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Use of Exam Wrappers to Enhance Students' Metacognitive Skills in a Large Introductory Food Science and Human Nutrition Course

P. Gizem Gezer-Templeton, Emily J. Mayhew, Debra S. Korte, and Shelly J. Schmidt

Abstract: Research shows that students struggle to develop higher order thinking skills and effective study strategies during the transition from high school to college. Therefore, in addition to teaching course content, effective instructors should assist students in developing metacognitive skills, that is, the practice of thinking about their thinking. An effective assignment that assists students in thinking about their exam performance is the exam wrapper. The objectives of this study were to examine students' metacognitive skills, evaluate the correlation between study behaviors and student performance, and assess student perception of exam wrappers. Exam wrapper assignments were offered as extra credit after the first 3 exams in a large introductory Food Science and Human Nutrition course, and student responses and exam performance were analyzed. Many students with poor exam performance overestimated their exam scores, indicating students' self-assessment skills could be sharpened. However, students demonstrated the ability to make and implement goals to improve study strategies throughout the semester. A modest relationship between use of study strategies and improved exam performance was observed, particularly for students with a B exam average, suggesting that students in the middle of the grade distribution may benefit most from this type of intervention. Finally, most students expressed a belief that exam wrappers helped them improve their study habits and exam scores, and that they planned to use the exam wrapper process in future classes. In summary, this study shows that the exam wrapper is a valued and effective postexam reflection tool for improving students' self-reported study habits.

Keywords: Education, exam wrappers, learning, metacognition, study strategies

Introduction

During the transition from high school to college, students struggle to develop higher-order thinking skills and effective study strategies (Alci 2015). According to the revised Bloom's taxonomy, the order of thinking skills builds from factual knowledge, to conceptual knowledge, to procedural knowledge, and to metacognitive knowledge (Krathwohl 2002). Pintrich (2002) defined metacognitive knowledge as knowledge of cognition in general as well as awareness and knowledge of one's own cognition. Since improved metacognitive skills positively correlate with enhanced learning and better study strategies for students, instructors should consider implementing strategies to help students develop metacognitive skills (Ambrose and others 2010).

Teaching students how to self-assess their knowledge and self-regulate their study behaviors may have positive, long-lasting effects on student learning. These skills can be developed by intentionally allocating class time to teach students alternative study strategies and/or by giving assignments that prompt students to practice these skills outside of class. Especially for large-enrollment, introductory classes, the former might not always be feasible. One possible means of embedding metacognitive training easily into a course is by utilizing course exams as an opportunity for students to practice metacognition. Cheelan Bo-Linn, Senior Specialist in Education, Center for Innovation in Teaching and Learning at the University of Illinois at Urbana-Champaign, introduced the exam wrapper concept to the last author as a way to harness the potential of exams as learning tools, and not just assessment tools. This recently developed assignment requires minimum class time and enables students to practice metacognitive skills (Lovett 2008).

The exam wrapper (also termed cognitive wrapper) concept was first introduced in the article entitled "Posttest analysis: A tool for

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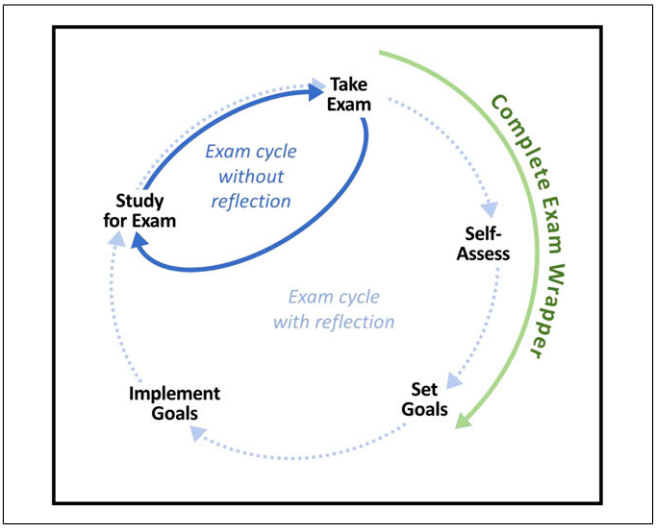

Figure 1–Diagram depicting different pathways students might follow for courses with more than 1 exam. Students can implement the same study practices and take exams (solid dark-blue cycle) or they can reflect on their study practices and exam scores and make changes accordingly (dashed light-blue cycle). The green arrow represents exam wrapper guided metacognition, in which students are led through the reflection cycle by completing the exam wrapper assignment.

developing students' metacognitive awareness and self-regulation," by Achacoso (2004). The reflective postexam questionnaire introduced by Achacoso (2004) forms the backbone of the exam wrappers in use today, with Lovett (2013) being the first to use the term exam wrapper. Exam wrappers are short, reflective writing activities that ask students to review their applied study strategies in relation to their performance on an exam with a focus on adjusting their future learning practices accordingly. The foundation of the exam wrapper consists of the following 3 questions: (1) How did you prepare for the exam?, (2) What kinds of errors did you make on the exam?, and (3) What could you do differently next time? (Lovett 2013). Instructors may decide to include additional questions in the exam wrapper, such as students' perception of their knowledge before and after taking the exam, how prepared they felt before the exam, and the hours they spent preparing for the exam (Achacoso 2004; Thompson 2012; Lovett 2013). The process of responding to exam wrapper questions enables students to develop self-regulation skills. Self-regulation encompasses the following skills in the learning how to learn context: self-assessment, finding the cause and effect relationship between effort and performance, identifying more effective study strategies, goal-setting, goal implementation, and monitoring progress (Zimmerman 2002).

