

Embedded Reporting or Frequent Metacognitive Reporting in Chemistry

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Background - Metacognition



- J.H. Flavell (1979) defined metacognition as “***knowledge and cognition about cognitive phenomena***”.
- Currently generalized to “***thinking about your own thinking***”.
- Explicitly teaching students about metacognition – being aware of one’s thinking and reflecting on one’s experiences – as tool to improve learning of STEM is well documented in the literature.

Consensus: Metacognitive interventions effect positive student outcomes in 1st year chemistry coursework (exam scores, final course grades, self-efficacy, STEM retention).



Flavell, J.H. Metacognition and Cognitive Monitoring: A New Area of Cognitive-Developmental Inquiry. *Am. Psychol.* **1979**, 34 (10), 906-911.

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Graham, K.J.; Bohn-Gettler, C.M.; Raigoza, A.F. *J. Chem. Educ.* **2019**, 96, 1539-1547.

Mutambuki, J.M.; Mwavita, M.; Muteti, C.Z.; Jacob, B.I.; Mohanty, S. *J. Chem. Educ.* **2020**, 97, 1832-1840.

Pertinent Research Student Voice and Student-Instructor Relationship

- Chickering and Gamson (1990) publicized the benefits of encouraging “***student-faculty contact***”.
- Christe (2013) calls for instructors who are “***accountable to students***” and hold “***high standards as caring and compassionate educators***”.
- Hampton & Blythman (2006) indicate that ***anonymity in reporting*** may overcome the student-instructor power dynamics inherent with formative feedback.
- Seale (2010) promoted “***listening to and valuing the views that students express regarding their learning experiences***”.



Chickering, A.W.; Gamson, Z.F. *New Dir. Teach. Learn.* **1999**, 80, 75-81.

Christe, B. *J. STEM Educ.* **2013**, 14 (3), 22-26.

Hampton, D.; Blythman, M. In *Researching Foundation Degrees: Linking Research and Practice*; Beaney, P., Ed.; FDF Publications: London, **2006**.

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Broad Goals of Weekly Metacognitive Reporting in *Intro Chemistry (in Fall 2022)

- Provide students with
 - frequent, scaffolded opportunities for metacognitive practice (implicit practice)
 - anonymous, student voice on course functioning
- Provide instructors with frequent formative feedback to enable just-in-time course and teaching modifications
- Improve student-instructor contact (and students' view of instructors as beneficent)



*Intro Chemistry (CHEM 110) - Large-enrollment (10 sec., 5 instructors, 628 stud.), 2-credit course. No associated lab. Prep course for Gen Chem 1.

Student Name:			Student Email:	
Instructor Name:			Instructor Email:	
Course Name/No.:			Report for Week of:	
Weekday	Hours Devoted to Attending Lecture	Detailed list of your lecture attending activities during the past week.	Hours Devoted to Additional Study	Detailed list of your additional study activities during the past week.
Sunday				
Monday				
Tuesday				
Wednesday				
Thursday				
Friday				
Saturday				
Identify content topics that you feel you have mastered ^d during the past week.				
What about these topics helped you to master them?				
Identify content topics that you feel comfortable with ^e from the past week.				
What about these topics is still fuzzy and is impeding your ability to master these topics? What will you do to improve your understanding of these topics?				
Identify those course content topics that you find totally confusing ^f from the past week.				
What about these topics is confusing and why? What will you do to improve your understanding of these topics?				
If you could tell your course instructor of one thing that helped you learn this past week, what would it be?				
If you could tell your course instructor about one thing that could improve your learning this past week, what would it be?				

