

Expression of Metacognition in Online STEM Courses: Functions and Effects

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Overview

Background: Metacognition is a valuable tool for learning, especially in an online setting, due to its role in self-regulated learning. This awareness may be especially crucial for students who face barriers and difficulties in academic settings. Here we investigate one such group: college students underrepresented in STEM (UR-STEM) in the context of an online STEM course. However, past research on metacognition has rarely looked at spontaneously produced metacognition in online settings. The online setting brings a new challenge of examining this on a large scale.

Method: We first created a tool for automatic detection of metacognitive language from text. We used this tool to analyze text from one forum of an introductory online, university-level science course. The tool exhibited high accuracy and thus provides a reliable, fast method for automatically annotating text corpora that are too large for manual annotation. We used linear regression to analyze the relation between students' metacognitive language and their academic performance. Confident versus unconfident metacognition and its relation to final exam scores were analyzed through a linear regression. Differences across demographic groups were analyzed using t-tests.

Results and Discussion: Although use of metacognitive language was significantly related to academic performance, no differences were found between UR students and other students. The results suggest that self-regulation in online courses, as indexed by metacognitive language, predicts positive outcomes equally for students from all groups. Implications of the results for teaching and learning STEM content in the online space is discussed.

Background

- Some students are vastly underrepresented in STEM. As an example, with 29.3% of U.S. population from underrepresented racial and ethnic minorities ("URMs": African American, Hispanic/Latinx, or Native American), only 15% of bachelor's, 13% of master's and 8% of doctoral degrees in STEM are awarded to these students (Estrada et al., 2018).
- URM students are flocking to online courses at greater rates than ever before (Gregory & Lampley, 2016).
- "Online learning has the potential to be a democratizing force in higher education; however, to meet this potential, it must not only improve access to college courses among traditionally underserved students, but it must also support the academic success of these students" (Xu & Jaggars, 2014).
- BROAD GOAL OF THIS PROJECT:** to examine successful behaviors of UR-STEM students in online STEM college courses.
- What behavior to target?** METACOGNITION, as a crucial type of self-regulated learning:
 - Self-regulation is important for success in online learning.
 - Metacognition differentiates between successful and low-performing students (Stanton, Neider, Gallegos, & Clark, 2015).
- Are all metacognitive behaviors functionally equivalent?
 - According to Kruger & Dunning (1999): no.
 - A positive assessment often reveals a bias to overpredict success
 - A negative assessment often reveals a hyperawareness of what you don't know
 - Negative metacognitive judgments stimulate additional studying, leading to success; positive metacognitive judgments do not.

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Research Questions

- RQ1:** What is the relation between students' spontaneous production of metacognitive comments and their final exam score?
- RQ2:** Does the relation between students' spontaneous production of metacognitive comments and their final exam score differ based on the production of confident (positive) versus unconfident (negative) metacognitive language?
- RQ3:** Do similar patterns hold true between UR- and non-UR-STEM students?

Method

Data Source:

13,372 forum posts from 205 students enrolled in an 8-week science course

Student Demographics:

- 30 ethnic minorities
- 51 females
- 32 first generation

Automatic Detection of Expressing Metacognition in Forum Posts:

Rationale and Explanation of Tool:

- Previous work has relied on time-intensive methods (e.g., post-activity inquiries, self-report) not appropriate for these data.
- Therefore, we (Huang, Valdiviejas, & Bosch, 2019) developed a computational tool that automatically flags metacognitive language and codes comments as *unconfident* (e.g., doubting understanding) or *confident* (e.g., endorsing understanding).
- The tool exhibits excellent reliability with human annotation (linear-weighted Cohen's Kappa = .82 for confident cases and Kappa = .82 for unconfident), with more than 1,000 online forum posts coded by expert-level humans.

Coding Examples:

Confident:

- I...believe, think, know, figure, consider, decided, felt, am curious, notice, wonder, imagine

Unconfident:

- I...am unsure, don't know, confused, uncertain, skeptical, forgot, misunderstood

Statistical Models

Linear regression, with total metacognitive comments (independent variable) explaining final exam score (outcome variable).