One factor inhibiting student improvement in courses may be students' failure to recognize the possible benefits of exams as a source of instructor feedback. Author Schmidt (Food Science and Human Nutrition 101 Instructor) has noticed, with disappointment, that after returning the exams back to her students', some students simply look at their grade, promptly place the exam into their binders (or worse yet the trash), then move on to the next course topic. As past research has documented, many students do not even pick up their exam results (Craig and others 2016). These observed student behaviors are indicative of a potentially ineffective cycle, shown by the solid dark blue arrows in Figure 1, in which the same study practices are used for each exam, regardless of previous exam performance.

A more effective cycle, shown by the dashed light blue arrows in Figure 1, involves the use of exam results as a student learning tool, not just an instructor assessment tool. Students with higher metacognitive skills might already be implementing the cycle with reflection. This cycle includes self-assessment of their exam preparation and performance, setting study strategy goals for their next exam, and implementing goals throughout the exam preparation process. Exam wrappers, as indicated by the green arrow, ensure that students will be led towards the reflective exam cycle by prompting them to reflect on their performance and study habits, as well as guiding them to set goals for an improved performance on the next exam. In this way, exam wrappers turn exams into learning tools for students by guiding students to enhance their metacognitive knowledge, specifically in terms of self-regulation.

In addition to being an effective learning tools for helping students develop metacognition skills, exam wrappers are also very easy to implement due to several factors. First, exam wrappers do not require much student time to complete or instructor time to assess. They are generally 1 to 2 pages in length, with mostly short-answer questions. Second, instructors can easily adapt exam wrappers to different classes and to any type of learning or assessment task (for example, lecture wrappers, homework wrappers, discussion wrappers) as suggested by Lovett (2008). Third, they are repeatable for subsequent exams, with minor changes to avoid being overly repetitive for the students. Finally, instructors can encourage students to apply the metacognition skills they are learning to their other tasks and classes (Lovett 2013).

Exam wrappers and their effect on student learning have been explored in various disciplines, such as introductory physics (Greco 2012), general chemistry (Butzler 2016), computer science (Craig and others 2016) and foreign language (Thompson 2012). The overall purpose of this classroom research project was to evaluate the impact of exam wrappers in a large, introductory Food Science and Human Nutrition course (FSHN 101) on students' study behaviors, as well as their perception of this new metacognitive learning tool. Korte and others (2016) reported certain student-centered learning practices, such as supplemental learning resources and optional study tools, can be effective in helping students learn how to learn in FSHN 101. These student-centered learning practices, which reinforced our aim of teaching metacognitive skills to students via the exam wrapper assignment, were also in place during this study. The specific objectives guiding this classroom study were to:

1. examine students' metacognitive skills (self-assessment, goal setting, goal implementation);
2. evaluate the correlation between study behaviors and student performance; and
3. assess student motivation to complete and perception of exam wrappers

Materials and Methods

Implementation of exam wrappers

Exam wrappers were utilized in a large (100 students), introductory food science and human nutrition course (FSHN 101) in the Fall semester of 2015. This class is a required course in the FSHN curriculum, and the majority of students enrolled in this class are freshman and sophomores who are majoring or minoring in one of the FSHN concentrations. There are 4 major (food science, human nutrition, dietetics, or hospitality management) and 2 minor (food science or human nutrition) options in the department. A small proportion of the students were upperclassmen who

either transferred into one of the majors or added a minor in food science and human nutrition. The course was structured into 4 sections: nutrition and health, food composition and chemistry, food microbiology and processing, and food laws, quality, and the consumer. After each section, there was a 50-minute exam, in which students were only responsible for material from that specific section. Each exam was worth a total of 100 points and was composed of 50 multiple choice and true/false questions with 2 additional bonus questions. The class met 3 times a week for 50 minutes in a lecture hall and the exams took place during the regularly scheduled course time. At the end of the semester, there was a comprehensive final exam with 100 questions, worth a total of 200 points. Students received error sheets outlining the questions they missed on each exam with the correct answers. Following the exam, the exam questions were made available through an online platform, Compass 2g (Blackboard Inc., Washington D.C., U.S.A.). Exam wrappers were uploaded to Compass 2g and offered as an extra credit assignment (worth 4 points per exam wrapper). Students handed in a hard copy of the exam wrappers to the members of the instructional team within a week after receiving their exam results, and retained their electronic copy for future reference. Exam wrappers were utilized after the first 3 exams, and consent forms releasing the data from both exam wrappers and grades were collected at the time of the 4th exam. This study received the University of Illinois Institutional Review Board (IRB) approval (IRB Protocol Number 16314) prior to data analysis.

Content of exam wrappers

The 3 fundamental questions, mentioned in the introduction, were asked in all 3 exam wrappers used in this study:

1. How did you prepare for the exam?
2. What types of questions on the exam were most challenging for you? Why do you think they were challenging?
3. What changes to your study habits do you plan to make when preparing for the next exam?

For each of these questions, example responses were provided to guide students toward the expected type of response. In addition to these fundamental questions, in all 3 exam wrappers the students were also asked how many hours they spent studying, how far in advance they began studying for the exam, what grade they expected before and right after the exam, and their actual exam score.

In the second and third exam wrapper, both Likert-scale and open-ended comment sections were added at the end. These questions prompted students to provide feedback on their motivation to complete each exam wrapper (for example, extra credit, they thought they would benefit from this assignment, they benefited from this assignment when they completed it, or a combination of these factors), and their perception regarding the usefulness of the exam wrappers (for example, if they found it helpful to improve their study habits, if they found it helpful to improve their exam scores, if they applied it to other classes this semester, and if they are planning to use it in the future). The 3 exam wrapper assignments used in this study are provided as supporting material.

