

A Semester-long Holistic Growth-Mindset Experience for First-Year Computing Students: Emerging Intersections

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Abstract—This innovative practice full paper examines mindset understandings of three cohorts of first-year student scholars in a College of Computing at a private technical Carnegie-classified Doctoral University in the northeastern United States. Grounded in theories of intelligence, a growth mindset posits that intelligence and skills can be developed through continued practice and learning, while a fixed mindset situates one with the skills they have at birth, never to evolve or grow. Thirty-two undergraduate students across three years (10 students in year one, cohort one; 10 students in year two, cohort two; and 12 students in year three, cohort three) participated in a holistic growth mindset program that included three pillars: (a) faculty-student mentoring infused with growth mindset, (b) growth-mindset augmentations to the introductory programming course and (c) a growth mindset-scholar seminar - a series of meetings where each cohort met as a group to discuss and practice activating a growth mindset. Previous work with students has focused on more limited growth mindset interventions rather than a holistic approach.

Prior to the scholars arriving on campus, the faculty involved in each of the pillars were part of a Community of Practice to learn about and activate their own growth mindset. At the end of their first semester in the project, each of the student cohorts participated in a focus group to learn about their understanding and application of growth and fixed mindset. We report findings from the student scholar data after one semester of participating in the three programmatic pillars in the context of growth mindset: mentoring, programming instruction, and the scholar seminar. Summary findings from the student perspectives are described including the use of illustrative quotes, in the students' own words, serving as a powerful reminder of the importance of growth mindset and relationship building. This has implications for addressing mindset in the future by considering how the innovative practice of embedding a growth mindset holistically into mentoring, instruction and a student seminar can provide support for students that standalone interventions cannot.

Keywords—mindset, growth mindset, faculty development

I. INTRODUCTION AND BACKGROUND

Growth and fixed mindset concepts are grounded in Carol Dweck's seminal work that identifies a growth mindset as

having the ability to view mistakes, challenges, problems and setbacks as steps toward success rather than roadblocks [1], [2]. In this way, intelligence and skills are considered to be malleable, rather than fixed. Thus, a fixed mindset posits that intelligence and skills are innate, or fixed at birth, and no amount of development can change them. People with a growth mindset tend to embrace challenges as a means to learning and developing their skills. This comes with an understanding that failure is possible or likely, and a tendency to reframe failures as opportunities to learn and grow as a sign of resiliency and perseverance. A degree of effort is required to accept the challenge and work through the hurdles that arise, suggesting that effort aligns with achievement and success. Criticisms that are an outcome of some challenge, or even a success, are considered as a tool for learning and growth. The accomplishments of others serve as inspiration and as a learning opportunity for what leads to success [1], [3]. A fixed mindset, on the other hand, can leave us discouraged by failures, and with a tendency to avoid challenges for the fear of appearing incapable or unintelligent. In addition to avoiding challenges, a fixed mindset may lead to giving up when an obstacle is faced, leading to progress being slowed or even halted. Effort that is part of the experience or challenge is viewed as negative and an indicator of lack of talent, particularly when there is an appearance that others are not struggling. The criticism that may go along with the challenge also serves as an external, critical judgment or attack. This can lead to a place where the success of others is coveted and viewed as threatening, revealing insecurities that an individual may be facing [1], [3]. Insecurities can unveil themselves as self-doubt, feelings of fraud or discovery that skills and talent are not real. Even though these insecurities may be unfounded, the effects due to the fear of failure can be impactful none-the-less, often noted as imposter syndrome [4], [5], [6] and with a prevalence in minoritized populations.

One particular means to addressing the growth and fixed mindsets outlined above is to focus on process-praise versus person-praise or product/outcome-praise, which can be either positive or negative in nature. Process-praise presents an opportunity to consider how intentional steps, challenges, setbacks or mistakes are part of the process toward success,

whereas focusing on praising the person or product can potentially lead to a more fixed mindset approach as skills are considered innate and unable to be developed [3]. For example, instead of a faculty member describing a student with the fixed mindset and indicator of innate intelligence such as, “They are terrible at programming,” the thinking could be reframed to a growth-mindset approach with, “how can I teach them in a way that connects them to the material?” This emphasis on process over personal traits or end results also provides a way to establish pathways forward when similar challenges may arise in the future, and to ensure continuous progress despite temporary setbacks [3].

