

Mastery meets mindset: Cultivating entrepreneurial mindset habits through mastery-based learning.

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Abstract

Mastery-Based Learning (MBL) shifts the focus from earning partial credit to demonstrating complete proficiency in specific skills. In this model, students often experience multiple failures before achieving mastery, making failure an integral part of the learning process. Prior research has shown that this approach can foster an entrepreneurial mindset (EM) by reshaping students' perceptions of failure and increasing their tolerance for future setbacks.

This study investigates the impact of MBL courses on the development of three specific EM habits defined by the KEEN framework:

1. Resilience: the ability to recover from setbacks and persist through challenges,
2. Growth Mindset: a commitment to learning and improvement through feedback, and
3. Accountability: taking ownership of actions and their outcomes.

Pre- and post-course survey data were collected from students enrolled in MBL courses across four universities. Results indicate that MBL assessments positively influence the development of these EM habits, suggesting that structured experiences with failure as an undergraduate can motivate EM growth.

1. Introduction

Engineering graduates are expected to work in environments marked by uncertainty and iteration. To thrive, they must do more than apply technical skills; they must persist through setbacks, integrate feedback, and assume responsibility for their own continued learning and performance. These capacities align with an entrepreneurial mindset (EM), which the KEEN Framework describes through the 3Cs of Curiosity, Connections, and Creating Value [1]. Recent work has sharpened and expanded this description by articulating specific habits that underlie EM, including persistence, resilience, and accountability. The “Habits of Entrepreneurial Mindset” card on Engineering Unleashed (Card #101) highlights these dispositions as enduring habits of mind that help students explore opportunities and create value [2].

For engineering educators, a central question is how course structures can cultivate these EM habits not only in design or co-curricular innovation contexts, but across the required engineering science curriculum. Mastery-Based Learning (MBL) offers one such structure. In MBL courses, students must demonstrate mastery of clearly defined skills to earn credit; assessments are evaluated on a “mastered/not-yet” basis, with opportunities for retesting throughout the term. Grades reflect the number and complexity of skills mastered rather than partial credit on high-stakes exams. This creates an environment in which repeated failure is expected and recoverable: students are invited to analyze errors, seek help, adjust strategies, and try again [3–5].

A previous study investigated how this structure relates to students' attitudes toward failure across several mechanical engineering and math-for-engineers courses at three institutions [6]. Using a pre/post survey adapted from a validated failure-tolerance instrument and open-ended prompts about students' responses to failure, the study found that MBL encouraged many students to move from abstract statements ("failure is part of success") to more concrete descriptions of how they reflected on mistakes, altered study behaviors, and used feedback. Students also noted that the opportunity to retake assessments reduced the perceived stakes of failure and made it easier to persist through early setbacks. Together, these findings established initial evidence that MBL can cultivate EM-related thinking about failure.

Conceptually, the first study centered on failure tolerance as a single construct. This study expands to examine a wider ecosystem of EM habits now emphasized in the KEEN framework [2]. Specifically, this study focuses on three EM habits:

1. Resilience: Bounces back from setbacks and recovers from failures.
2. Growth Mindset: Embraces learning and feedback for development.
3. Accountability: Takes responsibility for actions, decisions, and their consequences.

Situating this work within the Habits of EM framework serves two purposes. First, it provides a theoretical basis for interpreting how repeated, low-stakes failure opportunities in MBL might translate into durable habits of mind. For example, a student who revisits "Not Yet" assessments by planning extra practice, attending office hours, and reflecting on errors is engaging in resilience, growth mindset, and accountability behaviors, and not simply "fearing failure less." Second, it enables instructors and EM practitioners to map concrete course features (such as retake structures, feedback mechanisms, and expectations for self-regulation) onto specific EM habits they hope to cultivate.

Overall, the goal of this paper is to evaluate if MBL assessment structures cultivate habits associated with resiliency, growth mindset, and accountability. This paper addresses this goal by 1) using established Likert-scale surveys to track student growth, 2) comparing open-ended question responses before and after taking an MBL course, and 3) identifying common trends in open-ended question responses.

2. Methods

2.1 Institutional Context and Participating Courses

Data were collected from five MBL courses across four universities: a small private Midwestern university (A; Ohio Northern University), a small private Northeastern college (B; Elizabethtown College), a mid-sized private university located in the Rocky Mountain region (C; University of Denver), and a large public university in the Southeastern United States (D; Florida Gulf Coast University). All participating courses implemented a mastery-based assessment model with the same core features [3,7-11]: clearly defined skill objectives, binary "mastered/not-yet" scoring, multiple opportunities to retake assessments, and structured mechanisms for feedback and revision. Table 1 summarizes the courses assessed in this study.

Table 1: MBL course enrollment details.

School	Sections	Total Enrollment	Responses	Level	Course
A	3	80	69	Junior	Machine Component Design
B	2	39	11	First Year	Foundations in Mathematics
B	3	59	18	Sophomore	Circuit Analysis
C	2	85	71	Sophomore	Statics
D	1	34	31	Sophomore	Statics and Dynamics

2.2 Survey Instrument Design

A pre-/post-course survey was developed to investigate how students' EM habits evolved over the academic term. The instrument included both Likert-scale measures aligned with each EM habit and open-ended prompts designed to elicit narrative descriptions of how students respond to failure, feedback, and responsibility in an MBL context. Survey items were informed by previously validated scales and adapted to fit the structure and expectations of MBL courses. All procedures were reviewed and approved under IRB exempt or expedited status. Only students who completed both the pre-course and post-course surveys and provided permission for their paired data to be analyzed were included in the dataset, resulting in 200 usable matched responses.

