Inferring Impulsive-Analytic Disposition from Written Responses

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Outline of Presentation

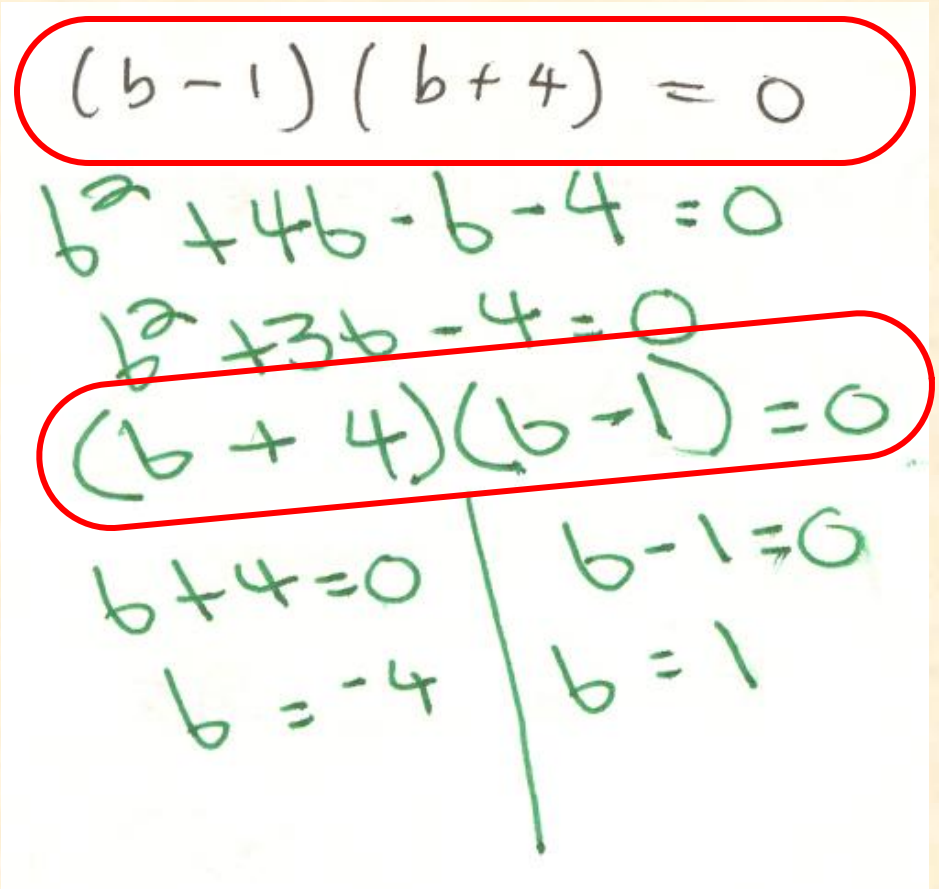
1. Introduction
2. Background
3. Research Design
4. Results
5. Conclusion

Inspired by …

"doing whatever first comes to mind … or diving into the first approach that comes to mind"

(Watson & Mason, 2007, p. 307)

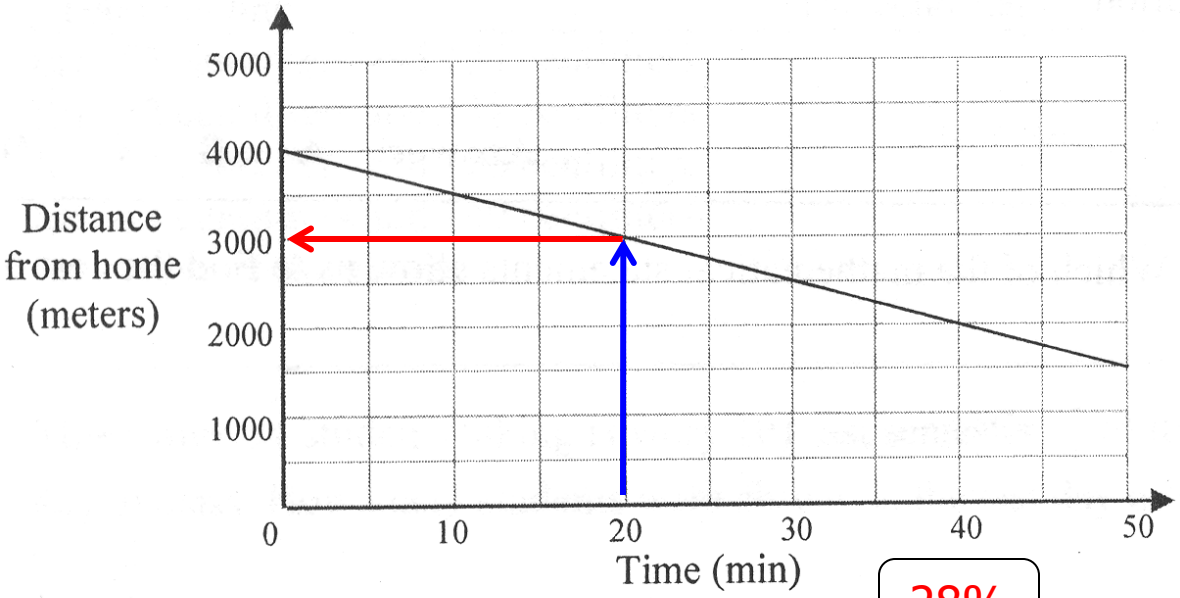
Evidence #1



A 9th Grader - Algebra II

Evidence #2

. Gina is traveling home from her friend's house. The graph represents a portion of Gina's journey. What is Gina's speed at the 20th minute?



