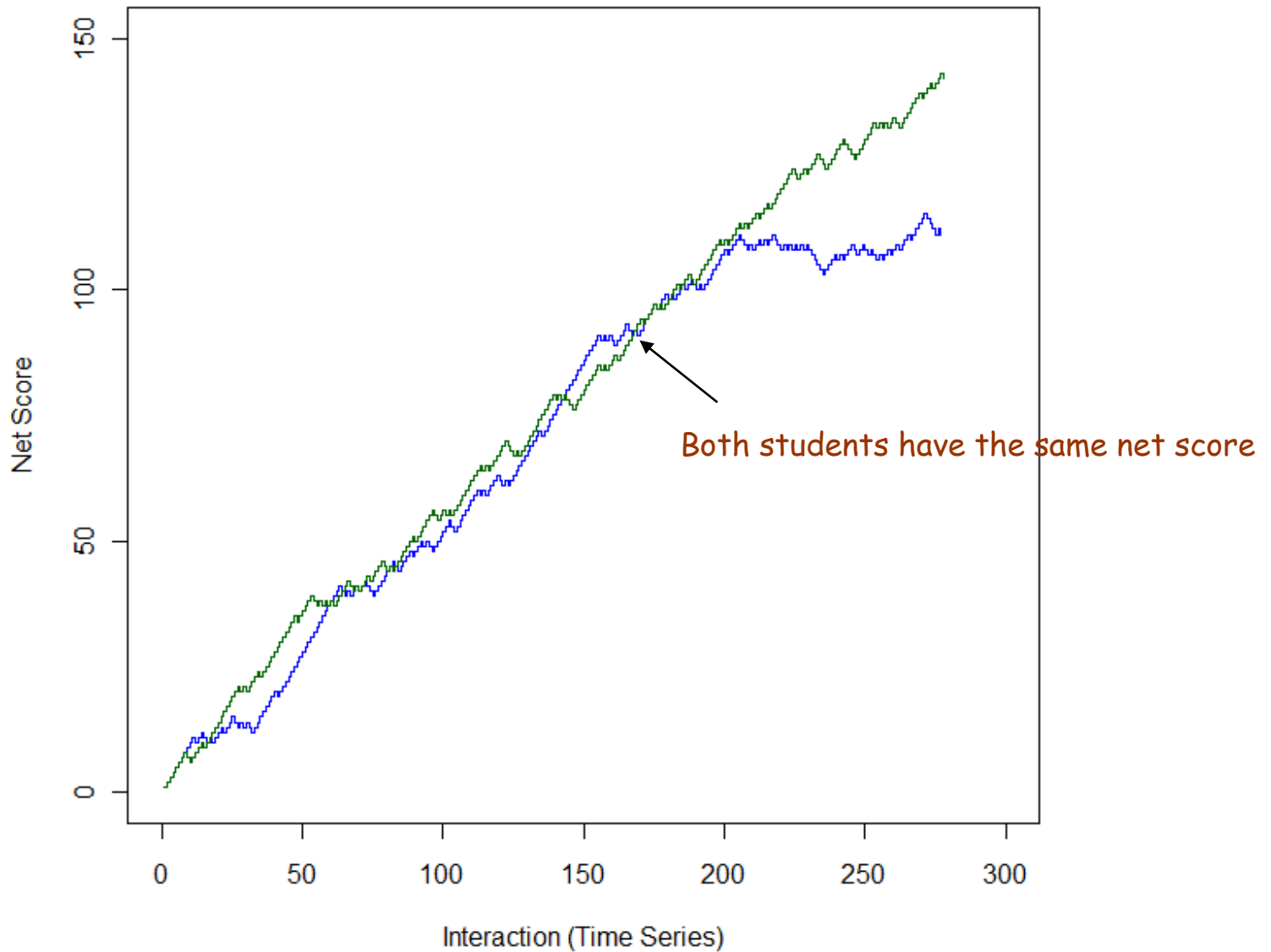
# A student with fractal dimension 1.81



# A student with fractal dimension 1.60