2.3 Resiliency Measures

Resiliency was measured using the Brief Resilience Scale (BRS) developed by Smith et al. [12]. Six questions assessed students' perceived ability to recover from setbacks (Tab. 2). Prompts 2, 4, and 6 were reverse-scored so that lower values indicate greater resilience. Students rated each item on a 5-point Likert scale from 1 - *Strongly Disagree* to 5 - *Strongly Agree*. Open ended questions were developed to explore student's ability to confront and work through low-stakes failures repeatedly (Tab. 2).

Table 2: Likert Scale and open-ended resiliency questions.

Type:	Prompt	Question	Pre-Course	Post Course
Likert	1	I tend to bounce back quickly after hard times.	x	x
Likert	2	I have a hard time making it through stressful events.	x	x
Likert	3	It does not take me long to recover from a stressful event.	x	x
Likert	4	It is hard for me to snap back when something bad happens.	x	x
Likert	5	I usually come through difficult times with little trouble.	x	x
Likert	6	I tend to take a long time to get over setbacks in my life.	x	x
Open-ended		What role does failure play in your learning process?	x	x
Open-ended		Describe a time in this class when you didn't succeed on your first try. How did you respond and what did you learn from the experience?		x

2.4 Growth Mindset Measures

Students' growth mindset beliefs were assessed using the 8-item Growth Mindset Scale (Tab. 3) introduced by Burnette et al. [13]. The questions measured beliefs regarding the malleability of ability, importance of effort, and value of challenge. Students rated agreement on a 5-point scale from 1 - *Not like me at all* to 5 - *Very much like me*. Open ended questions were developed to explore student's response to the iterative feedback-driven learning process at the core of MBL (Tab. 3).

Table 3: Likert Scale and open-ended growth mindset questions.

Type:	Prompt	Question	Pre-Course	Post Course
Likert	1	I know that with effort I can improve my skills and knowledge	x	x
Likert	2	I can influence and change my development in general	x	x
Likert	3	I can change my skills and knowledge through practice	x	x
Likert	4	I like to take challenges and try new things	x	x
Likert	5	I see learning as my goal	x	x
Likert	6	Effort makes me stronger	x	x
Likert	7	I want to spend more time and work more on an area/theme/skill to develop my skills and knowledge	x	x
Likert	8	I have faith in my own skills and my possibilities	x	x
Open-ended		How do you typically react to constructive feedback from instructors or peers?	x	x
Open-ended		Can you describe a time in this course when you learned something important from a mistake or failure? What did you take away from it?		x

2.5 Accountability Measures

Accountability was measured using the 11-item single-factor Accountability Scale (Tab. 4) validated by Witvliet et al. [14]. The questions assessed students' responsibility for their own learning behaviors, openness to evaluation, willingness to be held accountable, and sense of obligation toward accurate and honest work. Students rated each item on a 5-point Likert scale from 1 - *Disagree Strongly* to 5 - *Agree Strongly*. Open ended questions were developed to investigate how students enact accountability behaviors within the MBL structure (Tab. 4).

Table 3: Likert Scale and open-ended accountability questions.

Type:	Prompt	Question	Pre-Course	Post Course
Likert	1	I usually welcome being accountable to others.	x	x
Likert	2	I am willing to be held responsible for my contributions on tasks.	x	x
Likert	3	I feel responsible for my work with others.	x	x
Likert	4	I try to understand the perspectives of people who evaluate me.	x	x
Likert	5	I willingly explain my work on a project to people I am responsible to.	x	x
Likert	6	I am comfortable showing the details of my work (e.g., for school, job, chores).	x	x
Likert	7	I care a lot about whether the people I am accountable to are fair.	x	x
Likert	8	I care about the people affected by what I do.	x	x
Likert	9	I welcome corrective feedback from people who evaluate me.	x	x
Likert	10	I take responsibility for my actions even if it costs me.	x	x
Likert	11	I benefit when I am held responsible for my behavior.	x	x
Open-ended		What does being accountable for your learning mean to you?	x	x
Open-ended		Describe a time when you took responsibility for your own learning or performance in this course. What actions did you take to address the situation?		x

2.6 Data Analysis

Open-ended responses were analyzed through a paired, pre/post qualitative coding procedure facilitated by Microsoft Copilot. Each response was examined for the presence of linguistic markers associated with entrepreneurial mindset habits, including growth-oriented phrasing, action-focused language, sentiment, and habit-specific indicators such as help-seeking, attention to detail, persistence, planning, or reflective takeaway. Coders assigned each of these features as either present or absent for every student response.

To determine whether the likelihood of demonstrating a given linguistic feature changed significantly over time, paired pre- and post-course indicators were analyzed using McNemar exact tests. This test evaluates whether students were more likely to add or lose a linguistic marker between timepoints by comparing discordant response pairs, making it particularly appropriate for identifying directional change in matched qualitative data. The resulting b (0→1) and c (1→0) values provide a direct measure of whether the course environment systematically increased the presence of specific habits in students' written reflections.

Several open-ended prompts asked students to describe events that occur only within the context of the MBL course and were asked only on the post-course survey. These post-course narratives were coded to exact core themes (Tab. 5), and the frequency with which students exhibited each theme was summarized.

Table 5: Core Trends for coding student open-ended responses to post-course only questions.