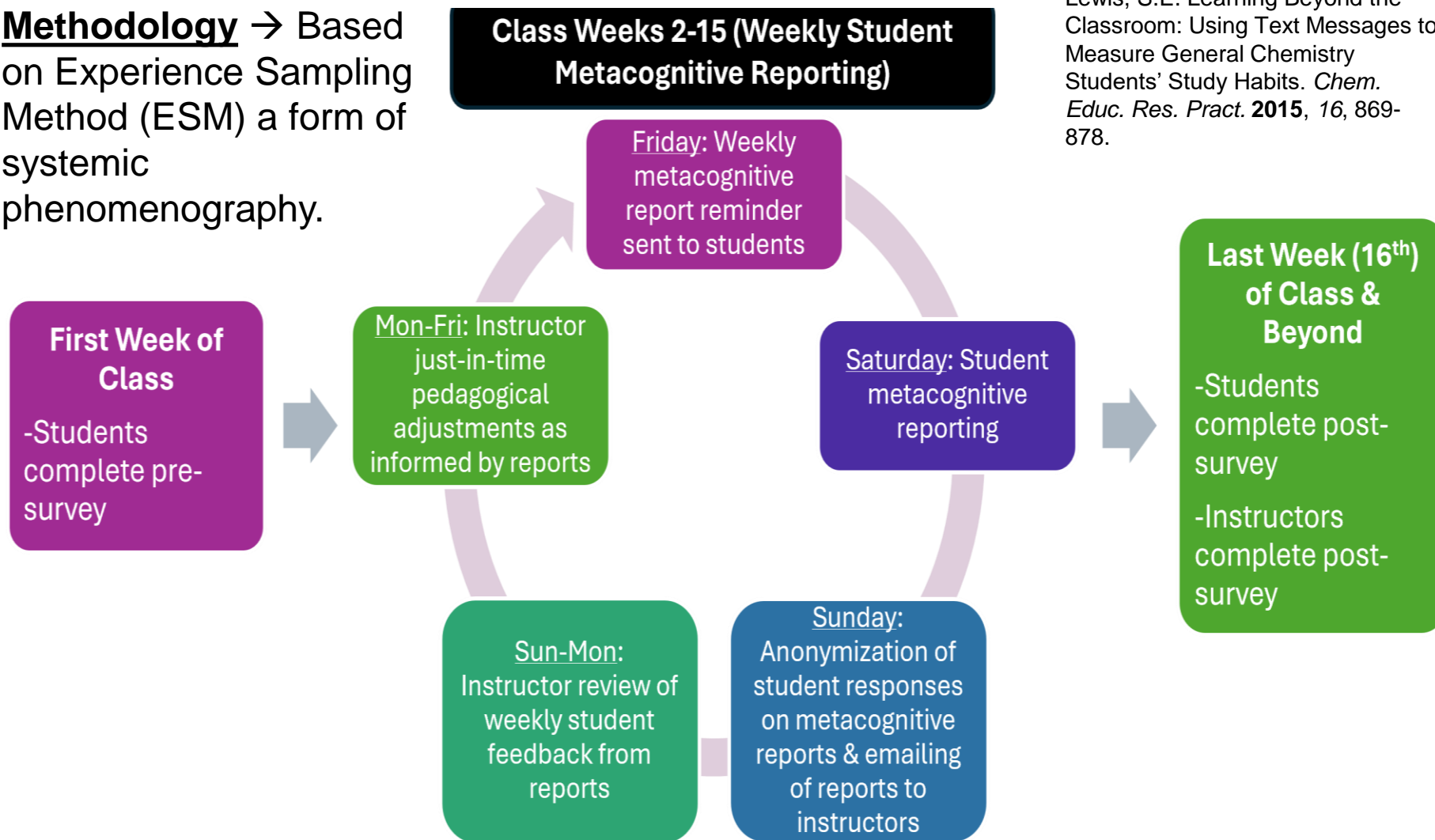
^dMastery implies that you feel you could "teach" the topics to a fellow student.

^eComfortable implies that you feel you understand the topics, but are not yet ready to "teach" these topics to a fellow student.

^fTotal confusion implies that you feel you do not understand the topics and would have trouble answering questions on these topics.

Overall Design

Methodology → Based on Experience Sampling Method (ESM) a form of systemic phenomenography.

