

Using a Learning Management System for Exam Wrapper Feedback to Prompt Metacognitive Awareness in Large Courses

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Abstract: An exam wrapper is a reflective exercise completed after an exam, designed to help foster students' metacognition and self-regulation. Typical exam wrappers ask students how they studied, what they missed and why, and how they would change their study behaviors to improve on the next exam. In small classes, exam wrappers can be administered as paper documents, with instructors providing feedback in writing or through one-on-one appointments. In large classes, however, this approach can be unrealistically time consuming. In this article, we describe the design and use, in a large introductory chemistry course, of an online exam wrapper administered using our institutional learning management system's test tool. This tool allows the instructor to provide automated, targeted feedback based on students' responses. We analyzed the effect of this tool on students' course outcomes and on their metacognitive awareness as measured by the Metacognitive Awareness Inventory (MAI). For first-year students, despite low completion rates of the wrapper, course grade was significantly related to exam wrapper use, independent of several academic variables. MAI scores were not related to exam wrapper use. We discuss the effect of multiple metacognitive awareness opportunities provided by the instructor, including the exam wrapper, on students' performance in the chemistry course. In large courses such as this, the success of this online exam wrapper may depend on providing both incentives for students to complete it and additional support for students to develop the metacognitive awareness to appreciate its value.

Keywords: Blackboard, instructor feedback, STEM, chemistry, student reflection.

In the first edition of their book, *Effective Grading*, Walvoord and Anderson (1998) parsed student learning into three major phases: *first exposure* to content, *processing* of those ideas, and *feedback* on understanding and skills developed. Of these phases, first exposure (e.g., lectures, readings, or videos) and feedback (e.g., comments on exams or papers, rubrics, or one-on-one meetings) are often the main responsibility of faculty. Generating meaningful feedback that students will actually access and learn from can be particularly challenging and time intensive. Instructors of large lecture courses, especially, face the challenge of providing adequate feedback without it consuming an inordinate amount of time. Yet feedback can support students by identifying their mistakes, teaching them to question their understanding, and contributing to their confidence by scaffolding their learning. Providing feedback is critical in any course in which content builds on an understanding of earlier topics, because if students do not learn from their early mistakes, they may be unable to recover and achieve a passing grade. Framing this feedback so that students see these early mistakes not primarily

as evidence of their inability to learn, but rather as part of a natural process of learning can be instrumental in helping students persevere in the face of challenges (Dweck, 2006).

Ideally, instructor feedback encourages students to reflect on their own learning processes and become more metacognitive and self-regulating. A learning management system (LMS) can be a useful tool for reaching out to students with feedback and encouragement based on the instructor's knowledge of typical mistakes and misunderstandings. It is also useful for communicating with students about, and encouraging them to use, resources and support services that can help them be more successful. In this article we discuss using an LMS as an efficient way for instructors in large classes to provide feedback to students on their exam performance via exam wrappers.

Exam wrappers are exercises students complete after an exam that ask them to reflect on their performance (Ambrose et al., 2010; Lovett, 2013). Many different forms of exam wrappers are available (Eberly Center, 2016), but typically the wrapper asks students how they studied for the exam, what kinds of questions they missed and why, and how they would change their study behaviors to improve on the next exam. Such an exercise prompts students to think critically and constructively about their performance, guiding them to be more metacognitive and plan more successful approaches in the future. Results of research on the effects of using exam wrappers on students' course performance and/or metacognitive awareness are mixed (Kustritz & Clarkson, 2017; Lovett, 2013; Rosales et al., 2019; Soicher & Gurung, 2017; Trogden & Royal, 2019). Teaching metacognition to students can have a positive impact on their performance (Cook et al., 2013; Zhao et al., 2014). Thus, teaching students about metacognition may play a role in the effectiveness of the exam wrapper tool.

Exam wrappers may not only help students understand their own approach to learning but also provide instructors with insight into students' thought processes. These responses can guide an instructor in offering feedback that contributes to the wrapper's effectiveness (Gezer-Templeton et al., 2017; Lovett, 2013). Traditionally, instructors assign exam wrappers, collect them, and provide students with some feedback or encouragement based on their responses. They may even allocate participation points for completing them, further validating the value of the task. Instructors are then encouraged to save them for students (ensuring they do not get lost) and redistribute them for their students' use before the next exam. This method works well in moderate-size classes, but in large classes of 100 students or more, the paper management and feedback load implications can be too overwhelming for instructors.

