A Student-Centered Approach to Identifying Strategies and Obstacles to Learning for Undergraduate STEM Courses

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Abstract

What motivates and demotivates students in their engagement in at-home work for high-stakes assignments, such as test preparation and writing and revising papers? This paper outlines a student-centered method to identify learning strategies students actually use and obstacles students actually face compared to what is reported in the literature. This method provides awareness and agency of strategies and obstacles to attempt to change student behavior and perceptions. The three research goals were 1) identifying learning strategies and obstacles with a user-centered design method, 2) mapping the strategies and obstacles to the Expectancy-Value-Cost Model (EVC Model) of motivation theory, and 3) noting the effectiveness of those strategies and obstacles and reporting the results to students in between major class assessments. Our results show that that across Science, Technology, Engineering, and Mathematics (STEM) disciplines and student levels, students use and encounter similar strategies and obstacles.

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College students often lack the motivation and ability to self-manage their learning as well as the study skills needed to succeed, especially when approaching entry-level courses that are seen as gatekeepers to their studies. Even when a course is designed to maximize learning opportunities, students may be reluctant to engage in those opportunities. Further, students may not know how to, or often do not, prioritize work outside of class, such as preparing for tests (exams and quizzes) or revising papers. For these reasons, we were interested in studying student motivation with regard to learning strategies and the obstacles students face in attempting to employ learning strategies.

Motivation has been widely studied. Barron and Hulleman (2015) developed the Expectancy-Value-Cost Model (EVC Model) of motivation that has been applied to educational settings. The model theorizes three components of motivation when students are presented with a learning task. Expectancy is how a student perceives their ability to complete the task. For example, in a math class, this would be the extent to which a student thought they could solve a new math problem. Value is the extent to which a student wants to do the task. For example, in a physics class, this could be the value the student sees from completing a degree requirement. Cost is a student's "perceived costs associated with performing the task" (p. 504). In this case, this could be time needed to complete the task that may take time away from another activity. Costs are often seen as barriers or obstacles to completing the learning task. In essence, the motivation model is

$$\text{Motivation} = \text{Expectancy} + \text{Value} - \text{Cost}$$

Both instructors -- and the students themselves -- can influence student motivation through changes in perception and methods of expectancy, value, and cost.

Other researchers have used related lenses to study student motivation. Donche et al. (2013) looked at the interplay of motivation, personality, and teaching strategies used. They found that teaching strategies do play a role in motivation, but personality is just as large of a factor. Berger et al. (2011) found that there was no evidence to suggest that motivation influences learning strategies used by students. Rather, it was value and cost of the assignment that best influenced motivation. Using self-determination theory, Liu et al. (2014) found that student motivation and use of learning strategies was most closely tied to needs satisfaction. These different approaches show that motivation is a complicated interplay of inherent and external factors.

Student engagement is also widely studied. Designing engaging material and tasks may be one way to increase students' motivation by providing students a sense of value of the learning tasks and developing students' expectancy at completing those learning tasks. Gasiewski et al. (2012) used a mixed-methods approach with 73 introductory science, technology, engineering, and mathematics (STEM) courses across 15 colleges to investigate the learning strategies and pedagogical practices related to student engagement. They found that students who were "excited about learning new concepts" (p. 241), had opportunities for "collaboration among peers" (p. 245), and "conceived of themselves as more resourceful" (p. 249) were more likely to have higher levels of engagement. Both Muis et al. (2013) and Pelton (2014) incorporated explicit instruction in metacognitive learning processes (critical thinking, multiple approaches to problem solving, etc.) and found that students reported statistically significant increases in motivation and a wider use of learning strategies. Students' excitement about learning falls within Baron and Hulleman's (2015) definition of value, and students seeing themselves as resourceful is an example of their expectancy framework. Conversely, students who "lack excitement for course material or go unchallenged by the rigor" or do not know who or how to ask for help were less successful. The value and expectancy aspects of motivation or "excitement" are clearly related to student success.