Since not only our own mindset but the mindset of those around us is critical to developing and applying a growth mindset, we designed this innovative practice on the premise that addressing growth and fixed mindset in a collegiate setting requires working with not only students, but faculty as well. Awarded a scholarship from the National Science Foundation (NSF) Scholarships in Science, Technology, Engineering, and Mathematics Program (S-STEM) [7], 32 computing students (referred to as student scholars hereafter) across three years (10 students in year one, cohort one; 10 students in year two, cohort two; and 12 students in year three, cohort three) participated in a holistic growth mindset experience that included (a) faculty-student mentoring, (b) growth mindset augmentations to the Programming I course and (c) a growth mindset scholar seminar - a series of meetings where each cohort met as a group to discuss and practice activating a growth mindset.

While significant work has been done with students and growth mindset, the research on faculty mindset is more limited in nature. Of the research that has been done with either group, the interventions were typically standalone or part of a limited experience. Our work differs in its approach by intentionally and repeatedly infusing growth mindset into multiple aspects of the student scholars’ experiences. By working with both faculty and students and focusing on development towards larger milestones or goals rather than personal traits and singular achievements, we strove to transform perceptions of setbacks as steps toward future successes, encouraged students to stretch to learn something new, viewed effort as talent rather than effort indicating lack of talent, promoted thriving on challenge, and sought to dismantle the notion of speed and perfection as key indicators of intelligence and overall develop an innovative approach to positively affecting students [1].

II. RELATED WORK

Growth and fixed mindset literature informed the project design and data analysis. Of particular interest in the literature is the emphasis on student interventions, with limited but impactful findings on faculty growth mindset. Most of the interventions that were enacted with students were standalone in nature or limited in their scope. For example, Cutts, Cutts, Draper, O’Donnell and Saffrey [8] reported a shift toward growth mindsets in an introductory computer programming class, when four 10-15 minute student-led growth mindset sessions were coupled with use of an assignment rubric.

Simon, et al. [9] used a ‘saying is believing’ activity to determine if a growth mindset-intervention could affect a mindset shift. A mindset survey was administered to students

(n=228) across three institutions at the beginning of the semester. Seven weeks later students received a lecture on growth mindset and then within a week, they got a reminder along with a series of exercise prompts (saying is believing) to describe a time when they learned something new other than programming and to describe the advice they would give to a new programmer. Both prompts were in the context of working on something really hard where there are challenges, and a post survey followed. Statistical analysis yielded little in terms of significant results from pre to post surveys regarding a change in mindset and differences were mixed across universities.

While the end goal may be influencing student mindset as a facet of success, faculty mindset beliefs are an important part of the holistic approach, with implications for STEM students’ achievements and classroom experiences. Meunks and Canning [10] reported that faculty members presenting a fixed (versus growth) mindset resulted in demotivating students. They also reported an impact on students’ grades, with a racial achievement gap twice as large for students in courses taught by professors with a more fixed mindset than courses taught by professors with a more growth mindset, and with all students performing higher in classes taught by a professor with a growth mindset [10]. These results were similarly echoed by LaCosse, Murphy, Garcia and Zirkel [11] who found that STEM students anticipated more negative psychological experiences, lower performance, and lower course interest when their professor embraced a more fixed mindset, and the effects were much larger for female students. While the mindset of the faculty member is critical, there is a likely correlation between growth mindset and beliefs held by the faculty member that the learning experiences they design can impact students, thus leading to more inclusive, student-centered and motivating pedagogical choices grounded in best practices [12].

The value of faculty mentoring on student success has also been broadly recognized, particularly for underserved students in STEM who may be more inclined to question their sense of belonging and ability as struggles and challenges arise [13], [14], [15], [16], [17]. Faculty mentoring is sometimes even cited within the context of student mindset [18]. Here again, the literature on mentoring with a growth mindset is limited, with an exception of one study that identified the benefits of using an approach emphasizing deliberate practice and mastery learning (akin to promoting process over personal traits) for endoscopy trainees [19].

It was with the above literature that the project was designed to create an innovative and holistic growth-mindset experience for student scholars where they were exposed continuously throughout the semester to multiple interventions rather than a standalone or limited session(s) that cannot afford regularity or consistency. The faculty mindset was critical to this holistic approach and was developed through a Community of Practice (CoP) and instantiated in the faculty mentoring, the programming instruction and the scholar seminar [20].