One of the authors, who teaches Introductory Chemistry at this university, discovered that the struggles identified by students after exams followed fairly predictable patterns. In an effort to provide more students in this large lecture course with an opportunity for interactive reflection and feedback, this instructor developed an online exam wrapper using the university's LMS. This new tool allowed for more individualized communication with students and captured typical faculty–student questions and responses in an automated format. The tool also permitted students who might be too anxious to ask for an appointment with the instructor to get advice about their learning strategies. The online format did not require the use of class time or the instructor to read each reflection. Rather, it provided a summary of responses that could be insightful for the instructor in determining how to follow up with the class as a whole.

In this study, we explored whether students' use of the exam wrappers was related to their metacognitive awareness and course performance. Online exam wrappers were administered in the fall 2017 term in a large introductory chemistry course. Students were also asked to complete the Metacognitive Awareness Inventory (MAI; Schraw & Dennison, 1994) at the beginning and end of the term. The MAI allowed them to self-assess their knowledge about cognition and their own regulation of it. We examined the data for students' use of the exam wrappers, their metacognitive awareness, and whether either of these variables was related to performance in the course.

Methods

Course Context and Structure

This study was conducted in the United States at a mid-size public research university designated as a minority-serving institution. Introductory chemistry at our institution serves students majoring in the sciences and some engineering fields, as well as those interested in a premedical track. In the fall semester of 2017, the course consisted of three sections with a total enrollment of over 800 students. The course was taught using a flipped, structured, active learning approach including online homework (ALEKS, 2020), reading quizzes (Hodges et al., 2015) and clicker question activities in class (Hodges et al., 2017). Students were also required to enroll in smaller weekly discussion sections (Ott et al., 2018) modeled after process-oriented guided inquiry learning (Moog & Spencer, 2008).

The instructor used our institution's LMS, Blackboard Learn 9.1, not only to provide exam wrappers but also to post course materials such as handouts and lecture slides. The ebook and online homework systems—Connect/LearnSmart (McGraw Hill, 2020) and ALEKS (2020), respectively—were integrated into the site. A discussion board was used as a place for students to post questions about the course or content. This was monitored by the instructor but did not impact student grades. Blackboard Collaborate was used weekly to host virtual office hours. Blackboard was also used exclusively to post announcements and contact students with announcements.

Exam wrappers were part of a larger effort that focused on enhancing students' metacognitive awareness. A 50-min interactive lecture on metacognitive learning strategies was given by the instructor after the first exam using the template provided by McGuire (2015). The MAI, which was completed at the beginning and end of the course, provided suggestions that had potential for influencing students' behavior. Students were also given the opportunity to create study guides prior to each exam. Those who created and uploaded their study guide were granted access to the instructor's version of the guide via the adaptive release function of the LMS.

Design and Implementation of the Exam Wrapper

The wrapper was administered using the LMS testing tool. The reflection was optional but was created as a graded assignment so that the system's feedback feature could be used. The instructor drew from questions about students' exam study habits that she typically asked students in a one-on-one conversation and coupled them with multiple-choice options. These choices included the ideal student response as well as responses that captured typically less successful approaches students employed. The reflection was designed to mimic the experience a student had when meeting one-on-one with the instructor. There were nine items on the wrapper with multiple choice or multiple selection options for each question (Figure 1).

