Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025
Paper ID #46912

BOARD # 25: Work in Progress: Impact of Metacognition Focused Activities on Development of Learning Habits in Physiology

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WIP: Impact of Metacognition Focused Activities on Development of Learning Habits in Physiology

Introduction

The ability to monitor and assess one's own knowledge and skills plays a pivotal role in learning [1]. Several have previously described the beneficial effect of this type of metacognitive tool through interventions such as exam wrappers, reflections and self-surveys [1-3]. Unfortunately, bioengineering curricula often do not give students sufficient practice developing these tools. For many students, it can be easy to fall into the trap of implementing ineffective learning strategies repeatedly without changes in outcome. A self-evaluation can be an obstacle for many students [4].

Allowing students to make errors and then reflect on why these occurred has been shown to positively impact learning [5]. By articulating the "whys" and "hows" of errors and finding gaps in thought processes and/or incorrect learnings, students can refine their understanding of course content. In this work-in-progress study, we hypothesize that the use of metacognitive tools such as exam error classification and progress planning in a sophomore level core curriculum physiology course will lead to more deep/strategic learning and engagement (as opposed to superficial/apathetic learning engagement). Furthermore, the evolution of perceived student strengths and weaknesses and clarity of action plans can be informative in assessing the depth of reflection and ability to self-correct. In the following paragraphs, we describe our pilot run of the error classification and progress planning exercise and observed results from last Spring.

Methods

Systems physiology is a core curriculum sophomore level course that applies principles of engineering to the excitatory tissue, cardiovascular, respiratory and renal organ systems. The nature of the course requires students to utilize critical thinking and quantitative reasoning skills to solve problems in living systems. Daily quizzes, problem sets, examinations and an open-ended proposal based on real world applications serve as assessments throughout the course. The exams consist of short answer (true/false, multiple-choice), calculation and derivation and application questions that are inspired by quizzes, problem sets and in class discussions. Students have access to all relevant equations for exams (appendix is attached to exam) to encourage students to focus on knowing how and when to apply relevant equations.

In the pilot version of this study, 36 undergraduate and 5 graduate students were enrolled in the course. Graduate students have similar requirements for the course with additional documentation due for the open-ended proposal. The metacognition assignment was designed to serve as extra-credit for exams I and II (both exams had 15 questions). To receive credit, students had to review their graded exams and classify errors into the following general categories as defined by the cited source: application, careless/running out of time, mastery, omission, prioritization, and procedural [6]. Students had to then think about errors, identify what they would do differently next time and reflect on their overall performance, their preparation strategy and whether the reflection was beneficial towards exam performance. The effect of the intervention was assessed using the following metrics: (1) a quantitative survey to evaluate the benefit of the exercise on exam performance using a 5-point Likert scale, (2) reduction in errors, and (3) overall exam grades. These metrics reflected a student evaluation of the metacognition assignment. Change in exam performance, error profile for exams and studying strategy was also examined for selected individuals (those that improved in exam performance) to evaluate possible trends to study in future iterations. Forty students completed the assignment after exam I and 37 completed the assignment after exam II. It is important to note that some students identified multiple error types per problem. Students were informed that the metacognition exercise was a part of a classroom-related research and that participation was optional. This study was conducted as per the umbrella IRB for teaching-related research (IRB-FY2023-239).

Results and Discussion

The majority of the students (22% strongly agree/59% agree) found the exercise to be beneficial in their exam performance (16% neutral, 3% disagree). While there was no statistically significant difference between exam grade averages, ~32% of the students improved their grade by at least 5 points on their second exam. This is consistent with previous trends from the past 4 years (2020 – 21%, 2021 – 38%, 2022 – 20%, 2023 – 46%). Many of these students reported increased time invested, early preparation, the act of explaining concepts to others and clearing up misconceptions through office hours as critical for their exam improvement. Interestingly, 3 of the 13 students cited the act of identifying gaps in knowledge and focusing on those areas as their most influential change, consistent with literature [7]. Students reported struggles with test-taking, following through with plans and time constraints as common obstacles in performing well on exams. In addition, an inability to see the big picture, master exam material and apply concepts to new situations were also commonly identified as playing a role.

Error Analysis.

Overall error profiles for exams were similar (**Figure 1**). The most common reported error type was mastery (36% for exam I, 31% for exam II), followed by errors caused by carelessness/running out of time (26% for exam I, 29% for exam II). This trend also held true for commonly missed exam problems on both exams. Application related errors were also common.