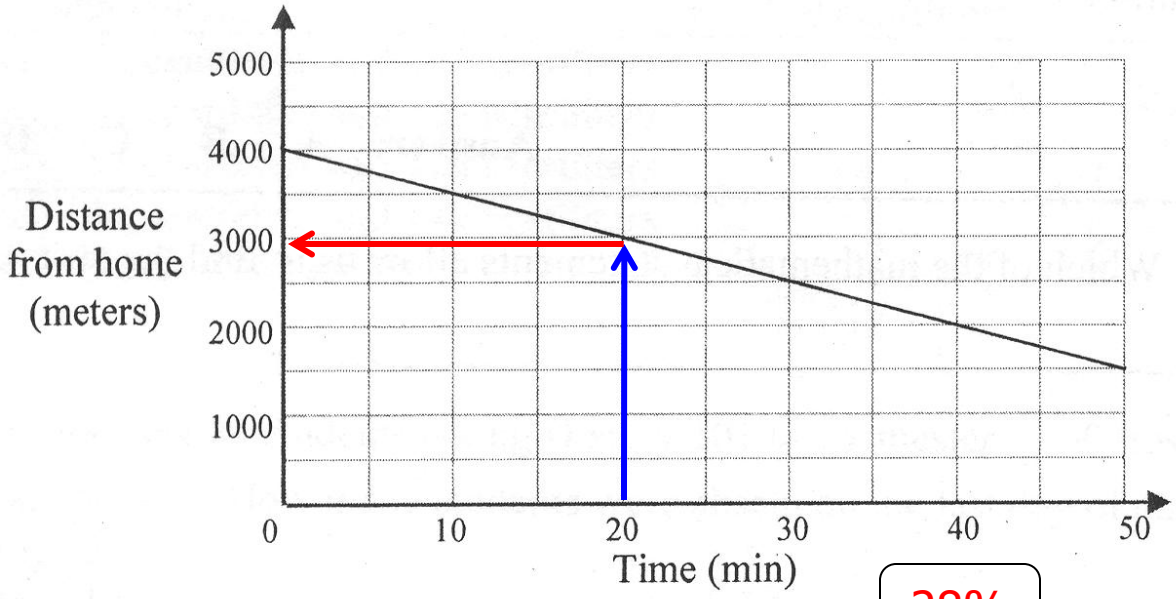
(a) Approximately 3000 meters — 28%
(b) Approximately 50 meters/min
(c) Approximately 80 meters/min
(d) Approximately 150 meters/min — 52%

Answer: A B C D

307 Pre-service EC-4 Teachers

Evidence #2

. Gina is traveling home from her friend's house. The graph represents a portion of Gina's journey. What is Gina's speed at the 20th minute?



Speed = $\frac{d}{t}$

$= \frac{3000}{20}$

$= 150$

(a) Approximately 3000 meters — 28%
(b) Approximately 50 meters/min
(c) Approximately 80 meters/min
(d) Approximately 150 meters/min — 52%

Answer: A B C D

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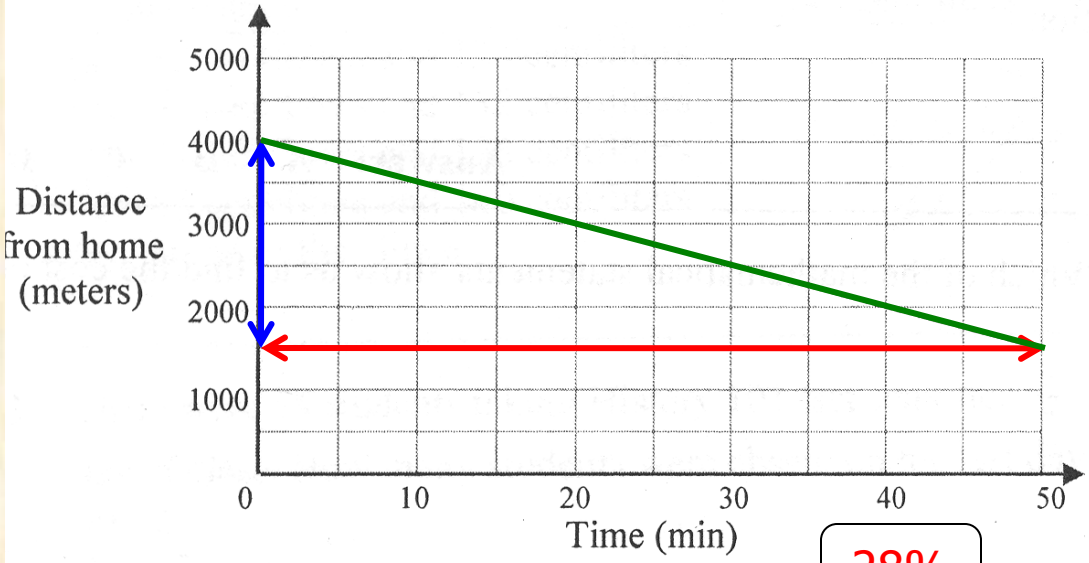
Evidence #2