Not surprisingly, instructors can influence student engagement and motivation. Gasiewski et al. (2012) found "that students had significantly lower levels of academic engagement in classrooms where faculty reported a lack of time to provide them with individualized attention or where faculty agreed that it is primarily up to students to be successful in their introductory courses" (p. 248). They concluded that both faculty and student actions affect engagement in introductory courses and recommend that all "need to simultaneously take proactive steps to train students how to be more like the 'engaged student'" (p. 254). Nelson Laird, et al. (2011) also emphasized the impact of the instructor. "We know of the positive impact of pedagogies of engagement not only on general student learning, but also on STEM learning, from years of research" (n.p.). They also found that "STEM seniors lag well behind non-STEM seniors in integrative and reflective learning at nearly all institutions," (n.p.) and propose that in addition to the active learning pedagogies currently being used, that integrative and reflective activities be added to the STEM classroom to increase student engagement.

Educators have created multiple activities and interventions to increase students' motivation and engagement. Value interventions have been widely studied by Hulleman and colleagues (e.g., Hulleman, 2007; Hulleman, Godes, Hendricks, & Harackiewicz, 2010; Hulleman, Kosovich, Barron, & Daniel, 2017, Rosenzweig, E. Q., Hulleman, C. S., Barron, K. E., Kosovich, J. J., & Wigfield,

A. 2018). Their research shows that explicit use of these interventions in the classroom can improve students' value of and engagement with the subject matter that in turn leads to a successful learning experience. Expectancy can also be directly influenced in a classroom setting. Using learning mindsets interventions (such as growth mindset, social belonging, and persistence) may be a way to increase students' expectancy. Emerging research on the effects of using learning mindset interventions is revealing the impact on student learning and engagement; in particular, a multi-year study from the Carnegie Foundation for the Advancement of Teaching and Learning (Yamada 2017) shows that students in the Quantway math pathway are more successful than matched comparison groups -- they passed the course at higher rates and are more likely to pass subsequent quantitative courses. They attribute much of this success to the "emphasis on strengthening growth mindset of students as mathematical learners and doers, enhancing their sense of belonging in a mathematical environment, and helping them develop the confidence and tenacity to grapple with the complex language of mathematics" (p. 8). In essence, students' expectations of their abilities to pass the class can be increased through purposeful introduction of mindset interventions.

However, Yeager and Walton (2011) warn that not all pedagogical changes and interventions will make significant impacts on student motivation and learning. For example, Cudney and Ezell (2017) saw no significant change in motivation for students after a significant change in course design in an engineering class. Yeager and Walton note that effective interventions should target "students experience in school from the student's perspective" and use "brief" and "stealthy persuasive tactics" that don't stigmatize students (p. 285). A similar result was found in a four-year longitudinal study of pharmacy school students where Persky (2018) reported that primary study strategies did not change significantly over time, though secondary strategies may be more flexible. Furthermore, the literature to date does not discuss interventions that focus on the cost component of motivation. With increasing demands on students' lives outside the classroom this component needs to be studied more fully.

In our work, we examined the integration of the Barron and Hulleman's Expectancy-Value-Cost Model of Motivation (2012), the engagement and motivation research, and value and learning mindset interventions with the recommendations of Yeager and Walton (2011). We used those components to design an activity to engage students in their own learning and give them an opportunity to collaboratively participate in knowledge generation about the components of the model from their perspective which included expectancy, value, and cost. We wanted to examine if students' participation in the generation of the learning strategies would increase their motivation through better understanding their own and others' strategies and obstacles. In particular, would students be more likely to try different strategies, reduce costs, and increase motivation to successfully complete key tasks in the course? Specifically, we asked students to examine their own motivation by reflecting on strategies for success and obstacles that interfered with that success. We reported to the students what these successful strategies were, with the intent to examine if reporting student success strategies influenced other students to follow those same strategies.

This paper describes the student-centered design method we employed in a range of STEM courses to determine what learning strategies and costs students encountered when preparing for a test or when writing and revising a paper.

Background: Identifying Student Study Process Model

The study took place at a four-year public university with over 5,200 students, 360 faculty, and offering over 45 undergraduate and graduate degrees. Within the university: 48% of the incoming first year students are first-generation, 35% of undergraduate students are eligible for Federal Pell grants, the student body ratio for female-to-male is nearly one-to-one, and the student body is one of the most ethnically diverse in the nation.