1. Did you feel that you were prepared for the exam?
 - a. Yes
 - b. No
2. Which of the following did you do to prepare for the exam (select all that apply)?
 - a. Read before coming to class.
 - b. Came to class.
 - c. Actually thought about the clicker questions and not just get answers from those around me
 - d. Did recommended problems from the end of each chapter.
3. Do you use ALEKS and LearnSmart as learning tools or do you just finish it as fast as possible to get the points?
 - a. I use ALEKS and LearnSmart as learning tools. I use the textbook to determine why I am getting questions wrong and work to understand the questions.
 - b. I do the assignments as fast as I can without reading the textbook or minimally reading the textbook.
4. How many of the instructor's recommended problems (from the list on the handout) do you do from the end of each chapter?
 - a. 0–20%
 - b. 20–40%
 - c. 40–60%
 - d. 60–80%
 - e. 80–100%
5. Did you miss any exam questions due to not reading the question carefully or making a mistake such as not paying attention to units? Take care in answering this question; if you made a mistake because you didn't really understand at the time, even if you understand now, that is not a careless mistake.
 - a. Yes
 - b. No
6. What was the main reason you missed questions on the exam?
 - a. I wasn't able to identify the appropriate concepts.
 - b. I was able to identify the appropriate concepts, but I didn't understand them well enough to use them.
 - c. I was able to identify the appropriate concepts, and I thought I understood them, but I applied them incorrectly.
 - d. I was able to identify the appropriate concepts, and I was applying them correctly, but I made a careless error or a math mistake.
7. Which type of question did you miss the most?
 - a. Calculation questions
 - b. Concept questions
 - c. I missed some of both.
8. Do you know all of the ways that you can get help in the course?
 - a. Yes
 - b. No
9. Do you feel that you have made a good assessment of your learning habits and know how to adjust your approach?
 - a. Yes
 - b. No

Figure 1. Exam wrapper questions and multiple choice/multiple selection options.

The ideal student response was coded as “correct” and delivered feedback that affirmed the action and offered additional support. All other responses were deemed “incorrect” by the system and triggered feedback the instructor had composed that suggested ways the student could improve their learning skills (for examples see Table 1). Students could complete the exam wrapper after each of the four in-class exams. Exam wrappers remained available to students all semester so that they could refer back to the instructor’s feedback at any point.

Table 1. Examples of instructor feedback from exam wrapper questions.

Question	Response	Correct or incorrect?	Feedback
Did you feel prepared for the exam?	Yes	Correct	Okay, let's figure out why you did not get the score you expected or were hoping for.
	No	Incorrect ^a	If you did not feel prepared, then you likely did not put enough time into learning the material for the exam. Continue for more tips.
How many of the instructor's recommended problems (from the list on the handout) do you do from the end of each chapter?	80–100%	Correct	Great! You are doing a lot of practice problems which is great for learning! It is a good idea to do all of the recommended problems. Another guideline is to do all of the "Review Questions" at the end of each chapter, at least half of the "Problems" and as many of the "Additional Problems" as you can. If you are still not happy with your exam score, you need to evaluate your approach to these problems. You want to avoid following steps from a different problem that you have seen worked out. This requires very little thought and can cause trouble when a problem looks different even though it uses the same concepts. The goal is to <u>understand why</u> you are doing a particular step, etc. Ask why! Why did you use that equation? Why did it work? Why did you set the problem up that way? How else could this question be asked? Can I write a similar problem that uses the same or additional concepts? The best thing you can do is overanalyze a problem and think about the solution. A correct answer doesn't help you prepare if you don't understand where it came from. This takes practice! I recommend working

Question	Response	Correct or incorrect?	Feedback
			problems in small groups so that you can learn from one another.
	0–20%, 20–40%, 40–60%, 60–80%	Incorrect ^a	<i>Identical to the text for the “correct” response with the exception of the opening sentences:</i> I recommend getting lots of practice to improve your exam performance! It's hard to do anything well without practicing it first.
Which type of question did you miss the most?	Calculation questions	Incorrect ^a	Evaluate why you think you missed the calculation questions. Did you do enough practice problems? Was your focus too narrow when doing practice problems? Are you having trouble with math in general? Are you memorizing steps instead of understanding <i>why</i> the problems is solved the way it is? Determine why you missed these questions so that you can work on fixing the problem.
	Concept questions; I missed some of both.	Incorrect ^a	The exams are typically 1/3 calculation and 2/3 conceptual. Be sure you do not spend all of your time practicing calculations while overlooking the concepts. And, while working calculation problems, really think about why the math is working. There is a concept behind all of the math and thinking about both at the same time will help you succeed all around.

^a Multiple choice answer identified by the learning management system as “incorrect” to trigger the appropriate response.