Data analysis

Statistical analyses of the quantitative responses, including analysis of variance (ANOVA), were carried out using Excel 2013, Data Analysis add-on package. Least significant difference (LSD) mean separation was calculated using an $\alpha = 0.05$ significance level. Textual responses given for the qualitative portion of the exam wrappers were coded by the researchers using the common themes that emerged from students' responses. These codes were used in the principal component analysis (PCA). Spearman correlation PCA with Varimax rotation was conducted using XLSTAT (Addinsoft, New York, N.Y., U.S.A.). In addition, data on students' grades were also collected with their consent. Exam grades were calculated as follows: average percent score of 4 exams (without bonus points) were calculated and converted to a letter grade based on the grade scale system given in the syllabus: A+ from 100% to 99%, A from 98% to 93%, A– from 92% to 90%, B+ from 89% to 97%, B from 86% to 83%, B– from 82% to 80%, C+ from 79% to 77%, C from 76% to 73%, C– from 72% to 70%, D+ from 69% to 67%, D from 66% to 63%, D– from 62% to 60%, F < 60%.

Results and Discussion

Among the 100 students who were enrolled in the course, 83 students gave their consent for this research study. The majority of these students completed all 3 exam wrappers (88%), while a minority only completed 2 (7%), 1 (2.5%), or none (2.5%). Since the number of students who did not complete all of the exam wrappers was significantly smaller compared to the number of students who did, it was not possible to compare these different populations in a meaningful manner. Therefore, we exclusively used data from the 73 students who completed all 3 exam wrappers in order to observe differences between the 3 exams. Attempts to correlate exam wrapper completion with exam performance were made through comparison of student exam grades to previous semester grades; however, it was not possible to draw conclusions on the direct effect of exam wrappers on students' grades, especially since there was no control group in this study.

Examination of students' metacognitive skills

The first objective of this study was to examine students' metacognitive skills in terms of self-regulation, which includes self-assessment, goal setting, and goal implementation.

Self-assessment. Students' ability to correctly estimate their grade immediately after the exam could be indicative of how accurately they can self-assess their performance. Students were asked to state their predicted letter grade after they took the exam. Students' predicted exam grades were compared with their actual exam grades to determine if students overestimated, underestimated, or correctly estimated their grades. Students were grouped into grade categories (based on their exam average), and the percentage of times that students overestimated, underestimated, or correctly estimated their exam grades were plotted by average exam grade category (Figure 2). As evidenced by Figure 2, students with a higher average exam grade tended to underestimate how well they did during the exam, whereas students with a lower average exam grade tended to overestimate their performance. This trend held for all 3 exams assessed, although the degree of over- or underestimation was not determined. The student behavior observed is in accordance with the Dunning–Kruger effect. Dunning and Kruger (1999) observed that the unskilled participants in their research study greatly overestimated their abilities. Dunning and Kruger suggested this was due to lack of metacognitive skills and improvement in metacognitive competence would result in not only better performance, but also better self-assessment capability. Our findings suggest that self-assessment is an area in which students have room to improve; exam wrappers could be one way in which educators can guide students to develop their self-assessment skills.

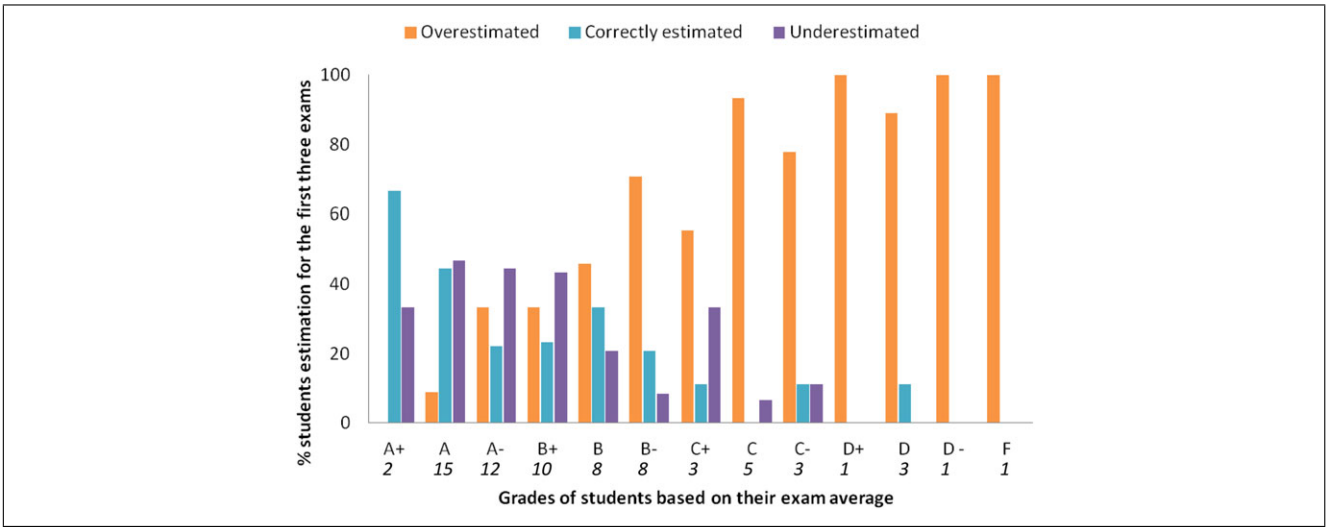

Figure 2–Student's estimation of their exam grades right after the exam compared with their actual exam scores grouped by their average exam grade category (number of students in each category is shown under grade axis).

Table 1–Responses given by the students to 'How did you prepare for the exam?'

Reported study strategy	Exam 1	Exam 2	Exam 3
Reviewed notes*	71	65	69
Used the study guide*	39	43	45
Created own notes/Rewrote slides/Created own study guide*	53	45	48
Attended review session	36	37	33
Utilized practice problems/exam	18	9	16
Followed LSU study cycle*	13	7	8
Formed a study group/Studied with a friend	9	18	20
Taught somebody about the subject	3	0	3
Applied self-quizzing	3	2	7
Went to office hours and asked questions*	3	5	3
Started early to study/Reviewed notes after each lecture/week	0	13	14
Utilized compass modules such as videos/visuals	0	0	5

*Example response provided in order to guide students toward the expected type of response.