Gina is traveling home from her friend's house. The graph represents a portion of Gina's journey.
What is Gina's speed at the 20th minute?



$\frac{4000 - 1500}{50} = 50$

(a) Approximately 3000 meters — 28%
(b) Approximately 50 meters/min — 18%
(c) Approximately 80 meters/min
(d) Approximately 150 meters/min — 52%

Answer: A B C D

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Need to advance students …

from Impulsive Disposition

a proclivity to spontaneously proceed with an action that comes to mind without checking its relevance

(i.e. tool-oriented)

to Analytic Disposition

a proclivity to analyze a problem situation

(i.e. situation-oriented)

Two Open Questions:

1. Can we advance students from being impulsive to being analytic?

   "Yes", in the context of overgeneralizing proportionality (Lim & Morera, 2010)

2. Can we measure students' impulsive-analytic disposition?

   Possibly, using the *likelihood-to-act* survey (Lim, Morera & Tchoshanov, 2009)

Three Related Constructs

- Einstellung Effect (Luchins, 1942)

  The phenomenon of solving a given problem in a fixated manner even when a better approach exists

- Spurious-Correlation (Ben-zeev & Star, 2001)

  A two-phase process

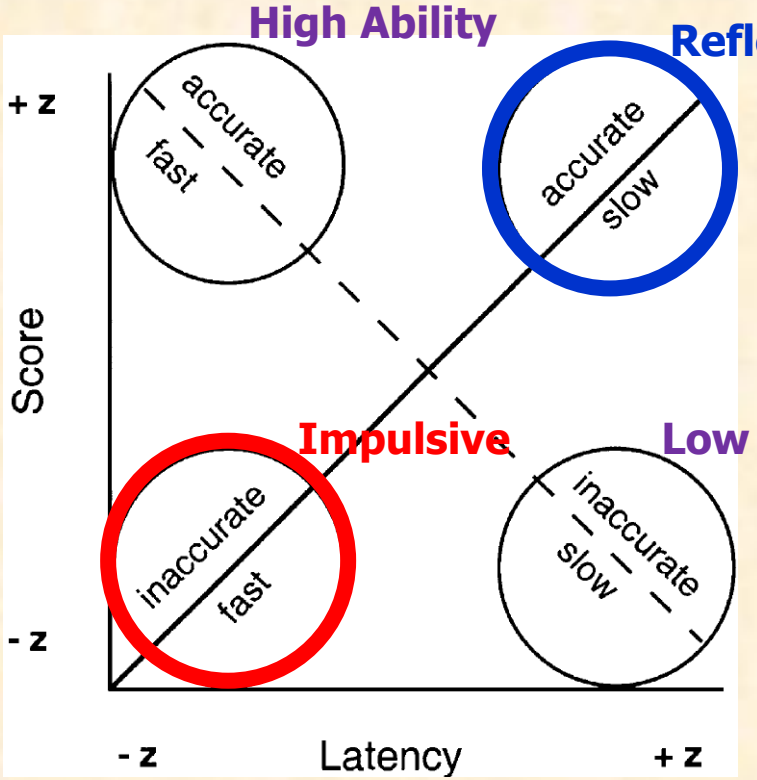
  – Conceiving an association
  – Applying the association to another seemingly similar situation