Core trend	Description
Behavioral adaptation	Student describes a concrete action taken after the mistake (e.g., <i>study, practice, review, rework, fix, correct, office hours, ask</i>)
Help-seeking	Student mentions formal or informal support (e.g., <i>office hours, professor/TA, learning hub/coaching, peers/group</i>)
Attention to detail	Student names a specific error topic they corrected (e.g., <i>units, sign conventions, FBDs, trig, moments, vectors, geometry, Mohr's circle, SolidWorks</i>)
Persistence	Student signals multiple attempts/iterations or “didn’t give up”
Reflective takeaway	Student articulates the lesson learned (e.g., <i>realized/understood/takeaway</i>)
Positive reframing	Overall tone more positive than negative (simple lexicon score > 0)
Planning & Time Management	References planning behaviors (e.g., <i>plan, schedule, deadlines, organized, on time</i>).

3. Results

3.1 Resilience

3.1.1 Brief Resilience Survey

Resilience was assessed using six items measuring students’ ability to recover from setbacks (Tab. 2). Paired pre- and post-course comparisons (Fig. 1.A) showed small but consistent shifts in the desired direction, with two of the three reverse-scored items decreasing slightly. Although the magnitude of change was modest (Fig. 1.B), the pattern indicates a mild improvement in students’ comfort with challenge and recovery from stressful events.

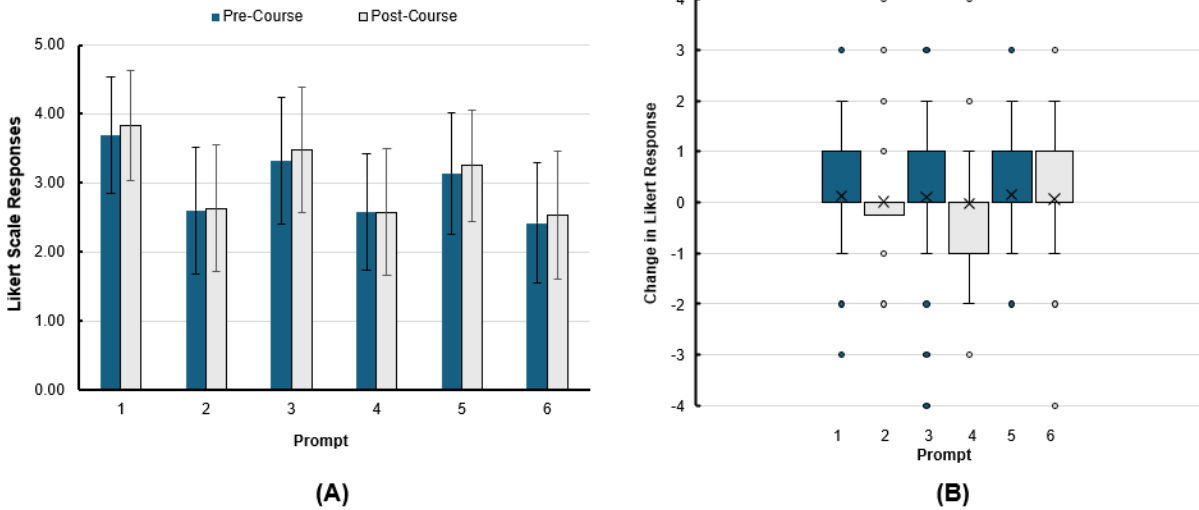


Figure 1: (A) Pre-course vs. post-course responses to Brief Resiliency Survey questions. For prompts 2,4, and 6, lower values represent increased resiliency. (B) Average score change across individual students on pre- vs. post-course surveys.

3.1.2 What role does failure play in your learning process?

Paired pre-/post- analyses of this prompt showed clear, statistically reliable movement toward more constructive descriptions of failure. Growth-oriented phrasing increased substantially, with many students adding explicit language about learning from errors by the end of the course (Tab. 6). References to concrete improvement behaviors (e.g. studying targeted topics, practicing with intent, and using office hours) also rose. Sentiment shifted positively, though the magnitude of that change was smaller than the shifts toward growth and action. Together, these results indicate that students did not simply profess a generic belief that failure can teach, but they increasingly described failure as a signal that directs effort, clarifies study priorities, and justifies the use of support resources. Example student responses are provided in Appendix 1 (Tab. A1).

Table 6: McNemar test results comparing student responses for “What role does failure play in your learning process?”

Outcome	Pre_ %	Post_ %	b (0→1)	c (1→0)	p
Growth markers	65.5	84.5	51	13	<0.001
Action terms	20	28.5	35	18	0.027
Positive sentiment	50	60	56	36	0.047

3.1.3 Can you describe a time in this course when you learned something important from a mistake or failure? What did you take away from it?

Post-course responses to this reflection described the concrete mechanics of resilience in practice. The most common pattern was behavioral adaptation (Fig. 2): students reported reworking problems, revisiting notes and examples, and preparing more deliberately for the next attempt. Help-seeking appeared as a normalized behavior, with students citing office hours, peer explanations, and tutoring resources as part of their adjustment process. Attention to detail emerged in a smaller but meaningful subset of answers, typically framed around catching unit errors, sign conventions, or diagramming mistakes that had previously derailed otherwise correct approaches. Although explicit statements of persistence were less frequent than action statements, many students implied persistence through narratives of repeated attempts. Example student responses are provided in Appendix 1 (Tab. A2).