Table 2–Reponses given by the students to the 'What changes to your study habits do you plan to make when preparing for the next exam?' question.

Planned study strategy	Exam 1	Exam 2	Exam 3
Start studying in advance / Review notes regularly*	43	41	37
Spend more hours studying	18	12	12
Apply self-quizzing	12	11	14
Create own notes / Create study guide	16	15	7
Attend review sessions*	15	14	7
Ask questions to professor and TAs*	14	9	9
Follow LSU study cycle*	19	6	8
Form/join a study group	7	6	2
Pay more attention in class	6	7	4
Utilize online resources	6	2	2
Work on practice problems	2	5	5
Attend all the classes*	0	2	2
Do not plan to make any changes	4	5	10

*Example response provided in order to guide students toward the expected type of response.

Another question important for self-assessment skills was that of how students prepared for the exam. The exercise of students' recalling their study practices was also important in order for students to develop their reflection habits and their thinking about the cause and effect relationship between the study strategies they utilized and their exam performance. Table 1 shows the student generated responses to "How did you prepare for the exam?" Some example responses were provided (marked with *) in order to guide students toward the expected type of response.

One might expect to find a positive correlation between the number of study strategies used by a student in preparation for an exam and their exam grade, however no significant correlation was observed in our study. Furthermore, students who used more effective study strategies, such as following the LSU study cycle method (The Center for Academic Success, Louisiana State Univ. 2016, Korte and others 2016), reviewing notes after each lecture, and teaching somebody about the subject, did not show improved grades compared to students who reported that they only reviewed class notes or attended review sessions. These findings may have been the result of a number of limitations of the study design. First, students were asked to identify study strategies they used in a free-response format, rather than selecting study strategies from a checklist. As a result, student responses lacked standardization. For instance, there were students who attended review sessions and/or came to the office hours, but did not include these practices as study strategies in their exam wrappers. Due to this type of omission by the students, the number of study strategies employed by a student could neither be standardized nor used as a variable in this study. Second, since the responses were self-reported, the accuracy of a response and/or the extent to which a listed strategy was implemented is unknown. For example, a student who reported having implemented the LSU study cycle may have done so for a couple lectures or for the entirety of the lectures leading up to the exam. By the nature of the study, it was not possible to accurately record and evaluate how students allocated their time as they prepared for the exam. Finally, even if it was possible to accurately determine the study strategies applied by the students, their grades may not directly correlate with these strategies. Certain factors, such as background knowledge, familiarity with the subject, and motivation to learn the material, can play a significant role in how the students perform in an exam. In fact, previous education research studies involving control groups have found that academic preparedness (Butzler 2016) and the motivation to take the class (Thompson 2012) have played a more significant role than instructors' efforts of teaching students self-regulation skills.

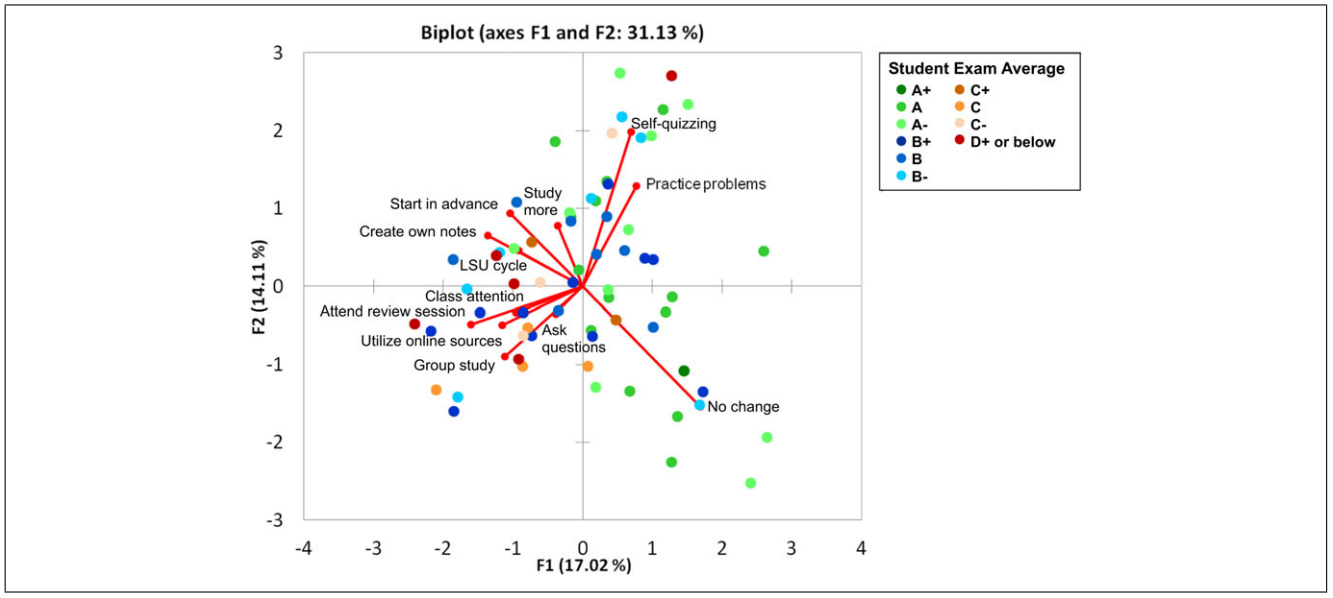

Figure 3–Spearman correlation principal component analysis biplot (Factor 1 compared with Factor 2) of student study goals, color-coded by average exam grade categories.

