# The Role of Metacognition in Learning and Strategies for Developing Student Metacognition: ASTRO 101 as a test-bed for implementation and assessment

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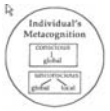
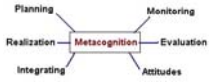
## Metacognition is an emergent and multi-faceted concept.[a]

- Self-awareness
- Self-regulation
- Self-monitoring
- Strategy use
- Motivation
- Attitudes

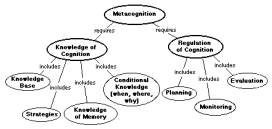
[a]E.g. Brown, 1987; Bjorklund et al., 1990; Dole, Duffy, Roehler, and Pearson, 1991




http://investigations.terc.edu/library/bookpapers/metacognition.cfm

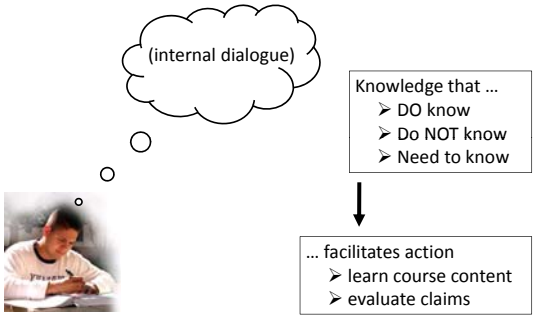



http://members.shaw.ca/donlockwood/critical.htm




http://dwb.unl.edu/Chau/SelfReg.html

## Metacognition refers to thinking about thinking.[a]




[a]E.g. Gredler, 1997

## Metacognition in the context of learning has demonstrated benefits.

- Improved recall of information[1]
- Improved understanding of course material[2]
- Increased ability to transfer understanding to new setting and events[3]

[1]Brown, 1980, Flavel, 1985, 1991
[2]White and Frederickson, 1998
[3]Palincsar and Brown, 1984; Scardamalia et al., 1984; Schoenfeld, 1991

## Explicit metacognitive instruction serves to develop independent, critical, and metacognitive thinkers.

Metacognitive instruction

- focuses on sense-making
- provides ongoing feedback
- models metacognitive processes
- provides prompts to be metacognitive

for the purpose of developing learner independence and adaptive expertise.

National Research Council, 2000

## An attempt at metacognitive instruction was made in an ASTRO 101 course during Fall 2007.

- Geared for non-science majors
- Enrollment of 150 students
- Peer instruction (e.g. paired or small group discussion)

- Clicker technology (classroom response system)

- Learning Assistants (LAs) who facilitate discussion

## An attempt at metacognitive instruction was made in an ASTRO 101 course during Fall 2007.

- The goal was to develop student thinking skills and abilities WRT
  - Thinking about how they study for the course
  - Evaluating "scientific" claims
- A curriculum of explicit metacognitive instruction was embedded into the framework of the regular curriculum for the course.

## Five different strategies constituted the explicit embedded metacognitive curriculum.

- *Explicit*: transparency with students
- *Embedded*: largely content-independent

1. Share and discuss learning goals and course expectations
2. Discuss and work with Bloom's Taxonomy
3. Provide performance feedback and studying advice
4. Discuss connection btw course learning and future career
5. Provide metacognitive practice and feedback

## Strategy 1 Example: Share and discuss learning goals and course expectations.

**The Montillation of Traxoline***

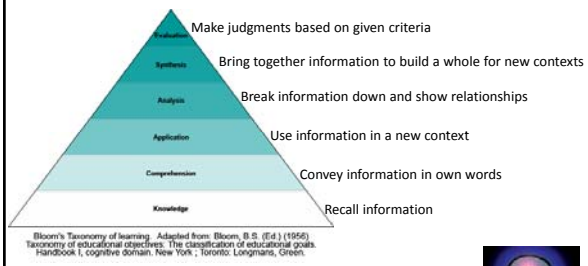
It is very important you learn about traxoline. Traxoline is a new form of zionter. It is montilled in Ceristanna. The Ceristanninans gristerlate large amounts of fevon and then brachter it to quasel traxoline. Traxoline may well be one of our most lukized snezlaus in the future because of our zionter lescelidge.

Directions: Answer the following questions in complete sentences. Be sure to use your best handwriting.

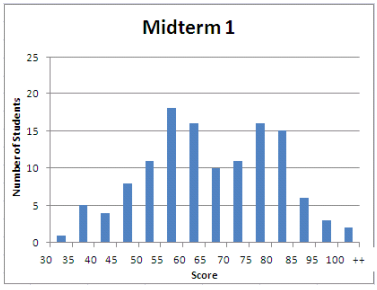
(1) What is traxoline?
(2) Where is traxoline montilled?
(3) How is traxoline quaselled?
(4) Why is it important to know about traxoline?