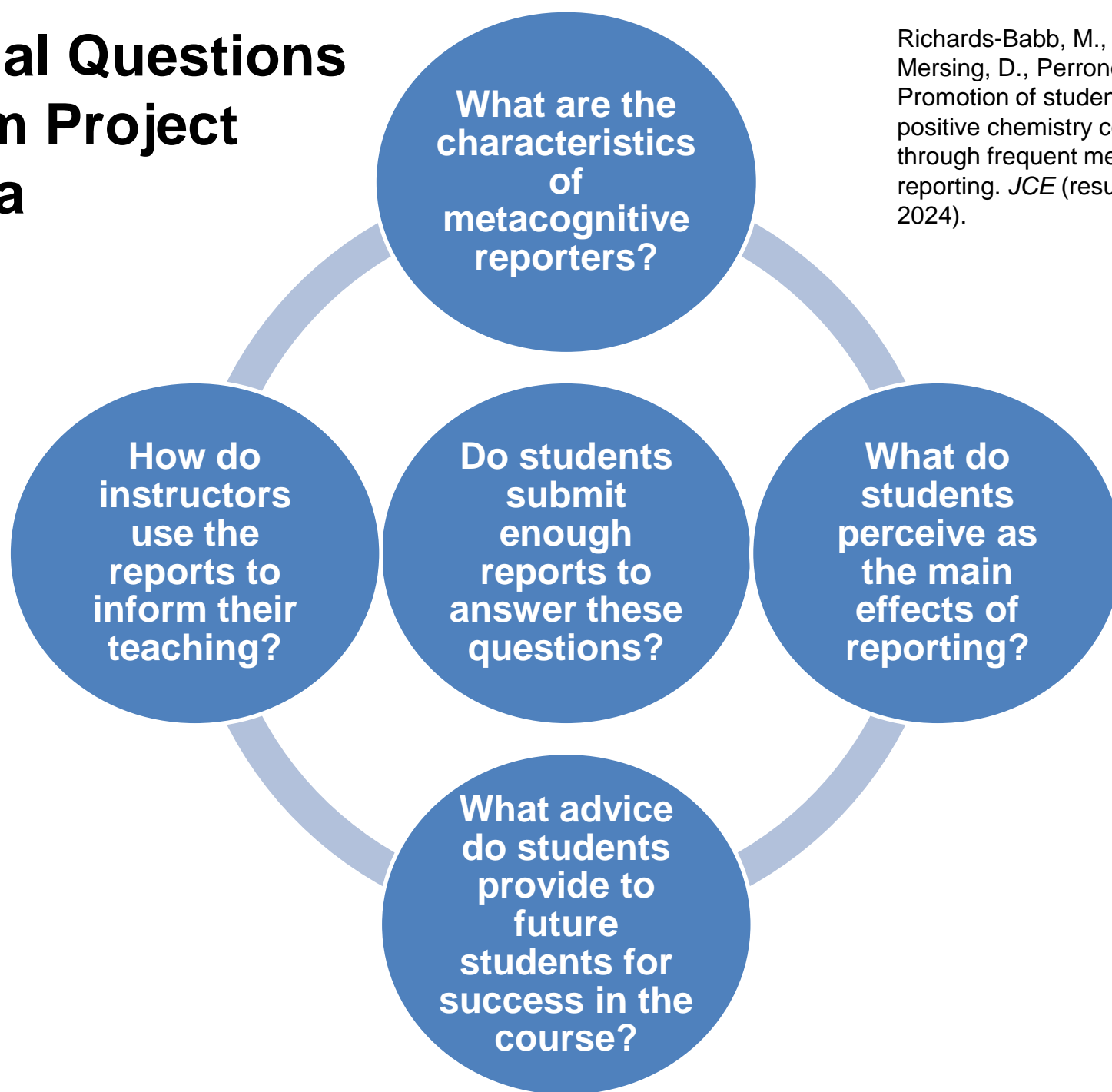


Ye, L.; Oueini, R.; Dickerson, A.P.; Lewis, S.E. Learning Beyond the Classroom: Using Text Messages to Measure General Chemistry Students' Study Habits. *Chem. Educ. Res. Pract.* **2015**, *16*, 869-878.