III. INSTITUTIONAL AND PROJECT CONTEXT

This work was conducted at a private university in western New York in the United States. The student scholars were undergraduate computing majors across five academic programs in the College of Computing that houses approximately 5,000

students: Computing and Information Technology, Software Engineering, Human Centered Computing, Cybersecurity and Web and Mobile Development [21]. The scholars were selected based on their academic accomplishments and financial need, and each received a \$20,000 scholarship divided across their first two years. The first cohort started in the fall of 2022, with a new group beginning in each of the subsequent two years. The project included three project ‘pillars’ to instantiate a growth mindset with the student scholars: (a) faculty mentoring grounded in growth mindset, (b) growth-mindset augmentations to the introductory programming classes and (c) a growth-mindset scholar seminar.

A. Faculty Mentoring

Student scholars were paired with a faculty mentor during the first two weeks of their freshman year. Pairings were made based on the student’s background and computing interests aligning with a faculty mentor. Faculty prepared for mentoring with a growth mindset as part of a CoP that met for 12 sessions at the beginning of the project. Faculty mentors and the programming instructor learned about the key aspects of growth and fixed mindset including, distinguishing aspects of a growth and fixed mindset, “risk versus effort,” malleable mindsets, shifting from fixed to growth mindset, feedback as a means to imparting growth mindset, normalizing mistakes, emphasizing the importance of process praise over product or personal praise and promoting a growth mindset through self-talk and during informal interactions with students [20]. The faculty mentors embraced a growth mindset approach and shared their experiences and advice with students during regular 1:1 meetings (typically every other week). Mentors have reported this to be a rewarding experience while also outlining challenges [22].

B. Programming Course Augmentations

All students in the majors included as part of the project are required to take programming in their first or second year. As mirrored by the national data, the programming courses present students with a challenging experience that is evidenced through grades and student attrition rates after the first and second semesters [23], [24], [25]. Thus, the Programming I and Programming II courses were identified as an opportunity for integrating growth mindset tenets. While both courses were augmented, only the Programming I revisions affected this set of data, and will serve as a focus of this innovative practice full paper.

Prior to any of the scholars arriving on campus, the lead Programming I and II instructor also participated in the faculty CoP to learn about growth and fixed mindset, develop their own growth mindset and consider how growth mindset could be integrated into the programming courses. The intent was not to change any of the curriculum, but rather to infuse a growth mindset into the existing assignments, classroom materials and projects throughout the semester. Iteratively approached over the duration of the project, the initial growth mindset augmentations focused on integrating an emphasis on process as a path toward overall success rather than solely on a singular outcome or product. This included changes to language and content in instructional slides, assignments and activities. For example, the processes for accomplishing a given programming

task were called out rather than merely the end goal. The next iteration of augmentations in the programming courses emphasized normalizing mistakes as a growth mindset tenet and combating the imposter syndrome.

Examples of the growth mindset augmentations included emphasizing zero syntax errors, making incremental progress as an error is noticed, taking time to understand the prompt, keeping a glossary of errors and fixes as a reference for students, building into assignments some intentional places where errors are common and making that part of the live classroom coding, and discussion of experiences that are typical to novice programmers and develop over time as part of the process, among others. While many of these augmentations had previously been done in the class in an ad hoc way, the course augmentations ensured that these growth mindset instructional approaches were intentional, planned and assured to happen. Scholars were then registered as a cohort for the programming course in order to benefit from both the growth-mindset infused materials and the preparation of the professor from the CoP.

C. Scholar Growth-mindset Seminar

Scholars participated in a growth-mindset seminar as part of the project. Led by the project PI and a co-PI, each scholar group met as a cohort (cohort 1 as C1, cohort 2 as C2, cohort 3 as C3) three-to-four times over the semester. Sessions focused on making meaning of growth and fixed mindset as well as practicing growth mindset in action. For example, scholars were asked to think about a time that they had seen a fixed mindset in themselves or in another individual and how that might be reframed with a growth mindset. The sessions also allowed for the scholars to engage with one another as a group to discuss shared experiences, particularly challenges they were facing and how they were moving through those challenges. Sometimes these involved academic challenges, specific to a course and/or assignment, and other times there were discussions about challenges outside of academics like getting a job on campus or working through the entanglements of finding housing.