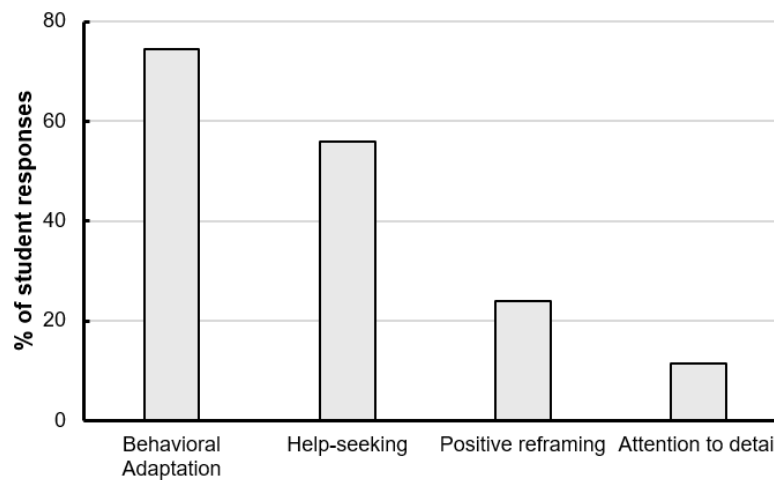


Figure 2: Common responses for open-ended question, “Describe a time in this class when you didn’t succeed on your first try. How did you respond and what did you learn from the experience?”

3.2 Growth Mindset

3.2.1 Growth Mindset Scale

Across eight items evaluating growth mindset (Tab. 3), means increased slightly from pre- to post-course (Fig. 3A). Changes were consistent but small, and the individual-level distribution again clustered around slight increases and decreases rather than large movements (Fig. 3.B). The pattern suggests gradual strengthening of growth-aligned beliefs over the academic term.

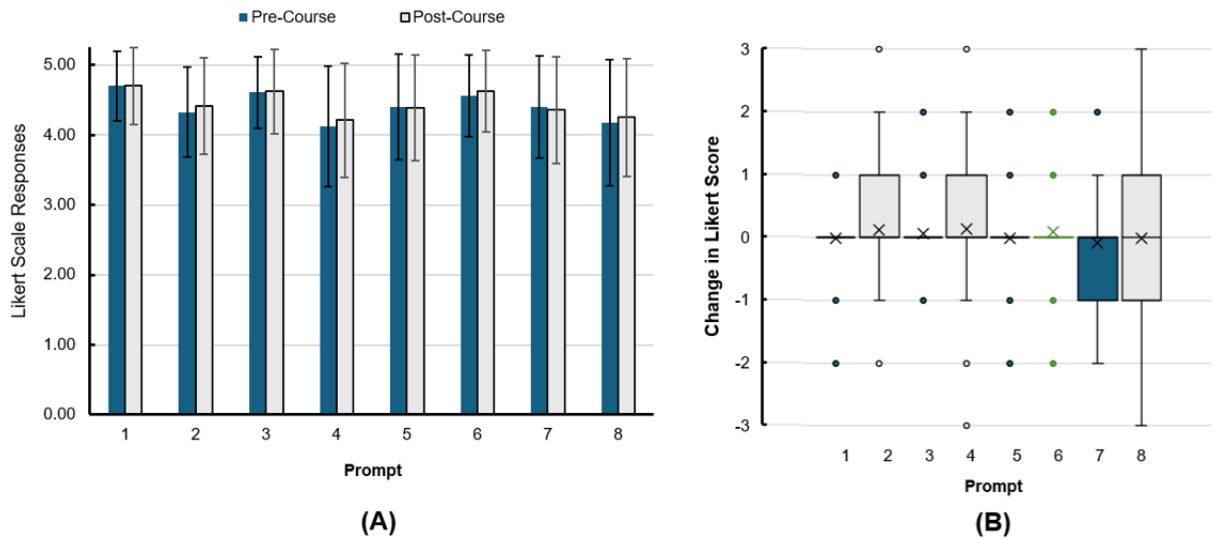


Figure 3: (A) Pre-course vs. post-course responses to Growth Mindset Scale questions. (B) Average score change across individual students on post- vs. pre-course surveys.

3.2.2 How do you typically react to constructive feedback from instructors or peers?

Paired analyses of this prompt revealed modest improvements that did not reach statistical significance for growth-oriented phrasing or action terms (Tab. 7). Nevertheless, the character of post-course responses shifted toward greater specificity: students more often described what they do with feedback, including revising work, applying corrections in the next submission, and asking targeted follow-up questions. Sentiment remained stable overall, which is consistent with a cohort that already endorsed feedback as useful at baseline. In practice, this pattern suggests that the course environment did not necessarily change how students feel about feedback, but it did nudge them toward more concrete implementation behaviors and clearer articulation of the link between critique and subsequent action. Example paired student responses are provided in Appendix 1 (Tab. A3).

Table 7: McNemar test results comparing student responses for “How do you typically react to constructive feedback from instructors or peers?”

Outcome	Pre_%	Post_%	b (0→1)	c (1→0)	p
Growth markers	56	63.5	55	40	0.1505
Action terms	23	25	32	28	0.6989
Positive sentiment	55	54	44	46	0.9161

3.2.3 Can you describe a time in this course when you learned something important from a mistake or failure? What did you take away from it?

Post-course narratives to this question emphasized the translation of mistakes into learning plans (Fig. 4). Most students described taking a specific action (e.g. reworking an item, practicing with a similar

problem type, or checking key steps against a rubric or example) rather than stopping at recognition that an error occurred. Help-seeking appeared frequently and was framed as a routine step rather than a last resort. A smaller but noteworthy fraction of responses named the technical locus of error, such as a sign convention or geometric relationship, which indicates maturation in self-diagnosis. Students also articulated brief lessons learned, connecting the immediate correction to a generalizable habit (e.g. checking units earlier, drawing diagrams more systematically, or planning study around error patterns). Example student responses are provided in Appendix 1 (Tab. A4).