The courses we taught represented a variety of STEM fields (chemistry, computer science, physics, and statistics) and skills (theory, applied usage, technical writing, science writing) as seen in Table 1.

We came together because, across all of our classes, our primary intent was to examine what motivated students to succeed on significant class assessments and what strategies they employed. We initially considered asking students to do a formal process modeling and concept mapping to help identify how they prepare or carry out work. However, this strategy had two primary disadvantages. The amount of class time needed to teach students visual notation required for process modeling (e.g., activity diagrams, model abstractions, non-linear flowcharts, etc.) would be significant and distract from course content. Additionally, studying and learning are inherently variable and highly iterative processes, which can be both difficult to illustrate on process models and can be difficult to compare. As a starting point in our research, we reflected on what our own personal education experiences are and how we individually learn. In this discussion, it became clear that our own study processes were highly variable and iterative in nature.

This exercise gave us insight that the most likely model that would arise in the students' study process models would be a random, highly-iterative study loop with an open choice of study methods and a variety of feedback mechanisms. We imagined their processes to be similar to an open-ended, iterative, feedback-oriented study process model as a reference point for students as described in Figure 1.

The Student Study Process Model is notated using an Unified Modeling Language (UML) activity diagram. The model begins with the student's evaluation of the class task based on the instructions provided by the instructor. The student chooses one or more methods to study, assess, or otherwise prepare to respond to a class task directive whether an exam, quiz, or writing assignment. This preparation step may involve many simultaneous work activities. The student periodically would assess whether or not they are finished with this step. If the student deter-

Course Name	Significant Assessments	Level	No. of Students	Focus/Aim
Introductory Statistics	Exams	300	33	Theory
Physics: Mechanics	Exams	100	58	Theory
Technical Writing	Papers	300	24	Writing
Integrative Studio: Production for Interactive Media Design	Quizzes	400	28	Studio
General Chemistry	Exams	100	110	Theory
First-Year Experience Course: Chemistry in the Kitchen	Papers	100	32	Writing & Theory

Table 1. Courses Involved in the Study

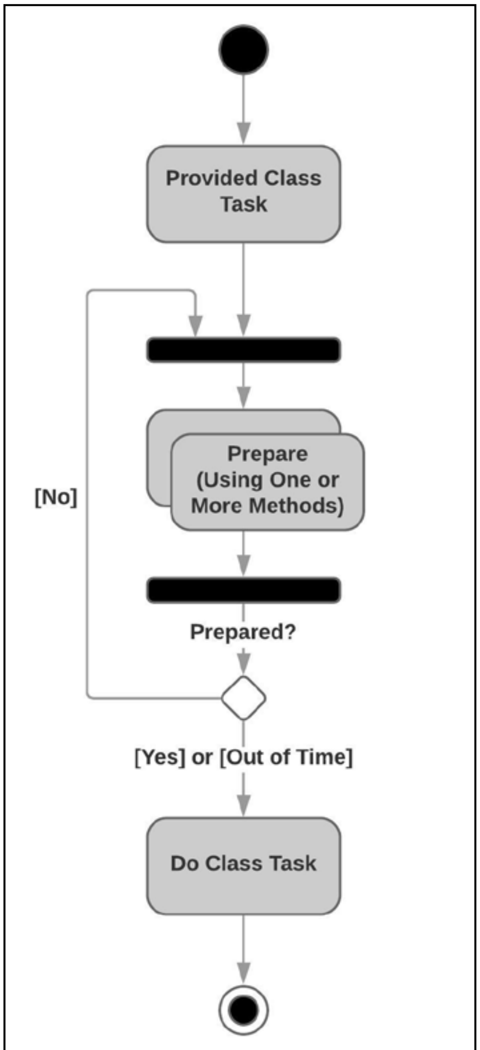

Figure 1. Student Study Process Model.

mines that they are not prepared, they would iterate and choose additional activities to prepare. These activities may be the same as previously performed (repetition) or new activities. This step may also end because of deadlines associated with the classwork -- they needed to sit the test or submit a writing assignment -- or because of other commitments: work, other class work, family, etc. The choice of methods used and their assessment of readiness are subjective and internal in nature.