As previously noted, this multi-faceted and planned multi-year approach to growth mindset provided student scholars with an opportunity to understand mindset in a holistic way. Not only were there multiple growth mindset intervention pillars (faculty mentoring, programming course augmentations, scholar seminar), but each pillar in and of itself was a semester-long and a multi-pronged experience for the scholars. This innovative holistic experience contrasts with previous work on growth mindset work with students, that has mostly focused on a discrete intervention or limited set of interventions and did not include faculty growth-mindset development.

IV. EVALUATION OF INNOVATIVE PRACTICE

A. Data Collection and Analysis

Each of the three scholar cohorts (with staggered fall starts) participated in a focus group at the end of their first semester of program involvement. The focus group data provided formative feedback to the project leadership for everyday operations of and directions of each of the three pillars, as well as formative evaluation of progress towards the project goals which focused on student success toward entering the computing workforce. The scholar focus group protocol included questions to elicit

from participants: descriptions of the project, explanations of growth and fixed mindsets, instances of their exhibiting a growth mindset as well as a fixed mindset, perceptions of growth and fixed mindset in the programming class, experiences and perceptions of mentors and mentoring, sense of the scholar seminar, whether scholars felt welcomed at various levels (college-level, department-level, program-level) and any suggestions for project improvement.

In this paper we report on the scholar focus group data, for each of the three cohorts (C1, C2, and C3), occurring after their first semester of programmatic involvement. By examining the first-semester responses for each cohort we are able to determine initial perceptions of the pillars from students with very limited collegiate experiences. The focus group discussions were audio recorded, and the verbatim transcripts were later anonymized and de-identified with a research ID assigned to each participant. Data analysis proceeded with both deductive and inductive coding [26]. First rounds of coding were conducted using a priori codes derived from growth mindset and fixed mindset such as normalizing mistakes, reframing failure, and being stuck [1], [2], [3] for example, and programmatic pillars, such as mention of mentors, the introductory programming course and the scholar seminar. Additional rounds of coding proceeded to identify emergent codes. Thematic analysis was conducted for intersections among the codes and programmatic pillars, and researcher analyses were reviewed among the project leadership for internal validation [26], [27], [28].

B. Findings

Examining three cohorts of student scholar perceptions after their first semester created a critical snapshot of scholar initial responses to the challenges of a complete collegiate semester, allowing insight into how and in what ways the program was supporting students, or not, in taking up a growth mindset. The thematic analysis of that snapshot revealed emergent relationships between codes: the mentoring providing support for scholars' application of growth mindset both within an academic locus and outside the academic locus; scholars taking away from the programming instruction a specific focus on process, normalizing mistakes, reframing failure and the imposter syndrome; and the significance of the scholar seminar in creating a community of learners who supported each other in practicing a growth mindset. The findings reported in the following sections present the student scholar data after one semester of participating in the three programmatic pillars in the context of growth mindset: mentoring, programming instruction and the scholar seminar. Findings from the student perspective are reported using illustrative quotes in the students' own words, serving as a powerful reminder of the importance of growth mindset and relationship building. In what follows, the speaker is identified only by their cohort number (C1, C2 or C3) to maintain anonymity.

1) *Growth-mindset-focused Mentoring*: Scholars across all three cohorts perceived the growth-mindset mentoring as supportive and in multiple ways. One unique finding was the value students attributed to growth mindset focused mentoring applied (a) both in and out of the academic setting as well as, (b) the specificity/breadth of issues brought to the mentoring

relationship. One scholar shared their thoughts about an academic mentoring experience:

I meet with my advisor every other [week].... Usually we don't talk about anything that has to do with schoolwork, just whatever's going on in our lives. But when I do have a question about usually the ... class I'm in, [they're] like, oh yeah, I didn't get that at first either. Then [they're] really good at breaking it down. I remember regular expressions. I was like, 'I have no idea what this means.' So, [they] broke it down literally piece by piece and went through it and [did] a really good job of like, 'Hey, if you just understand this little part, then you can understand this part.' [They're] very good at explaining things and making me feel like, 'Oh, I get that.' (C1)

Another scholar shared their experience of discussing issues outside of academics with their mentor:

I liked how my mentor, it wasn't academic focused. It wasn't just, 'Oh I need help with this assignment or something.' It was like I could just talk to [them] about anything kind of. And yeah, it was just nice to have somebody to talk to about other stuff, like stuff other than school. (C2)