Implementation of the MAI

Students were asked to take the MAI at the beginning of the course and again at the end using 1 point on the first and final exams as incentives. The MAI (Appendix 1) is a 52-item survey with two categories that probe individuals’ self-reported understanding of both knowledge and regulation of cognition. Within each category, subscale questions address various facets of each, such as declarative, procedural, and conditional knowledge as well as planning, management, monitoring, debugging, and evaluation phases of regulation. For example, *knowledge about cognition* items probe student perceptions, such as: “I know what kind of information is most important to learn” and “I use my intellectual strengths to compensate for my weaknesses.” *Regulation of cognition* items include, for instance, “I try to

translate new information into my own words,” “I ask myself questions about the material before I begin,” and “I summarize what I’ve learned after I finish.” Although scoring options for the MAI vary from a bipolar sliding scale (Schraw & Dennison, 1994) to a 5-point Likert scale (Harrison & Vallin, 2018), we chose to use a dichotomous version as per Soicher and Gurung (2017). Students indicated whether the statement was “true or false as it generally applies to you when you are in the role of a learner.” The maximum score was 52, corresponding to the 52 items on the scale.

Results

A total of 656 students completed the course and gave consent for their data to be used in the present study. Of this total, 78% were new (<30 credits) and 22% were upper level (transfers or students with 30 or more credits at this university). There were 307 (47%) females and 349 (53%) males in the class.

Descriptive and inferential statistics were calculated using SPSS Version 25. Random missing data due to noncompliance were handled by pairwise deletion. The project was approved as exempt through our Institutional Review Board (Protocol Y18LH26015).

Assessing Metacognitive Awareness

Nearly 96% of students ($n = 629$) completed the first administration of the MAI (MAI-Pre) and scores ranged from 0 to the maximum score of 52, with the mean score being 39.7 ($Mdn = 40$). After removing 57 outlying scores of 0, 1, or 50–52, reduced mean (38.6) and median (39) scores for the remaining 572 students were observed. Of these students, 474 completed the second administration of the MAI (MAI-Post), and their scores increased significantly: $M = 40.2$, $Mdn = 42$, $t(474) = 4.14$, $p < .001$.

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Certain subscale items tended to be affirmed less often than others by most students who completed the MAI (Table 2). On average, students were less likely to report having knowledge of learning objectives and expectations (Declarative Knowledge). They were less likely to indicate using strategies that involve planning prior to engaging in a learning task (Planning), monitoring strategy use and subsequent learning (Comprehension Monitoring), and evaluating performance and strategy effectiveness after a learning session (Evaluation).

Table 2. Metacognitive Awareness Inventory (MAI) subscale items, “least used” strategies, and significant subscale increases.

and significant subscale increases:				
MAI subscale	Item nos.	Least used strategies (item nos.) ^a		Significant increases in subscale scores ^b (MAI-Pre to MAI-Post) <i>N</i> = 473
		MAI-Pre	MAI-Post	
Knowledge of cognition				
Declarative Knowledge	5, 10, 12, 16, 17, 20, 32, 46	10, 12, 16, 17	10, 12, 16, 17	Mean difference = .24, <i>t</i> (473) = 3.07**
Procedural Knowledge	3, 14, 27, 33	14, 33	33	Mean difference = .14, <i>t</i> (473) = 2.71**
Conditional Knowledge	15, 18, 26, 29, 35	35	35	
Regulation of cognition				
Planning	4, 6, 8, 22, 23, 42, 45	4, 6, 8, 22, 23, 45	4, 6, 8, 22, 45	Mean difference = .43, <i>t</i> (473) = 5.27***
Information Management Strategies	9, 13, 30, 31, 37, 39, 41, 43, 47, 48	31, 37, 47, 48	31, 37, 48	
Comprehension Monitoring	1, 2, 11, 21, 28, 34, 49	11, 21, 28, 34, 49	11, 21, 28, 34	
Debugging Strategies	25, 40, 44, 51, 52	—	—	
Evaluation	7, 19, 24, 36, 38, 50	7, 19, 24, 36, 38, 50	7, 24, 38, 50	Mean difference = .45, <i>t</i> (473) = 5.48***

Note. The MAI-Pre was offered at the beginning of the introductory chemistry class and the MAI-Post at the end of the class.