Goal setting. In FSHN 101, there were a number of efforts, other than exam wrapper assignments, to teach students learning how to learn skills, as previously reported by Korte and others (2016). Certain study strategies were regularly emphasized to help students realize the importance of preparing for each class, regularly reviewing their notes, utilizing provided online resources such as study guides and practice problems, and proactively attending office hours and review sessions. Table 2 was generated by the self-reported responses of the students to the question, "What changes to your study habits do you plan to make when preparing for the next exam?" It was promising to observe that students were able to generate their own study strategies in addition to the examples provided, which are marked with an asterisk (*). Even though this does not necessarily imply that the students were successful in following through with their goals, it showed they were able to reflect, identify strategies, and plan for the future.

As can be observed in Table 2, the number of students who reported starting to review notes earlier increased after the first exam. This was a positive change as it showed that some of the students were applying study strategies recommended by the teaching team as effective techniques. In fact, starting in advance was one of the study goals most frequently identified by students (Table 2).

Principal component analysis was conducted to observe the correlation between specific study strategies that students identified as future goals and the students' average exam grade categories. The results are shown in Figure 3. A moderate 31.13% of the total variation in students' study goals was explained by the first 2 factors. All study goals except for self-quizzing and practice problems were loaded on the negative Factor 1 axis, while the response 'no change in study habits' was loaded on the positive Factor 1 axis. Study goals were distributed across the Factor 2 axis in both the positive and negative directions, although the response "no change in study habits" was again separated from the other responses at the far negative end of the axis. Factor score coordinates of students were color-coded by their average exam grades and plotted on the biplot to show general trends in study goals. One emerging trend from this analysis was that, in general, students with an A were concentrated towards the positive Factor 1 and negative Factor 2 axes on which the "no change in study habits" response was highly loaded. In contrast, none of the students with a D+ or below and very few students with a C, can be seen in proximity to this "no change in study habits" direction. The first conclusion from this plot was that students with an A may have been content with both their study habits and their performance and decided no change in their study habits was necessary. The second conclusion was that students who are in need of developing better study habits may have been able to make the cause and effect correlation between their study habits and their exam performance. This was one of the desired outcomes of the use of exam wrappers, enabling students to self-evaluate and make plans for improved future study strategies.

Goal implementation. It is important to note that goal-setting does not automatically imply goal-implementation. In fact, some of the students informed us with their additional comments they wrote on the exam wrappers that, even though they found exam wrappers helped them reflect, they were not able to follow through with the goals they set. Two sample comments that expressed these thoughts were as follows:

"I am made really aware of my mistakes, but I really need to execute the plan I came up with."

"[The exam wrapper] is somewhat helpful when you don't have other hard courses to deal [with]."

As reported in Table 2, two of the most frequently mentioned future goals were starting to study in advance, as opposed to cramming at the last minute, and spending more time on exam preparation. Self-reported data regarding both of these parameters were collected on all 3 exam wrappers. Evaluation of both of these parameters yielded promising results, indicating that students implemented these study strategies as planned.

Students reported earlier initiation of exam preparation in later exams compared to exams from earlier in the semester. Student responses were grouped into 5 categories: 1 to 6 hours, 1 to 2 days, 3 to 6 days, 1 week, and more than 1 week in advance. The bar plot in Figure 4 shows a trend in which students started to prepare

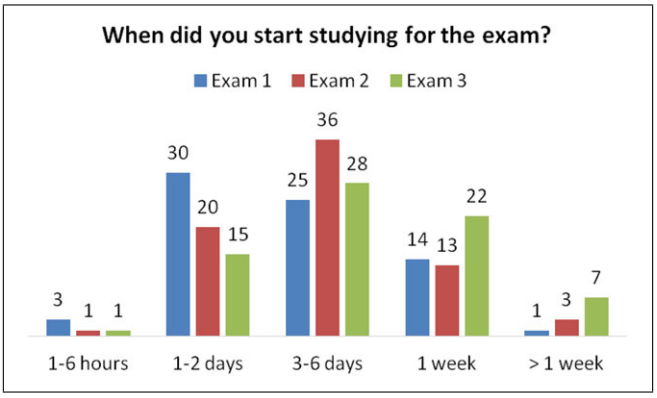

Figure 4–Frequency of students who started preparation for each exam at different time intervals. Numbers on each bar indicate number of students who started studying for the exam in the given time interval.

Table 3–Average and median hours spent by students preparing for each exam. Average values with the same superscript are not significantly different ($\alpha = 0.05$).

Exam number	Average hours of study	Median hours of study
Exam 1	$5.90^{A} \pm 2.82$	5
Exam 2	$7.77^{B} \pm 4.22$	7
Exam 3	$9.03^{B} \pm 5.81$	8

earlier with each consecutive exam. These 5 categories were coded with dummy variables (from 1 to 5). A significant difference was found between each exam according to ANOVA ($P = 0.0014$). The comparison was also made on a student-by-student basis by using a paired 2-sample *t*-test. This analysis revealed that students started studying earlier for exam 2 than exam 1 ($P = 0.035$) and exam 3 than exam 2 ($P = 0.032$).

This finding indicated that students not only made the right plans, such as not waiting until the last minute to study, but were also able to follow through with the plans they set for themselves. As mentioned previously, there were multiple resources provided in FSHN 101 to guide students towards this goal. Thus, exam wrappers may not be the sole factor that contributed to this positive outcome.

In all 3 exam wrapper assignments, students were asked to recall and report how many hours they spent studying for the previous exam. Table 3, which contains the average and standard deviation of the self-reported hours spent for exam preparation, shows an increasing trend in the average number of hours spent studying. The median was also calculated to ensure that the observed increase in mean study hours was not skewed by a small subset of the students greatly increasing the number of hours spent in preparation. The median values of hours spent on exam preparation were 5, 7, and 8 h for exam 1, 2, and 3, respectively, showing the trend in mean values observed is reflective of an increase in hours of exam preparation made by many students during the semester.