Multiple scholars expressed how supportive it was to know that someone was reliably there for them, that they could call or reach out to, someone that was connected to them and was ready to help with small and big issues they had, both in and out of the academic setting. The mentors served an important role in supporting students in their process of working through their first semester:

I mean, I think they're just there for you. If you sometimes come into school, you don't feel like you have anybody. And ... [they were] there for me when I was going through a hard time, which I was really thankful for. It's kind of weird, but yeah. It's nice knowing that you had support. (C2)

This growth-mindset mentoring relationship, enacted with the above variations - academic versus non-academic focus, student scholar driven versus mentor driven, specific versus broad, created a wide safety-net for the student scholars that could meet their individual needs while being grounded in a shared understanding of growth mindset.

2) *Growth-mindset Programming Instruction*: Scholar perceptions of growth mindset embedded in the Programming course instruction centered around the growth mindset tenets of emphasizing process over person/product, normalizing mistakes as part of the learning, and mitigating imposter syndrome, and as planned by the leadership team and programming instructor. Scholars internalized that the focus of the course was on the process of learning as a means toward an end goal of computing expertise, rather than solely on the product, and through actions taken across the semester by the programming course instructor:

[The professor] really emphasized on the fact that the whole point of the class isn't to perfectly know how to code and solve all the problems right away. The point of the class is to teach us how, when we make a mistake,

how to find the solution to that mistake so that we can understand how to solve any type of problem like that in the future, rather than just automatically knowing what to do, but knowing how to fix or how to solve something that comes across, code or anything like that. (C1)

Also in support of process over person/product, the instructor provided students with multiple modes for seeking support, e.g. through an active Discord channel, through the teaching assistants, through emails, and through affinity groups that provided tutoring. The scholars connected making use of resources and asking questions with the instructor, as well as themselves, enacting a growth mindset.

I remember one class, he just specifically listed out how we could go to the Tutoring Center or Women in Computing or Society of Software Engineering, those places where we can just seek help for any [coding] assignments that we could be struggling in. That in itself just shows that he believes that we should all have a growth mindset because if we don't go into those tutoring centers with the growth mindset, then how will we actually get anything valuable out of it in the first place? It was just really nice that at least he kept that in mind while, even before going on with a lecture, he'll ensure that we knew about that. (C1)

While mistakes were emphasized as part of the process, they were also normalized as necessary steps for a programmer, and necessary for learning, through explicit and implicit actions, some planned and some off-the-cuff as can be seen in the following scholar quotes:

I think another helpful thing is since [the professor] does live coding in front of us, sometimes [they'll] make mistakes and then we get to watch [them] troubleshoot and try to figure out, okay, why doesn't this work? Let's try and fix it. And just being able to watch somebody else debug their code helps you. At least it helped me a lot to understand, okay, I have an issue, let's see the first step of what I need to do to fix this. Just being able to see it happening in front of you helped, because it's one thing to explain, this is how you use the debugger, this is how you fix an issue, and another thing to actually see somebody be like, okay, I don't know what's wrong, but let's try to figure out what the issue is. (C1)

Beyond just making mistakes, student scholars were able to recognize that the instructor engaged them in the growth-mindset process of finding and mitigating mistakes:

[The Professor] allowed us to realize [their] mistakes. A lot of times [they] wouldn't necessarily point it out, but almost wait for one of the students to find it. And then it's an eye opening moment for everyone. (C1)

An emergent finding related to the growth-mindset-infused programming instruction on scholars was how the instructor addressed the Imposter Syndrome [6] as a way of shifting fixed mindsets to more growth oriented. Multiple scholars remarked how the instructor normalized the feeling of not belonging, resulting in a mitigation of those feelings and helping them move forward.

I guess something good [for the instructor] to keep doing is that quite a few times the instructor has mentioned feeling like an imposter syndrome, and going into how that's normal. 'You're not the only one that feels like that.' And I think that that's really good for people to know. I think more encouragement like that is good. (C2)

3) *Growth-mindset Scholar Seminar*: Scholars perceived the value of the seminar as creating a community of learners who supported each other in practicing a growth mindset and in moving forward toward success. Scholars expressed how important it was for them to have a place where they could openly talk with people going through similar challenges and also working to collectively develop a growth mindset.