Identifying this as a primary learning model helped us focus on what we wanted to research: helping students identify successful study strategies, and obstacles that may reduce success. This led us to develop the data collection methods described below that helped students identify and name common study strategies and obstacles, and monitor student behaviors after each significant class assessment, i.e., tests and papers.

Methods

Student Consent with Confidentiality

Each instructor arranged for a different research faculty member to come to their class to discuss the research and data collection, explain the consent form, and collect the signed consent forms. During this time, the course instructor was not present. By having someone else discuss consent, students were not influenced to participate in the study by their instructor nor did the instructor know what questions were asked or who might be indicating consent. The research faculty also acted as a contact for students with any questions or concerns about the research. All signed consent forms were kept by the research faculty member until after grades were posted at the end of the quarter to maintain confidentiality of student consent.

Part 1: Identifying Strategies and Obstacles

Early in the quarter, each course in the study required students to participate in an in-class activity to create a set of lists: what strategies they used to study for a test or revise/write a paper, and what obstacles they faced during these activities.

The brainstorming prompt, and therefore the corresponding lists, were slightly different depending on the course. For all courses, students were asked one of two questions: "What strategies do you use to study for quizzes and exams? OR "What strategies do you use to write a paper?". Writing courses included a second strategies question: "What strategies do you use when revising a written piece?" In both types of courses, the prompt for the study obstacles was "What obstacles prevent you from studying (or writing/revising)?"

Students first considered the prompt individually, writing their personal strategies or obstacles on individual sticky notes. They were encouraged to write as many strategies or obstacles as possible, even if the strategies or obstacles were very similar. Next, students formed small groups of three to six to compare strategies and obstacles. The students developed a classification system to group similar strategies or obstacles together. This activity organized dozens of individual items into a manageable number of categories. Finally, the small groups came together as a class to discuss the strategies and obstacles. At the end of the activity, instructors collected the sticky notes. This method allowed students multiple opportunities to give input both verbally (small group or class discussion) and non-verbally (on the sticky notes for more apprehensive students.

Three of us used the class discussion time to allow students to further refine the categories before creating a "master list" of strategies and obstacles for use on the student surveys. Two of us created the "master list" using the categories developed during the small-group sessions with no additional categorization from the class discussion time. This difference in approach led to some surveys including more detailed options, but these were later mapped to broader categories during data analysis and comparison across the different courses. In recognition of these slight differences, as well as the fact that students may encounter strategies or obstacles not listed during the exercise, all surveys included an "other" option that students could select and elaborate on.

An important aspect of the method described is that students had the ability to identify their own strategies and obstacles. This process gave students agency to identify and reflect on their own work without the encumbrance of a preconceived list of strategies or obstacles. During the group and class discussions, students had opportunities to hear and learn about new or different study strategies or identify shared obstacles. This opportunity to discuss and learn about strategies or obstacles also aligns with the research goals. The discussions also provided awareness of and agency for students to change their behavior or perceptions.

Part 2: Strategies and Obstacles Survey Administration.

Survey class participation. Despite the consent given or refused, completing the survey was considered class participation credit to maximize participation in responding to the surveys, and so that those refusing consent could not be identified by the instructor.

The number of surveys offered was based on the number of relevant exams or assignments. While the number of surveys differs between courses, the questions and options themselves remained the same for each survey during the quarter in the same course. This was done to eliminate the potential for wording changes to affect student responses when taking multiple surveys for the same course. In the rare situation where a student only participated in one survey (or only a subset of the total surveys), their results are not used for any behavior-over-time analysis. "Such analysis has only been undertaken in a preliminary manner so far."

The survey was conducted after each quiz/exam and writing assignment. Students were asked to identify which strategies they used for studying for that particular quiz/exam or writing/revising that particular paper, and which obstacles hindered those activities. As stated, for cases where students used a strategy or encountered an obstacle that fell outside of the categories from the initial exercise, the surveys provided an "Other" option. An additional question asked students to rate how prepared they felt for the completed exam or how well they felt their paper met the requirements.