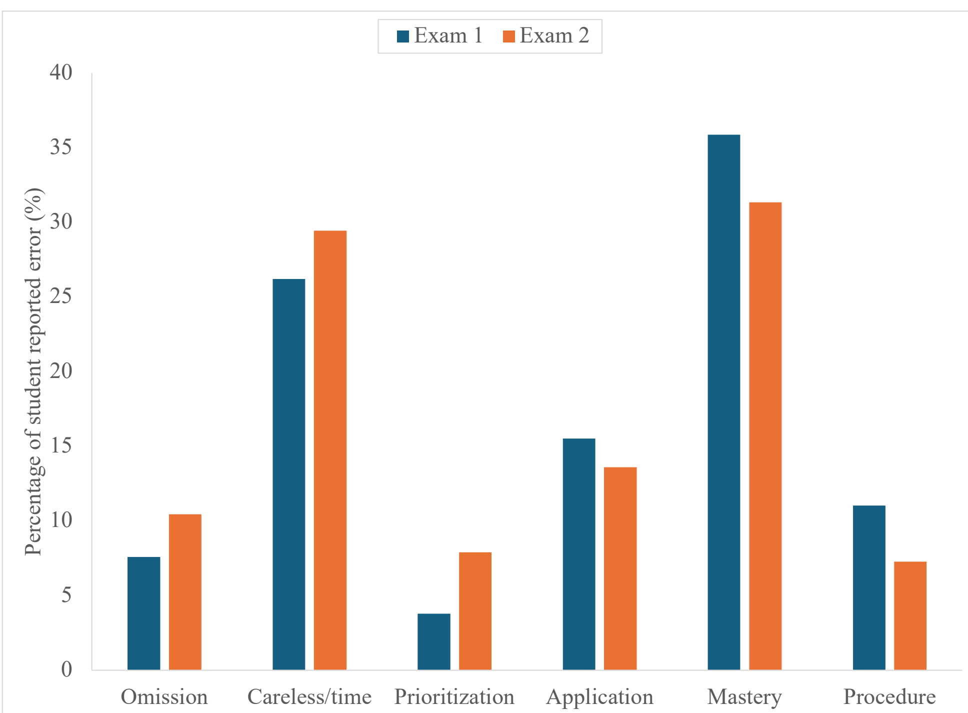

Figure 1. Student reported error types for exams. Error profiles show similar trends for examinations in course.

To further assess if error types varied among student types, students were separated into low, medium and high error categories based on average number of errors. For example, the average number of errors was 8 with a standard deviation of 3 for exam I. This information was then translated to a “low”, “middle” and “high” error category pertaining to 5 and under, 6-10 and 11 and over categories, respectively for exam I. This delineation was conducted for both exams to evaluate whether error amount related to type of errors. As **Figure 2** indicates, mastery, application and carelessness related errors were most common regardless of error category or exam.

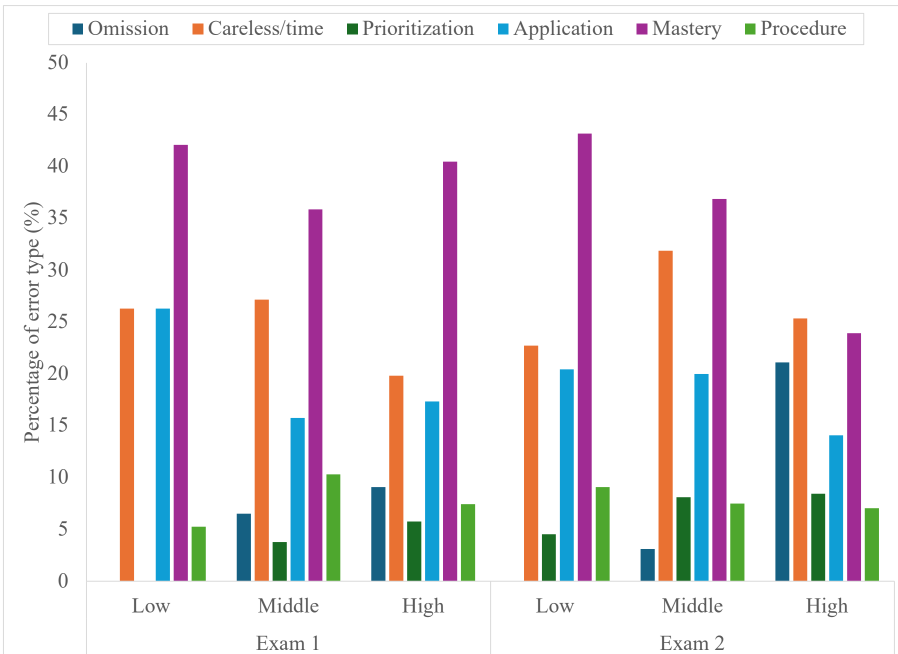

Figure 2. Error profile for low, middle, and high error student categories. Average and standard deviation calculations were used to construct low, middle and high error categories.

Future Work

More data is needed to demonstrate the benefits of this metacognitive exercise in this course. While a subset of students appeared to “course-correct” with knowledge gap identification and study strategy adaptation, many showed similar errors in exams even with the metacognitive exercise. It should be noted that it is possible students’ inability to correctly classify error type and assess effects of exam preparation strategy contributed to inaccuracies. It is also possible that external factors such as competing deadlines and timing of exam II played a role in the overall trends observed. In this pilot run, no changes were made to the teaching or assessment style following submission of assignments. Future iterations will include a more in-depth review of these to personalize one on one help sessions with students looking to improve course performance. Future iterations will also examine if there exists any correlation between error amount and type for students. These overall trends can be helpful for instructors to tailor teaching strategy for increased teaching effectiveness (e.g. more opportunities for students to apply concepts in class and demonstrate mastery).

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