Linear regression confident and unconfident metacognitive comments explaining final exam scores.

t-tests: three tests, with two independent samples (UR and non-UR students), comparing group differences (means) for (1) unconfident, (2) confident, and (3) total metacognitive comments.

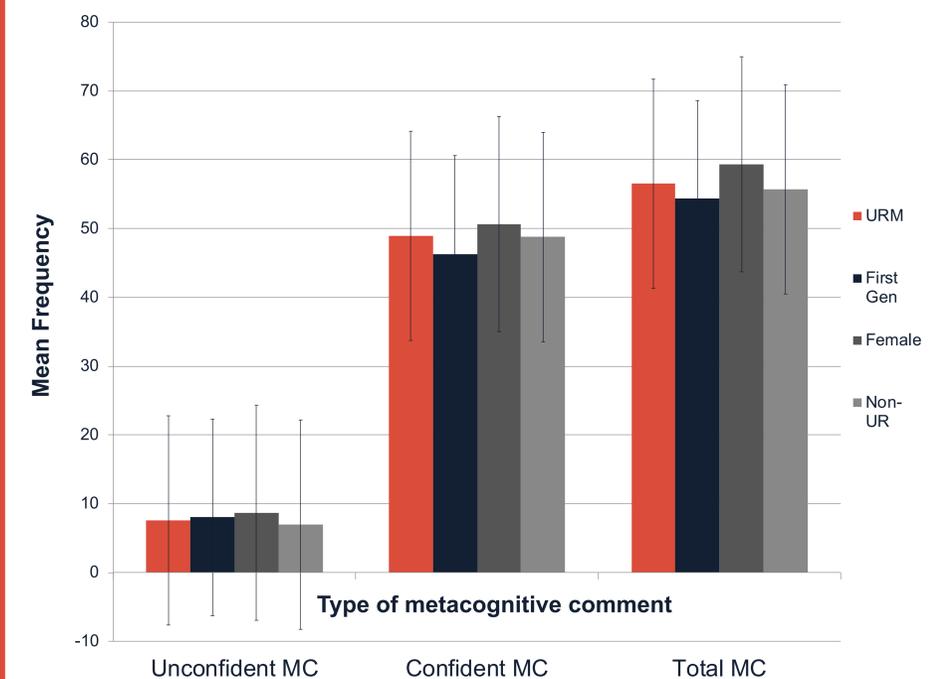
Results

Descriptive Statistics

- Students produced a total of 11,600 metacognitive comments in 7,040 posts.
- On average, we found 2 metacognitive comments per post:
 - 87% of these were classified as confident and only 13% as unconfident.
- Average number of metacognitive words per student = 56 (s.d. = 24).

Results

- RQ1:** Students who used more metacognitive comments got significantly higher final exam scores $F(1,203) = 8.88, p = .003$.
- RQ2:** We did not find a different relation between confident (positive) and unconfident (negative) metacognitive language. This is likely the case because these were highly correlated ($r(203) = .49, p < .001$).
- RQ3:** We did not uncover a relationship between UR- or non-UR-STEM student and their production of metacognitive language, as shown in this figure:



Discussion

- Metacognition:** Students who demonstrate more metacognitive language in forum posts are more likely to have higher grades on their final exam. This suggests that self-regulation, as expressed through metacognitive language, may support student learning in the online space.
- Dunning-Kruger effect:** We found no evidence of the Dunning-Kruger effect: confident and unconfident metacognitive language (which was rare) were strongly related, thus potentially overwhelming the Dunning-Kruger effect.
- UR-STEM Students:** We found no evidence of differences between any of the groups identified for this investigation. This suggests that the online space may allow these students full access to learning opportunities, in ways not typically seen in traditional face-to-face college STEM classes.
- Future Direction:** Expand to different courses.
- Implications:** By understanding metacognition's role in the online space via students' self-produced forum posts, researchers can create effective and inexpensive learning interventions in the online space in the form of early detection of information. The automatic detection tool has great potential for educational purposes, like expanding the algorithm to equip instructors with the ability to detect promotions of successful learning experiences.