ANOVA analysis showed the average hours spent studying prior to each exam were significantly different than each other ($P = 0.00017$). Post hoc analysis using the Fisher LSD test revealed that students spent more hours studying for exam 2 and exam 3 compared to exam 1. However, average study hours for exam 3 did not significantly differ from exam 2.

When examined on an individual basis, the majority of the students (85%) reported spending more hours studying for exam 2 and/or exam 3 compared to exam 1. The increase in study hours between the first and second exam might be because students were informed that exam 2, which covers the food composition and chemistry section, has historically been the most challenging of the course. Later in the semester, students might also be dealing with a larger number of competing stressors, such as assignments and exams for other classes, which restrict the amount of time available to study for Exam 3. The overall effect of increased study hours was observed when student responses were grouped into 3 categories: increased the study hours at least for 1 exam (85% of the students), did not make any changes in study hours (4%), and decreased study hours (11%).

Correlation of study behaviors and student performance

The second objective of this study included assessment of how study behaviors impacted student performance and if some specific study practices related more strongly to improved grades. Students self-reported use of study habits were compared to students' exam and final grades, but showed no consistent trends. However, when the students were grouped by final grade and the same analysis was performed, trends emerged between use of study behaviors and student improvement from Exam 1 to their average exam score (Figure 5). PCA biplots for capturing responses for students earning an A, B, or C average exam score explained 47.28%, 45.32%, and 50.51% of the total variation in reported study behaviors between the first 2 factors, respectively. Since all study behaviors included are positive behaviors, it is interesting to observe that reported use of study behaviors tend to fall primarily in one half of each biplot. This concentrated loading of reported study behaviors, on the positive Factor 2 axis for students earning an A and on the positive Factor 1 axis for students earning a B or a C, suggests that the number of study behaviors utilized may separate students more than use of specific study behaviors. The relationship between utilization of certain study practices and improvement in exam scores was more modest for students earning an A or C. In both cases, students whose average exam grade was lower than their first exam grade were clustered together on the PCA biplots away from some study strategies known to be effective, such as studying in a group and taking practice exams. The clearest impact of study behaviors on grade improvement was observed for students with a B. In the PCA biplot for students with a B, all study behaviors assessed were concentrated in one quadrant. Students who improved their exam scores to earn a B in the course consistently utilized the study behaviors included in the analysis, while students whose grades showed no change or negative change had more uneven usage of these study behaviors. These findings suggest that implementation of certain study behaviors, including practice exams and creating notes, may be most impactful for students in the middle of the grade distribution.

As is commonly true in applied social science research, this research study did not include a control group (Mertens 2015). In addition, there were multiple types of interventions guiding students to develop their metacognitive skills, resulting in better self-regulation of study habits. For these mentioned reasons, determining students' motivation to complete and perception of exam wrappers was important to understand the effectiveness of exam wrappers.

Student motivation to complete and perception of exam wrappers

Motivation to complete exam wrappers. As mentioned in the Materials and Methods section, exam wrappers were provided in