The WVU Institutional Review Board (Office of Human Research Protections) approved this research (IRB Protocol # 2101212046).

Initial Questions from Project Data

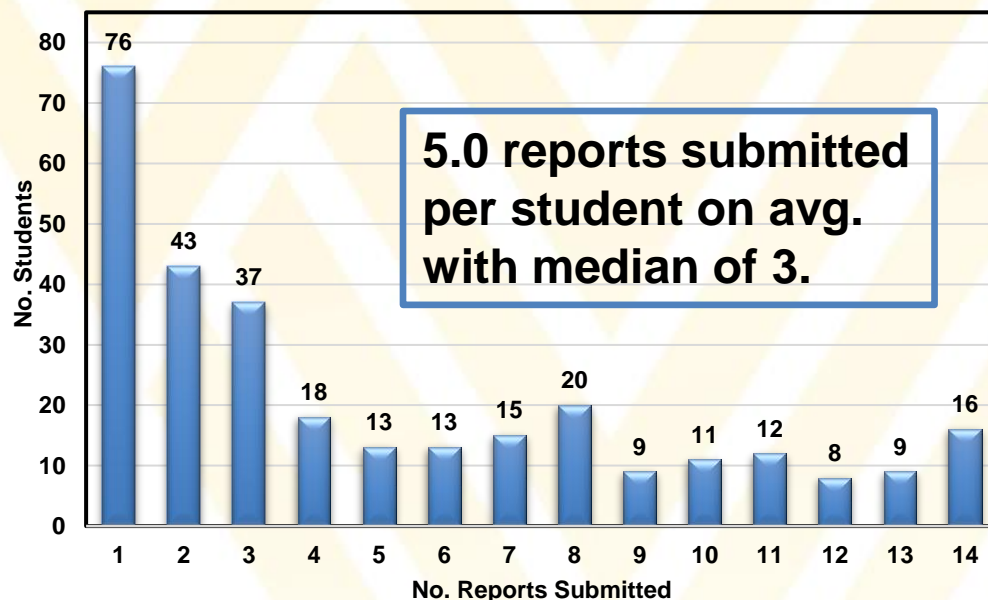
Richards-Babb, M., Gordon, C., Mersing, D., Perrone, T., Ratcliff, B. Promotion of student success and positive chemistry course perception through frequent metacognitive reporting. *JCE* (resubmitted as of July 2024).



Students Engaged in Metacognitive Reporting for Extra Credit in Intro Chem!

Fall 2022: Intro Chem Participant Data	Numbers that Engaged in Embedded Project
No. Sections	10 of 10 sections
No. Instructors	5 of 5 instructors
No. Students Submitting Metacog. Reports (1 or more)	300 of 629 (47.7%)

247 Pre-Surveys Submitted (39.3%)
 1,513 Weekly Reports (~108/wk)
 123 Post-Surveys Submitted (19.6%)



Extra Credit? Instructors offered **0.375 pts** added to final exam score for each report/survey submitted. Max pts? $0.375 \text{ pts} \times 16 = 6 \text{ pts}$, worth 25% of final letter grade (or **1.5 pts max**). Mean pts earned? **0.51 pts** ($M = 5.4$ reports/surveys submitted)



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Metacognitive Reporters Were More Successful Than Non-Reporters in Intro Chem!

Fall 2022: Intro Chem Student Population (excludes students who withdrew/W)	No. Students	Mean Grade Point Average (GPA)	No. ABC Letter Grades (%)
Reporting Students (Submit 1 or more metacog. reports)	262	3.00 ± 0.95	245 (93.5%)
Non-Reporting Students (Submit zero metacog. reports)	269	2.36 ± 1.22	210 (78.1%)

- Mean GPA is significantly higher (by 0.64 GPA points) for reporters than for non-reporters ($t(529) = 6.6652, p < 0.05 (\eta^2 = 0.077, \text{medium effect size/strength of association})$).
- Success (ABC letter grade attainment as proxy) is significantly higher (by 15.4%) for reporters than for non-reporters ($X^2(1, N=531) = 25.815, p < 0.05, V = 0.22, \text{small to medium effect size}$).



