# Self-Directed Learning Skills:
## Strategies to Support Student Learning in Online STEM Courses

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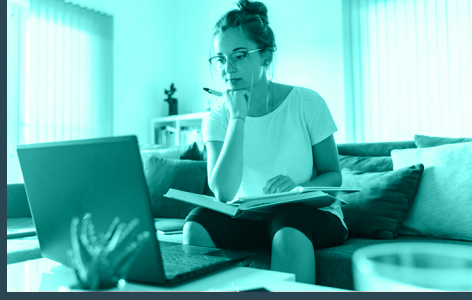
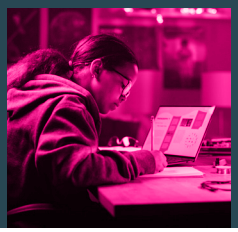
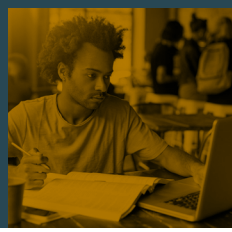






The increase in online course offerings at community colleges and open-access institutions since the COVID-19 pandemic has been a boon for many students who otherwise would not be able to attend college and obtain the degrees and certificates they seek. The flexibility and convenience of learning online are not without challenges, however, especially in introductory courses where students may be asked to manage the demands and expectations of college-level courses on their own for the first time.

In some online courses, there may be little or no interaction with the instructor or other learners, so students may not feel connected to a class community, leading to feelings of isolation and to lower engagement and motivation.[1] Students in online courses may also experience challenges with learning independently, including planning their time and study strategies, asking for help, and accessing resources. Some research contends these factors contribute to lower persistence and success rates for students in online courses.[2]

Low success rates are especially concerning in online science, technology, engineering, and mathematics (STEM) courses, which are important requirements for programs such as nursing, allied health, computer technology, and other fields that can lead to good jobs and economic mobility. One study found that rates of course completion for students taking online STEM courses were almost 20% lower than rates for students taking in-person STEM courses, which underscores the need for improving online course delivery.[3] Increasing the success of diverse students in STEM programs is also a concern and is particularly important for societal goals of creating equitable pathways to higher wage jobs, reducing income inequality, and building wealth, especially for individuals who have been underserved by educational institutions and public policy. Improving success in online STEM courses and programs is one strategy for beginning to address longstanding inequities by race/ethnicity and gender in credential attainment.[4]

The Postsecondary Teaching with Technology Collaborative (the Collaborative) is currently researching the obstacles students face in online STEM courses and the ways that institutions and instructors can better support these students. As part of this research program, we conducted qualitative research in partnership with six community colleges and two comprehensive universities to learn if, when, and how instructors support self-directed learning (SDL) skill development in their online courses. SDL skills can be understood as motivational, metacognitive, and applied learning processes—in other words, the

ways that students maintain motivation, reflect and think about their learning, plan and set goals, and adjust their study strategies. In spring 2022, we surveyed 141 STEM instructors online and conducted 12 virtual "course tours" with STEM instructors who shared their screens and walked researchers through their course structure and content in the learning management system. In this brief, we will discuss some of the challenges with online teaching that instructors reported, introduce a theoretical SDL framework intended to address these challenges, and highlight strategies that may support students as they develop SDL skills and that can be readily integrated into teaching practices.

## Faculty-Reported Challenges With Online Teaching

A common belief about college learning is that students plan their own study time, set their own goals for completing coursework while juggling other responsibilities, and monitor progress toward their goals to stay up to date with assignments and tasks. This may be true for some students, but research suggests a large proportion of students struggle with some or all of these skills.[5] Additionally, this planning, goal setting, and progress monitoring are made more challenging in an online environment because students may experience less of the modeling of these skills by instructors and peers than they would in in-person classes.

