Metacognition in Mathematical and Scientific Thinking

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Welcome!

Outline: Reading Apprenticeship in STEM

Metacognition as Foundation:
- Discovery of Reading Process and Reading Strategies List

Problem Solving Discourse Protocol:
- “TAPPS”

Metacognitive Text Dense Problem Solving and Troublesome Concept Understanding:
- “TWRAMPS”

Other Routines/Frameworks:
- Metacognitive Videos
- Reading Logs
- Talking to the text

Evaluation
Creating a Community of Learners

Creating a safe space for uncertainties, misunderstandings and questions

Setting Norms
Reading Apprenticeship in STEM

A partnership of expertise between the teacher and students . . .

. . . drawing on what content area instructors know and do as skilled discipline-based readers and problem solvers and on students’ unique and often underestimated strengths.
Simple Carbohydrates Include Monosaccharides and Disaccharides.

Monosaccharides are organic molecules made up of carbon, hydrogen, and oxygen atoms. They are the most basic form of carbohydrates and include simple sugars such as glucose, fructose, and galactose. Each monosaccharide consists of one or more carbon atoms, and can be classified as either a ketone (like fructose) or an aldose (like glucose).

Disaccharides, on the other hand, are formed by the linkage of two monosaccharides. Examples include sucrose (table sugar), lactose (milk sugar), and maltose (found in malt and beer). The carbon atoms of the two monosaccharides are joined together by a glycosidic bond, which is a type of covalent bond.

Understanding the structure and properties of carbohydrates is crucial in nutrition and health, as they provide energy and support various biological processes.
Read the text silently as you normally would when you want to understand something. You’ll have about five minutes to read, and then we’ll do a short writing piece afterward.

Please re-read if you finish early.
Capturing your Reading Process

Inquiry Protocol

What did I do?
Where did I do it?
How did that affect my reading and understanding?
Capturing your Reading Process

Debrief

What did you notice about your or someone else’s reading that is new or surprising?

What are some of the benefits and challenges of doing RPA with your students?

What modifications would you make?

How can you begin a metacognitive conversation with students about their own literacy experiences?
Scaffolding for Problem Solving Discourse

Think Aloud Paired Problem Solving (TAPPS)

Starting Question:
What, besides content, do you want your students to gain while in your course?
## Think Aloud Paired Problem Solving Protocol – Role cards

<table>
<thead>
<tr>
<th>The Problem Solver</th>
<th>The Listener</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Read and solve the problem as much as you can on your own.</td>
<td>1. Listen to your partner/s Think Aloud comments and watch your partner’s solution work.</td>
</tr>
<tr>
<td>2. Whenever you read or write, say out loud the thoughts you are thinking to understand and solve the problem.</td>
<td>2. Make notes about your partner’s reading and problem solving processes.</td>
</tr>
<tr>
<td>3. Afterwards, listen to your partner’s report. Then discuss your processes and solution approaches with your partner.</td>
<td>3. Prompt your partner to say aloud his/her thoughts whenever they stop thinking aloud.</td>
</tr>
<tr>
<td>4. Afterwards, tell your partner what you notices about their reading and problem solving processes.</td>
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</tbody>
</table>
# TAPPS

## Metacognitive Prompts:

<table>
<thead>
<tr>
<th>Problem Solver</th>
<th>Listener</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am looking for...</td>
<td>I am confused by...</td>
</tr>
<tr>
<td>I notice...</td>
<td>What might be true is...</td>
</tr>
<tr>
<td>What’s important is...</td>
<td>I predict...</td>
</tr>
<tr>
<td>This reminds me of...</td>
<td>I could try...</td>
</tr>
<tr>
<td>I am thinking about...</td>
<td>An equation I could write is...</td>
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</table>

These prompts are used in TWRAMPS.
The first partner will have three minutes to problem solve.

The listener is to record the strategies used by the solver.

Use the suggestive metacognitive prompts. No HINTS!

Debrief:

What strategies did you notice being used?
TAPPS Second Round Protocol: Switch roles

The second partner will have three minutes to problem solve.

The listener is to record the strategies used by the solver.

Use the suggested metacognitive prompts. No HINTS!

Debrief:
What strategies did you notice being used?

WestEd
Metacognitive text-dense problem solving or troublesome concept understanding

1. **Think-Aloud &/or Talking-to-the-Text**
   - What is unknown? What is equivalent?
   - Translate the situation into mathematical sentences.

2. **Write-Aloud**
   - Re-write, E/I, Draw
   - Rewrite the problem in your own words
   - With the last sentence is a question & connect with prior knowledge

3. **Read-Aloud**
   - Read aloud the original problem in pairs
   - Read aloud the rewrite & discuss
   - Modify your rewrite

4. **Metacognitive Problem Solving Modeling:**
   - Solve & Check

**T.W.R.A.M.P.S. PROTOCOL**

WestEd
Math Anxiety

Alisa has a retirement account valued at $400,000. She would like to earn $30,400 per year. If she invested $120,000 at a 9% account. What rate should she earn in the remainder to achieve her goal?