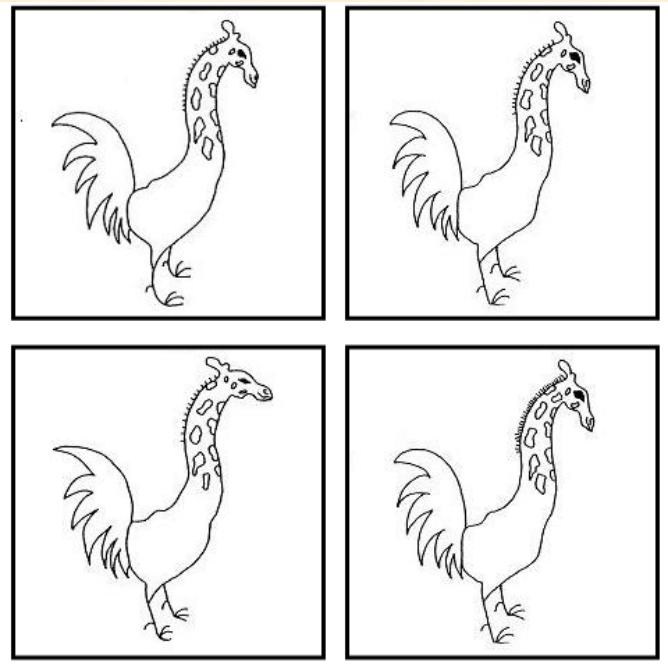
- Impulsive Disposition (Lim, Morera, Tchoshanov, 2009)

  A proclivity to spontaneously proceed with an action that comes to mind without checking its relevance.

Assessing Impulsivity

- Matching-familiar Figure Test
  (Kagan, Rosman, Day, Albert, & Phillips 1964)
  - Speed-accuracy continuum





Source: Spring, F & Meier, P (online)

Assessing Impulsivity

- Matching-familiar Figure Test
  (Kagan, Rosman, Day, Albert, & Phillips, 1964)
- Cognitive Reflection Test
  (Frederick, 2005)

A bat and a ball cost $1.10 in total.
The bat costs $1.00 more than the ball.
How much does the ball cost?

Assessing Impulsivity

- Matching-familiar Figure Test
  (Kagan, Rosman, Day, Albert, & Phillips, 1964)
- Cognitive Reflection Test
  (Frederick, 2005)
- Self-reported Questionnaires
  - Need for Cognition (Cacioppo & Petty, 1992)

    High: "I would prefer complex to simple problems."
    Low: "I only think as hard as I have to."

Assessing Impulsivity

- Matching-familiar Figure Test
  (Kagan, Rosman, Day, Albert, & Phillips, 1964)
- Cognitive Reflection Test
  (Frederick, 2005)
- Self-reported Questionnaires
  - Need for Cognition (Cacioppo & Petty, 1992)
  - Barrett Impulsiveness Scale (Cacioppo & Petty, 1992)
    1. Attention — "I don't pay attention."
    2. Motor — "I act on impulse."
    3. Self-control — "I am self controlled."
    4. Cognitive complexity — "I like puzzles."
    5. Perseverance — "I change jobs."
    6. Cognitive instability — "I have 'racing' thoughts."

Assessing Impulsivity

- Matching-familiar Figure Test
  (Kagan, Rosman, Day, Albert, & Phillips, 1964)
- Cognitive Reflection Test
  (Frederick, 2005)
- Self-reported Questionnaires
  - Need for Cognition (Cacioppo & Petty, 1992)
  - Barrett Impulsiveness Scale (Cacioppo & Petty, 1992)
- Task-based interviews
- Likelihood-to-act Survey
  (Lim, Morera & Tchoshanov, 2009)

Likelihood-to-Act Survey: Items

Impulsive Item

$(x - 5)(x - 8) = 0$

When asked to solve for x, how likely are you to multiply out the terms (i.e., FOIL) and then solve $x^2 - 13x + 40 = 0$ using the quadratic formula?

Analytic Item

$(x - 7)(x - 4) = 0$

When asked to solve for x, how likely are you to study the equation and predict the solution?

1	2	3	4	5	6
Extremely Unlikely	Unlikely	Somewhat Unlikely	Somewhat Likely	Likely	Extremely Likely

Likelihood-to-Act Survey: Format

- 32 items
- Two types
  - 16 Impulsive Items
  - 16 Analytic Items
- Four categories
  - 8 Algebra
  - 8 Word Problem
  - 8 Fraction
  - 8 General (non-mathematically specific)

Likelihood-to-Act Survey: Items

General-Impulsive Item

In solving a problem in mathematics, how likely are you to use the first idea that comes to mind?

General-Analytic Item

In solving a problem in mathematics, how likely are you to interpret and understand the problem thoroughly before deciding what to do?

Likelihood-to-Act Survey: Testing

	Semester	# of Participants
18 Items	Fall 08	326 undergrads

Lim, K. H., Morera, O., & Tchoshanov, M. (2009). Assessing problem-solving dispositions: Likelihood-to-act survey. In S.L. Swars, D.W. Stinson & S. Lemons-Smith (Eds.), *Proceedings of the 31st PME-NA Meeting* (pp. 700-708). Atlanta: Georgia State University.

Likelihood-to-Act Survey: Testing

	Semester	# of Participants
18 Items	Fall 08	326 undergrads
32 Items (Version 1-online)	Spr 09 Su 09	535 undergrads 19 teachers
32 Items (Version 2)	Fall 09	99 undergrads & 20 teachers
32 Items (Version 3)	Spr 10	495 undergrads

Research Objectives

- to investigate the validity of the LtA survey
- to improve the LtA items

Participants

1. A professional development workshop
   - 27 in-service teachers
   - 10 pre-service teachers

2. Two math classes
   - 29 pre-service teachers (EC-4)
   - 9 pre-service teachers (4-8)
   - 16 pre-service teachers (Special ed., Bilingual ed.)

