Designing Technology-based interventions to help introductory biology students develop self-regulation.
Jenny Knight Faculty Fellows Program 2023-2024

Summary

Students often report that remaining in a STEM major includes surmounting many learning barriers, such as lack of timely help, adapting to different expectations, and developing appropriate study skills (Daempfle, 2003; Hurtado et al., 2007; Hunter, 2019). Adopting new strategies can be particularly challenging when a student is not adept at judging their knowledge (a **metacognitive** practice), as such awareness precedes the ability to evaluate and modify practices (all components of **self-regulated learning**; Schraw et al., 2006). Several lines of prior research have demonstrated that students who develop self-regulated learning (SRL) skills have better academic success and are more likely to persist in STEM courses than those who do not (Hartwig & Dunlosky, 2012; Sebesta & Speth 2017; Rodriguez et al., 2018; Hunter, 2019). These strategies also strengthen students' ability to transfer their learning to new settings and events (Bransford et al., 2000; Zhao et al., 2014). However, learning how to engage in SRL is challenging for most students because there are few resources in place to promote such practices. This project builds on the existing base of knowledge regarding self-regulation and motivation to create products that can both help identify students' needs and help them increase the use of these components. By designing and testing the impact of individual interventions at a large scale on student self-regulation, motivation, and performance, we hope to gain a better understanding of their utility and the extent of their impact.

Challenge and Desired outcomes

We often encourage students to be reflective, to plan ahead, and to try new study strategies. However, most students use the strategies they have used before, even if they are not working well. We theorize that if students have explicit opportunities to explore facets of self-regulation, tied to course assignments, they may be more likely to adopt new approaches. To facilitate these opportunities, we are designing a series of components that will be accessed by students through Canvas, with accompanying assignments to ensure that all students engage in the exercises. Ultimately, we will be testing how students engage with the components we have designed and will determine whether engaging in self-regulated learning strategies improves their learning over other non-metacognitive exercises.

Project Description and Outcomes

This year, we worked on two components of a larger project that involves developing an entire set of resources and testing them in a randomized, crossover design in several introductory biology courses at CU. At this point, we are still in the development stages.

Project 1: Encourage students to articulate their learning strategies. Based on the idea of evaluating study strategies in detail as a mechanism to build self-regulation (Schraw 1998; Schraw et al., 2006), we created and test an assignment called "Best Learning Strategies." Building this profile is intended to facilitate reflection on study strategies prior to each course exam. We piloted this assignment in a course I taught this spring, MCDB 2150 Principles of Genetics. Students received an email with a downloadable template (see Table 1) and instructions to complete the chart, listing their most-used strategies for learning and answering the questions of why, how, and when they use a strategy. They were asked to complete the matrix a total of three times, each time with a prompt to re-order the strategies if they now felt a different strategy was better, or to add completely new strategies. Completing the matrix is intended to stimulate metacognitive reflection, and the final matrix is intended to serve as a tool for success in future courses. We collected each submission and began to determine

the types of strategies students list as most favored, and whether and how they changed their strategies over the course of the semester.

Best Learning Strategies (Idealized Example)			
Strategy	**Why to Use (declarative knowledge)**	**How to Use (procedural knowledge)**	**When to Use (conditional knowledge)**
Self-testing	Forces me practice applying the content.	Do the practice questions and practice quizzes, generate my own questions.	Every study session and leading up to the test.
Spacing	Better than studying all at once (don't cram!).	Make a plan for when to study, and then do it.	Try to study a little bit after every class period.
Evaluating	Helps to figure out what I need to study.	Go through notes and find things that were confusing- make note of them.	Work on the hardest things first.

Table 1. Example of a Best Learning Strategies matrix.

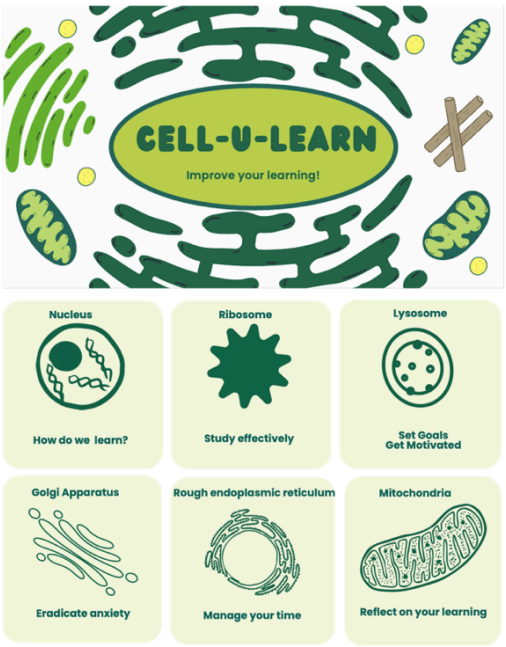
Thus far, we have found that most students *submit* their learning strategy assignment following the directions but very few revise their strategies over the semester. In a data set of 50 individuals who submitted more than once, only 21 revised their entries in any way. The lack of revisions has several implications: students likely enter the course already using a set of strategies they like, and don't necessarily change those strategies. This may be because students are comfortable with their current strategies, or that this assignment does not stimulate them to reflect carefully on their strategies, nor change them. Most changes were from one active strategy to another (e.g. "re-do in class activities" to "use the practice tests"). It is not yet clear whether this activity will improve student self-regulation, although some students, in the "why to use" section, offer metacognitive explanations (Table 2) that are likely worth characterizing.