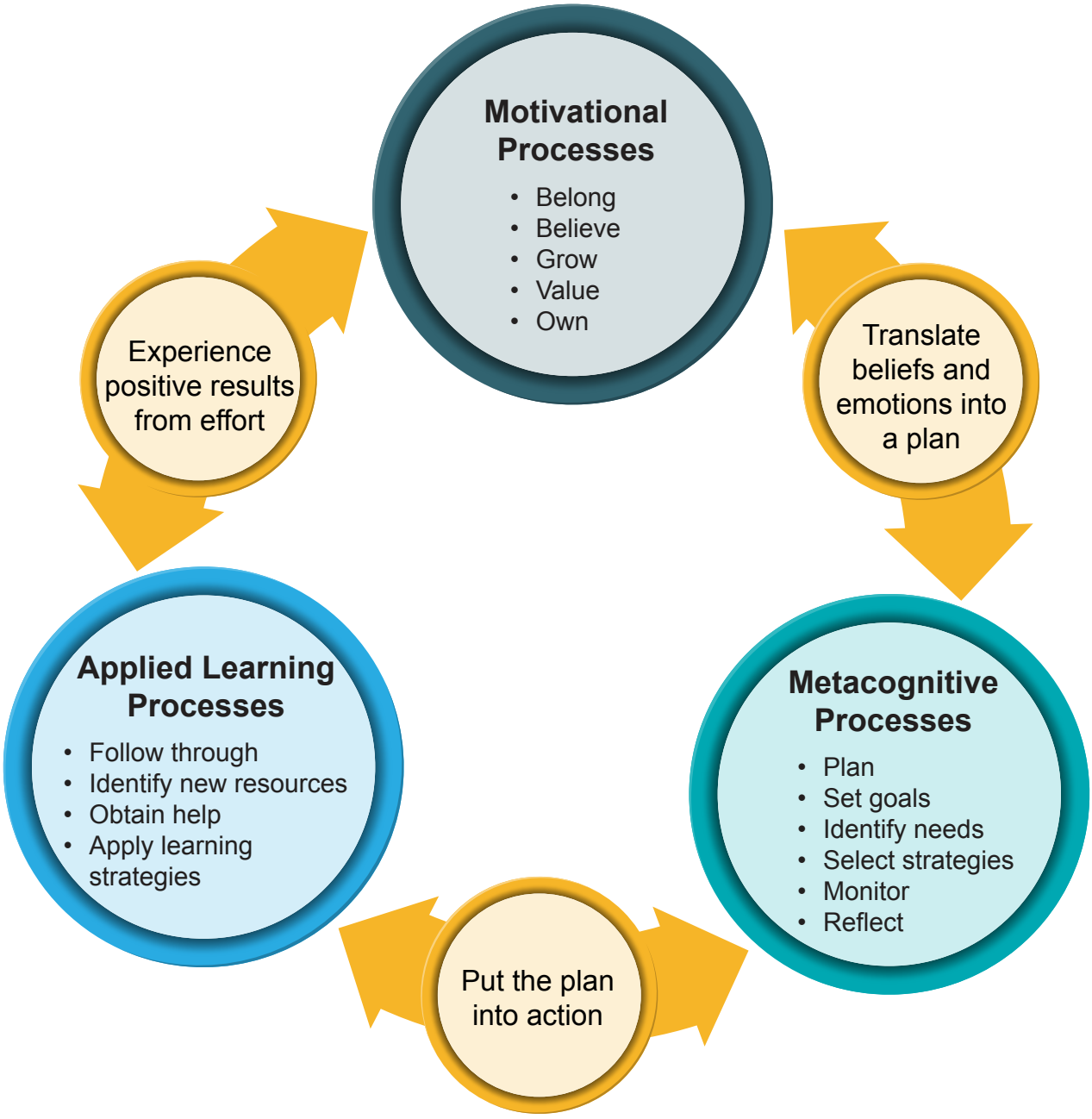
Data from the Collaborative's faculty survey and interviews affirm this understanding. Instructors in our sample perceived online courses as learning environments where it is more difficult to engage students and help them stay on track with their coursework. According to faculty, students in online courses are less likely to experience the excitement and motivation of being part of a community of learners because of the lack of opportunities to engage with peers. Instructors also described fewer opportunities to learn about and build connections with their students through informal conversations. The online instructional delivery modality affects instructors' ability to engage students as well. For example, faculty in our sample reported that it is difficult to promote student engagement in fully asynchronous courses, where instructors and students have no live interactions. Faculty from the physical sciences in particular were concerned about student engagement in online laboratory sections that do not provide opportunities for hands-on learning. A more thorough discussion of the perspectives of faculty and staff on online learning during COVID-19 is provided in another report from this study.[6]

## The Self-Directed Learning Framework

The Collaborative's SDL Framework (Figure 1) describes mindsets and skills that, according to the research literature, successful students use to manage their learning. This evidence-based framework includes skills for maintaining a growth mindset about the ability to learn, setting personally relevant goals, monitoring progress, managing time and priorities, and seeking help when needed.[7] These mindsets and skills can be grouped into the three broad categories of motivational, metacognitive, and applied learning processes,[8] and they have the potential to deepen student engagement and improve

student success, particularly in online courses. A glossary of terms related to SDL skills can be found on the Collaborative's website.

