Using Reflective Activity to Improve Student Metacognition and Attitudes in Post-Secondary Education

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Square-Finding Activity
How many different-sized squares can you find in this 6 x 6 grid if every corner of the square has to reside at a grid point?
Outline

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- Description of Students
- Literature on Metacognition

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Study
- Types of Metacognitive Knowledge
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Purpose

Instructor:
• Orient students more positively to their mathematical self and to strengthen their abilities in mathematization!

Literature:
• “Students’ epistemological beliefs seem to shape their metalearning assumptions and influence their learning orientations” (Chin & Brown, 2000, p. 113).
• “We need, however, to determine far more precisely what metacognitive knowledge or skill component can be assessed successfully by which method” (Veenman et al., 2006, p. 9).
Description of Students

Affective Axis:
- ~70% dislike, anxiety, phobia, useless
- ~30% appreciation, importance

Cognitive Axis:
- ~30% ‘easy’ math course
- ~70% elementary teacher

Dual Learning Viewpoint:
- Future teacher of elementary students
- Student in this course
Tanner, 2012, p. 116:
Promotes reflective journals in science teaching in order “to explicitly charge students to identify what they are confused about and then to embrace, work on, and wrestle with that confusion as they participate in the learning activities of the course”; and emphasizes that “students will not really learn new information if they do not go through a metacognitive realization that requires them to examine how they thought about the topic before and how they are thinking differently about that topic now”.

Literature on Metacognition
Three fundamental principles are known from the literature for successful metacognitive instruction:

a) embedding metacognitive instruction in the content matter to ensure connectivity,

b) informing learners about the usefulness of metacognitive activities to make them exert the initial extra effort, and

c) prolonged training to guarantee the smooth and maintained application of metacognitive activity.
Description of Course:

- MATH 190 *Principles of Mathematics for Teachers*
- ‘Gateway’ course for teacher education program
- Math content course for elementary teachers
- Q-Course (quantitative)
- Versions:
  - face-to-face: 40-100 students, 2/3 terms
  - online: 25-40 students, 3/3 terms
Reflection Activity

Instructional Sequence:

• **Instructor** provides reflection prompt *(12, 1/wk)*: either a general question about a mathematical concept or related to a mathematical exploration;

• **Student** provides a response by analysing how the concept/exploration is affecting and changing her mathematical perspective along with her knowledge, thinking and learning *(self-graded)*;

• **Instructor** selects one pre-constructed feedback to each student response as support for the metacognitive analysis.
Reflection Activity Sample Prompts

• **Prompt 1:** What do you struggle with the most during problem solving activities? When do problems appear easier to manage?

• **Prompt 2:** Recall the Sisters and Brothers and Hot Dog activities. What – if anything – was challenging for you in these activities?

• **Prompt 12:** Reflect back how you dealt with and felt about problem solving at the very beginning of the term, and share what – if anything – has changed for you, and explain why.
# Feedback Rationale

## Feedback Categories

If a particular feedback characteristic is apparent in the student response then apply that feedback. If none of the feedbacks readily applies, then use exclusion as a selection strategy. The **Breaking Down a Problem** feedback is the default feedback.

## Breaking Down a Problem (default feedback)

How do you go about breaking down a problem? Reading? Re-wording? Applying visualization techniques such as drawing diagrams or sketching out relationships?

### Rationale

- Demonstrates no in-depth or just a tentative analysis of their own thinking and approach to problem solving;
- States detached, too broadly or cliché-like without specific details; or
- Often indicates being challenged by problem solving (where to begin).

### Response Examples

- *With problem solving activities I struggle most with thinking outside of the box in order to figure out the most effective solution. I give up quickly if the answer is not easily found. Problems appear easier to manage if the question is broken into simpler steps.*
- *Sometimes problems appear easier or more straightforward than they actually are and I will overlook a minor detail since I am focusing on the overall concept [...]. Problems appear easier to manage when they are broken down [...]*
- *During problem solving activities, I find it most challenging to get the ball rolling and begin exploring ways to solve the problem. If it does not jump out at me immediately, I tend to quickly move onto the next question [...]*

## Frustrated or Defeated Problem Solver

Thank you for sharing. Feeling frustrated, anxious or defeated during problem solving is not a good feeling. Perhaps taking a break once in a while during problem solving is a good strategy and then coming back to it refreshed. It is always a good idea to grasp the problem through re-reading, perhaps re-wording, or applying some visualization techniques such as drawing diagrams, sketching out the relationships, making a table/list of the quantities involved or representing quantities with real items and acting out the relationships.

