Finding the Write Answer: Deepening Mathematics Learning through Writing

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Today's Outline

- Introduction to Writing in Mathematics
  - The literature: Why write in mathematics?
  - Common Core State Standards
    - Standards for Mathematical Practice
    - Literacy Standards
- Great Writing Assignments
  - Why do assignments matter?
  - Template and exemplars
  - Make your own
- Additional Resources
- Q & A

Why write in mathematics?

“I’m a math teacher, not an English teacher”

“This isn’t English class.”

Why write in mathematics?

Writing in the math classroom…

- is not about math teachers teaching writing.
- is about math teachers using writing to support content learning.

Why write in mathematics?

Writing to communicate ideas learned

- Clarify, refine, and consolidate thinking
- Authentically practice vocabulary
- Reflect on understanding of mathematics or learning process

Writing as assessment (formative and summative)

- Identifies preconceptions, misconceptions, incomplete conceptions
- Gets at students' understanding at the conceptual level

Feedback for writing

- Enhances depth of communication between each individual student and teacher

Writing = Thinking

Writing allows the brain time to reflect on learning. Thinking time is necessary to process learning.

When thinking about the concept or idea students can go back to the way they have created meaning.

Connie Schrock, NCTM E-seminar Series, 2014

CCSS-M
Standards for Mathematical Practice

1. **Make sense of problems and persevere in solving them.**
2. Reason abstractly and quantitatively.
3. **Construct viable arguments and critique the reasoning of others.**
4. **Model with mathematics**
5. Use appropriate tools strategically.
6. **Attend to precision.**
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning

SMP1. Make sense of problems and persevere in solving them.

Mathematically proficient students start by **explaining to themselves the meaning** of a problem and looking for entry points to its solution. They **analyze** givens, constraints, relationships, and goals. They **make conjectures about the form and meaning** of the solution and **plan a solution pathway** rather than simply jumping into a solution attempt. They consider analogous problems, and try special cases and simpler forms of the original problem in order to gain insight into its solution. They **monitor and evaluate their progress** and change course if necessary. Older students might, depending on the context of the problem, transform algebraic expressions or change the viewing window on their graphing calculator to get the information they need. Mathematically proficient students can **explain correspondences between** equations, verbal descriptions, tables, and graphs or draw diagrams of important features and relationships, graph data, and search for regularity or trends. Younger students might rely on using concrete objects or pictures to help conceptualize and solve a problem. Mathematically proficient students check their answers to problems using a different method, and they **continually ask themselves, “Does this make sense?”** They can **understand the approaches of others** to solving complex problems and **identify**

SMP3. Construct viable arguments and critique the reasoning of others.

Mathematically proficient students **understand and use stated assumptions, definitions, and previously established results in constructing arguments**. They **make conjectures** and build a logical progression of statements to explore the truth of their conjectures. They are able to analyze situations by breaking them into cases, and can recognize and use counterexamples. They **justify their conclusions, communicate them** to others, and **respond to the arguments of others.** They reason inductively about data, **making plausible arguments** that take into account the context from which the data arose. Mathematically proficient students are also able to **compare the effectiveness of two plausible arguments,** distinguish correct logic or reasoning from that which is flawed, and—**if there is a flaw in an argument—explain what it is.** Elementary students can **construct arguments** using concrete referents such as objects, drawings, diagrams, and actions. Such arguments can make sense and be correct, even though they are not generalized or made formal until later grades. Later, students learn to determine domains to which an argument applies. Students at all grades can listen or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments.

SMP4. Model with mathematics

Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. In early grades, this might be as simple as writing an addition equation to describe a situation. In middle grades, a student might apply proportional reasoning to plan a school event or analyze a problem in the community. By high school, a student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another. Mathematically proficient students who can apply what they know are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They can **analyze those relationships** mathematically to draw conclusions. They **routinely interpret their mathematical results** in the context of the situation and **reflect on whether the results make sense,** possibly improving the model if it has not served its purpose.

SMP6. Attend to precision.