**Figure 1. Self-Directed Learning Framework**

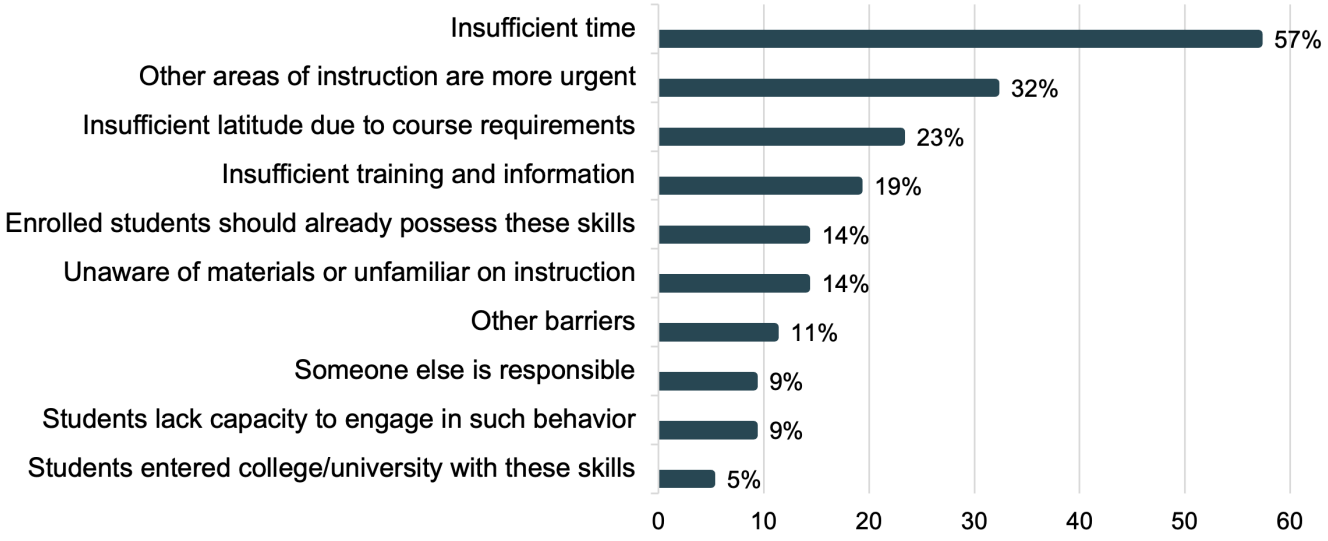


**Motivational processes** are based on students' emotions and beliefs about learning and may impact the amount of time and effort students spend on learning. **Metacognitive processes** are used to plan, monitor, and assess learning performance. Using **applied learning processes**, students follow through on their plans, seek help when needed, and practice learning techniques such as taking notes, writing about learning, teaching another person, and spacing out their studying. As the framework depicts, motivational, metacognitive, and applied learning processes work together to create a self-directed learning cycle that we theorize leads to study and learning behaviors that help students meet the demands of online learning and achieve success in their coursework.[9] The more success a student experiences by applying the processes, the more motivated they become and the better they can refine their learning behaviors.

## Barriers to Incorporating SDL Skills Into Instruction

Nearly 20% of all survey respondents were wholly unaware of the idea of SDL, and another third of respondents reported lacking the training and information to incorporate it into their practice. The SDL cycle reflected in our framework is aspirational, so it is not surprising that we found faculty experience barriers to helping students develop and practice these mindsets and skills. We surveyed faculty to understand the barriers that they feel prevent them from supporting these skills. We provided survey participants with a list of 10 pre-defined barriers[10] and asked them to identify the top three reasons they do not incorporate SDL strategies into their courses. As Figure 2 indicates, the barriers mentioned most frequently by online STEM instructors are insufficient time in their course designs to incorporate more content or activities into the syllabus, the greater urgency of other areas of instruction, and lack of latitude to make changes due to course requirements.