Data Collection

1. Likelihood-to-act Survey

2. Opinion-seeking Question

   In your opinion, which aspect(s) of problem-solving disposition do you think the 32-item survey is trying to quantify (i.e., measure)?

3. Questionnaire (6 open-ended questions)

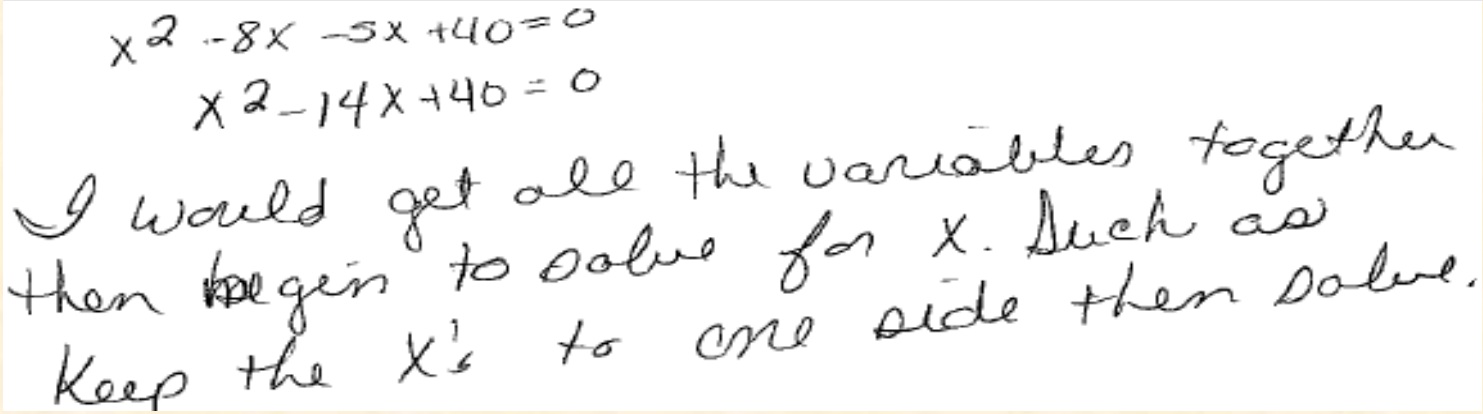
   What are the first few actions that you would take when asked to solve $(x - 5)(x - 8) = 0$ for x?

Research Questions

1. What solution strategies were mentioned in the open-ended questionnaire responses?
2. How well did the open-ended questionnaire results correlate with the LtA survey results?
3. What did the respondents think the LtA survey was trying to measure?

Data Analysis

What are the first few actions that you would take when asked to solve $(x - 5)(x - 8) = 0$ for x?



S1: FOIL	57%

I+	62%

Data Analysis

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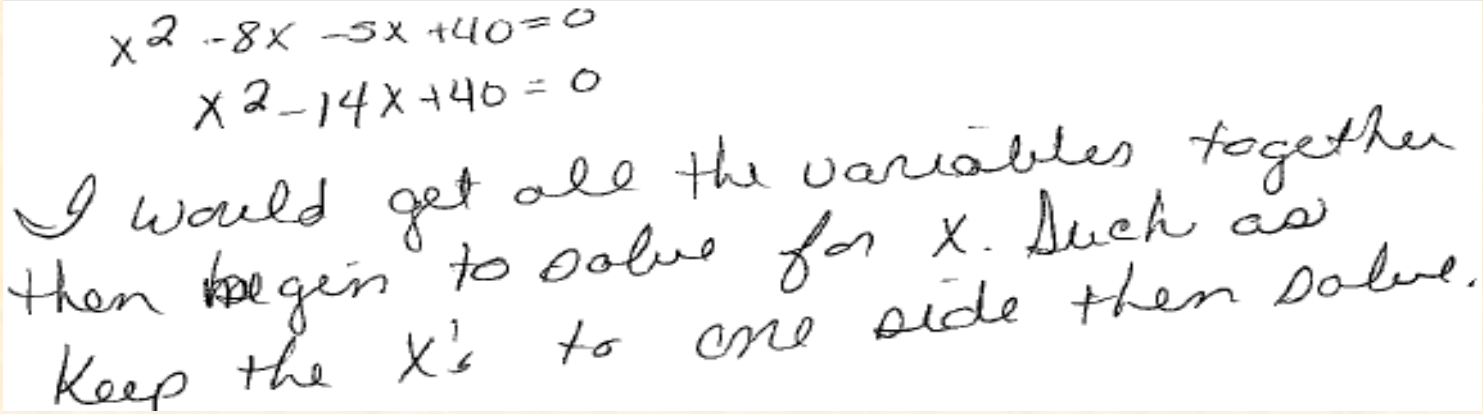