Survey differences. There were some minor survey differences between courses. 1) Only BPHYS 121 collected baseline data before the first exam. All other courses only collected data after the first quiz/exam or after the first paper was written. 2) The number of surveys varied. For example, BCHEM 143 completed three surveys while the writing courses varied from two to four. 3) Some courses used paper surveys and others used online surveys. While these differences exist, the overall processes used for each class and each assessment were consistent to collect student thinking in a participative manner for each unique class situation.

Paper surveys. Paper surveys were administered at the next class period following the test or paper being submitted, but before students received a grade. This delay was used so that students did not have to use their test time to take a survey, thus reducing any time-related stress.

Paper survey results were submitted using the student's ID number, which is unique to each student but not easily memorable by the instructor. This allowed results to not be associated with the student. The results were entered into an Excel database by a grader using the student number. The aggregate results could be examined by the instructor without association to any particular student.

Online surveys. Online surveys were offered after each test or writing task was completed, but before students were given their grade. After taking the survey, students could see their own responses, but could not see any other student responses nor could they see average or aggregate responses.

Omitting data. Student's survey results were omitted for two reasons: 1) for any students that did not consent to their data being used after the quarter grades were submitted and consent forms were returned to instructors, and 2) for any student that did not complete the test or writing assignment, but did fill in the survey, because it was not possible to link the student's performance with their study strategies and obstacles.

Initial survey reporting. After each survey was completed, the instructors provided preliminary results for students. In particular, instructors provided feedback to let students know which strategies appeared to be the most successful. This information was provided to students so that they could see some of the results of the work they were participating in and to provide feedback to help them modify their own strategies or change their perceptions based on which were successful. Only one course (CSS 301) reported preliminary information about study obstacles to students as the instructor found more obvious correlations between obstacles and student performance. For both online and paper surveys, results presented to students by the instructor during the quarter were based on aggregate responses only.

Results

Sample

A total of 285 students were registered across the six courses and were treated as unique without accounting for overlap amongst the courses. Those students who did not consent to the use of their data were omitted from the data set, leaving 233 for analysis, an overall 81.8% consent rate. For those students who gave consent, participation in each survey administered by their faculty member ranged from 67% to 98%. Across the courses in total, 51% of the consenting students were first year, 21% were seniors, 15% juniors, 12% sophomores, and 1% post-baccalaureate/non-matriculated. Just over 40% of the students identified as female.

Categorization

A compiled list of strategies and obstacles from all courses resulted in a range of 24 to 43 topics. However, we determined that the topics could be further condensed into categories due to similarities throughout. A collaborative norming session resulted in 7 to 9 major strategy and obstacle categories for both tests and writing assignments. The categories and corresponding example topics are provided in Table 2. Additional topics can be found in Appendix A.

Themes Across Classes

When students brainstormed strategies and obstacles, the resulting categories were very similar across all courses in the study with a particularly strong overlap in obstacles. For example, each course had a category of obstacles involving technology, television, internet, music, social media, and video games that we placed under the larger category of "Time Management" (see Appendix A, Table 5). Other common obstacles were hunger, work, family life, and other classes. All the courses with exams had categories that included strategies for reviewing notes, reviewing the textbook, and practicing problems. All of the writing courses had strategies about reviewing instructor comments. Of the nine categories for test strategies, seven overlapped for at least three courses. Of the nine categories for writing strategies, all but one category crossed both writing courses, where it seems that first year students focused on approaches to writing the content of their papers, such as focusing on the beginning and ending of the paper, writing it all at once, and writing in sections. A summary of overlap is provided in the