^aLeast used strategies: More than 25% of students indicated that the statement does not generally apply to them when in the role of a learner. MAI-Pre: *N* = 572; MAI-Post: *N* = 474.

^bOutliers removed (0, 1, or 50–52 on the MAI-Pre).

p* < .01. *p* < .001.

Exam Wrapper Use and Course Performance

Exam wrapper use in the introductory chemistry course was low; students completed an average of 13% of the available (optional) wrappers, whether they were new or upper-level students, male or female. Students with a stronger academic history (high school GPA) were somewhat more likely to use the wrappers. There was no clear relation between exam wrapper use and course grades based on student ethnicity.

Course grades in introductory chemistry significantly correlated with prior GPA ($r = .49, p < .001$), early performance (Exam 1) in the course ($r = .67, p < .001$), and exam wrapper use ($r = .09, p < .05$). A regression equation was significant in predicting course grade from these variables, $F(3, 649) = 220.34, p < .001, R^2 = .51$. Prior GPA ($\beta = .24, t = 7.92, p < .001$) and Exam 1 grade ($\beta = .57, t = 18.73, p < .001$) contributed uniquely to the variance, but exam wrappers did not. Only among new students (< 30 credits) did introductory chemistry exam wrappers significantly relate to the grade in the course. A significant regression equation involving new students only, $F(3, 507) = 165.66, p < .001$, demonstrated the contributions of prior GPA ($\beta = .23, t = 6.59, p < .001$), Exam 1 score ($\beta = .58, t = 16.93, p < .001$), and introductory chemistry exam wrappers ($\beta = .07, t = 2.23, p < .05$) to course grade variance. With exam wrapper completion rates as low as they were, a significant effect (albeit small) on course grade seems noteworthy and warrants further study.

Exam Wrapper Content and Metacognition

Each exam wrapper item provided multiple metacognitive prompts, both in the question and in the feedback provided to students. For example, Item 4 asked, “How many of the instructor’s recommended problems do you do from the end of each chapter?” The question itself may have prompted reflection on declarative and procedural knowledge.

Exam wrapper feedback, across all nine items, concentrated on the MAI subscales of Declarative Knowledge, Information Management Strategies, Comprehension Monitoring, Planning, and Evaluation. MAI scores increased significantly from MAI-Pre to MAI-Post for the Declarative Knowledge, Planning, and Evaluation subscales, as well as for Procedural Knowledge. Significant correlations of exam wrapper use and MAI-Post subscale scores were observed, but only for Planning ($r = .16, p = .001$) and Evaluation ($r = .12, p < .01$).

Discussion

Exam wrappers are designed to organize learning situations, prompt student reflection and examination of the strategies used to prepare for exams, and promote more effective strategies for the future. In large classes, administering the exam wrapper via an LMS allows the instructor to accomplish the same goal as using a paper version and presents students with the opportunity to reflect in a way they may not have done otherwise. Feedback provided via an LMS provides an avenue for the instructor to guide students in their reflection even when they cannot meet with them one-on-one or hand back personal written feedback.

Simply reading the exam wrapper questions is an exercise in the evaluation of learning strategies. Feedback can then prompt awareness of other metacognitive behaviors exemplified in the MAI subscales and items, primarily planning, information management, comprehension monitoring, and evaluation strategies. That said, students may not necessarily have enough self-awareness to recognize strengths and weaknesses in their learning strategies. For example, self-assessments of metacognitive awareness via the MAI were almost as high at the beginning of the course as at the end. To some extent, the dichotomous response options may have contributed to inflated MAI-Pre scores,

although similar findings have been reported using a 7-point response scale (Trogden & Royal, 2019). Students may also lack the initiative to act on what they recognize as productive behaviors. Exam wrappers exemplified many of the metacognitive behaviors that students claimed to practice according to their MAI-Pre scores, and yet their use of the wrappers was very low. Even so, performance in the introductory chemistry course was related to the use of the wrappers, independent of prior GPA and early exam grades in the course.

