# Dissemination of Growth Mindset Principles and Attitudes in the Division of Science and Mathematics at a Liberal Arts College

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## Abstract

There remains a need for more diverse STEM students that will be equipped with the necessary skills and growth mindset principles to pursue STEM positions and careers. While previous research has examined broadening participation through interventions geared toward a specific group, the intervention method used in this research case study utilized a multi-faceted approach to disseminate growth mindset principles across an entire division. We found that the multi-faceted intervention approach contributed to a statistically significant increase in students' attitudes and behaviours associated with growth mindset principles. Furthermore, a chi-square analysis revealed a statistically significant correlation between student classification and understanding of growth mindset principles within the freshman year which is where students encounter most gate-keeper courses. These results provide implications about the effect of disseminating growth mindset principles across an entire division and the impact this approach can have on students as they matriculate through the STEM pipeline.

***Keywords:*** *Growth Mindset, Broadening Participation, STEM Education, Intervention, Persistence*

## Introduction

With technology constantly growing and developing, there is an increasing demand for more professionals within science, technology, engineering, and mathematics (STEM) fields. In 2018, there were roughly 500,000 unfilled computing jobs, and by 2020 there were potentially 500,000 more unfilled positions (Lazio & Ford Jr., 2019). This trend indicates a need to produce more college graduates in STEM fields. Broadening student participation in STEM is an approach being utilized to increase student interest in STEM degree programs. The National Science Foundation introduced this initiative, and one of its main tenets is to prepare a diverse STEM workforce that supports underrepresented groups' pursuit of STEM professions (National Science Foundation, 2019). According to the National Science Foundation (2019), This approach to expanding the reach of STEM experiences and opportunities has been endorsed and utilized by businesses, institutions, policymakers, and researchers to change STEM jobs' trajectory going unfilled.

Promoting a growth mindset among students can be seen to broaden student participation within STEM degree programs. Due to several contextual factors, students lack specific practical scientific literacy skills that have been beneficial to student STEM success, including possessing a growth mindset. Carol Dweck introduced what it means to possess a growth mindset as the belief that students who have this mindset are more likely to be resilient in the face of adversity (Dweck, 2006; Dweck, 2016). A growth mindset can be helpful to STEM students encountering challenging gate-keeper courses, which are introductory courses used within STEM majors to weed out students. These courses are normally a review of the high school curriculum but also include a more in depth understanding of the material. Growth mindset principles were determined based on a survey conducted with over 1500 students at several institutions to create a reliable and valid scientific literacy assessment (Benjamin, Thomas, Marks, Demetrikopoulos, Rose Pollard, Thomas, & Muldrow, 2017). The findings from these results were embedded within a utilitarian scientific literacy curriculum developed based on why students leave STEM majors, foster identity, confidence, and commitment as a scientist and skill development (Chambers, B., Salter, A., & Muldrow, L., 2019).

Attrition rates for African American STEM students remain relatively high due to perceived hardness of "STEM" classes, poor learning environments, no team/community collaboration, lack of support systems, poor pedagogy, low STEM self-efficacy (Heilbronner, 2009; Mitchell, 2011) and fixed mindsets (Dweck, 2006). The utilitarian scientific literacy curriculum coupled with growth mindset principles serves as a broadening participation intervention that provides students with the necessary foundation to succeed in STEM. The scientific literacy course was designed to prepare students with the necessary skills to be a successful STEM major. These skills include understanding scientific discoveries, articulating scientific research, and having an aptitude for scientific reasoning. Adding the growth mindset intervention to the scientific literacy curriculum allows the course to go beyond merely skill building but also mindset formation. Students need to have the skills to be a successful STEM major but they also need to have the mindset that they can be successful in their STEM major. Scientific literacy and growth mindset combined offer students a comprehensive approach to becoming literate as to what it takes to be a successful STEM major in college.

This case study examines the dissemination of growth mindset principles through an entire Division of Science and Mathematics at a liberal arts college using a multi-faceted intervention. First, it measures the impact on participants' growth mindset attitudes and behaviours. Utilizing direct and indirect methods of exposure, students, faculty, and staff, were exposed to growth mindset principles through the online utilitarian scientific literacy course, residential summer program, new student orientation (NSO), faculty professional development and interaction, residential life programs, advisement sessions, and peer-to-peer interactions. The skills and attitudes developed from being exposed to growth mindset principles have been identified in the literature as key components that can increase a students' likelihood to persist in STEM degree programs and pursue STEM professions (Dweck, 2006). With the need for more underrepresented graduates in STEM degree programs, disseminating growth mindset principles across the entire Division of Science and Mathematics may be essential to increasing student persistence, retention, and overall success within their major while broadening participation in STEM across the United States.