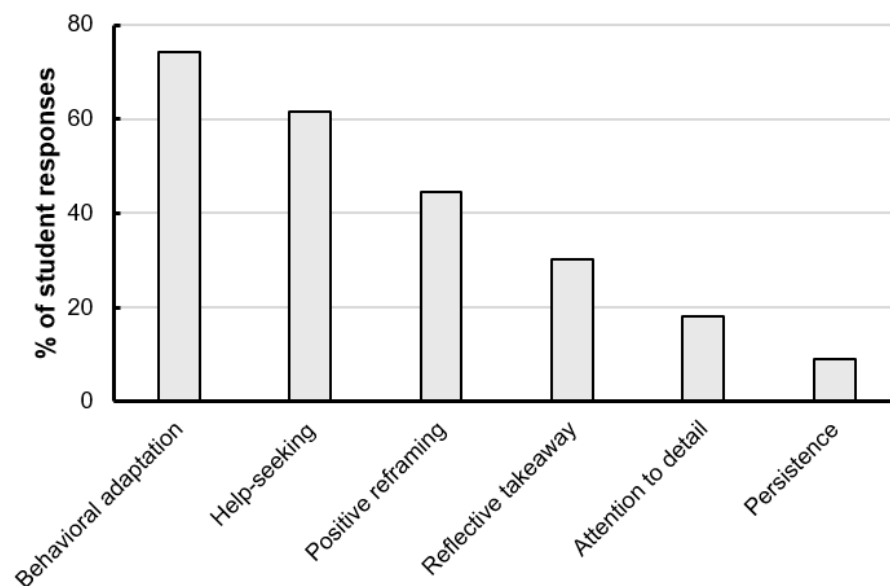


Figure 4: Common responses for open-ended question, “Can you describe a time in this course when you learned something important from a mistake or failure? What did you take away from it?”

3.3 Accountability

3.3.1 Accountability Scale

Accountability was assessed across eleven items describing responsibility for performance, openness to evaluation, transparency in work, and willingness to be held to standards by others (Tab. 4). Item-level means trended upward modestly, with the clearest movement in items reflecting responsibility for one’s contributions and comfort with corrective feedback (Fig. 5.A). As with the other constructs, most individual changes were slight and in the desired direction (Fig. 5.B).

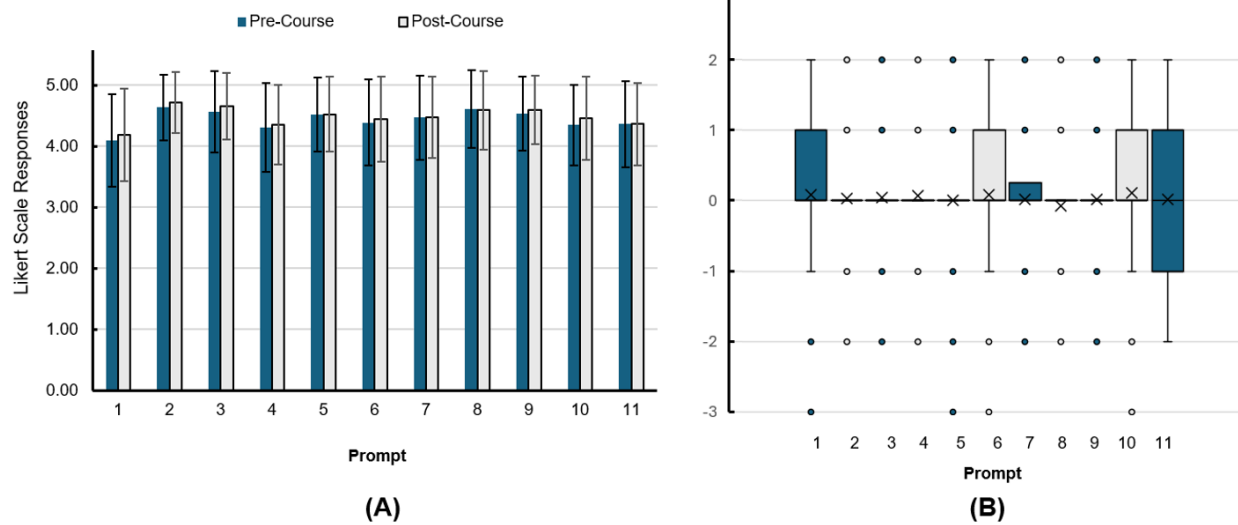


Figure 5: (A) Pre-course vs. post-course responses to Growth Mindset Scale questions. (B) Average score change across individual students on post- vs. pre-course surveys.

3.3.2 What does being accountable for your learning mean to you?

Paired analyses of student responses to this prompt showed a statistically significant increase in positive framing of accountability, with non-significant but directionally positive movement in explicit accountability language and action terms (Tab. 8). Students’ post-course definitions were more likely to emphasize ownership and agency, with many describing accountability as a personal commitment to effort, honesty, and responsiveness to feedback rather than as an external requirement. Although the rise in action terms was modest, qualitatively the responses increasingly linked the concept of accountability to concrete behaviors. Example paired student responses are provided in Appendix 1 (Tab. A5).

Table 8: McNemar test results comparing student responses for “What does being accountable for your learning mean to you?”

Outcome	Pre_%	Post_%	b (0→1)	c (1→0)	p
Accountability markers	51	54.5	47	40	0.5203
Action terms	23.5	26	34	29	0.6147
Positive sentiment	63.5	73.5	45	25	0.0225

3.3.3 Describe a time when you took responsibility for your own learning or performance in this course. What actions did you take to address the situation?