**Figure 2. Percent of Respondents Mentioning Each Barrier**



Many respondents also indicated that they had not received training or information about SDL and are generally unfamiliar with SDL instructional strategies. In a few cases, instructors reported that they received professional development from their institution about online teaching practices that focused on metacognition and course design, and others have gained experience by exploring SDL on their own. Overall, the survey and interviews revealed that, among our sample, faculty incorporation of SDL-supportive practices is not consistent or prevalent. Many instructors perceived that adding non-academic content into their STEM courses would overburden students, and some felt they could not make substantial changes to course design.

## SDL Skills Supported by Faculty

Our survey offered brief descriptions of the seven SDL skills or mindsets reflected in our framework and asked instructors of introductory STEM courses to rank these SDL skills or mindsets by the frequency—"often," "sometimes," "rarely," "never," or "I prefer not to answer"—with which they provide student support in each. Nearly one third (30%) of the STEM instructors in the study reported that they "often" incorporate support for one of seven SDL skills or mindsets that we measured. Instructors support help seeking the most, usually by listing their office hours and providing links to the college tutoring center and other online resources. Monitoring progress and planning are also supported to a lesser degree through reflection and planning activities. Fewer instructors use specific strategies to support sense of belonging and self-efficacy mindsets. Table 1 provides a ranked list of the seven SDL skills or mindsets faculty reported supporting.

**Table 1. Most Frequently Supported SDL Skills/Mindsets**

| Rank | SDL Framework Category | SDL Skill/Mindset | Survey Respondents Who Support This SDL Skill/Mindset *Often* (%) |
|---|---|---|---|
| 1 | Applied Learning | Help Seeking | 70% |
| 2 | Metacognitive | Monitoring Progress | 45% |
| 3 | Metacognitive | Planning | 45% |
| 4 | Motivational | Sense of Belonging | 36% |
| 5 | Metacognitive | Goal Setting | 35% |
| 6 | Metacognitive | Reflection | 29% |
| 7 | Motivational | Self-Efficacy | 25% |

Although support for SDL skills was not prevalent, some instructors described strong examples of strategies that are valuable for understanding what can work for students in online courses. In the survey and during course-tour interviews, instructors reported using a range of activities, assignments, and technology tools to support SDL development. Table 2 lists a selection of the strategies and activities instructors indicated they use to support the processes that are theorized to lead to SDL skill development. Some of the examples below are unique to one or two instructors, while others are more

commonly implemented. The examples are organized according to the three categories of the SDL Framework; because the processes are interconnected and overlapping, some practices may align with more than one category of processes.

**Table 2. Strategies and Activities to Support SDL Development Processes**

| SDL Processes | Strategies & Activities |
|---|---|
| **Motivational Processes** (foster sense of belonging, self-efficacy, growth mindset) | *Sense of Belonging*<br>• *Introductory course video*. The instructor records a video welcoming students, explaining how to navigate the Learning Management System (LMS) and how the course is structured.<br>• *Student video introductions*. Students create videos to introduce themselves to the class and build a sense of belonging.<br>• *Testimonials to future students*. Students write notes to future students about their experiences in the course. New students reflect on these testimonials and what they learned from them.<br>• *Connection apps*. Instructor encourages ongoing peer communication forums using LMS discussion boards as well as external apps (e.g., GroupMe).<br>*Self-Efficacy*<br>• *Low-stakes assessments*. Low-stakes assessments, especially at the beginning of the course, are intended to build student confidence/ self-efficacy. |
| **Metacognitive Processes** (set goals, identify needs and strategies) | *Setting Goals/Managing Time*<br>• *SMART goals*. Students set goals for the course that are sustainable, measurable, actionable, realistic, and timebound (SMART), and they reflect on their progress periodically.<br>• *Time tracker*. Students use a matrix planning/scheduling document (e.g., Excel) to track how they spend their time and when they will do coursework.<br>• *Task time estimates*. Instructor provides estimated time for task completion so students can plan.<br>*Monitoring Progress*<br>• *Periodic progress check-ins*. Instructor asks students to describe their progress toward goals in a reflection assignment.<br>• *Exam wrappers*. Students engage in pre-exam planning and post-exam reflection activities about study habits, assessment results, and improvement plans. |

| SDL Processes | Strategies & Activities |
|---|---|
| **Applied Learning Processes** (follow through on plans, seek help, apply study strategies) | *Study Strategies & Resources*<br>• *Structured note-taking*. Instructor provides note-taking guidelines to help students better absorb content through writing about what they have learned. Students submit notes that are graded based on completeness.<br>• *Resource videos*. Instructor develops videos on specific topics in the course that students can access as a supplemental resource.<br>• *Collaborative problem solving*. Students create and share videos of their solutions to problems and compare them to those of their peers.<br>*Help Seeking*<br>• *Tutoring resources*. Instructor mentions and provides links to tutoring resources on a weekly basis.<br>• *Office hours*. Instructor provides office hours via Zoom and in the evening.<br>• *Check-ins*. Instructor checks in periodically with struggling students.<br>• *Rapid response*. Instructor responds rapidly to questions and provides encouragement to reinforce help-seeking behavior. |