Strategy	**Explanation of why strategy is useful**
Annotating my notes.	Allows me to re-read my notes while also dissecting further important information.
Going over notes with my classmates.	My group members might've caught something in class that I didn't. They have different Learning Strategies of their own. They help me grow just like I help them to grow.
Re-reading my notes. Did prep questions. Summarized my notes.	By re-reading and re-wording my notes it helps me make sure I understand the concepts and put them into my own terms. It helps put my mind in the headspace for what the quiz questions may look like. Helps me find the overall points of the day's notes and pinpoints what I need to work on.
Practice questions + utilizing the study path.	Repetition of material, similar to actual quiz, strengthens my understanding.
Re-do in class activities.	I can easily review the content from class in a more concise way that is translatable to the quizzes. I can have these printed off for the quiz as well to help me go through similar questions on the quiz.

Table 2. A sample of student strategies and their explanations.

Project 2: Engage students in understanding the components of self-regulated learning through an interactive website.

Students are more likely to engage in practices that they perceive as high value for low cost (Wigfield and Eccles, 2000). Our plan is to design instructional modules that meet these criteria by making them eye-catching, fun, and relevant, either in a web-based environment, or using image mapping in Canvas. Generating this resource will involve using basic HTML coding to construct a series of pages or a website that can be hosted for free (e.g. on GitHub or Web Express) and linked to the course, with an accompanying assignment. Students will be introduced to the ideas and value of self-regulated learning through a series of information and animations. Students will have the opportunity to navigate through the information as if they are traveling through a eukaryotic cell to give the exercise biological relevance. They can choose to click on any organelle to learn more about each component. In each of the component sections, students can read relevant information and then answer reflection questions and construct goals as a Canvas assignment, so they are actively engaged with the content (Hounsell 2007; Torres et al., 2022). The goal is to expose students to possible resources that emphasize metacognitive practices, why they are valuable, how the skills are attainable, and how elements of their course will help them practice each skill. Students will answer a set of questions related to each module to submit as an assignment in Canvas.



Thus far, we have collected and interpreted prior literature on self-regulated learning, and assembled skills and strategies we believe will be most impactful for students. We did this through an extensive literature review (an undergraduate and two Ph.D. rotation students helped to collect this information). We then organized the information into the different modules and worked on different ideas for connecting each main idea to a biological phenomenon that takes place inside the cell. We brainstormed a lot of ideas, tried out different visual representations, and eventually settled on a set of materials we think will be engaging. In addition to this work, it took some time to find someone who could do the web designing part, but I eventually connected with another undergraduate in CMCI who began working about half-way through the spring semester to design the flow of each submodule in Figma. She will continue working over the summer to do the actual html coding to create the website. The draft images and overall flow of the modules as they stand now can be found here (already obsolete, as we are continuing to edit the materials and the animations):
https://www.canva.com/design/DAGCOsBdNKw/6rJyWRxusvcMwUqGJu9znQ/edit#11

Designing these modules was much more work than I initially imagined. As the project is nowhere near complete, we have not gotten feedback from students on its design, flow, or usability, all of which I hoped to do during the spring semester. However, as soon as we have one module ready (hopefully before the end of the summer), we will interview students to help us make decisions about the next steps of the design process.

Reflection

I enjoyed being part of the Faculty Fellows program this year. Hearing about similar struggles from others as well as brainstorming ideas and solutions was affirming. It's so helpful to be around other people who are thinking about student learning, are committed to making changes, and are enthusiastic about helping students. Our conversations helped me decide how to frame the interventions described here, and really helped me as I wrote an NSF grant (submitted in January). And, I'm excited that the reviews and conversations with the

program officer suggest that this project will be funded later this fall! I greatly appreciate the camaraderie and support that this program provided.

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