## Literature Review

### *Growth Mindset*

During a student's early years in education, they are introduced to different academic skills needed to graduate. Students are then expected to build upon these skills from year to year as they also expand their knowledge base in the main core components of education (English, math, science, and history). However, as some students matriculate, they start to believe that they cannot add to their intellectual skill set or change the way they perform even if they tried and this ideology can be called a "fixed mindset" (Dweck, 2006; Dweck, 2016).

Once students possess a fixed mindset, this typically leads to others around them believing that the student's skills and abilities are limited, ultimately perpetuating the fixed mindset mentality.

Faculty weigh heavily on the persistence of students within STEM degree programs and whether these students pursue graduate programs and careers in STEM (Flynn, 2016, Ashford-Hanserd, Daniel, , García, , & Idema, 2020). Due to a historical belief that African Americans and other underrepresented minority (URM) students are less likely to possess the natural ability to perform well in science and mathematics courses, faculty may form an implicit bias that views these groups from a deficit approach (Ashford-Hanserd, et al. 2020). These faculty will then label these students as lacking the necessary aptitude for STEM fields due to its rigorous tradition. However, according to Carol Dweck (1986, 2006, 2016), these students do not need natural competence in STEM. Instead, they need a developed attitude that center around a growth mindset. Dweck (1986) introduced the phenomenon of having a fixed mindset that is ability-focused versus having a growth mindset that is effort-focused through a case study. This study discovered that girls who identified themselves as smart and scored high on exams were more likely to possess a fixed mindset when met with adversity (Dweck, 1986). The explanation for this outcome stems from these students believing that their abilities are fixed and can't be changed. Therefore, despite their high self-perceived intelligence, they likely lacked the necessary mindset to persist when faced with challenges as they matriculated through education.

People with a fixed mindset believe that their intelligence and persona were predetermined, and therefore, it is not something that can be changed (Dweck, 2016; Woods, 2020). Usually, those with a fixed mindset will not pursue a task a second time if they fail the first time. This kind of mindset can hinder students' development and persistence, especially those pursuing degrees in STEM.

Fixed mindset students may achieve less than their full potential because they believe their basic qualities, like intelligence or talent, are fixed traits – talent alone creates success without effort. Therefore, fixed mindset students see efforts as fruitless, avoid challenges, give up easily and ignore corrective criticism.

A growth mindset allows one to grow and adapt to any environment they encounter. It is the belief that through planning and execution, one can accomplish any assigned task or goal (Woods, 2020). Those with a growth mindset operate with the attitude of always trying to improve versus proving themselves (Woods 2020).

Growth mindset students are always reaching higher levels of achievements because they believe that their most basic abilities can be developed through dedication and hard work. Therefore, growth mindset students; see efforts as the path to mastery, embrace challenges, persist in the face of setbacks, and learn from criticism. According to Dweck (2006), individuals with fixed mindsets can be taught to have a growth mindset as they meet new challenges within educational settings. In addition, a longitudinal study on adolescents indicated growth mindsets significantly boosted achievements (Blackwell, Trześniewski, & Dweck, 2007), indicating that students benefit from being taught growth mindset principles early on to help them persevere through academic challenges.

With the need for more STEM students, growth mindset principles have been looked upon to help students overcome the challenges faced within STEM courses, but despite the positive results and findings surrounding the growth mindset theory, there has been some ridicule concerning the theory's efficacy and actual application. In an article released in 2018, the writer breaks down the issues with growth mindset and how it is creating an illusion for educators and students (Beall, 2018). The article goes on to mention a meta-analysis that was conducted to report the overall impact of growth mindset principles and applications on student achievement. What the researchers found showed there is a small correlation between growth mindset and academic achievement but that this correlation is not large enough to substantiate the claims of impact associated with having a growth mindset (Beall, 2018).

Critics have expressed that instead of championing growth mindset principles as a breakthrough intervention, it should be touted as a small step in the right direction when supporting students' academic needs. Researchers who are critics of the growth mindset theory believe that money allocated toward growth mindset interventions should be used toward more cost efficient and effective strategies. However, in a more recent article surrounding the usability and usefulness of growth mindset, the writers feel that growth mindset impact has to be taken into context the methods of implementation and the environment where it is being implemented (Denworth, 2019). The article goes on to contend that even with a small effect size, growth mindset has still proven to be more effective than most other interventions (Denworth, 2019).