Tests (Exams and Quizzes)	
Strategies	
Category	**Example Topic**
Content Creation	Concept mapping course content
Content Practice	Mock tests
Content Review	Reviewing class slides and lectures
External Support/Tools	Form study groups
Kinesthetic/Sensory	Watch videos on the content
Physical Condition	Get enough sleep
Prioritization	Focus on difficult material
Time Management	[Used as a general term]
Don't Study	[Singular topic from one course]
Obstacles	
Category	**Example Topic**
Assignment Challenges	Not knowing where to start studying
External Support/Tools	Trouble accessing class material
Job/Work/Other Courses	Homework from other courses
Life Events/Distractions	Bad study location
Motivation/Time Management	Procrastination
Physical Condition	Hunger
Family/Friends/Partners	[Comprehensive]
Writing	
Strategies	
Category	**Example Topic**
Aesthetics	Page layout and design
External Support/Tools	Read comments on drafts from the instructor or a peer
Goal Setting	Use a sample or model
Mechanics	Check sentences
Paragraph	Check transitions between paragraphs
Physical Review	Read paper aloud
Research	Look at online resources
Rubric	Use rubric to check paper
Writing Content Strategy	Focus on beginning and ending of paper
Obstacles	
Category	**Example Topic**
Assignment Challenges	Confusion about where to start
External Support/Tools	Instructor handwriting is unclear
Family/Friends/Partner	People problems
Life Events/Distractions	Bad writing location
Motivation/Time Management	Apathy
Physical Condition	Anxiety
Job/Work/Other Classes	[Comprehensive]

Table 2. Major categories and example topics of each category for exam and writing strategies and obstacles

Test Preparation Overlap		
Course	**Strategies**	**Obstacles**
All 4 Courses	Content Practice, Content Review, External Support / Tools [a]	Family / Friends / Partner [a], Job / Work / Other Classes [a], Motivation / Time Management [a], Physical Condition [a]
3 out of 4 Courses	Content Creation, Kinesthetic / Sensory, Physical Condition, Time management	Assignment Challenges [a], Life Events / Distractions [a],
2 out of 4 Courses		External Support / Tools [a]
One Course	Don't study, Prioritization	
Writing Revision Overlap		
Course	**Strategies**	**Obstacles**
Both Courses	Aesthetics, External Support / Tools [a], Goal Setting, Mechanics. Paragraph, Physical Review, Research, Rubric	Assignment Challenges [a], Family / Friends / Partner [a], Job / Work / Other Classes [a], Motivation / Time Management
One Course	Writing Content Strategy	External Support / Tools [a], Life Events / Distractions [a], Physical Condition [a]

[a] Categories that exist in both classes with tests and writing assignments.

Table 3. Overlap of Strategies and Obstacles Across Classes

Table 3.

Mapping to Motivational Theory

For each obstacle category, we determined (Table 4) within which component of the EVC Model that category fell based on the definitions provided by Barron and Hulleman (2015).

Discussion

Despite the varied classes taught by us, and the assessment we wanted to examine (tests vs. writing assignments), our intention was similar: determine what learning strategies students use and obstacles they face in order to help motivate students to succeed. The goals that arose from this aim included: 1) identifying learning strategies and obstacles through a user-centered design method, 2) mapping the strategies and obstacles to the EVC Model of motivation theory, and 3) analyzing the effectiveness of those strategies and obstacles and reporting the results to students in between major class assessments.

We captured student's perspectives about learning and the process of learning -- a challenging metacognitive process -- as well as having students share their ideas and strategies with each other and the instructor. The survey-generating activity allowed students to discover new ways to learn, and empowered us, as instructors, to highlight successful strategies that were shared with, rather than dictated to, the students. In addition, we gained insight into the complex lives and demands for our students' time, which provided valuable feedback into the feasibility of our course workloads. This student-generated approach of brainstorming, collating strategies and obstacles, collecting strategies used and obstacles faced with each assessment, reporting results to students, and iterating for each assessment was effective across disciplines, school levels, classroom settings, and assessment types as evidenced by the strong overlap in the strategies and obstacles reported and classified. Any college instructor could replicate this activity in order to help their students reflect on their learning strategies and obstacles and gain insights into their students' perspectives.