# Putting the SDL Framework Into Action

Drawing on data from the course tours and interviews, we present three examples of SDL instruction that faculty incorporated into their STEM course teaching. In these cases, instructors thoughtfully supported SDL skills at the beginning, middle, and end of a course. We describe the instructional activities, the elements of our SDL framework they address, and the ways these were addressed. We rely on self-reports of faculty to describe what changes they observed in students' learning behaviors and course outcomes.[a]

## Case Example: Connecting Motivation, Metacognition, and Applied Learning

In a synchronous eight-week online biology course, the instructor incorporated teaching strategies intended to boost students' motivation and sense of belonging. Students participated in weekly reflections using Flip Video technology.[b] They created short video reflections about their triumphs, concerns, and questions in the course in a given week. These low-stakes assignments used a

[a] Due to the nature of this analysis, we were unable to validate reported changes in students' learning behaviors or course outcomes. Another body of quasi-experimental research underway by Collaborative researchers is exploring the relationships between instructional strategies, students' academic behaviors, and course outcomes more rigorously.

[b] Flip (formerly FlipGrid) is a free web and mobile app from Microsoft where educators create safe, online groups for students to express their ideas asynchronously in short video, text, and audio messages.

rose–thorn–bud framework where students described what was going well (the rose), what was challenging or problematic (the thorn), and what they found promising in their strategies (the bud). Students shared their videos with their peers and the instructor on the LMS site. The instructor reported that the video exchange deepened the connection between him and his students and built a sense of belonging among the students as they got to know each other and share common experiences.

The reflection assignment also guided students in the metacognitive act of thinking about their accomplishments and strengths, as well as areas for growth. The instructor responded briefly to each posting with guidance about specific study strategies students could use to make the improvements in their learning behavior that they had identified. By showcasing their peers' study approaches, the video reflections also helped students learn about other applied learning processes, including those they could benefit from adopting. According to the instructor, as students gained experience with new strategies, their successes increased, which had a positive impact on their self-efficacy. The instructor explained that after a few weeks of exchanging reflections with each other, student engagement in the course increased beyond the reflection assignment, normalizing success and struggle while providing tactical guidance to students needing help.

## Case Example: Metacognitive Exercises in Gateway Math

An instructor teaching an asynchronous online gateway math course used reflection to spark metacognition and help students think about how they were learning. From the beginning of the course, the instructor incorporated content weekly into the slides the students reviewed that was related to metacognition, habits of thought, decision-making, and communication to support students with their math learning. She emphasized that mathematical reasoning involves a metacognitive process of thinking about an approach to a problem and choosing strategies to find a solution.

To facilitate this thinking, the instructor required students to share their math work using Google Slides each week so students could see how others solved problems or approached an assignment. Throughout the course, the instructor periodically assigned required check-ins during which students reflected on their learning progress by responding to a set of questions including:

- What were the main mathematical ideas that we discussed in class this week?
- What was an "aha" moment you had?
- What questions did you have about the topics we studied?
- Describe an approach another person used that was similar to or different from your own.
- What did you learn from another person's response?

Students used Google Slides or a video platform to post their check-in responses and comments for each other. The check-in reflections were low-stakes assessments that, according to the instructor, did not require extensive time to respond to or grade, but they made a difference for student engagement.

Further, the instructor explained that students were surprised by the sense of community they felt in the class, despite it being an online course, and the videos, check-ins, and slides contributed to their interaction and sense of belonging.

### Case Example: Applying Learning Strategies in an Independent Research Project

In an asynchronous eight-week online biology course, students set goals and reflected on their work and learning as they conducted a research project to gain hands-on experience with the scientific method, working with publicly accessible data about smoking among adults. The assignments included a lab, a presentation about their findings, interaction with fellow students on discussion boards, and a reflection on their work and that of their peers.