Yeah. I feel like I was good doing it in a group setting because it really directed your attention towards this new way of thinking where it's like, I'm sure that we've all passively encountered a growth and fixed mindset in our lives beforehand. But to have that explained to us and to have someone tell us that this should be the ideal that we should be shooting for, it's obviously just going to motivate us to hopefully reach that goal because there really isn't any detriment towards having a growth mindset outside of burning out, which, again, you can have a growth mindset to burning out as well. It's like all in all is a trust the process sort of thing and ... the way they presented it during the meetings because [the professors], they're just really nice people and they made every meeting feel very homey and very nice. So, I enjoyed that. (C1)

More specifically, student scholars described their understandings of growth mindset in recognizing that there are steps toward building skills and learning, and that the success of others can also serve as opportunities to learn about those processes:

... [about] talking to the people in the group. Like [scholar X] said, ... 'oh yeah, I didn't do good on this test', so I looked at other ways of studying and just hearing other people's - what they did when they needed help or were struggling. It's good to like, 'oh, when I need to do that stuff now I know because it helped them. It's a good chance that'll help me too.' (C1)

Scholars were able to articulate specific seminar activities where they practiced activating a growth mindset in themselves, providing a foundation for later retrieval:

I remember this one exercise we did where it was a [document] and there was a statement something like, 'Oh, I don't like this class or I don't like this professor, or I can't do this.' And they told us to write down responses, what we would say to that person. And I think that was good because we could say those things to ourselves and we could just develop more. (C2)

Equally significant was the value student scholars attributed to the relationships developed through a seminar grounded in learning about growth mindset and community building:

I know a lot of people [live] that dream, like age 0 through 18, they just have an easy ride and like get good grades and a lot of my peers at high school are like that, but I was always in very like advanced classes, but I also had very bad grades sometimes like not general grades. But I could completely bomb an assignment and that wasn't a very common thing among the people at my high school. And so I often felt alone and I also felt a failure and like an idiot a lot of times. And so I kind of had to teach myself [to have a] growth mindset because I wouldn't have good grades if I had just let that get me down, especially with all the you know, uniqueness that that example was. So I think it's comforting to hear that - to have a group that, you know, like we said earlier, fosters that growth mindset because it really is so important, especially when you have so many failures. Like I've literally gotten zeros on assignments and 25% and stuff like that. And I don't care anymore because I know that I'm going to succeed regardless. (C3)

Similarly, student scholars valued the sharing of resources:

Like I said earlier, [the seminar] opens up the resources on campus. Because I came on not really knowing much about the campus at all. So just when it open up resources for help, if I ever needed it, it was nice. So I know that if I'm stuck on something [and] I have to figure [it] out myself, I can go for help. So that's helped me just if I ever need help, I know where to go. So if it wasn't for [the seminar], I'd probably not know about most of this stuff. (C3)

Likewise, scholars valued the community support for solving problems that extended beyond the program:

Again, it's definitely just giving you a community that you may - you can always just - when we come in here [in] the beginning, we just spend most of the time just talking about our days or different classes or different funny things that have happened. And it's just almost, it's just a little community that we have and I get to see these people at my classes, which is just comforting, just to see another face that, you know, that is also going through - has similar things in common with you, even if you're not super close with them. (C3)

Lastly, scholars perceived the community built during the seminar as extending to their experience of the growth mindset-infused programming course, with the following:

We're all in the same [programming] class together and it's just nice to hear that I'm not the only one that's struggling or has a fixed mindset. (C2)

This was echoed from another scholar with:

I really like the convenience of all of us being in the same [programming] class. It was really nice that we'd have this hour meeting before going to [the programming class] together and it made it feel easier for when we'd have problems. (C1)

V. DISCUSSION AND CONCLUSIONS

These results have implications for designing growth mindset interventions for students. Using a holistic approach provided support for scholars beyond what would be expected with standalone interventions. In addition, recurring experiences across the semester provided opportunities for continued growth-mindset application and development, further extending the wide net created by an innovative holistic approach through mentoring, programming instruction and a scholar seminar, and as visualized in Fig. 1. In this sense, the faculty member enacting a growth mindset in the context of a given pillar, intersected to support the students' developing growth mindset, and supports consideration of how scholars made use of, valued and internalized understanding of each pillars.