In recent years, Woods (2020) implemented a goal-setting strategy that has been linked to helping students cultivate a growth mindset into an IT course designed to help students solve real-world problems using technology. This study showed that students demonstrated a growth mindset after being exposed to growth mindset principles throughout their capstone project. Even those students who rated their efforts poorly stated that they would continue working on their project (Woods, 2020), highlighting the resilience of students exposed to these principles. Overall, the results were promising because they suggest that something as simple as goal setting could help a student unlock their growth mindset, using it to overcome obstacles within education and everyday life. In alignment with the literature, this paper will discuss and highlight the dissemination of growth mindset principles for STEM students, through multi-faceted exposure methods, at a historically black liberal arts institution to determine the impact of this dissemination on student's growth mindset attitudes and behaviours.

### *Growth Mindset Implementation*

Unlike most interventions that only target a select group of students, this intervention targets all students within an entire division. Initially, growth mindset principles were introduced and implemented within the Division of Science and Mathematics through a scientific literacy course offered to select incoming first-year STEM students. The course evolved from 2009 to 2016 to eventually include a chapter on growth mindset, which has been linked to student success due to students' forming a resilient attitude (Dweck 1986; Dweck, 2006; Dweck, 2016). The growth mindset principles embedded within the course were blended into other exposure methods to initiate a growth mindset culture. This division-wide exposure is novel to the institution and the literature due to the multi-faceted approach of the intervention.

There were several objectives within in this intervention, which include understanding the mindset necessary for success in a STEM major and career in STEM, learning and understanding the principles of having a growth mindset, and establishing an increased scientific identity, self-efficacy, as well as other relevant attitudes and intellectual behaviours essential to success in STEM. However, the main objective was to disseminate growth mindset principles to all students in the division and train some faculty to incorporate growth mindset principles into their teaching methods. Therefore, the target population for this study was pre-freshmen and freshmen STEM majors. The need for identifying this target population at the institution for comprehensive treatment is based on two primary reasons. First, a significant percentage of students do not pass the first course in their STEM major; second, most students leave a STEM major before the end of the sophomore year. As a result, the retention rate to graduation for STEM majors at the institution was only 25% (Benjamin, et al., 2017).

This study utilized direct and indirect exposure methods that allowed students to be exposed through multiple venues while also passing along the principles to other students through everyday social interaction. Eligibility for any direct exposure method included declaring "a major in a STEM discipline (biology, chemistry, physics, computer science, dual-degree engineering, mathematics or psychology) and interest in pursuing a STEM career.

There were seven intervention methods utilized in spreading growth mindset principles through the Division of Science and Mathematics at the institution, which included: the online scientific literacy summer course, a residential summer program, new student orientation,

residential life programs, advisement sessions, faculty mentoring/advisement, and peer-to-peer interactions. Each of these direct and indirect methods allowed students to experience growth mindset principles throughout the campus community fluently.

### Direct Exposure Methods

Within this case study, direct exposure is defined as an intervention method that includes students being exposed to growth mindset principles by a researcher or facilitator trained in growth mindset implementation. This direct exposure consisted of activities and resources that could be used after the intervention ended and indirect exposure through traditional campus engagement.

*Utilitarian Scientific Literacy Course:* An online Scientific Literacy course offered to incoming first-year STEM majors during the summer before enrollment was a direct method used in this study. Previous face-to-face and flipped classroom studies on this course documented statistically significant results pertaining to student retention and interest in STEM (Chambers, et al., 2019; Jackson et al, 2021). An average of 30 students completed the online course per year between 2016 and 2019 and students reported in 2016 that this course was relevant, effective, and valuable based on an average 4.35 score on a 5-point Likert scale.

The course contains 12 chapters designed to build skills, attitudes, and behaviours necessary for success as a STEM major. Chapter 4 was designed to facilitate a growth mindset and is one of the most comprehensive, interactive chapters. This growth mindset chapter contains a lecture with PowerPoint slides, a quiz, and three active learning activities. Embedded within the lecture are original animations that demonstrate the brain's ability to reorganize itself by forming new neural connections as growth mindset principles become a way of life. This innovative animation was incorporated as a hook to promote understanding and remembrance of how a growth mindset can change a person.