The instructor supported metacognitive planning and applied learning strategies by using transparent assignment design principles[11] that described the purpose of the project and provided a detailed list of project tasks and grading criteria. Students were provided with a rubric that included the project's learning goals that helped them relate the course content to their lives and gave them clear guidelines for a successful project that supported their sense of ownership of the assignment. To help students plan, the instructor assigned a weekly activity that asked students to establish goals for the week. To help students reflect on their performance, the instructor asked them to reflect on their progress each week and write about what they had learned so far. In addition, the instructor supported students with methods for understanding and interpreting the data, tables, and graphs in the publicly available dataset, introducing this material through an online lab, and encouraged students to reach out to her and seek help. The instructor developed these low- and medium-stakes assignments to motivate students and help build their self-efficacy and growth mindset about their ability to handle the steps of the research project and the course itself.

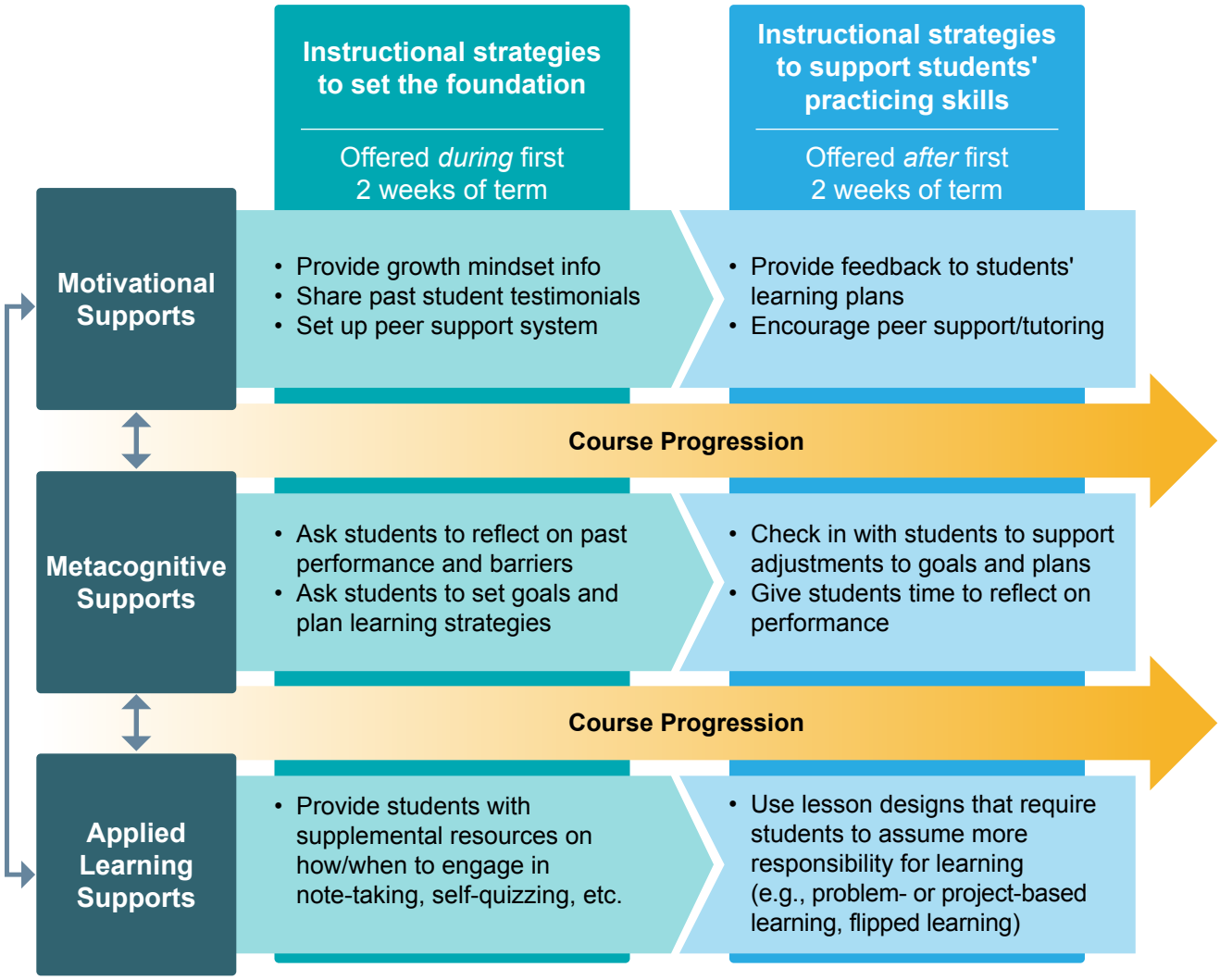
The instructor's approach to the project enabled students to practice a range of SDL skills in the context of a major course assignment. The instructor took care to provide scaffolding and gave students repeated opportunities to practice and apply the SDL skills of time management, goal setting, reflection, and help seeking. According to the instructor, student retention and successful completion of the course improved substantially compared to course sections that did not integrate these approaches into the project.