Post-course accounts of responsibility foregrounded action (Fig. 6). Most students described a specific sequence of steps they initiated (e.g. reviewing lecture materials, practicing with new variations, attending office hours, and retesting) to resolve a performance gap. Help-seeking was common and

framed as effective rather than remedial. Planning and time-management behaviors appeared less frequently than direct action and support-seeking, suggesting that students prioritized immediate corrective work over long-range scheduling narratives in this context. Even when students did not explicitly label their response as “accountability,” their examples consistently depicted ownership: the student recognized a deficiency, chose a response, and executed a plan to close the gap. Example student responses are provided in Appendix 1 (Tab. A6).

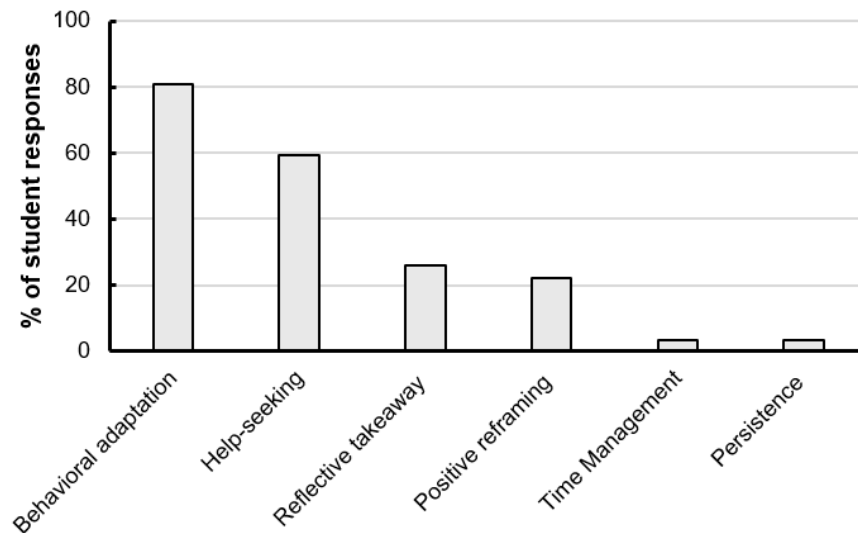


Figure 6: Common responses for open-ended question, “Describe a time when you took responsibility for your own learning or performance in this course. What actions did you take to address the situation?”

3.4 Likert Scale Summary

To further contextualize individual level changes, summed scores for Likert surveys were classified as decrease, no change, or increase relative to each student’s pre-course scores. Most students fell into the “slight decrease” or “slight increase” categories, indicating that the majority of shifts were subtle (Fig. 7). Overall, students were more likely to increase their summed Likert survey scores for the Brief Resiliency Survey (39.2%), the Growth Mindset Scale (26.3%), the Accountability Scale (44.3%) on post-course surveys compared to the pre-course surveys.

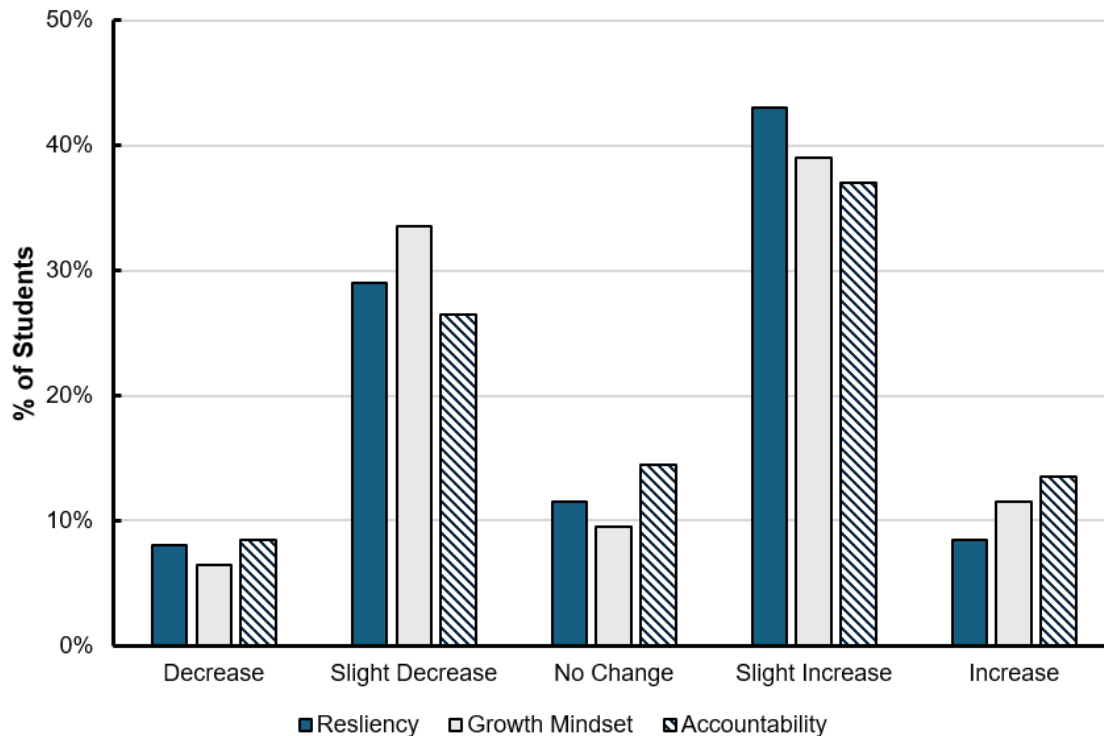


Figure 7: Total change in summed score for each student on Likert surveys. Slight increase or decrease was defined as changes ± 1 to ± 4 for sum of responses when comparing post-course to pre-course surveys.