Providing multiple metacognitive opportunities, and incentivizing their use, may contribute to better outcomes. For example, Hodges et al. (2020) found that course grades and cumulative college GPA were stronger for students who completed exam wrappers across multiple courses, independent of prior achievement and early exam grades. It should be noted that exam wrappers were required and/or offered extra credit points in most of those courses. Completion rates were higher than in the introductory chemistry course, as was the relation between exam wrappers and grades. Given the ease of use of online tools, such as exam wrappers, for promoting metacognitive awareness, and their apparent impact on student learning, instructors of large classes might consider utilizing them and incentivizing their use. An LMS is an efficient, accessible way to engage students in large courses in these opportunities—one that allows instructors to scaffold student learning via functions such as adaptive release, adaptive learning exercises, and automated feedback.

There are a few limitations of this study to note. The generalizability of our results is limited by the focus on a single course in a single semester. The small number of students completing the exam wrapper in this course also affects the findings. A positive finding from this study is that using the LMS was an efficient and effective way to deliver an exam wrapper. Using the LMS's test tool for this purpose, however, also had several disadvantages. For example, to trigger the feedback function, students had to be "graded" on the assignment. Even though the instructor assured them that the exam wrapper responses did not affect their course grade, students could have easily been confused. The apparent grading could also make them less honest in their responses, which would limit the appropriateness of the feedback they received. Another drawback is that the feedback generated by the LMS based on student response was held back until the entire assessment was completed. Ideally, students would get feedback after each question was answered so that it was immediately relevant and connected to their response. Finally, the LMS lacked the functionality for students to be questioned in an order and with an appropriateness based on their individual answers. In other words, with more flexibility and functionality in the LMS, the exam wrapper could be even more tailored to each student's situation.

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Appendix

Appendix 1. The Metacognitive Awareness Inventory (Schraw & Dennison, 1994) Students responded 'true' or 'false' to each item.

Item
1. I ask myself periodically if I am meeting my goals.
2. I consider several alternatives to a problem before I answer.
3. I try to use strategies that have worked in the past.
4. I pace myself while learning in order to have enough time.
5. I understand my intellectual strengths and weaknesses.
6. I think about what I really need to learn before I begin a task.
7. I know how well I did once I finish a test.
8. I set specific goals before I begin a task.
9. I slow down when I encounter important information.
10. I know what kind of information is most important to learn.
11. I ask myself if I have considered all options when solving a problem.
12. I am good at organizing information.
13. I consciously focus my attention on important information.
14. I have a specific purpose for each strategy I use.
15. I learn best when I know something about the topic.
16. I know what the teacher expects me to learn.
17. I am good at remembering information.
18. I use different learning strategies depending on the situation.
19. I ask myself if there was an easier way to do things after I finish a task.
20. I have control over how well I learn.
21. I periodically review to help me understand important relationships.
22. I ask myself questions about the material before I begin.
23. I think of several ways to solve a problem and choose the best one.
24. I summarize what I've learned after I finish.
25. I ask others for help when I don't understand something.
26. I can motivate myself to learn when I need to.
27. I am aware of what strategies I use when I study.
28. I find myself analyzing the usefulness of strategies while I study.
29. I use my intellectual strengths to compensate for my weaknesses.
30. I focus on the meaning and significance of new information.
31. I create my own examples to make information more meaningful.
32. I am a good judge of how well I understand something.
33. I find myself using helpful learning strategies automatically.
34. I find myself pausing regularly to check my comprehension.
35. I know when each strategy I use will be most effective.
36. I ask myself how well I accomplish my goals once I'm finished.
37. I draw pictures or diagrams to help me understand while learning.
38. I ask myself if I have considered all options after I solve a problem.
39. I try to translate new information into my own words.
40. I change strategies when I fail to understand.
41. I use the organizational structure of the text to help me learn.

Item
42. I read instructions carefully before I begin a task.
43. I ask myself if what I'm reading is related to what I already know.
44. I reevaluate my assumptions when I get confused.
45. I organize my time to best accomplish my goals.
46. I learn more when I am interested in the topic.
47. I try to break studying down into smaller steps.
48. I focus on overall meaning rather than specifics.
49. I ask myself questions about how well I am doing while I am learning something new.
50. I ask myself if I learned as much as I could have once I finish a task.
51. I stop and go back over new information that is not clear.
52. I stop and reread when I get confused.

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