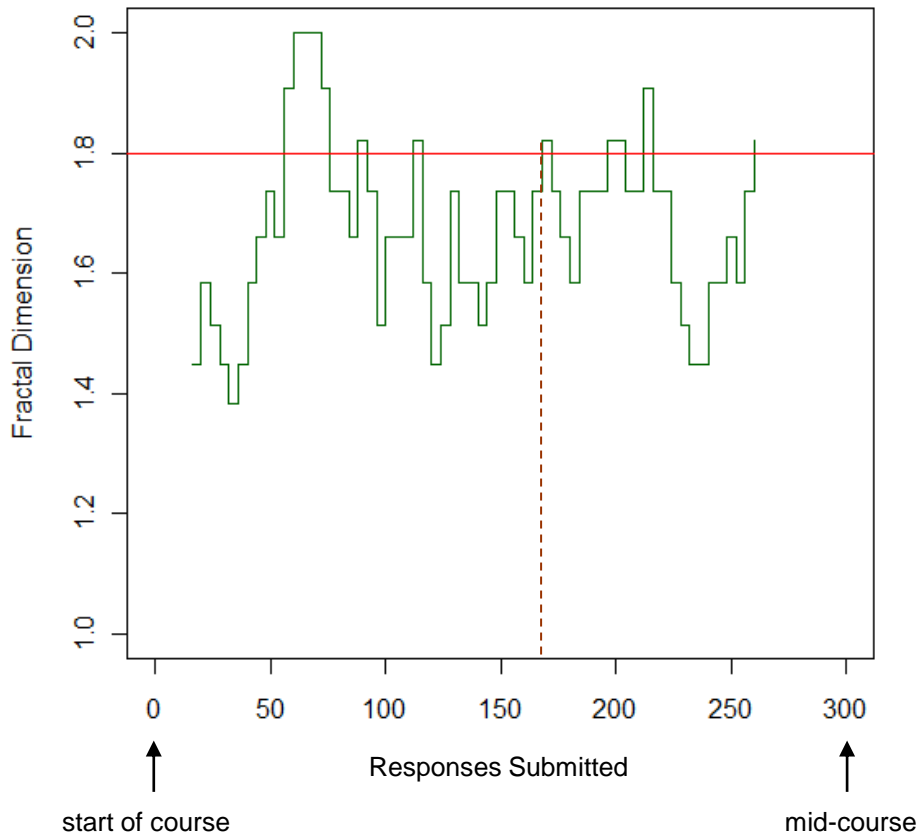
# A Tale of Two Students



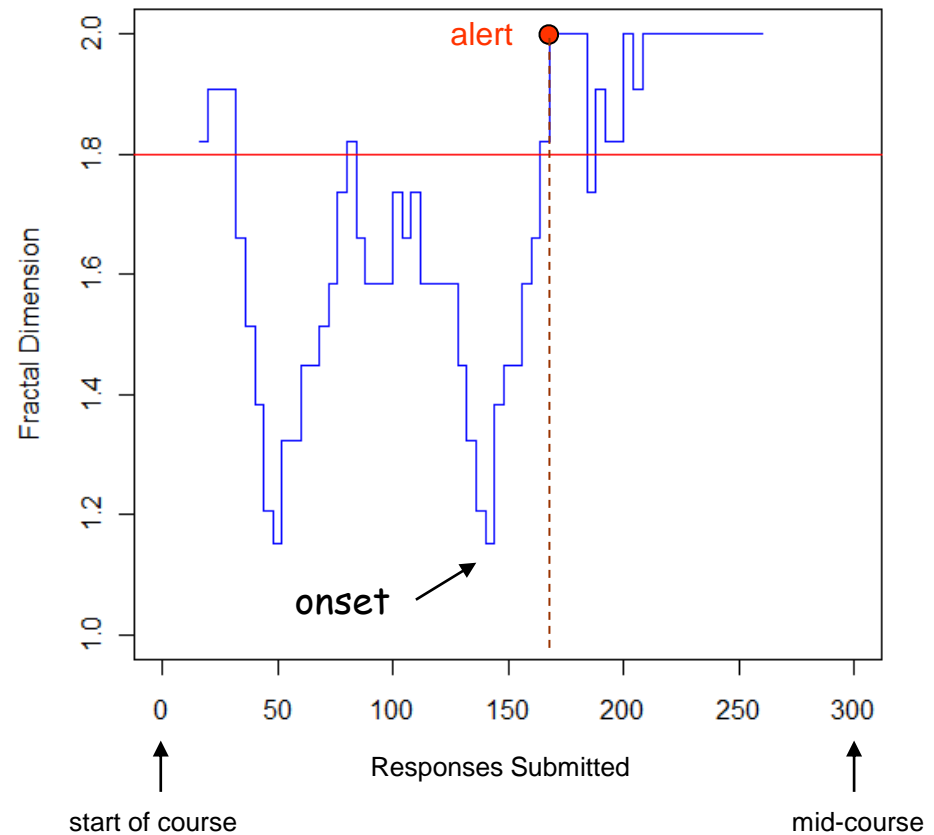


# The Struggling Student