“Math?” “Word problem?”
Brain: “Sorry, close the door!”
Roger works in King Hand-made Wooden Toy-car shop right next to the AMC Movie Theater in Arcadia Mall. He can make one wooden toy-car in 45 minutes while his supervisor Paul can make the same size of wooden toy-car 50% faster than him. Roger worked for 15 minutes and realized that he had two free movie tickets that would expire in 20 minutes. However, the twin brothers who just ordered a wooden toy-car were waiting in the store to pick up the car. He decided to ask Paul to help him and work together to finish the job earlier, and hoped they could use the two free movie tickets in time. How many more minutes will they need to work together to finish making a wooden toy-car? Will they be able to use the free tickets to watch the movie?
Problem

Mark has a night shift for his work in Mountain Bikes at 8:30 pm. At 6:10 pm he receives a call from his co-worker Tom that he needs him to go to the shop earlier if possible to assemble a high tech bike together for a customer who needs it by 8:00 pm. Working alone, Tom can assemble the same bike in 4 hours while Mark can assemble the same bike twice as fast as Tom. Mark is standing in a line to buy his dinner in a popular dining store with a 50% off promotion on Labor Day. He really likes to help his co-worker Tom, but he has picked his dinner and does not want to miss this promotion opportunity. Though there is a long line, there are five cashiers to serve customers at one time. Mark counts and finds 28 people ahead of him. Once a customer is served by a cashier, it takes about 3 minutes to pay and 2 minute to get the drink. Tom has started assembling the bike since 5:30 pm. When will Mark make to his work place? Will Mark and Tom finish assembling the bike for their customer by 8:00 pm? Remember that he needs to take into account a 20-minute drive from the dining store to his work place, Mountain Bikes.
Let's spend 2 minutes for Think-Aloud

TWRAMPS

Make a prediction, ask a question, clarify something that was confusing, make a comment, make a connection, etc..

What roadblocks did you face?

How did you work through them?
And/or Let's spend 2 minutes for *Talking-to-the-Text* around the problem

**TWRAMPS**

This is an effective alternative to *Think Aloud*

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What did you mark?

How did that help you gain access into the problem?
Let's spend 2 minutes for **Write-Aloud E/I Log**

**TWRAMPS**

On the left, write down what “I notice…”

On the right, write down what “I interpret, I wonder, I made a connect…”

What did you feel about this part?

How did that help you gain access into the problem?
Let’s spend 2 minutes for Write-Aloud Rewriting

- List down important pieces of given information with possible interpretation or connection.
- The last one should be a question sentence.
- Draw a diagram or a table if you like.

TWRAMPS

You may ask students to do either E/I Log or Rewrite

Some students found beneficial to do both

Did you feel more clear about the situation now?

How did that help you gain access into the problem?
Let’s spend 2 minutes for Read-Aloud

TW R AMP

Read-Aloud the ORIGINAL PROBLEM

Read-Aloud your REWRITE

• Read-Aloud the ORIGINAL PROBLEM to your partner clearly and slowly. (Feel differently from the 1st time?)

• Did you overlook any information? Adjust Rewrite.

• Read-Aloud your REWRITE to your partner clearly and slowly.

• Did you overlook any information? Adjust Rewrite.

Did you feel more clear about the situation now?

How did that help you gain access into the problem?
Let's spend 2 more minutes for continued Metacognitive Problem Solving: do Modeling, Solve & Check

Connect with your prior knowledge to choose a right point of view for this situation.

Use your critical thinking skill to find a numerical relationship among the given information.

How to set up the model? Why?

How to solve the model and check?

(May use TAPPS Metacognitive Prompts.

1st partner problem solve, 2nd partner record.

Then switch roles.)
Debrief Metacognitive Routines

Noticing your thinking
"I'm bored."
"I wish he would stop talking."
"I can't get that argument with my mom out of my head."

Focusing on reading
"I lost focus when they introduced some terms I didn't understand."
"Wait...who is this new character? I'm confused."
"There's a lot of information in this word problem...what am I supposed to do here?"

Taking charge of reading
"I'm going to look at the illustrations and figures to see if they help me understand the key terms."
"I need to figure out what this word problem is asking for...I'll summarize it to see if that helps."

Becoming aware of subject area discourse
"Whose point of view is this? Can/should I trust it?"
"How can I translate this problem into numbers and symbols?"
Think the Way Mathematicians Think!
Work the Way Mathematicians Work!

The rewrite step is not just a simple exercise.
It is a way a mathematician approaches a real world problem.

The rewrite step is a way to sharpen your understanding of the problem.
Critical Thinking Log

• How-What-Why Critical Thinking Log
• Action-Work-Reasoning
• For solving equation, simplifying expressions, deriving formulas, proofs, etc.

Critical Thinking Worksheet
Mathematician ________________________________

<table>
<thead>
<tr>
<th>Action</th>
<th>Work</th>
<th>Reasoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>How</td>
<td>What</td>
<td>Why</td>
</tr>
</tbody>
</table>
Other Routines

Metacognitive Videos
- Example

Metacognitive Reading or Video Logs
- I saw/read/heard; I thought/felt/wondered

Think Aloud

Talking to the text
Conclusions

can be applied and adapted in STEM disciplines

can help instructors become more “student centered”

offers instructors insights into their own and their students’ thinking.

Reading Apprenticeship...
Evaluation

1) What were your major takeaways from today’s session? In what ways was it informative or useful?

2) Any remaining questions or comments?
Thank you!

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