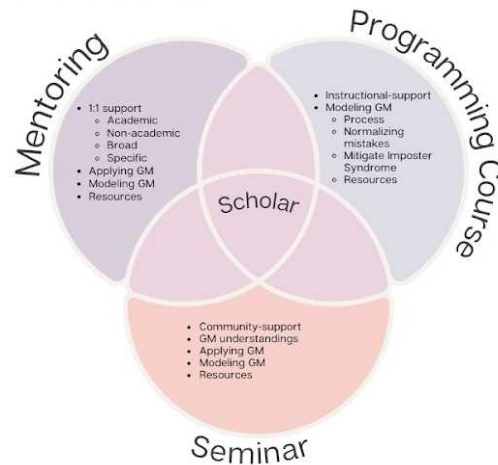


Fig. 1. Holistic growth-mindset approach and findings.

An example of intersection in the context of the mentoring was the room for personalization that each mentoring pair had: academic and non-academic issues along with specific and broad questions. Mentors using a growth mindset approach afforded flexibility to meet students' needs without expectation of the mentoring being limited to academic matters [22]. Making space for scholars to bring non-academic challenges was critically important to students who may have less stability in their personal lives, and provided an opportunity for mentors to have a positive influence. This flexibility also accommodated issues of varying scope from small issues to big issues as students were integrating into new university communities and first-time experiences. The regularly scheduled meetings appeared to take some pressure off of the scholars to always come with a need and was important for those who were hesitant to open up until trust and reliability was established. This resulted in a stability of the relationship where their mentor became someone scholars could count and rely on, someone who they saw as 'being there' for them all semester long.

In the context of the growth mindset-infused programming course, the instructor's focus on normalizing programming errors, and especially during the live coding sessions, created intersections between the programming instructor and the scholars' developing mindsets. Scholars were afforded opportunities to apply a growth mindset in action, which modeled to students the importance of the process for working

through the problem to reach the end solution and the value of programming errors as steps along the way. As for the instructor's efforts to mitigate Imposter Syndrome, and as illustrated above, the student scholars recognized that errors are common, and do not indicate that a programmer is unskilled. Scholars articulated that novice programmers are not expected to have all the right answers all the time. Scholars also recalled the instructor's comments regarding the purpose of the class not leading to perfect coding and problem solution right away, but that those skills are gained over time through practice and persistence in correcting errors.

Because the programming course instructor exhibited growth mindset tenets through their design of course materials and course structures, e.g. group problem solving, supported scholars (and all students), they could respond to and anticipate student challenges through the instructional augmentations and by modeling growth mindset strategies/approaches. These innovations occurred throughout the semester, rather than a limited set of instances as with previous work.

Lastly, there were multiple emerging intersections in the context of the growth mindset scholar seminar: safety, support, and learning provided by the seminar leaders and valued by the scholars, a scholar community based on shared challenges and experiences, and extensions of that supportive community into the programming course environment. The seminar leaders, who also participated in the growth-mindset CoP, worked to create a comforting, safe, supportive semester-long experience where students felt safe to share their struggles and successes. Indeed, this was evident to the scholars as one specifically noted the importance of having a space to share failures while knowing that they would not be considered a failure themselves. Scholars articulated that they were able to activate a growth mindset through the practice sessions with growth mindset activities across the semester. Contrast this to related work, where limited effects were noted as a result of limited growth-mindset activities [8], [9].

Therefore, the recurring and interconnected nature of the seminar, the programming course, and the mentoring, not only provided multiple, varied experiences that developed scholars' growth-mindset understandings but also laid the groundwork for supportive, on-going relationships among and between scholars and faculty. This work has implications for integrating a growth mindset into student experiences at other universities. Starting with the faculty mindset as a foundation for holistically embedding a growth mindset into mentoring, instruction and student interactions provided support for students that standalone interventions could not. Student-scholars were able to articulate their understandings of growth mindset and even after only one semester of the holistic approach, were already making connections between the interventions. This implies that the multi-faceted approach toward managing challenges and embracing struggles in a way that allows students to continue to move forward toward success is possible with careful planning and at a low cost. This is encouraging as we consider that the interventions applied throughout the semester relied predominantly on developing faculty understandings of growth mindset in order to reach more inclusive, student-centered and motivating experiences and interactions grounded in best practices [10], [11], [12], and that they are adaptable to other

academic settings and domains. While the findings after one semester are encouraging, the next steps involve looking at the evolution of student mindset over the full two years as they continued to experience the interventions, as well as beyond.

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