Mathematically proficient students try to **communicate precisely to others**. They try to **use clear definitions in discussion with others and in their own reasoning**. They **state the meaning of the symbols** they choose, including using the equal sign consistently and appropriately. They are careful about specifying units of measure, and labeling axes to clarify the correspondence with quantities in a problem. They calculate accurately and efficiently, express numerical answers with a degree of precision appropriate for the problem context. In the elementary grades, students **give carefully formulated explanations to each other.** By the time they reach high school they have learned to **examine claims and make explicit use of definitions**.

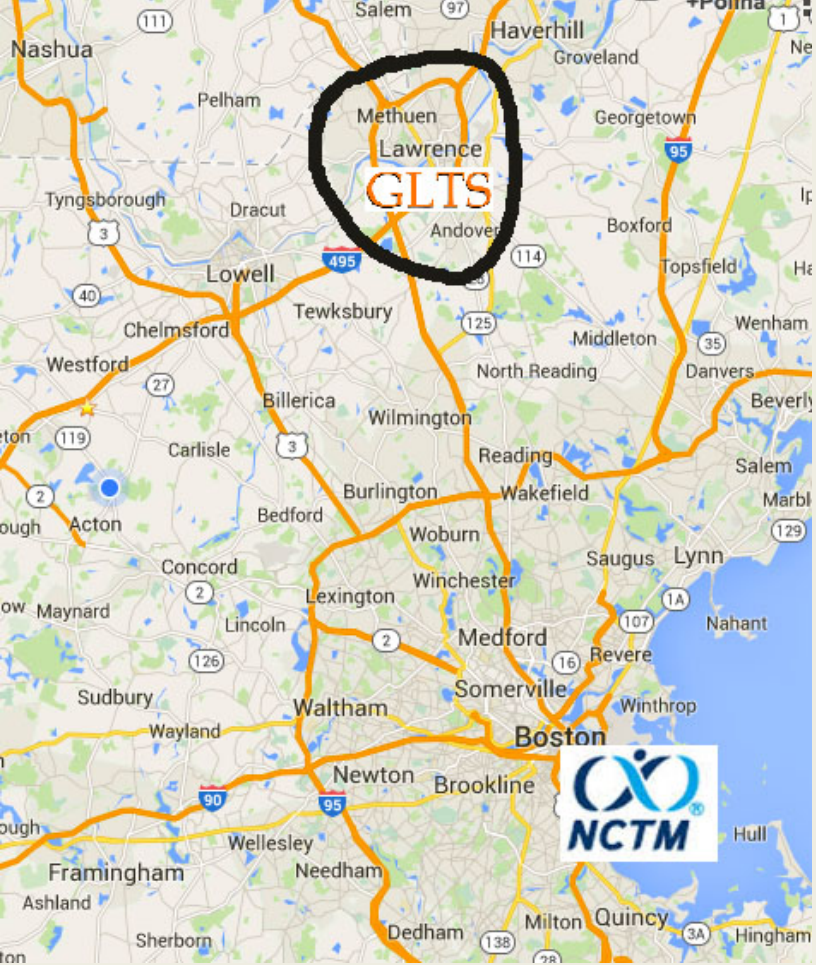
CCSS-ELA
Writing Anchor Standards

1. Write **arguments** to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.

2. Writing **informative/explanatory texts** to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

4. Produce clear and coherent writing in which the **development, organization, and style** are **appropriate** to **task, purpose, and audience**.

10. Write routinely over **extended time frames** (time for research, reflection, and revision) and **shorter time frames** (a single sitting or a day or two) for a range of tasks, purposes, and audiences.



Vocational Technical High School serving Lawrence, Methuen, Andover, N. Andover

- 1,352 students
  - ~80% Free and Reduced Lunch
  - 78.3% Hispanic; 18.9% White; 2.8% all others
  - 21% SPED
  - 7.9% ELL; 24.3% First Language not English
- Attendance: 96% ☺

Greater Lawrence Technical School

- 2014 Math MCAS:
  - Advanced - 26%,
  - Proficient - 33%,
  - Needs Improvement - 32%,
  - Warning - 10%
- Composite Performance Index (CPI)
  - 74.8 in 2012
  - 80.9 in 2014

Greater Lawrence Technical School

SCHOOL IMPROVEMENT!