Limitations: Causative direction (Are successful students more likely to submit more metacognitive reports?) and small-medium effect sizes.

Equivalency of Student Groups: Reporters vs. Non-Reporters

- Groups were relatively equivalent in college entry indicators.
- Significantly more female students engaged in reporting (64.0% vs 45.1%, $X^2(1, N=628) = 22.490, p < 0.05, V = 0.19$). Aligns with Harrison et al.
- On average, reporting students of both genders had significantly higher course GPAs than non-reporting students.

Intro Chem Student Population	Female – Mean Course GPA	Male – Mean Course GPA
Reporters	2.59 (<i>n</i> = 192)	2.66 (<i>n</i> = 108)
Non-Reporters	2.10 (<i>n</i> = 148)	1.81 (<i>n</i> = 180)
Statistics	+0.49 (<i>t</i> (339) = -3.19, <i>p</i> = 0.002 (η^2 = 0.03))	+0.85 (<i>t</i> (287) = -5.31, <i>p</i> < 0.001 (η^2 = 0.09))



Intro Chem Student Perceptions of Reporting Were Varied But Overall Positive ($n = 117$)

Students modified study habits/methods (72%)

"...helped me realize my study habits and improve them by seeing how many hours I was studying during the week."

"...professor...took classes suggestions into consideration and implemented tools to help us during class"

Students observed instructors responding to reports (20%)

Students perceived positive impacts on grades/performance (10%)

"It allowed instructor to review concepts that we understood the least. It really helped on exams."

"...made for an improved class experience as it tailored it more to our needs."

Students perceived improved student-instructor interaction (9%)



Post-survey Question: Did you think about or do anything differently that you would attribute to the reporting? Did writing your reports affect how you studied for your CHEM 110 or other STEM math and/or science classes?)

Intro Chem Instructors Reviewed Weekly Metacognitive Reports and Made Adjustments

Instructors ($n = 4$) on average indicated:

- they read over ~87% of embedded reports,
- used feedback to make ~4.5 instructional adjustments,
 - Additional review of significant figures
 - Provided answer keys to extra practice problems
 - Modified the lighting and sound in the classroom
 - Addressed comments on the class pace and encouraged use of posted slide outlines (notably, did not reduce content coverage)
 - Implemented “problem-solving/review days” before major assessments
 - Stopped presentation of new material and retaught a critical topic



Intro Chem Instructors Valued the Metacognitive Reports

Beyond instructional adjustments, instructors indicated that the reports provided:

[student voice] “By answering questions (sic) and addressing ideas from the surveys in class my students felt heard. They knew I was reading them and taking time to listen and work to answer their concerns about the material.”

“A general idea of what students thought of the material and how much students were working beyond the classroom sessions.”



[student voice] “Students [were] very very appreciative that they were allowed this means of anonymous feedback, especially on the days that I explicitly told them that I was responding directly to their comments.”



Conclusions

- A modest amount of extra credit incentivized students to submit metacognitive reports.
- Metacognitive reporters earned significantly higher final course grades than non-reporters but with small to medium effect sizes and no information on direction of causality. However, this aligns with research by Casselman et al. (2017) and Hawker et al. (2016).
- Female students engaged in metacognitive reporting at a higher rate than male students and reporting students of both genders received higher course grades.
- Students were generally positive about the effects of reporting and indicated modification of study methods and improved student-instructor interactions.
- Instructors skimmed the reports and used student-voiced feedback to make instructional adjustments.



Acknowledgements

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- the 5 instructors (all of whom agreed to receive the weekly reports).
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