The active learning activities in this chapter consisted of self-analysis of a student's mindset relative to science, mathematics, intelligence, and personage; an avatar-based time-capsule of how a growth mindset was developed over an individual's lifespan; and a writing assignment to encourage another student to use growth mindset principles. After completion of this chapter and the entire Scientific Literacy course in 2016, students' averaged a 4.2 on a 5-point Likert (scale ranging from 1- not effective to 5- very effective) for the following statement *"the extent to which this activity facilitated your possessing a scientist identity and STEM self-efficacy, as well as other relevant attitude and intellectual behaviours for success in STEM.,"* which suggests that the students felt positively impacted by this online course.

*Residential Summer Program:* This pre-freshman residential program was the most comprehensive direct method of exposing students to growth mindset principles which utilized an experiential growth mindset curriculum. An average of 26 students participated in this two-week-long program directly after completing the online course per year.

Growth mindset attitudes and behaviours were fostered in an interactive classroom setting where students and faculty shared personal growth mindset experiences. Faculty members supported students in their projects and fostered a growth mindset atmosphere through teaching students about resilience and overcoming challenges. Initially, students were tasked with a challenging, do-it-yourself (DIY), research and development makerspace project in which faculty members would assist them for 12 hours a day. However, as with any research and development project there were problems that required changing directions. The difficulty of altering or formulating a new topic provided students the opportunity to apply growth mindset principles while overcoming a conventional challenge in STEM fields. Overall, students had to be resilient, which resulted in them making statements such as, "persistence makes a good researcher," and "not to give up on the end goal, I had to change my experiment procedure, process and hypothesis at least three times." These statements align with characteristics associated with having a growth mindset.

During the day, students worked with hands-on activities where they applied the principles of "you don't give up" and in the evening, students watched videos on critical thinking and growth mindset. In 2016 and 2017, students rated the self-perceived value and effectiveness of the videos with a 4.3 out of 5 and reported that the videos were useful in their ability to think creatively and innovatively.

At the conclusion of the growth mindset bootcamp experience, students presented their research in a competition amongst each other. On a self-reported Likert scale assessment (ranging from 1 to 5; very low to very high), students scored an average score of 4.21 on the item stating, "I believe this program will help me be successful as a college STEM major." Like the online Scientific Literacy course, the evaluation of these students suggested that they had a positive experience within the growth mindset bootcamp.

Ultimately, the space was designed to see if students retained a growth mindset and could apply the principles in a way that would drive them to overcome challenges and persist. Students were asked about their plans after college in a pre and post assessment. At the start, only a few students responded with plans to attend graduate school, however, after participating in the program, a vast majority of students wanted to go to graduate school. To emphasize the importance of maintaining a growth mindset as a STEM major, students were charged with spreading growth mindset principles to their peers in hopes that it would support those students in their matriculation through their STEM major. In summary, students continued to learn growth mindset principles in a challenging, DIY, makerspace bootcamp research experience that required a growth mindset to rise to the occasion.

*New Student Orientation:* For three years, all incoming freshmen STEM majors at the college were required to participate in a six and a half-hour, three-part scientific literacy workshop during the new student orientation period. This shortened version of the Scientific Literacy course included several hours discussing growth mindset principles with an active learning exercise. During the orientation, select faculty and upper-level students shared stories of when they had to employ growth mindset principles and how it contributed to them overcoming a challenge.

Students received lectures that provided insight into the understanding and application of growth mindset principles. Formative evaluation of these students in the first year suggested that students felt this activity was useful. Descriptive statistics showed average scores ranging from 4.32 to 4.5 on a 5-point Likert scale. The scale measured if students felt the workshop would help them be successful, if they would recommend the activity to other students, and if they wanted additional scientific literacy/growth mindset workshops.

*Residential Life Programs:* After the first year, additional scientific literacy/growth mindset sessions were offered to students during the academic year as another direct method of dissemination. STEM majors often lived in the same dormitory, and residential advisors (RAs) often hosted STEM-based programs, activities, and lectures for students. During programming, RAs brought in a trained speaker to teach growth mindset principles on four different occasions. In addition to the lectures, several RAs participated in faculty professional development training on growth mindset and were empowered to apply growth mindset principles within the dormitory through everyday life interactions and activities. These interactions and activities included scheduled dorm events and daily conversations with students where RAs may provide growth mindset principles to a student overcoming an academic or personal challenge.

