Enhancing metacognition in general chemistry

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Introduction

Self-regulated learning encompasses how students approach their learning, do their work, and evaluate their processes. It brings together cognitive strategies, metacognition, and motivational beliefs.[1] A recent meta-analysis showed that metacognitive strategies have the largest effect size on academic performance, and active learning combined with teaching metacognitive strategies improves performance in general chemistry.[2,3]

Strategies to improve and enhance metacognition were introduced in synchronous, online general chemistry 1 and 2 courses in three semesters: Spring 2020, Fall 2020, and Spring 2021.

Cycle of Self-Regulated Learning

Metacognitive Strategies Implemented

1. *Brainstorming sessions*

- Beginning of class for approximately 5 minutes
- Students responses were recorded by the instructor on an electronic whiteboard
- Example prompts

  "What is one thing you remember from our last class?"

  "Can anyone build off of what (student) said?"

  "Is there anything you can add based on what you did for lab?"

2. *Process reminders and strategies written for teams on collaborative whiteboards*

- Examples

Invite others to talk, rephrase what your teammates say, show all work, explain your thought process to others, ask questions, and write throrough answers. It's how you learn! Answer all CTQs in your workbook. Put the answers indicated on the Jamboard.

Discuss, collaborate, question, elaborate

Today, work on your critical thinking skills. That means, when you state an answer, have a reason to support your answer. Work on articulating your thoughts in a thorough manner orally and in writing. You got this!!

3. *End of class metacognition*

- Responses collected via google docs
- Example prompts

  "What was the most important concept you learned?"

  "What is an insight you've had about learning or about chemistry this semester?"

4. *Reflector reports*

- Completed after class through the learning management system (1 report per team)
- Questions address
  - Specific process skills
  - Individual or team concerns (content or process
- Exam-wrappers (4 tests per semester)[3]
  - Reflections on preparation (pre-test), performance (post-test) and strategies going forward

5. *Study guide assignment*

- Due evening before exam
- Provided with a rubric with criteria and ratings
  - Description of major concepts
  - Sample problems
  - Lab concepts are addressed
  - Quiz material
  - Presentation

Implications and Questions Raised

1. Students commented favorably about starting classes with a review
   - *With face-to-face classes, better to do "brainstorming" in teams, then report out*
2. Do written reminders about process improve students' process skills?
3. How do instructors better "teach" the skill of metacognition?
4. End of class metacognition responses revealed misconceptions, substantial differences in understanding and ability to identify the "most important" concept
   - *What interventions might help students focus on the main objectives?*
   - *Would tracking student responses across the semester provide useful information?*
5. Study guides not perceived as a strategy for learning, but as a "grade"
   - *How can this be conveyed as a strategy for improving performance?*

References

1. VanderStoep et al. *Contemporary Educational Psychology* **21** (1996)
2. Theobald, *Contemporary Educational Psychology* **66** (2021)
3. Mutambuki et al. Journal of Chemical Education **97** (7) (2020)
4. Ambrose et al. *How Learning Works : Seven Research-Based Principles for Smart Teaching*, John Wiley & Sons, Incorporated, 2010. ProQuest Ebook Central, https://ebookcentral-proquest-com.proxy.library.vcu.edu/lib/vcu/detail.action?docID=529947.