*Attributed to the insight of Judy Lanier.

## Strategy 2 Example: Discuss and work with Bloom's Taxonomy of the cognitive domain.




## Strategy 3 Example: Provide students post-midterm feedback and advice on how to study.




1. Pre- test
2. Attendance
3. Homework
4. Strategies

## Strategy 4 Example: Discuss learning and how it relates to future career.

If you ask your LA a question, do you prefer that she …

A. Tell you the answer (45)
B. Give you hints so that you can figure out the answer (54)

## Strategy 4 Example: Discuss learning and how it relates to future career.

Which do you think results in more long-lasting learning?

A. When my LA tells me the answer (21)

B. When she gives me hints so that I can figure out the answer myself (78)

## Strategy 4 Example: Discuss learning and how it relates to future career.

Do you expect one day to have a job that requires you to figure things out on your own?

A. Yes (93)

B. No (7)

## Strategy 5 Example: Provide opportunities to practice thinking critically and being metacognitive.

Go to the www or to YouTube, or both. Find two science websites or videos on scientific subjects, one that you think is really good, and one that you think is bogus. If you can find sites related to the science of astronomy, great, but other sciences are fine. For the "bogus" site, I'll be most impressed if you find something that looks credible, but is actually not true.

Write the web addresses or identifying information from YouTube here:

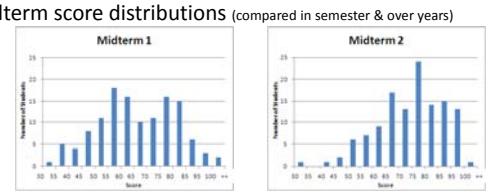
Good site: _____

Bogus site: _____

Now comes the most important part of the exercise. Explain how you decide whether something you read or see on the web is true or false. How did you decide that your bogus site was not telling the truth? Do you apply the same criteria to something you see on TV or read in the paper? Please be thoughtful about your answer, and write it here. Turn this paper in to your learning assistant in recitation.

## Four types of evidence suggest that these strategies positively developed student metacognition.

1. Scenario-based homework and class work (compared in semester)
2. Midterm score distributions (compared in semester & over years)




3. Survey questions about how they think about science and learning science [a]
4. Interviews about evaluating scientific claims and science [a]

[a] Compared with a "control" ASTRO 101 course in same term

## One of the survey questions asked: Has this class changed the way that you think about science?

| Type of Response | No. of Students | |
|---|---|---|
| | Meta* | Reg* |
| I can distinguish good science from bad science and pseudoscience. | 49 | 1 |
| I question the credibility of information more, can find credible sources of information, am able to make more educated decisions, and am less fooled by scams. | 75 | 7 |
| I notice and think about astronomy day-to-day more than I did before (e.g. phases of the moon, shadows, etc.) | 38 | 72 |
| I will continue to learn more about astronomy either on my own (e.g. reading books, using Google, etc.) or by taking another ASTRO course. | 18 | 42 |
| I changed my views about how I see science (e.g. what is known is continuously changing, astronomy is more than memorizing facts). | 23 | 25 |

*n=116 for both classes. Students could provide multiple types of responses.

## A representative student quote sums up the desired impact of the embedded metacognitive curriculum.

**Before taking this class I probably would have believed claims about psychic ability, astrology, and "wonder drugs".** Now I take the quote, "Science is a way of trying not to fool yourself" to heart. …. This affects my life because **now I am able to make more educated decisions ….**

## One of the interview questions asked: … How are [two] different conclusions possible if scientists … use the same data …?

| Type of Response | No. of Students | |
|---|---|---|
| | Meta* | Reg* |
| People see different things in the data, think about the data differently, and interpret the data differently. | 15 | 6 |
| More data, material, or information is needed to narrow down the possibilities to one conclusion. | 4 | 3 |
| People have different opinions. (Note: Also made NO reference to evaluating the data.) | 0 | 5 |
| The data just supports both of the conclusions. (Note: Also did NOT generate explanation for why that would be.) | 0 | 7 |
| Miscellaneous | 5 | 1 |

*n=20 for both classes. Students could provide multiple types of responses.

## The strategies used in the embedded metacognitive curriculum seem to have positively affected the development of student metacognition.

1. Implemented regularly
2. Made explicit what would otherwise be internal dialogues
3. Discussion-based strategies took 5-10 min
4. Focused on feedback on the quality of student thoughts, actions, and evaluations
5. Transferable to other courses

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