S1: FOIL	57%

I+	62%
I-	
U	
A-	
A+	

Data Analysis

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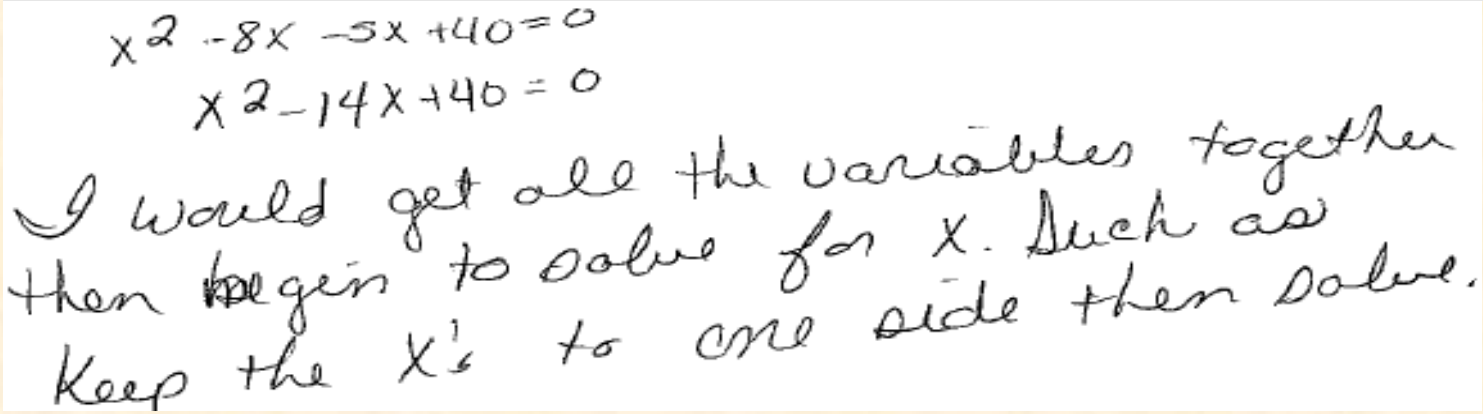
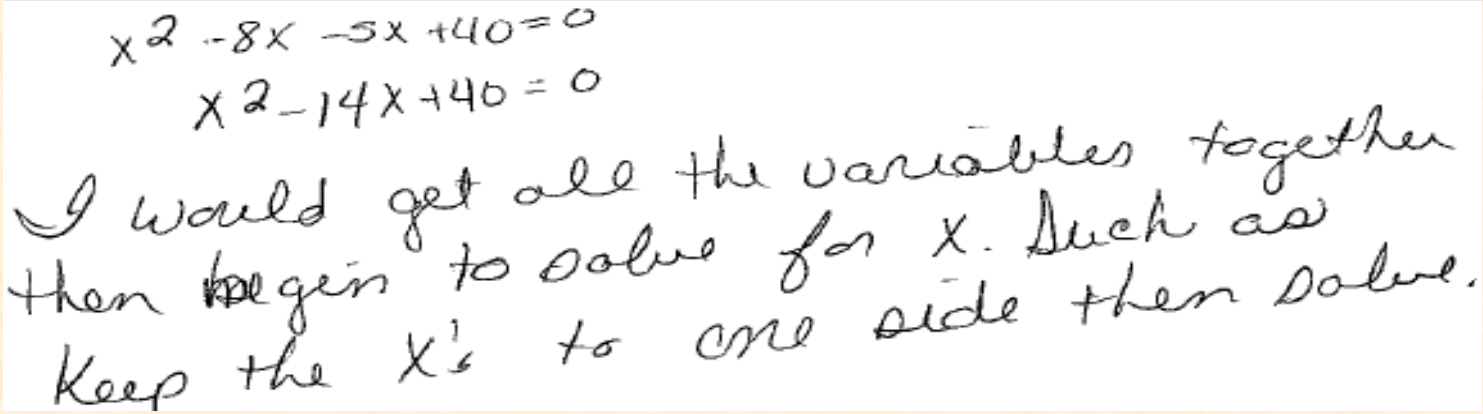


S1: FOIL	57%
S2: $x-5=0$ and $x-8=0$	23%
S3: Guess and check	6%
S4: Analyzing the problem/ following proper procedure	6%
Others	6%

I+	62%
I-	
U	
A-	
A+	

Data Analysis

What are the first few actions that you would take when asked to solve $(x - 5)(x - 8) = 0$ for x?