can be Identified

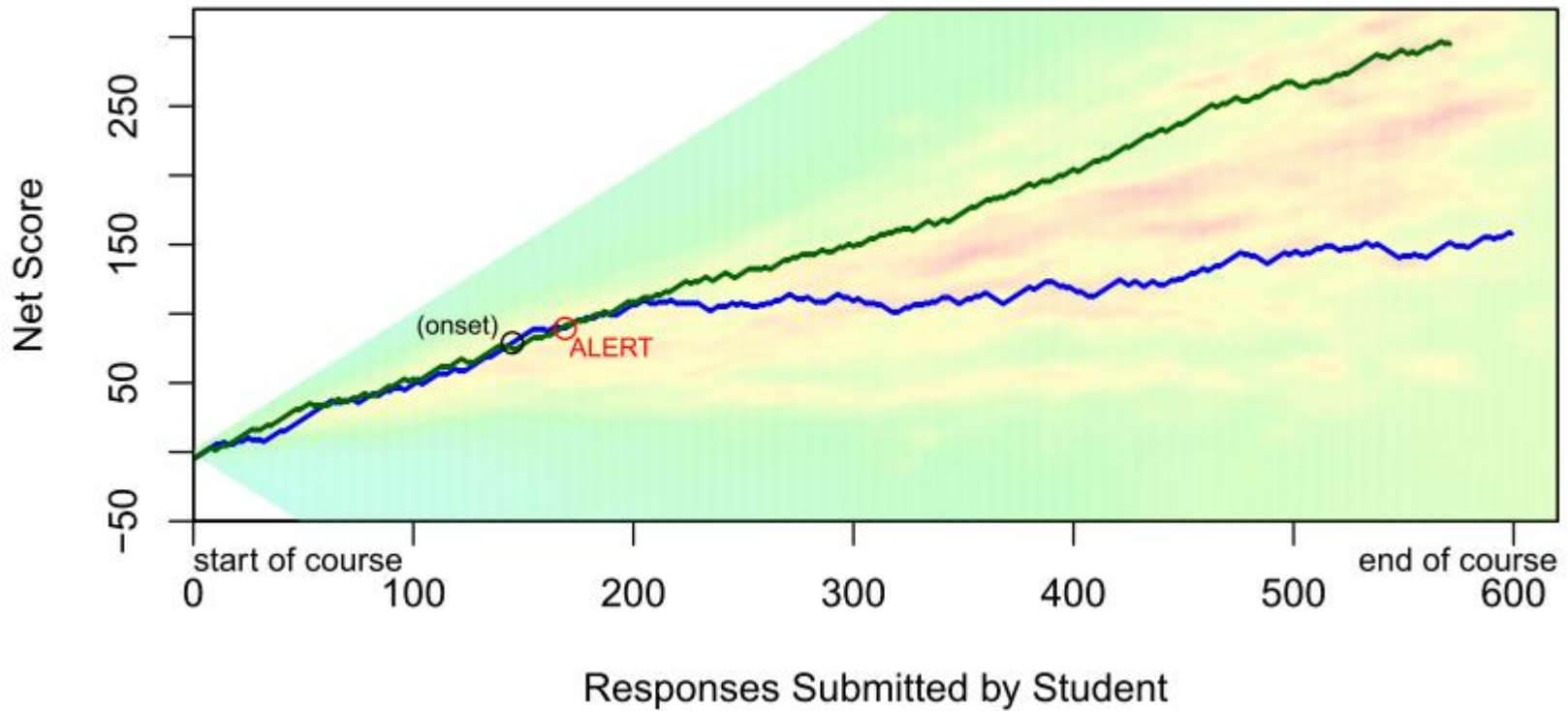
Short runs of smoothness followed by short runs of irregularity.