As seen in Table 4, in addition to the significant overlap in the strategies and obstacles, the obstacles mapped consistently between the types of assessments to proportions of Expectancy, Value, and Cost. That Cost proved to have the largest number of mapped obstacle categories provides further evidence that Cost is warranted as a distinct component in motivation theory (Barron and Hulleman, 2015). While the categories listed under Cost are commonly under the purview of students, knowledge of the complex lives of our students reminds us to reexamine the reasonableness of the workload of our individual courses. Meanwhile, where faculty can have the most impact is in the Expectancy category: assignments can be revised for clarity and brevity, and external tools and sup-

Expectancy	Value	Cost
Assignment Challenges External Support/Tools	Motivation/Time Management	Family/Friends/Partner Job/Work/Other Classes Life Events/Distractions Physical Condition

Table 4. Obstacle categories mapped to EVC Motivation Model

port can be supplied by the instructor or better communicated if already in place. Value can be influenced by both the student and faculty member. One way faculty can add perceived value is to relate assignments to students' daily lives or future classes. Additionally, time management resources can be made available to students in several forms: online tools, courses, and sharing tips and techniques.

Limitations

Our study encountered some limitations. Sometimes we were not able to give timely feedback to students in between major assessments on the correlations between grades, strategies, and/or obstacles. We also were not able to do extensive analysis of how students were employing successful strategies or avoiding obstacles. Both of these limitations were constrained primarily by time, as our university operates on a quarter system and each of us administered an average of three major assessments during the term in addition to other required coursework. This often resulted in an approximately two-week timeframe between assessments: very little time to grade, analyze data, report results, and provide time for students to make changes to their behavior or perceptions. Additional limitations included small class sizes in some of the courses, and a lack of a control group for each course.

Conclusions and Future Study

The current paper outlines our method approach, in future papers, we would like to include a quantitative analysis of the relationships between student grades on tests and papers with the learning strategies and obstacles to determine which types of strategies may correlate with higher or lower grades, and which obstacles undermine success, as well as the impact of quantity of strategies or obstacles employed. Each student will be tracked to determine if changes to behavior were made, and whether or not those changes were related to the instructor-reported strategies or obstacles. We will also examine student awareness of preparedness level versus actual performance. Our research would benefit from future studies examining how students enact strategies and avoid obstacles, what is the quality of those activities, what is the amount of time dedicated, and how was the time allocated each day/week.

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Appendix A

Tests (Exams and Quizzes)	
Strategies	
Category	**Topics**
Content Creation	Create problems Map class content / Find Trends / Concepts Group like terms
Content Practice	Mock tests / Old exams Practice problems Reference real world
Content Review	Notes / Re-write notes Flashcards Read textbook Review Class Slides / lecture Memorize Notecard / Cheat-sheet Online Resources Review homework problems / Redo problems View solutions Quizlet Read study guide Review worksheets
External Support / Tools	Study group Ask instructor / Office hours Tutoring center Peers ask questions / Teach someone else Peer review
Kinesthetic / Sensory	Read aloud Visuals Highlight words Videos on content
Physical Condition	Quiet space / Separate space / Best location Sleep Food Stress Relief

Table 5. Categorization of All Topics

Prioritization	Solve errors Focus on difficult material Problem strategies
Time Management	Time management Review materials right before quiz
Don't Study	Don't Study
Obstacles	
Category	**Topics**
Assignment Challenges	Confusion / Where to start / What to review / Unclear Memorizing Multiple topics in one course No reading comprehension Repetition
External Support / Tools	Missing info Bad study group / Peer review Accessing class material Library hours No correct answer No examples No tutoring center help Technology
Family / Friends / Partner	Family / Friends / Partner
Job / Work / Other Classes	Other classes Job Homework
Life Events / Distractions	Life events Distractions / Bad location / Clutter Car Politics
Motivation / Time Management	Procrastination Apathy / Boredom / Laziness Lack of time management Exercise Media Internet / Social Media / Games Studied as much as felt necessary / Study unnecessary Hobbies