## Supporting SDL Skills Throughout a Course

The empirical and theoretical evidence on SDL skills suggests timing and sequencing may matter for certain skills. For example, Walton and Yeager (2020) argue that establishing a sense of belonging early and before encouraging students to adopt a growth mindset may generate more favorable outcomes.[12] A limited number of one-time SDL-like interventions including nudges, growth mindset

activities, and building a sense of belonging have been shown to have positive effects on academic outcomes.[13] The three areas of the SDL Framework—motivational, metacognitive, and applied learning processes—are intended to work together throughout a course to help students adopt behaviors and mindsets to support their success. Instructors who start a course by connecting with students and fostering a sense of belonging among peers are engaging in activities that the literature suggests are associated with increasing students' motivation. Some of the instructors in our sample use motivational and metacognitive activities like weekly reflections on triumphs, challenges, and goals to maintain the momentum that is built early in the class. Instructors also continuously support the application of study skills through ongoing note-taking assignments, making it easier for students to seek help when they need it and providing opportunities for collaborative problem solving and peer teaching. Figure 3 reflects our early vision of the types of instructional strategies that support SDL skill development and how they can be used throughout a course.

**Figure 3. Instructional Strategies to Support SDL Skills**



## Looking Ahead

The work of the Postsecondary Teaching with Technology Collaborative is focused on helping institutions and instructors support equitable student success in online courses, particularly STEM courses. Instructors in our study described how they thoughtfully integrate supports for student motivational, metacognitive, and applied learning processes, which can improve student learning in online courses. Our research also revealed that support for SDL skill development is inconsistent among STEM instructors. This underscores the need to build awareness of the promise of SDL skills in supporting student success in STEM courses. We recognize that efforts to encourage the use of SDL instructional strategies must be sensitive to the demands of online STEM courses, which are often characterized by faculty as content heavy and time intensive. The SDL Framework provides an evidence-based theory for instructors as they consider what skills and mindsets to focus on and what strategies they might use.

The framework is evolving through ongoing research and in collaboration with faculty and others at partner sites. The Collaborative seeks to build on the examples of ways that some faculty, instructional designers, and professional development staff are already experimenting with SDL-supportive instructional approaches. We aim to strengthen and scale up online instructional practices that support SDL skills (see also Brown et al., 2024) and to generate resources to support instructors as they integrate these practices into their online teaching. Thus, the Collaborative is working to develop and then test an integrated set of technology-enabled strategies that instructors can embed in part or in whole in their courses.

Based on this design and testing, we next plan to design a toolkit of resources that instructors can use to implement SDL supports throughout their online courses. We are exploring ways that technology can be an asset by limiting the burden for instructors or students to integrate SDL skill support. As colleges continue to adapt to the expanded prevalence of online courses, it is the Collaborative's aim that our work to support SDL skills will ultimately contribute to reducing disparities in STEM course success for students from systemically marginalized groups.

# Endnotes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The Postsecondary Teaching with Technology Collaborative (the Collaborative) is a U.S. Department of Education, Institute of Education Sciences R&D center, co-led by SRI Education and the Community College Research Center at Teachers College, Columbia University, in partnership with Achieving the Dream. The Collaborative uses research findings to build the capacity of institutions and instructors to establish inclusive learning environments and incorporate technology in ways that improve learning and success in postsecondary online courses. Our research analysis aims to contribute to knowledge and understanding of how instruction can support students to employ a constellation of motivational and metacognitive processes and certain applied learning processes—which we refer to as self-directed learning (SDL)—to manage their learning more effectively in online courses and increase their postsecondary success.

Postsecondary Teaching with Technology Collaborative

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