ENCOURAGING PRODUCTIVE STRUGGLE

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nine

fifty-four

eighty-one

thirty-six

tenenty-seventy

sixty-three

forty-five

seventy-two

eighteen

ninety
<table>
<thead>
<tr>
<th>Number</th>
<th>Equation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>0 + 9 = 9</td>
<td>9</td>
</tr>
<tr>
<td>18</td>
<td>1 + 8 = 9</td>
<td>9</td>
</tr>
<tr>
<td>27</td>
<td>2 + 7 = 9</td>
<td>9</td>
</tr>
<tr>
<td>36</td>
<td>3 + 6 = 9</td>
<td>9</td>
</tr>
<tr>
<td>45</td>
<td>4 + 5 = 9</td>
<td>9</td>
</tr>
<tr>
<td>54</td>
<td>5 + 4 = 9</td>
<td>9</td>
</tr>
<tr>
<td>63</td>
<td>6 + 3 = 9</td>
<td>9</td>
</tr>
<tr>
<td>72</td>
<td>7 + 2 = 9</td>
<td>9</td>
</tr>
<tr>
<td>81</td>
<td>8 + 1 = 9</td>
<td>9</td>
</tr>
<tr>
<td>90</td>
<td>9 + 0 = 9</td>
<td>9</td>
</tr>
</tbody>
</table>

This book explains the basic whys and hows of our number system in a clear, entertaining way. Packed with curiosities, riddles, tricks, games. It makes a pleasure of mathematics.

IRVING ADLER
Illustrated by Ruth Adler
Math is an ADVENTURE
– PAUL LOCKHART, MATHEMATICIAN’S LAMENT
1. Broken into tiny bits
2. Smooth out obstacles
3. Focus on procedures
Culture: Expect everything to be explained
Mindset: Give up too easily
Application: Struggle to apply knowledge
TIME TO DO MATH!
\[
4 \frac{2}{5} - 2 \frac{2}{3}
\]
BROKEN CALCULATOR
Culture: Expect everything to be explained

Mindset: Give up too easily

Application: Struggle to apply knowledge
ANTIDOTE IS PROBLEM SOLVING
JUSTIFYING PROBLEM SOLVING

1. Inquiry & problem solving are at the heart of mathematics and science

2. Provides opportunities to develop perseverance

3. Students who experience problem based learning perform BETTER on standardized tests.†

J. Boaler (1998) Open and Closed Mathematics: Student Experiences and Understandings
NEW RULES

1. Start with a problem
2. Allow productive struggle
3. Support when necessary
4. Direct instruction
ACHIEVING THE VISION

• Create a culture of engagement & perseverance
• Spark curiosity
• Mindset
THE ONE ACTIVITY WHERE STUDENTS ARE ENGAGED & PERSEVERE...
ALSO THE ONE PLACE WHERE KIDS NEVER ASK...

“WHEN AM I EVER GOING TO USE THIS?”
PLAYING A GAME IS THE VOLUNTARY ATTEMPT TO OVERCOME UNNECESSARY OBSTACLES

BERNARD SUITS - PHILOSOPHER
SELF-EFFICACY
PROGRESSIVE CHALLENGE
NORMALIZE FAILURE

It’s only FUN to “fail” if the game seems FAIR and you have HOPE of SUCCESS
DESCRIPTIVE FEEDBACK
DESCRIPTIVE FEEDBACK

• Where am I going?
• Where am I now?
• What is going well?
• How can I improve?
• What did I learn from this attempt?
DON’T ELECTROCUTE THE DEER
LETTING GO

• We tend to want to alleviate struggle

• Goal is to support not rescue
“Video games don’t judge me.”
– JADEN SHAH, PHILOSOPHER
CULTURE OF ENGAGEMENT

- Give students choice
- Start really simple then increase the demand
- Normalize failure and lower the stakes
- Deliver descriptive feedback
- Stop giving the answers
ACHIEVING THE VISION

• Create a culture of engagement and perseverance

• Spark curiosity

• Mindset
“The biggest problem in education is the giving of answers to questions that have not yet been asked.”

– DR. ARTHUR COMBS
QUESTIONS ASKED BY AGE

Frequency per Day vs. Age

- Mostly “Why?”
  - Age 0: 65
  - Age 20: 32
  - Age 50: 6

- Rarely “Why?”
  - Age 0: 0
  - Age 20: 0
  - Age 50: 0

What a Great Idea! Chic Thompson
SPARK CURIOSITY

Create a gap between what’s known and unknown
Let students pose questions

The figure below is composed of 6 identical squares. The area of the entire figure is 150 cm². What is the perimeter of the figure?
NOTICE ANYTHING? QUESTIONS?
SMUDGE MATH
(PETER LILJEDAHLL)

$34 \div 5 = 6 \text{ R}4$

Can this statement be true?

1. $\text{ } \div \text{ 5} = 6 \text{ R}4$
2. $\text{ } \div \text{ 5} = \text{ R}4$
3. $\text{ } \div \text{ 5} = 6 \text{ R}$
4. $34 \div \text{ 5} = \text{ R}4$
5. $34 \div \text{ 5} = 6 \text{ R}$
6. $34 \div 5 = \text{ R}$

\[
\frac{3}{5} \div \frac{4}{5} = \frac{12}{5}
\]
Compute the Area

The area is 12.

What are some possible dimensions?
OPEN MIDDLE

Fill in the boxes with the numbers 1-9 to create a difference as close to 500 as possible. You may only use each number once.

\[
\begin{array}{cccc}
\hline
\phantom{0}
& \phantom{0}
& \phantom{0}
& \phantom{0}

\hline
\phantom{0}
& \phantom{0}
& \phantom{0}
& \phantom{0}

\hline
500
\end{array}
\]
How much is a pound of dimes worth?
How much is a pound of quarters worth?
Would you rather have a pound of quarters or a pound of dimes?

1 dime is 2.268 grams  
1 qtr is 0.0125 pounds
ACHIEVING THE VISION

• Create a culture of engagement and perseverance
• Spark curiosity
• Mindset
GROWTH VS. FIXED

- Praise effort over outcomes
- Use descriptive feedback
- Add “...yet” to “I can’t do x”
- Share stories of growth

“If you manage people or are a parent (which is a form of managing people), drop everything and read Mindset.”
—Guy Kawasaki, author of The Art of the Start

mindset
THE NEW PSYCHOLOGY OF SUCCESS

HOW WE CAN LEARN TO FULFILL OUR POTENTIAL

* parenting
* business
* school
* relationships

CAROL S. DWECK, Ph.D.
Why are my arms and legs flailing apart?!
SUMMARY

• Take time to spark curiosity
• Give students some control
• Start simple!
• Monitor students’ hope of success
• Give descriptive feedback
• Stop giving answers
“I have no special talents. I am just passionately curious.”

– ALBERT EINSTEIN