4. Discussion

Likert-scale measures of resilience, growth mindset, and accountability each showed small, coherent improvements from pre to post (Fig. 1, 3, and 5), with most individual changes falling in the slight-change categories (Fig. 7). In contrast, open-ended responses provide stronger evidence of growth in how students approach challenge (Tab. 6), feedback (Tab. 7), and responsibility (Tab. 8). Across prompts, students increasingly described failure and critique as signals that directed effort, specified concrete next steps that they could execute, and normalized the use of support resources (Fig. 2, 4, and 6). Additionally, MBL shifted the mechanics of students' responses, more than their self-ratings of underlying dispositions, which remained stable but trended positive. In combination, these results depict a learning environment in which students gradually refine actionable strategies for improvement while consolidating, albeit modestly, their self-perceived beliefs and responsibilities.

The mixed-methods study design presented in this paper allowed for triangulation between self-reported Likert measures and narrative descriptions of student behavior. While Likert-scale changes captured students' global perceptions of their habits, the open-ended responses provided richer evidence of how they enacted those habits in concrete situations. This combined approach supports a more nuanced interpretation of how MBL environments influence EM-related behaviors, enabling comparison between what students say they believe and how they describe responding to failure, feedback, and responsibility in practice.

There are several limitations worth noting. Only students who completed both surveys and agreed to participate were included, which may bias results toward more engaged or reflective students. Automated coding through Copilot enabled a large-scale paired comparison, but future studies could strengthen validity by combining automated and manual qualitative coding. Finally, because this study examined only MBL courses, future work could compare these results with non-MBL sections to better isolate the influence of course structure.

Overall, this paper shows that MBL provides repeated opportunities for students to practice behaviors associated with EM habits. While Likert scores reveal gradual shifts in underlying dispositions, the open-ended responses illustrate how students begin to operationalize those habits in concrete ways. This distinction is important: students may develop the behaviors of resilience, growth mindset, and accountability before those behaviors are fully reflected in their self-reported mindsets. These results add to prior work suggesting that MBL environments help students reframe challenge as an expected and solvable component of learning [6]. By lowering the stakes of early attempts and emphasizing revision, MBL appears to create conditions that support the development of EM-aligned habits even in technically focused courses.

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Appendix 1: Open-ended Response Examples

Table A1: Paired example student responses for “What role does failure play in your learning process?”

Student	Pre-course	Post-Course
1	“Failure sets me back in my learning progress typically, it is difficult for me to get right back and being proactive in my studying when I do poorly on a test. That motivation is hard to regain the confidence and ability to study once again.”	“Failure teaches me how to study better. Depending on each course, my strategy for studying changes.”
2	“I believe learning to accept and work with failure is one of the most crucial skill to develop. That said, I struggle deeply with failure and have found the fear of failure extremely limiting in the past. Over time, I've kind of learned to take fails easier and grow, but I struggle to recover from how deeply personally I take it when I experience negative feedback or erroneous results.”	“Failure plays the valuable role in my learning process of explicitly highlighting my weak areas and where I need to improve. I can feel completely confident in a task, but if I attempt that task and receive feedback on areas where I have failed to meet expectations, it opens up a new door for me to improve upon a skill in which I may not have recognized I was lacking in before. This gives a clear goal for what things I need to study more in depth so I can be more knowledgeable the next time I have to apply that skill. Exposing these not only allows you to improve that skill for next assignment/experiment/exam/ etc., but it opens my eyes when I see similar problems to go through the process of “Oh! I missed this when doing X, so I know to be extra cautious with X formula to get it right.”
3	“It is the best teacher”	“I tend to take failure as an opportunity to grow and fix what made me fail in the first place. I find it annoying, especially if its a repeated or simple mistake, but I still overcome said failures and try to make myself better in response.”
4	“It is what allows me to continue growing. When I fail, I am made aware of were I’m not the strongest and were I can improve/learn.”	“Failure is what allows me to learn, when given proper time to fail and learn from failure. Given proper time, failures highlights the areas where I am not my strongest. Paired with proper analyze of failures and potential corrections, failure benefits me more than getting everything right the first time. In addition being able to make as many mistakes as I need relieves the stress of having to get it right the first time. However if not allowed enough time to properly learn from my failures, they become stressful and taxing on my mental well being. If time is short and few mistakes can happen, I am more likely to make more mistakes and not learn from failure.”

Table A2: Example core trend responses for “Describe a time in this class when you didn’t succeed on your first try. How did you respond and what did you learn from the experience?”

Trend	Quote
Behavior adaptation	"At the start of the class, I thought I was able to take the tests without studying and struggled. I then started working harder on the problems and studying outside of class, and started to see more success."
Help-seeking	"I think of my second year college where I had begun testing different study methods and allotting time to ensure I felt confident on topics I was nervous about. Despite my efforts, I didn't perform as well as I had anticipated. While I was initially upset, I took it as a learning lesson to continue trying and refining my understanding of concepts, as well as reaching out for help from peers and professors!"
Attention to detail	"This class definitely gave me plenty of experience with failure. One particular topic I can remember struggling with in the very beginning of the course was S-3R Multiaxial Loading. I had taken it the first time, and realized afterward as I was reviewing that I had not properly understood one-plane vs two-plane bending or even fully how to determine the bending. This encouraged me to spend more time reviewing on my own, and influenced me to start going to office hours, which built a habit. After this, I would regularly attend office hours even if I didn't have questions and were to just do busy work or look over projects."
Positive Reframing	"P6, LMAO, it took me about 3 weeks because I didn't understand a crucial concept on it. I studied it further for those weeks and I took time out of my weekends to be able to get that single concept and then I was able to get it done the 4th week! yippie"

Table A3: Paired example student responses for “How do you typically react to constructive feedback from instructors or peers?”