- Literacy Initiative 2011-14
- One-to-One Chromebook Initiative 2014-
- Curriculum Redesigned and Aligned to Common Core/CVTE Frameworks (by teachers) 2011-
- Research for Better Teaching
- PLCs
- Mathematics, Science, Literacy, Differentiated Education Consultants

RESULTS: Level 3 ⟹ Level 1

Great Writing Assignments

Why do assignments matter?

- GLTS Writing Committee review of student writing showed a direct correlation between assignment clarity and student production.
- The literature says so, in particular Jim Burke (*Content Area Writing*) and Kelly Gallagher (*Teaching Adolescent Writers*).

Great Writing Assignments

PURPOSE: Why you are asking your students to write
[i.e., teacher's goal]

TASK: What you are asking your students to write
[i.e., student's goal]

AUDIENCE: Who you are asking your students to write for

Great Writing Assignments

Assignment Title
Due Date

Purpose:
Audience:
Task:
Steps:
Criteria for Success:

Created by GLTS Writing Committee, Summer 2013

Great Writing Assignments

Criteria for Success	Possible Points	Points Earned
CONTENT		
•		
•		
•		
VOCABULARY	10	
WRITING: Writing is clear and correct	10	
TOTAL	**100**	

Created by GLTS Writing Committee, Summer 2013

Summative Assessment

“Great Writing Assignments”

- The Cell Phone Problem - Grade 9
- Town Statistics - Grade 12

The Cell Phone Problem:
Explicit/Recursive Argument Writing Assignment

Purpose:

1. To assess your understanding of explicit and recursive functions
2. To help you reach a deeper level of understanding
3. To enable you to explain how explicit and recursive function rules work

Audience:Teacher and other 9th grade math students

Created by GLTS teachers Cerulli, Foley, Gonet, Heffron, & Mahoney 2014/2015

The Cell Phone Problem: Task

Write an argument that answers the question:

Suppose you would like to buy a new smart phone that costs $250, which loan option would you prefer?

The Cell Phone Problem: Task Continued

Loan Option 1: You borrow the money from your parents and with the money you earn from a part-time job, you pay them back $20 per week.

Loan Option 2: Suppose that instead of borrowing the cash from your parents, you use a credit card. Your balance is $250 and you are charged a $15 monthly interest. You do not have to make any payments for 12 months. You make the minimum monthly payment of $25.

Loan Option 3: Suppose that instead of borrowing the cash from your parents, you use a credit card. You have a $250 credit card balance on which you are charged a $15 monthly interest. You make the minimum monthly payment of $25.

The Cell Phone Problem: Steps

1. Write the recursive and explicit formulas for ***each of the three options***
2. Write at least the first 5 terms of the sequence ***for each of the three options***
3. Evaluate ***each situation*** by answering the following question:
   (a) How long will it take you to pay off the loan?
   (b) What will you owe at the end of 12 months?
4. Write a ***claim*** that explains your choice of loan option.

The Cell Phone Problem: Steps Continued

5. Give ***specific mathematical evidence*** from the information provided to support your claim. (Use the word bank to help you.)

6. Give a ***counterclaim*** by explaining why you would not choose the other loan options. (Use the word bank to help you.)

7. Check ***Criteria for Success*** and make sure you have included everything you need.

The Cell Phone Problem: Steps Continued

You may use the following word bank to help you form your explanations:

Required Words:

first term
sequence
recursive
explicit
term
common difference

Helpful Suggestions:

add
multiply
pattern
previous
solution
debt
rule
equation
depend
value
calculate
repeat
less expensive
more expensive
reason
continue

The Cell Phone Problem: Criteria for Success

Content	**Meets**	**Not Yet**
Claim: Includes a claim that states which loan option was chosen and explains why.		
Evidence: Supports the claim with correct mathematical evidence from the information provided (your facts are the answers to steps 1, 2 & 3)		
Reasoning: Explains how the mathematical evidence supports the claim (your thinking)		
Counterclaim: Explains why you did not choose the other options		
Vocabulary: Includes the words **first term**, **sequence**, **recursive**, **explicit**, **term, common difference**		
Writing		
Has capital letters, periods, and complete sentences		
Appendix		
Your mathematical work (The work completed for steps 1, 2 & 3)		

Which SMPs are here?