S1: FOIL	57%
S2: $x - 5 = 0$ and $x - 8 = 0$	23%
S3: Guess and check	6%
S4: Analyzing the problem/ following proper procedure	6%
Others	6%

I+	62%
I-	4%
U	6%
A-	6%
A+	21%

Strategies for Open-ended Items

	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
Strategy 1	57%											
Strategy 2	23%											
Strategy 3	6%											
Strategy 4	6%											
Others	6%											

- Strategies are listed from most to least frequent
- Strategy 1 is consistent with the corresponding impulsive LtA item

$(x-5)(x-8)=0$

When asked to solve for x, how likely are you to multiply out the terms (i.e., FOIL) and then solve $x^2-13x+40=0$ using the quadratic formula?

Strategies for Open-ended Items

	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
Strategy 1	57%	60%	79%	45%	30%	68%	73%	38%	58%	78%	33%	30%
Strategy 2	23%											
Strategy 3	6%											
Strategy 4	6%											
Others	6%											

- Strategies are listed from most to least frequent
- For each item, except B6, the most frequent strategy (S1) is consistent with its corresponding impulsive LtA item

What are the first few actions that you would take when asked to find the answer for $\frac{55}{95} \div \frac{11}{95}$ without using a calculator?

Strategies for Open-ended Items

	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
Strategy 1	57%	60%	79%	45%	30%	68%	73%	38%	58%	78%	33%	30%
Strategy 2	23%	21%	11%	9%	30%	13%	24%	38%	20%	13%	27%	25%
Strategy 3	6%	6%	8%	6%	26%	9%	2%	9%	7%	4%	24%	18%
Strategy 4	6%	-	2%	6%	4%	4%	-	4%	4%	-	7%	7%
Others	6%	13%	-	34%	11%	6%	-	11%	11%	4%	9%	23%

- Strategies are listed from most to least frequent
- For each item, except B6, the most frequent strategy (S1) is consistent with its corresponding impulsive LtA item

Disposition Codes for Open-ended Items

	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
I+	62%											
I-	4%											
U	6%											
A-	6%											
A+	21%											

- I+ is the most frequent

Disposition Codes for Open-ended Items

	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
I+	62%	75%	81%	66%	60%	94%	76%	58%	78%	87%	76%	61%
I-	4%	11%	-	15%	2%	-	-	-	-	-	-	32%
U	6%	6%	-	11%	4%	-	-	2%	2%	-	-	-
A-	6%	6%	13%	2%	6%	-	-	2%	-	-	-	-
A+	21%	2%	6%	6%	28%	6%	24%	38%	20%	13%	24%	7%

- I+ is the most frequent for all items
- For some items, there were no I-, U, and A-

Disposition Codes for Open-ended Items

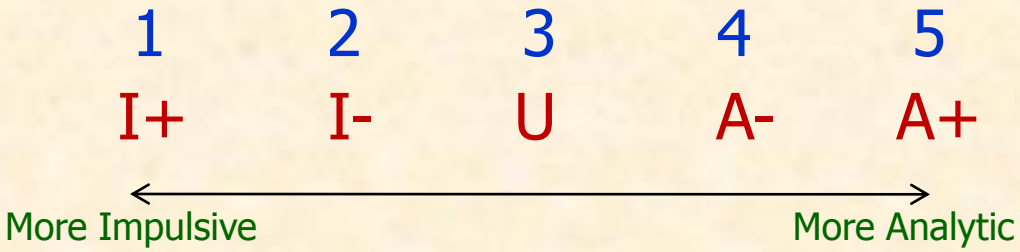
	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
I+	62%	75%	81%	66%	60%	94%	76%	58%	78%	87%	76%	61%
I-	4%	11%	-	15%	2%	-	-	-	-	-	-	32%
U	6%	6%	-	11%	4%	-	-	2%	2%	-	-	-
A-	6%	6%	13%	2%	6%	-	-	2%	-	-	-	-
A+	21%	2%	6%	6%	28%	6%	24%	38%	20%	13%	24%	7%

Inter-rater reliability: 0.89 **Inter-rater reliability: 0.96**

- I+ is the most frequent for all items
- For some items, there were no I-, U, and A-
- Two versions were coded by two teams

Correlation between Disposition Scores and LtA Scores

- Quantifying Disposition Codes



- Consider Item A1, its mean disposition score is 2.23

1	I+	62%
2	I-	4%
3	U	6%
4	A-	6%
5	A+	21%

Correlation between Disposition Scores and LtA Scores

	Mean Disposition Score
Item A1	2.23
Item A2	
Item A3	
Item A4	
Item A5	
Item A6	
Item B1	
Item B2	
Item B3	
Item B4	
Item B5	
Item B6	

Correlation between Disposition Scores and LtA Scores

	Mean Disposition Score
Item A1	2.23
Item A2	1.51
Item A3	1.64
Item A4	1.68
Item A5	2.40
Item A6	1.26
Item B1	1.98
Item B2	2.62
Item B3	1.89
Item B4	1.53
Item B5	1.98
Item B6	1.56

Correlation between Disposition Scores and LtA Scores

	Mean Disposition Score	Correlation with Impulsive LtA Subscale
Item A1	2.23	-0.21
Item A2	1.51	-0.11
Item A3	1.64	-0.40**
Item A4	1.68	-0.41**
Item A5	2.40	-0.16
Item A6	1.26	-0.43**
Item B1	1.98	-0.48**
Item B2	2.62	-0.39**
Item B3	1.89	-0.47**
Item B4	1.53	-0.48**
Item B5	1.98	-0.13
Item B6	1.56	-0.17

*$p < .05$, **$p < .01$.