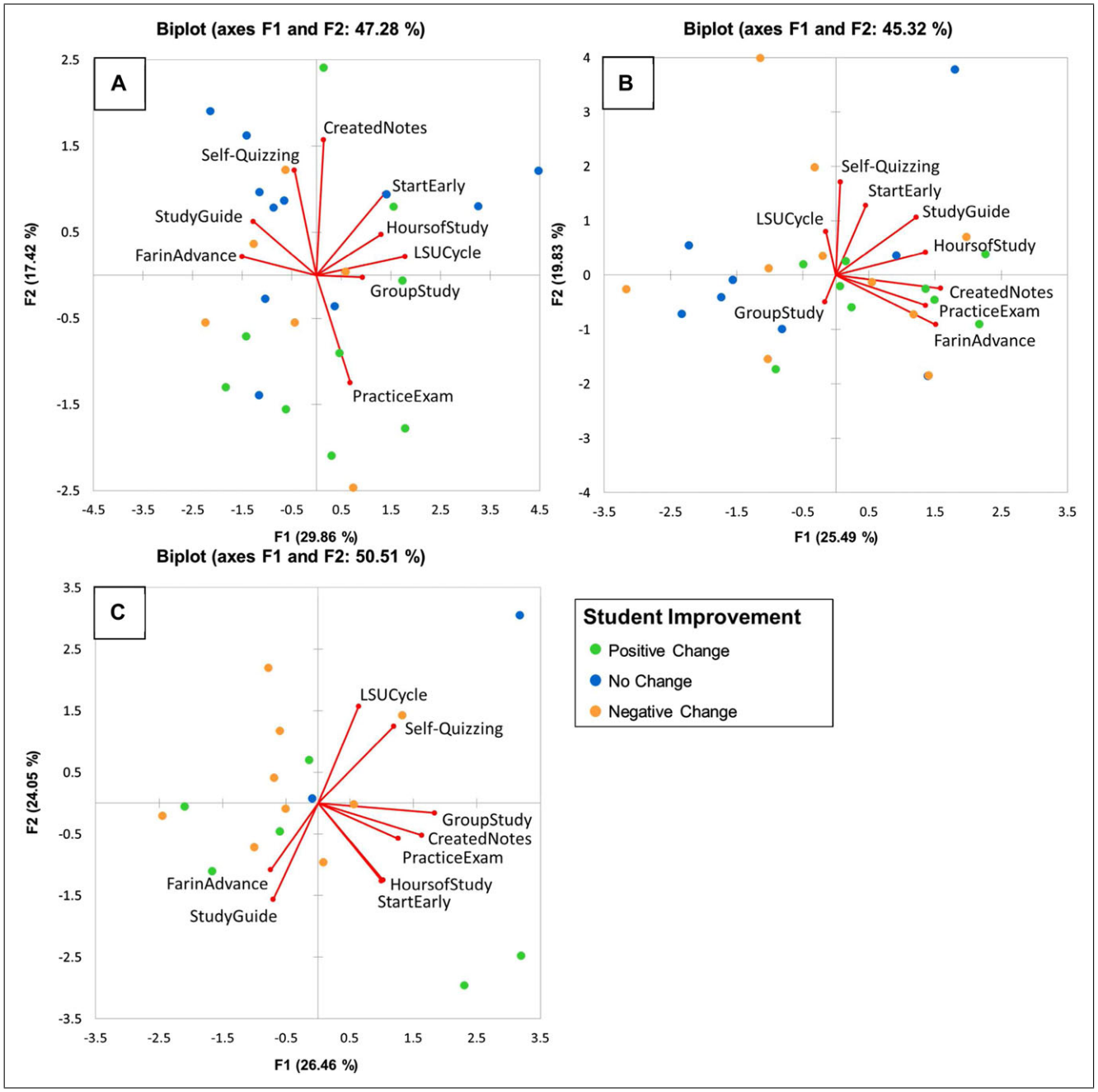

Figure 5–Spearman correlation principal component analysis biplots with Varimax rotation of student study behaviors for students earning, clockwise from top left, an A, B, or C in the course, color-coded to indicate student improvement from Exam 1 scores to average exam scores.

the form of an extra credit assignment. The opportunity to earn extra credit was a strong incentive for students to complete exam wrappers, as evidenced by the fact that 88% of students completed all 3 exam wrappers. When students were asked what motivated them to complete each of the exam wrappers, not surprisingly, extra credit points were found to be a major motivational driver. Most students selected extra credit points as one of their motivational factors for exam 1 (76%), exam 2 (66%), and exam 3 (73%). About half of the students stated they completed the first exam wrapper because they thought the exam wrapper might be helpful for their exam preparation (56%) or exam score (45%) when completing the first exam wrapper. When they were completing the second exam wrapper, the percentage of students who believed the exam wrapper might be helpful for their exam preparation or exam score increased to 72%. Furthermore, students reported that one of the motivational factors behind completing the exam wrapper was because the previous exam wrapper helped them improve their score. The percentage of students who reported this increased from 31% after the second exam to 44% after the last exam wrapper.

These findings showed that extra credit points were not the only reason students were completing exam wrappers, which is important since students need to mentally focus on this assignment in order to obtain the metacognitive benefits that it offers. Repeated

use of exam wrappers also helped students appreciate this self-reflection tool as a means to improve not only their study habits, but also their exam scores. The exact role exam wrappers played in their exam scores remains a complex puzzle to be solved, as there seem to be many variables affecting their exam performance.

Perception of exam wrappers. Students were asked to respond to several Likert-scale questions to determine their perceptions of the exam wrappers. Based on these responses, 72% of students either *Strongly Agreed* or *Agreed* that the exam wrappers helped them improve their study habits, whereas only 2% of the students *Disagreed* with this statement. When asked if they thought exam wrappers helped them improve their exam scores, 52% of the students either *Strongly Agreed* or *Agreed* and 7% *Disagreed*. These results showed students perceived this self-reflection assignment as an effective tool to improve their study habits and/or exam scores.

When asked to respond to the statement "I applied the exam wrapper process (postexam reflection) for my other classes this semester," 59% either Strongly Agreed or Agreed. Furthermore, the majority of the students (71%) either Strongly Agreed or Agreed, and only 6% Disagreed, with the statement that they would use exam wrapper concept for future classes. These findings imply that exam wrappers were perceived by the students as a valuable learning tool. Thus, students not only benefited from the use of the exam wrapper assignment in FSHN 101, but they were also able to add a valuable skill to their cognitive toolbox for future classes.

In addition to responding to Likert-scale questions, students also wrote in comments to the open-ended question, 'Is there anything you would like to share about your experience using exam wrappers?' A representative selection of responses showing different students' perspectives is included below:

"*It's clear to see that these self-reflections have had a positive effect on not only my study habits for this class and many others, but it has helped my grade as well. My test scores have only gotten better, even though some of the material is a bit harder. I truly think they have made a big difference in my grade in this class, and other classes too. I feel more prepared and more confident for future tests.*"

"*I truly believe that the Exam Wrappers do help us reflect on our study habits. However, I haven't taken action from what I've perceived/realized from doing the Exam Wrappers that could help pull up my grade for the next exam. I have been meaning to apply what I've realized from reflecting through completing the Exam Wrappers, but laziness got the best of me. Thus, I end up reviewing/studying 1–2 days before the exams, instead of what I would've prefer a week in advance. In conclusion, I believe that if one applies what they've come into terms with from reflecting through completing the Exam Wrappers, it should help improve their next exam grade.*"

"*Using the Exam Wrappers really does help me reflect on my preparation for exams and my performance. I am forced to understand where my errors occurred and challenged to work towards overcoming any of my gaps in understanding. I hope to continue using these wrappers in the future.*"

"*I think that the exam wrappers are very helpful in that they assist me in reflecting on the exam and how I can improve my score even more moving forward. Often times this step is skipped students just continue how they have been studying. There is always room for improvements organizing your thoughts in this specific assignment is a great way to do so.*"

"*I always do these exam wrappers and hope that they will help me. I try new things, I feel like I improve my study habits and I feel like I am better prepared than the exam before and then my grade decreases instead. I do not know what I am doing wrong but I'm sure these exam wrappers have better affects for other people, maybe I just do them wrong or not to the best extent. I do like getting extra credit because I try and try and get bad grades on these tests and I always want to go for any extra credit offered.*"

"*I think that the exam wrappers were beneficial because it encouraged me to study more often on a regular basis. Also they encouraged me to focus on studying the types of questions that were most challenging for me, so that they would be easier on the next test.*"

These voluntarily comments were generally very positive and showed that the students understood what exam wrappers are designed to accomplish, though some also acknowledged disappointments and other factors that limited implementation of their goals. Most students also mentioned that they valued these assignments, which was a major objective in implementing exam wrappers in FSHN 101.