### Indirect Exposure Methods

Within this case study, indirect exposure can be defined as methods with no direct contact with growth mindset principles by a mindset expert or supplemental curriculum and activities. This form of indirect exposure occurs when the student or faculty encounters another individual who experienced direct exposure methods related to growth mindset principles. These indirect exposure methods are intended to be useful in continuing

to spread growth mindset principles across the campus culture.

*Faculty Professional Development and Interaction:* Students were exposed to faculty members that participated in faculty development and training centered on growth mindset principles. For three years, approximately one-third of the Division of Science and Mathematics faculty participated in the growth mindset scientific literacy faculty development workshops. Participation in this program required these faculty to attend a half-day professional development workshop on growth mindset principles. Each year faculty were expected to participate in the workshop and expand the use of growth mindset principles in their teaching.

The interactive professional development showed faculty how to integrate growth mindset principles into their teaching pedagogy through lectures, and workshop activities. Within the workshop, faculty were tasked with addressing and analyzing five case studies where they proposed the best way to apply growth mindset principles in different settings. Faculty were given a chance to write a growth mindset letter and share their personal stories, as well as participate in extensive training with a growth mindset expert. Resources and materials that would support implementation within the classroom and around campus were provided.

Six faculty mentors that worked in the Residential Summer Program were given additional training. This training allowed these faculty members to do a deeper dive into what is a growth mindset and how to promote this mindset best when working with students. Some of the activities these faculty experienced included, additional faculty development workshop sessions and development of personal growth mindset stories that were shared with students. Growth mindset storytelling is essential to understanding how a growth mindset works and how to best incorporate these principles into everyday life practices. These stories encouraged students to share their own personal growth mindset stories.

In year 3, following the growth mindset faculty professional development, all faculty indicated how they embodied a growth mindset in their post-survey responses. Again, pre- and post-survey data were collected to document the effectiveness of the training. The post-survey data showed that all participants agreed or strongly agreed that the professional development was relevant and extended their knowledge. On a Likert scale ranging from 1- strongly disagree to 5- strongly agree concerning the impact of professional development, the faculty averaged a score of 4.0 to 4.67 on all survey items.

*Faculty Mentoring and Advisement:* Mentoring and advisement consisted of one-on-one or small group sessions between faculty and students where they were given advice centered on growth mindset principles. Faculty would support students in making decisions concerning their academic endeavours and to some degree, their personal life experiences that may be impacting their academic performance.

In a post-survey, faculty responses to their experiences and exposure to growth mindset principles included, *"...immediately relevant for enhancing my teaching philosophy and pedagogy," "I would like to read more about growth mindset; it seems like this idea needs to be used on policy level to affect change in culture," and "I will explicitly teach growth mindset to my students. I will explicitly reference my assessment strategies and teaching outcomes to growth mindset and the research being done; I feel like I have been operating in this paradigm without knowing it."* Each response lends to the utilization and impact of growth mindset principles when supporting students in STEM through faculty development and interaction.

*Peer-to-Peer Interaction:* Students that were directly exposed to growth mindset principles were charged with the personal responsibility to share the information they learned with their peers. During several direct exposure methods, students developed techniques on sharing growth mindset principles with their peers, which included writing a letter and sharing personal experiences where students felt they developed a growth mindset. As a result, the directly exposed students could help other students in the division who could be at risk of dropping out of their STEM degree program develop the skills and attitudes that align with a growth mindset. Ultimately, helping them mitigate some of the challenges associated with graduating with a degree in STEM.

Each implementation method allowed for spreading growth mindset principles across the institution's Division of Science and Mathematics. The researchers grouped each growth mindset intervention method into one multi-faceted intervention to investigate the impact of spreading growth mindset principles across an entire division. There were two research questions used to examine the intervention:

1. Will students' growth mindset attitudes and behaviours improve as a function of the multi-faceted intervention?
2. Did students' understanding of a growth mindset vary among classifications?

## Methodology:

### *Intervention Development*

For each implementation method, the pre-first year and first-year target populations remained the same, but the recruitment methods for those participants slightly varied from one venue to another. Due to the different exposure methods, this allowed for a diverse representation of students being exposed to growth mindset principles. The intent was to disseminate growth mindset principles across the Division of Science and Mathematics at the institution so that all students could benefit from the multi-faceted intervention.