Student	Pre-course	Post-Course
1	"Positively"	"I respond fairly well to constructive feedback because it helps me understand what i can do better."
2	"Feedback is one of my weaknesses. I kind of see it as the work I was so proud to put out not being good enough, which can discourage me, especially if I put a lot of time and effort into the work I put out."	"It can be frustrating sometimes but, in the end, I take it as a recipe for my success."
3	"I will take any feedback I get and do my best to learn from it."	"I was always able to take feedback from instructors because I always assumed that they were the professional. I used to have a harder time taking feedback from peers and trusting that they knew what they were doing. I now know that my peers can bring really great ideas to the table and another perspective is always a good thing."
4	"at first it hurts but then it helps me see what i need to change and work on"	"I honestly really like constructive feedback because I am a person who is not confident in things so it helps me to see exactly what I need to fix and how I can improve."

Table A4: Example core trend responses for "Can you describe a time in this course when you learned something important from a mistake or failure? What did you take away from it?"

Trend	Quote
Behavior adaptation	"I would say when I was building my op-amp circuit for a mastery skill, but I missed a key component, and I was pretty let down as I was very close to having the answer. From this I learned to take more time in my thinking process, instead of rushing. And as far as what I took away from this experience, I think it will serve as a good reminder to me in the future to work carefully instead of just swiftly."
Help-seeking	"I learned that sometimes you have to try different methods in order to get something to work. So, if I wasn't passing a skill for multiple weeks then I would change up my studying strategy including studying by myself, with friends, or seeking help from the professor. This taught me that if one way isn't working then you shouldn't keep using that method and that a new method can help to solve the problem."
Attention to detail	"One important learning moment in this course was when I solved a P4 quiz problem incorrectly because I set up the coordinate system the wrong way. That mistake led me to write the wrong position vector, which threw off the entire cross product. This is one of the many examples throughout the quarter that taught me how important it is to slow down, visualize the geometry, and make sure the coordinate system matches the physical situation before trying to run through the math. Especially when learning the basics because everything moving forward is based on that."
Positive Reframing	"During week 10 Thursday testing I did not pass E2, S3, or S4 which I took as an opportunity to not slack off and challenge myself to achieve the full A. Whether I accomplished that isn't exactly what I will be taking away from that experience but rather I can push myself to learn even when I don't necessarily have to. I choose to look at that failure as a challenge because I knew that I wasn't putting my best foot forward that day and I was hoping by more so luck that I would pass one of them."
Persistence	"I learned that if you attempt things more, you will succeed more. If I only attempted the quizzes a couple times, there are quizzes I would have never passed. In fact, I think I failed every quiz I attempted to take for the first time, but since I knew more attempts and more exposure would do the trick, I continued to persevere."
Reflective takeaway	"when the additional topics started to be tested we had less time in class to learn the topics. this resulted in me not being able to pass work energy and impulse momentum. I took away that I needed to study more and put in more effort if I wanted to succeed."

Table A5: Paired example student responses for “What does being accountable for your learning mean to you?”

Student	Pre-course	Post-Course
1	"Doing the practice problems and making sure if I need help I ask for it and not just wait."	"For me, being accountable for my learning means taking responsibility for how much effort I put into understanding the material, not just waiting for someone else to explain everything to me. It means practicing problems even when they're frustrating, and being honest with myself about what I do and don't understand."
2	"Being honest and getting everything done well on time"	"Being accountable means taking responsibility for my academic performance and making changes as necessary, especially after making errors and mistakes, rather than blaming others or coming up with excuses."
3	"It means embracing relationships in a way where it fosters personal growth."	"It means you are willing to take initiative when you recognize and accept that there are gaps in your knowledge, whether that's through seeking help or taking the time to practice."
4	"Allows me to grow faster"	"It means that you get out what you put in. I know the more accountable I am to the task at hand and the more time and effort I put into it, the more I'm going to get out of it in the end."

Table A6: Example core trend responses for " Describe a time when you took responsibility for your own learning or performance in this course. What actions did you take to address the situation?"

Trend	Quote
Behavior adaptation	"After I didn't pass that first skills test, I went to the learning hub to solidify my understanding before the test. Having guidance really helped me learn. Since that first skills test, I have gone to the learning hub to study, even if I think I know what i'm doing. I learned that having that extra support was very helpful. I took responsibility for failing the first skills test, and went to the learning hub to improve my performance on the next one."
Help-seeking	"I took responsibility by showing up to class almost every day because this allowed me to progress fast by being able to ask for help from the professor, student helpers, and classmates."
Planning and Time Management	"We had a group project and i made sure everyone did their part before the deadline so we were not struggling with time."
Positive Reframing	"I wasn't passing skills. And I was frustrated because I am not used to consistent setbacks in my classes. I usually bounce right back and get back to high grades when I experience a bad one. I was honest with myself about how hard I had been trying to learn/pass skills, and that I was expecting to pass them without maybe putting in the extra effort necessary. I realized my self-pity for being lost in the class material was holding me back, because I was perfectly capable of learning it. I held myself accountable and started asking for help, trying new things, and now here I am either finishing with my goal or potentially even better!"
Persistence	"I took multiple attempts to pass the free body diagram test (I think maybe it's P4) despite feeling very confident every time. I assumed that since I have always done well in physics and had a good conceptual understanding, the test would be easy for me. In fact, I struggled to get the moments correct each time, and had to go back and do extra studying beyond the homework. I found videos online which explained the concept and took some practice quizzes, and met the skill on the next try."
Reflective takeaway	"With velocity acceleration i dropped my ego and acknowledged my errors and changed my trajectory ."