Table 5 (contined). Categorization of All Topics

Physical Condition	Hunger Illness Tired Anxiety / Stress / Overwhelmed Alcohol / Drugs Personal Needs
Writing	
Strategies	
Category	**Topics**
Aesthetics	Aesthetics Contrast, Repetition, Alignment, and Proximity (C.R.A.P.)
External Support / Tools	Ask instructor / Office hours Read comments on draft Someone else read paper Writing center tutoring
Goal Setting	Sample / Model Brainstorm Check organization Check purpose Determine goal Outline Re- / Read assignment
Mechanics	Check sentences Spelling / Grammar check Control F Markup
Paragraph	Check sections Check transitions Glossing Paragraph Restructure Revise paragraphs

Table 5 (contined). Categorization of All Topics

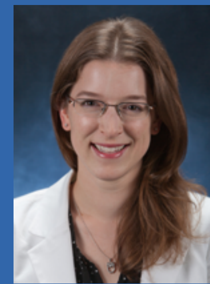
Physical Review	Re-read Read aloud Print on paper Quiet space / Separate space / Best location Read backwards Use colored pen Wait time
Research	Review Class Slides / Lecture Extra research Notes / Re-write notes Online Resources Research general content Research specific content Research with physical resources
Rubric	Use rubric to check paper
Writing Content Strategy	Focus on beginning and ending Word Count Write all at once Write and then fill in Write in sections
Obstacles	
Category	**Topics**
Assignment Challenges	Believe Confusion / Where to start / What to review / Unclear Brainstorm Not having the right words Poor draft Word count
External Support / Tools	Bad study group / Peer review Handwriting MS grammar check
Family / Friends / Partner	Family / Friends / Partner People problem
Job / Work / Other Classes	Other classes Job

Table 5 (contined). Categorization of All Topics

Life Events / Distractions	Distractions / Bad location / Clutter Life events
Motivation / Time Management	Apathy / Boredom / Laziness / Low priority Internet / Social Media / Games Lack of time management Procrastination
Physical Condition	Anxiety / Stress / Overwhelmed Hunger Illness Tired

Table 5 (contined). Categorization of All Topics

Dr. Erin Hill is passionate about student learning and thoroughly enjoys assisting students in discovering their strengths, passions, and ability to learn anything to which they set their minds. Dr. Hill received her Ph.D. in physics from the University of California, Irvine with a focus on biophysics. She is currently a physics Lecturer in the School of STEM at the University of Washington Bothell. Dr. Hill focuses her scholarship on physics education research, active learning, and student motivation and learning strategies. She has presented her work at multiple national and international conferences on teaching and learning.



Laurie Anderson, Ph.D. focuses her teaching in creating active learning experiences that make lasting impressions. Dr. Anderson has a varied background in computer science, business, and cultural ecology. After 20 years in business, she is now a Senior Lecturer for the Division of Computing and Software Systems in the School of STEM at the University of Washington Bothell for over 17 years where she teaches various technical writing courses for both undergraduates and graduates, society and computing ethics, and courses in the Applied Computing degree.

Dr. Brandon Finley is currently a lecturer with the School of STEM at the University of Washington Bothell. His research currently focuses on undergraduate student learning and applying active learning techniques to general chemistry labs. He received his Ph.D. in Earth System Science from the University of California, Irvine. When not explaining chemical theory or research techniques, he most enjoys teaching the two greatest applications of chemistry- cooking and brewing.

Cinnamon Hillyard is an Associate Professor of Mathematics and Associate Vice Chancellor for Undergraduate Learning. Her research focuses on how people use quantitative information to make decisions and how undergraduate education can foster the development of quantitative literacy. She is a Carnegie National Faculty member where she has led multiple initiatives around the Carnegie Pathways program including developing initiatives to support learning mindsets, belonging, and motivation. She has also held leadership positions in the National Numeracy Network and Math Association of America's working group on Quantitative Literacy.

Mr. Mark Kochanski combines theory and practice to show students how to apply their knowledge, skills, and experience to become leaders in the fields. Mr. Kochanski received his M.S in Economic Geology from Purdue University and has worked in computing industry for over 40 years. Mr. Kochanski is a Sr. Lecturer for the Division of Computing and Software System in the School of STEM at the University of Washington Bothell where he uses active learning and high-impact pedagogies to teach computing subjects at the intersection of multiple disciplines such as management, human-centered design, public policy, media, and humanities.