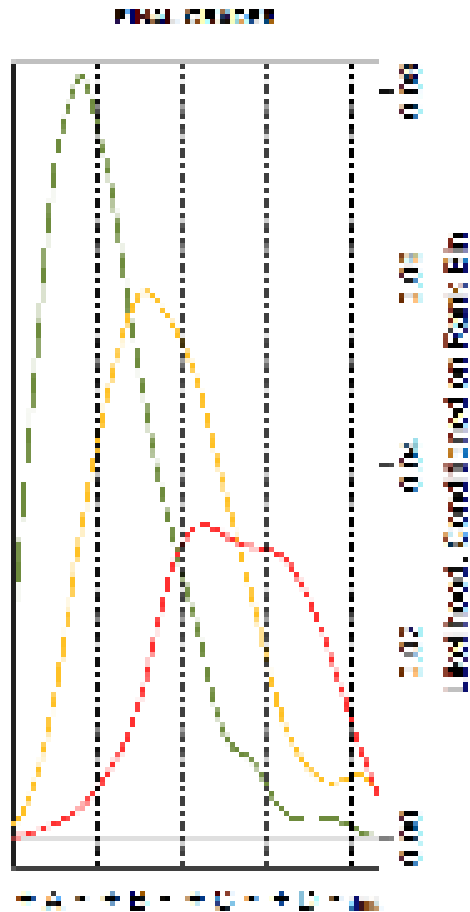
Long runs of smoothness followed by long runs of irregularity, then a tipping point (onset).