### The student:

- Needs to be acknowledged for honestly writing about frustration with mathematics. This frustration overrides any other feedback that may fit as well; or
- Voices frustration or defeat with mathematical problem solving for a variety of reasons (inability to organize thoughts, inability to consider many strategies, inability to identify knowledge, inability to collect information, language barrier, being reactive rather than taking time, lacking patience and persistence).

### Response Examples

- *For some of the questions I came to the right answer but I wasn’t confident I was right or certain. I also had poor grasp of what I was doing or what was going on. I couldn’t come up with alternative ways to solve problems or visualize or explain what I was doing. I knew what to do to get the answer but I didn’t really understand what was going on.*
- *The thing I struggle most with problem solving activities is my self. I am very quick to jump to “I can’t do it.” I easily get confused and automatically shut down. I need to remind myself that I am able to do the question and that I just need to work through it slowly. I have also noticed that I struggle with my lack of knowledge around those activities. I have not done math for a very long time. This also acts as a barrier where I continuously second guess myself and my ability.*
- *When it comes to problem solving, I tend to struggle with organizing my thoughts, and focusing on the steps of the problem in the correct sequence. I find myself jumping to certain parts of the problem that I found easier or can make sense of first, before tackling the more difficult areas. This either works in my favor, or against...*
Audience Reflection Response  
Square-Finding Activity
Types of Metacognitive Knowledge

Planning and monitoring heuristics and strategies:
• task-oriented, specifies or provides detail about a heuristic/strategy that usually involves an action verb

Evaluating heuristics, strategies and self:
• task- and self-oriented

Awareness of knowledge I possess:
• self-oriented

Feelings about self:
• self-oriented
Indicators

represent, reread, rewrite, ...
break down into steps, chunk down, think through, ...

struggle with, have difficulty, do poorly, grow, am likely to, tend to, ...

unable to, able to, easily see, learned, realize, notice, rely on, know, understand, ...

confident, take enjoyment from, despise, unsure, intimidating, frustrating, confusing, shock, helpless, ...

Inter-rater Reliability is 79%
Result – Metacognitive Knowledge

**Prompt 1:** What do you struggle with the most during problem solving activities? When do problems appear easier to manage?

**Prompt 12:** Reflect back how you dealt with and felt about problem solving at the very beginning of the term, and share what – if anything – has changed for you, and explain why.

The phrasing of prompts brings out different types of metacognitive knowledge.
Prompt 1: What strategies did you use while engaging with the square-finding activity?

Prompt 2: How did you feel while engaging with the square-finding activity?
I just wanted to thank you for helping me gain more confidence in teaching math in this course.

After being encouraged to draw pictures and learning other ways to go about the same questions, I still feel that first overwhelming rush, but now I feel much more confident with finding a way to solve the problem, little by little. I have noticed that as the semester has gone on I have gotten more comfortable answering the problem solving questions and seem to be understanding them better.

The reflection activity allows students to bring their feelings about their mathematical ability into the open, and perhaps foster a new relationship with mathematics.
Although the answers may not always be right I am better able to determine and understand the process needed to get to the right answer which I think is more important than the answer itself.

To truly succeed, especially as a mathematics teacher, you need to really slow down and approach a problem in several different ways. [...] I feel much better equipped to help others learn, and to help them through their own problem-solving now.

The reflection activity allows students to verbalize their strategies, but also their general disposition towards mathematics; and perhaps to start questioning their beliefs.
Observations

• Verbalizing one's thoughts and feelings is the first step of metacognition.
• Reflection prompts are an effective instructional strategy to make thinking and learning visible.
• Making learning visible promotes further reflection, learning and metacognition.
• Prompts can be intentionally designed to foster different metacognitive knowledge.
• Confidence can be built up over the course of the term; beliefs are harder to change.
• Petra’s reflection!
References


Thank You!

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