Correlation between Disposition Scores and LtA Scores

	Mean Disposition Score	Correlation with Impulsive LtA Subscale	Correlation with Analytic LtA Subscale
Item A1	2.23	-0.21	0.25
Item A2	1.51	-0.11	0.20
Item A3	1.64	-0.40**	0.45**
Item A4	1.68	-0.41**	0.21
Item A5	2.40	-0.16	0.17
Item A6	1.26	-0.43**	0.50**
Item B1	1.98	-0.48**	0.44**
Item B2	2.62	-0.39**	0.17
Item B3	1.89	-0.47**	0.21
Item B4	1.53	-0.48**	0.19
Item B5	1.98	-0.13	0.14
Item B6	1.56	-0.17	0.08

*$p < .05$, **$p < .01$.

Correlation between Disposition Scores and LtA Scores

	Mean Disposition Score	Correlation with Impulsive LtA Subscale	Correlation with Analytic LtA Subscale	Correlation with Analytic-Impulsive Difference
Item A1	2.23	-0.21	0.25	0.31*
Item A2	1.51	-0.11	0.20	0.22
Item A3	1.64	-0.40**	0.45**	0.58**
Item A4	1.68	-0.41**	0.21	0.41**
Item A5	2.40	-0.16	0.17	0.22
Item A6	1.26	-0.43**	0.50**	0.63**
Item B1	1.98	-0.48**	0.44**	0.62**
Item B2	2.62	-0.39**	0.17	0.39**
Item B3	1.89	-0.47**	0.21	0.47**
Item B4	1.53	-0.48**	0.19	0.46**
Item B5	1.98	-0.13	0.14	0.18
Item B6	1.56	-0.17	0.08	0.17

*$p < .05$, **$p < .01$.

Correlation between Disposition Scores and LtA Scores

	Correlation with Impulsive LtA Subscale	Correlation with Analytic LtA Subscale
Item A1	-0.21	0.25
Item A2	-0.11	0.20
Item A3	-0.40**	0.45**
Item A4	-0.41**	0.21
Item A5	-0.16	0.17
Item A6	-0.43**	0.50**
Item B1	-0.48**	0.44**
Item B2	-0.39**	0.17
Item B3	-0.47**	0.21
Item B4	-0.48**	0.19
Item B5	-0.13	0.14
Item B6	-0.17	0.08

*$p < .05$, **$p < .01$.

Overall -0.488** 0.373**

Participants' Opinions of LtA Survey

In your opinion, which aspect(s) of problem-solving disposition do you think the 32-item survey is trying to quantify (i.e., measure)?

Participants' Opinions of LtA Survey

	Count
Analyzing or identifying relationships	30
Interpreting or understanding the problem	13
Finding an easier way, a shortcut, or alternative ways	7

Participants' Opinions of LtA Survey

	Count
Analyzing or identifying relationships	30
Interpreting or understanding the problem	13
Finding an easier way, a shortcut, or alternative ways	7
Following procedures	14
Acting quickly without thinking	8
Assessing fastness in solving problems	7

Participants' Opinions of LtA Survey

	Count
Analyzing or identifying relationships	30
Interpreting or understanding the problem	13
Finding an easier way, a shortcut, or alternative ways	7
Following procedures	14
Acting quickly without thinking	8
Assessing fastness in solving problems	7
Finding out how one approaches a problem	43
Assessing knowledge/skill/problem-solving	26
Predicting	17
Commenting about teaching and learning	13
Visualizing or mentally computing	11
Assessing competence in specific math topics	6
Others	5

Participants' Opinions of LtA Survey

	Count	Rank
Analyzing or identifying relationships	30	2
Interpreting or understanding the problem	13	6
Finding an easier way, a shortcut, or alternative ways	7	10
Following procedures	14	5
Acting quickly without thinking	8	9
Assessing fastness in solving problems	7	10
Finding out how one approaches a problem	43	1
Assessing knowledge/skill/problem-solving	26	3
Predicting	17	4
Commenting about teaching and learning	13	6
Visualizing or mentally computing	11	8
Assessing competence in specific math topics	6	12
Others	5	13

Concluding Remarks

- Students' strategies in open-ended responses were consistent with impulsive LtA items
- Significant correlations between LtA and Open-ended Responses
- Results helped us identify weak LtA items
- Students' opinions informed us how to revise some of the LtA items

Discussion

Thank You