Student Learning Outcomes

As the teaching team, we recommend exam wrappers be applied in future food science classes, especially courses with predominantly underclassman enrollment. Students reported finding exam wrappers to be a useful tool they plan to use in the future. Instructors who would like to help students learn how to learn could utilize this easy-to-implement tool as it does not require any class time and requires minimum preparation time. In addition, students do not need to spend too much time to complete this self-reflection task.

With the implementation of exam wrappers in classes, the goal is to achieve the following student centered learning outcomes. Students will be able to:

- Enhance their metacognitive skills by reflecting on their exam performance and adapt their study strategies accordingly.
- Identify specific study strategies that would help them improve their exam scores.
- Implement the exam wrapper technique for use in other classes and for life-long learning.

Future recommendations and conclusions

For research purposes, students might be given a check-box type of answer sheet for the 3 fundamental, qualitative questions for standardization among students. This would enable the researchers to accurately count and observe the effect of total number of study strategies used, or even specific study strategies used to prepare for the exams. In addition, spaces for open-ended responses could also be provided, so as not to put a limit on the possible student responses.

Further research is needed to determine the exact contribution of exam wrappers to students' exam performance. This could be achieved by conducting a controlled study, however this would require a more intensive IRB approval process. Considering the fact that even the controlled studies on the effectiveness of exam wrappers did not yield significantly different results between the control group and the intervention group (Thompson 2012; Butzler 2016), it might be beneficial to collect data on some of the possible confounding factors. This information may be collected by asking the students to provide information about how familiar they are with each of the course sections, their standardized test

scores, their major or minor in the department, and their year in school (freshman, sophomore compared to upperclassmen). These factors could shed some light which students receive the most benefit from exam wrappers, and if there is a correlation between these factors and exam performance regardless of the exam wrapper intervention.

Metacognitive skills are very important for student learning; however, many students have yet to fully develop these skills upon entering college level courses. Moreover, many students spend little time reflecting on why they did not perform as well as they thought they should have on a given exam, missing a prime opportunity for improvement. Asking students to reflect on their exam performance has been shown to be an excellent learning tool, as it teaches students metacognitive skills. Our hypothesis was that by asking students to analyze the underlying cause(s) responsible for their exam performance, students would be able to identify which study strategies are effective and which strategies are ineffective. Students would then be able to adapt these study strategies in the future. Exam wrappers were found to be an effective tool by the students and teaching team to improve self-assessment, goal setting and self-regulation skills, which corresponds to an overall improved metacognitive knowledge.[i]

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References

Achacoso MV. 2004. Post-test analysis: a tool for developing students' metacognitive awareness and self-regulation. New Direct Teach Learning 2004(100):115–9.

Alci B. 2015. The influence of self-efficacy and motivational factors on academic performance in general chemistry course: a modeling study. Educ Res Rev 10(4):453–61.

Ambrose SA, Bridges MW, DiPietro M, Lovett MC, Norman MK. 2010. How do students become self-directed learners? In: How learning works: Seven research-based principles for smart teaching. San Francisco: Jossey-Bass. p 188–216.

Butzler KB. 2016. The synergistic effects of self-regulation tools and the flipped classroom. Comput Schools 33(1):11–23.

Craig M, Horton D, Zingaro D, Heap D. 2016. Introducing and evaluating exam wrappers in CS2. Proceedings of the 47th ACM Technical Symposium on Computing Science Education. ACM. p 285–90.

Korte D, Reitz N, Schmidt SJ. 2016, Implementing student-centered learning practices in a large enrollment, introductory Food Science and Human Nutrition course. J Food Sci Educ 15:23–33.

Krathwohl DR. 2002. A revision of Bloom's taxonomy: an overview. Theory Pract 41(4):212–8.

Kruger J, Dunning D. 1999. Unskilled and unaware of it: how difficulties in recognizing one's own incompetence lead to inflated self-assessments. J Personal Soc Psychol 77(6):1121–34.

Lovett MC. 2008. Teaching metacognition. Unpublished paper presented at the Educause. Available at: https://net.educause.edu/upload/presentations/eli081/fs03/metacognition-eli.pdf Lasted accessed August 9, 2016.

Lovett Martha C. 2013. Make exams worth more than the grade. In: Kaplan M and others, editors. Using reflection and metacognition to improve student learning: across the disciplines, across the academy. Sterling, Va.: Stylus Publishing. p 18–52.

Mertens DM. 2015. An introduction to research. In: Research and evaluation in education and psychology: integrating diversity with quantitative, qualitative, and mixed methods. 4th ed. Thousand Oaks, Calif: SAGE Publications, Inc. p 1–45.

Pintrich PR. 2002. The role of metacognitive knowledge in learning, teaching, and assessing. Theory Pract 41(4):219–25.

The Center for Academic Success at Louisiana State Univ. 2016. The study cycle. Available from: http://students.lsu.edu/academicsuccess/faculty/performance/studycycle. Accessed 2016 July 13.

Thompson DR. 2012. Promoting metacognitive skills in intermediate Spanish: report of a classroom research project. Foreign Lang Ann 45(3):447–62.

Zimmerman BJ. 2002. Becoming a self-regulated learner: an overview. Theory Pract 41(2):64–70.

Supporting Information

Additional supporting information may be found in the online version of this article at publisher's website:

Exam Wrappers for FSHN 101 Hour Exams 1, 2, and 3

[i] https://mediaspace.illinois.edu/media/Exam+Wrappers+-+A+Better+Way+for+Students+to+Prepare+for+Exams/1_fokszlhn.