# Towards Predictive Analytics



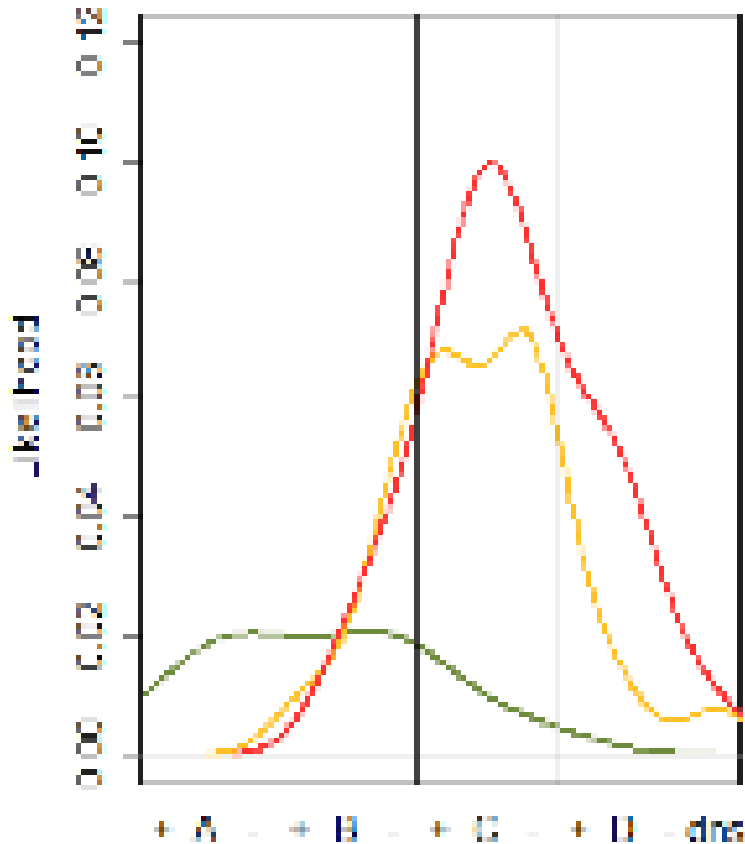
# Spring 2013 Pilot – 1300 students



<i>Low Alerts</i>	<i>Medium Alerts</i>	<i>High Alerts</i>
<b>88%</b> <i>A's and B's</i>	<b>77%</b> <i>B's &amp; C's</i>	<b>73%</b> <i>C's &amp; D's</i>
<b>&lt;2%</b> <i>D+ or lower</i>	<b>&lt;10%</b> <i>D+ or lower</i>	<b>~40%</b> <i>D+ or lower</i>

# Alerts identify previously invisible at-risk students

Final Grades by Early Alert, QEQ = (86%-95%)



Despite high homework scores (86-95%), students that were identified as high alert, most often got a final course grade of C.

→ Algorithm identifies what was a previously invisible population of at-risk students.

# Fall 2013 Pilot - 1500 students, 8 schools



The screenshot shows a mobile application interface for a student list. The top status bar displays 'AT&T', 'VPN', and '10:28 AM'. The browser address bar shows 'earlyalerts.dev.ea.ecolle' and a search bar. The page title is 'Untitled'. Below the search bar, there is a 'Student List' header with a menu icon. The list is for course '13001-007' and instructor 'MPSCHROEDER18583'. A 'Show:' dropdown is set to 'All (9)' and an 'Email to List' button is present. The table below has columns for 'Name', 'Weeks 3-4', and 'Alerts'. The data rows are as follows:

Name	Weeks 3-4	Alerts
Haribhakti, Sapan	4	High
Kollar, David	2.2	High
Six, Shawn	2.3	Medium
Smith, Kelly	2	Medium
Rondini, Samantha	1.9	Medium
Rilly, Marshall	1.8	Medium
Hunter, Hannah	1	Low

The bottom of the screen features an orange bar with 'ALWAYS LEARNING' and 'PEARSON' logos, and a navigation bar with icons for back, forward, share, book, and notifications (4).

73% of instructors agreed alerts were **accurate**

Instructors **intervened** with students whose grades were average, but who had high alert levels — expanding office hours & reviews; adding Adaptive Follow-up assignments

Students reported being **motivated** by the EA notification to attend office hours and reviews

# A Fractal Based Decision Engine for Int

Patent Awarded: January 2014

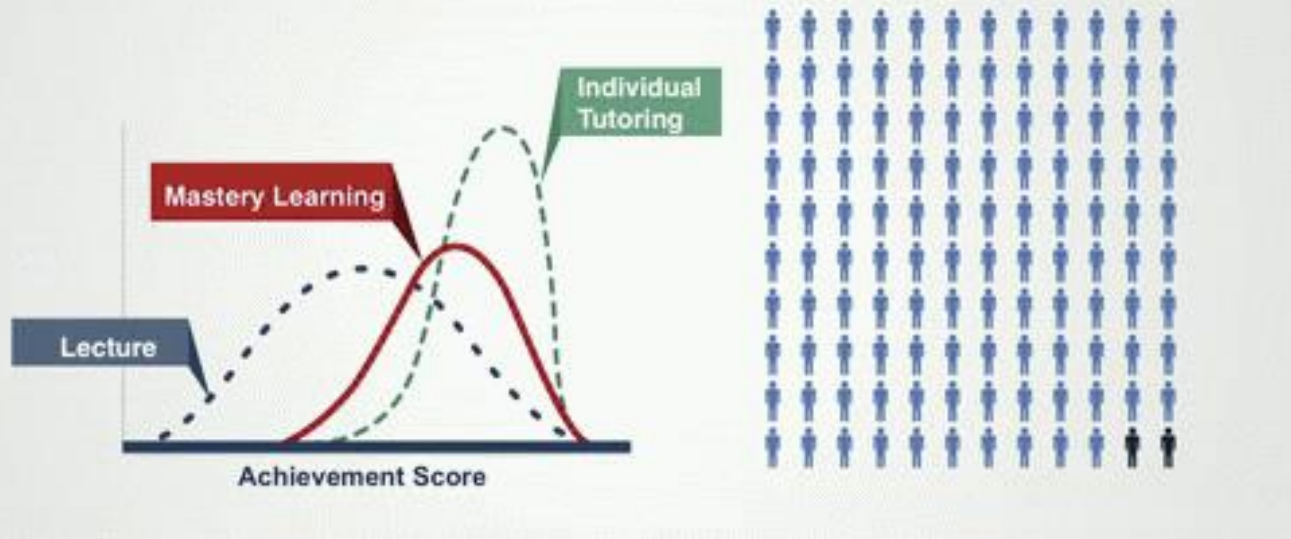
Inventors:

Dr. William Galen

Dr. Rasil Warnakulasooriya

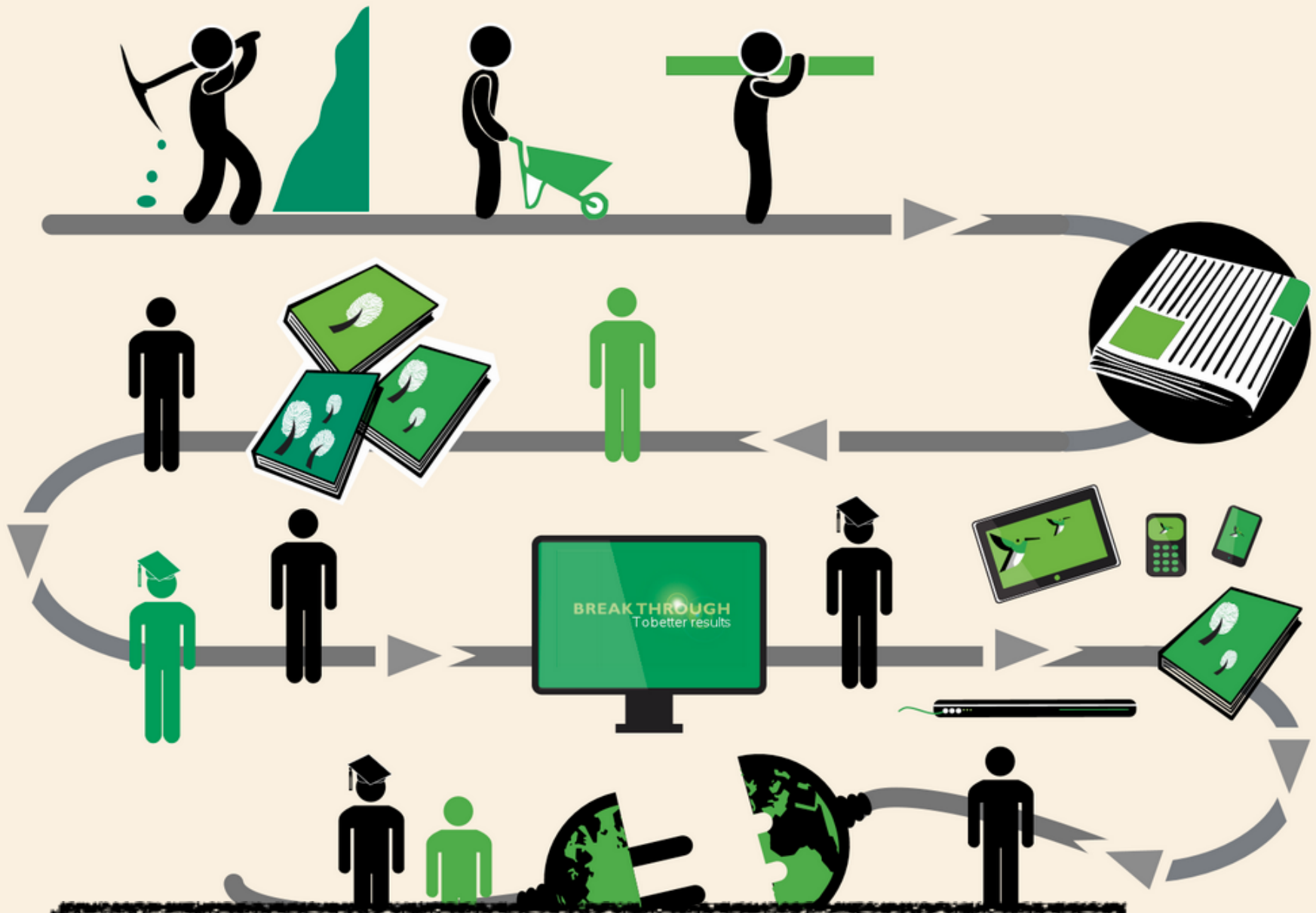
# Towards a Two Sigma Solution

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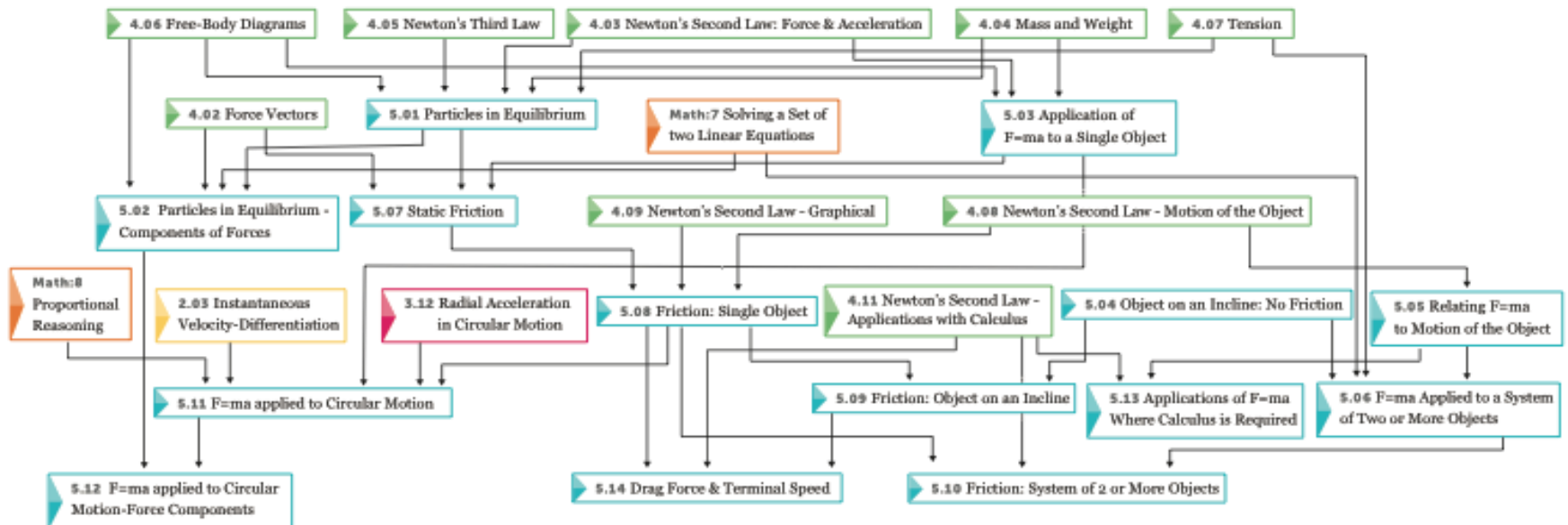


ALWAYS  
LEARNING





\*\*\*NEED THIS SLIDE, OR SKIP???\*



\*\*\*NEED THIS SLIDE, OR SKIP???\*

## Next Steps

[Or just skip to the next slide...]

\*\*\*NEED THIS SLIDE, OR SKIP???

ALWAYS  
LEARNING



Building the  
next generation  
of systems, products, and services

\*\*\*NEED THIS SLIDE, OR SKIP???\*