Think-Pair-Share

Which SMPs are addressed in the Cell Phone Problem Assignment?
Where exactly do they come into play?

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Standards for Mathematical Practice

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4. Model with mathematics.

6. Attend to precision.

Town Statistics:
Argument Writing Assignment

Purpose: To engage students in using data so they better understand the use of Statistics.

Task: Use www.City-Data.com to answer a research question of interest to you. Your essay must make a claim that answers your question and use data from three cities as evidence to support your claim.

Created by GLTS teacher M. Sheehan 2014/2015

Town Statistics: Steps

Pre-Writing Activity:

1. Select a city or town that you are interested in learning about.
2. Use the “www.City-Data.com” website for your research data.
3. Develop a research question.
4. Identify factors that help to answer your research question and form a claim (hypothesis).
5. Find data from at least two other cities or towns that support your claim (hypothesis). One city should be similar to yours and the other one should be different.

Town Statistics: Steps Continued

Writing Assignment (5 paragraph Essay)**:**

1. Paragraph 1 states your town/city of interest, states your research question and describes the data from which you created the research question.
2. Paragraph 2 states your claim (hypothesis) and describes the indicators that support your claim.
3. Paragraph 3 describes how you support your claim with data from the similar town/city.
4. Paragraph 4 describes how you support your claim with data from the different town/city.
5. Paragraph 5 summarizes your finding and makes recommendations.

Town Statistics: Word Bank

sample
wages
population
per capita
poverty
mean
trends
causation
scatter plot
qualitative data

ethnicity
unemployment
demographics
percentage
education
data
hypothesis
correlation
stem-n-leaf plot

employment
questionnaire
educational
transportation
industries
average
median income
hystogram
circle graph
quantitative data

survey

attainment level
occupation
religion
statistics

bar graph
pie chart

Town Statistics:
Criteria for Success

Item Description	Points
1. States a research question based on city data	10
2. States a claim/hypothesis based on city data	10
3. Uses data to support your claim (three cities)	45
4. Uses 10 vocabulary words correctly (word bank)	10
5. Summarizes convincingly	10
6. Includes 5 paragraphs	5
7. Writing, grammar and punctuation are clear and correct	10

Make Your Own

Purpose: To practice creating great math writing assignments

Task: Create the Purpose, Task, Audience, Steps, and Criteria for Success for a writing assignment for your next curriculum unit. Make sure the assignment is authentic to the needs of the content.

Audience: Your students

Steps:

1. Identify your Purpose. *Content? Skills? Formative or summative?*
2. Identify your Task. *What kind of writing will accomplish your purpose?*
3. Identify your Audience. *Can you come up with a real life audience?*
4. List your Steps. *What will students need to do to accomplish the task?*
5. Create your Criteria for Success. *What does the finished product need to include? How do you want to allocate your points?*

Resources

- Michigan Department of Education: Writing Across the Curriculum - Mathematics
  - http://www.michigan.gov/documents/mde/Writing_to_Learn_Mathematics_306722_7.pdf
- Massachusetts Department of Elementary and Secondary Education Model Curriculum Units
  - http://www.doe.mass.edu/candi/model/ /
- Using Writing in Mathematics
  - http://www2.ups.edu/community/tofu/lev2/journaling/writemath.htm
- Schrock, C.S. (2014) Can Writing be the Missing Link for Mathematical Understanding, NCTM Seminar Series.
  - http://www.nctm.org/Conferences-and-Professional-Development/Webinars-and-Webcasts/

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Mason, R.T. & McFeetors, P. J. (2002). *Interactive Writing in Mathematics Class: Getting Started.* Mathematics Teacher. 95 (7): 532 - 536.

McIntosh, M.E. & Draper, R.J. (1997). *Write Starts: 101 Writing Prompts for Math.* Dale Seymour Publication, Palo Alto, CA.

Pugalee, D. K. (1997). *Connecting Writing to the Mathematics Curriculum.* Mathematics Teacher. 90: 308-310.

Q & A

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