After three years of direct and indirect exposure to growth mindset principles, a growth mindset survey was designed and administered to students in the Division of Science and Mathematics. Based on the literature and the characteristics that have been aligned with having a growth mindset, five items were selected for the survey to measure whether growth mindset principles were spread across the division and whether these principles impacted students' growth mindset attitudes and behaviours. These items included, *"I believe that success comes through hard work," "I embrace hard courses," "I learn from my failures in school," "I do not give up easily when challenged in class," and "I learn from criticism."*

## Data Collection

### *Growth Mindset Survey*

The growth mindset survey contained 24 items, 10 of which were before/now items that were designed to measure attitudinal changes and the overall effectiveness of the intervention. The remaining 14 items contained demographic information about participants, venue participation, and knowledge of growth mindset principles. Fifteen items out of the total 24 were answered on a five-point Likert scale ranging from 1-strongly disagree, 2-disagree, 3-neither 4-agree, and 5-strongly agree.

### *Growth Mindset Survey Participants:*

Across the division of science and mathematics, student participants (n=105) were recruited using convenience sampling to capture only STEM majors within a classroom, dormitory, and cafeteria area. Participants who did not complete the entire survey were removed from the analysis, bringing the number of survey participants to (n=93). Table 1 shows the demographic

| **Classification (n = 93)** | |
|---|---|
| Freshman | 28 (30.1%) |
| Sophomore | 13 (14%) |
| Junior | 28 (30.1%) |
| Senior | 24 (25.8%) |
| Total | 93 (100%) |
| **Major (n = 93)** | |
| Biology | 13 (14.0%) |
| Chemistry | 11 (11.8%) |
| Psychology | 8 (8.6%) |
| Physics | 5 (5.4%) |
| Dual Degree Engineering | 13 (14%) |
| Computer Science | 25 (26.9%) |
| Mathematics | 9 (9.7%) |
| General Science | 9 (9.7%) |
| **Total** | 93 (100%) |

**Table 1. Student Survey Demographic Data**

| | Growth Mindset Venues | |
|---|---|---|
| **Direct Exposure Methods** | Utilitarian Scientific Literacy Course | 29 |
| | Residential Summer Program | 22 |
| | New Student Orientation | 31 |
| | Residential Life Program | 12 |
| **Indirect Exposure Methods** | Faculty Professional Development and Interaction | 15 |
| | Advisement Sessions | 7 |
| | Peer-to-Peer | 15 |
| **Total** | | **131** |

Table 2. Exposure Venues Demographics

data for the students that participated in the survey. The goal was to get a representative sample for each classification and major to see how well growth mindset principles were spread across the Division of Science and Mathematics at the institution.

### *Exposure Demographics*

Since the overall goal was to create a growth mindset culture across the entire division, researchers attempted to expose each participant to the concept through direct and indirect venues. Thus, the participants had the opportunity to engage with multiple venues across the institution. First, the data were cleaned to remove those that did not complete the survey. The next item instructed participants to answer, *"Do you remember being taught about or introduced to the concept of a growth mindset vs. fixed mindset while at the institution?"* Out of the 93 survey participants, 77 or 82.3% responded that they did remember being exposed to growth mindset principles. These survey participants were allowed to proceed to the remaining questions within the survey. Participants were then asked to identify the venues they participated in and selected all that applied. From the survey responses, researchers found that 29 participated in the online utilitarian scientific literacy course, 22 participated in the residential summer program, 31 remembered participating in the new student orientation (NSO), 15 participated in the faculty professional development and interaction, 12 participated in the residential life program, seven participated in the advisement sessions, and 15 experienced peer-to-peer interactions. In sum, there were 131 responses recorded by students when asked about direct and indirect exposure methods. Table 2 illustrates descriptive data about student participation at each venue.

| Question | N | Before/Now | Mean | Std. Dev. | Std. Error Mean | *t*-value | Cohen's *d* |
|---|---|---|---|---|---|---|---|
| I believe that success comes through hard work | 62 | Before | 2.94 | 1.598 | .203 | -6.177 | 1.768 |
| | | Now | 4.32 | .845 | .107 | $p < .0001^*$ | |
| I embrace hard courses | 61 | Before | 2.77 | 1.334 | .171 | -5.910 | 1.473 |
| | | Now | 3.89 | .968 | .124 | $p < .0001^*$ | |
| I learn from my failures in school | 59 | Before | 2.85 | 1.257 | .164 | -6.679 | 1.306 |
| | | Now | 3.98 | .974 | .127 | $p < .0001^*$ | |
| I do not give up easily when challenged in school | 62 | Before | 3.02 | 1.312 | .167 | -5.179 | 1.324 |
| | | Now | 3.89 | .851 | .108 | $p < .0001^*$ | |
| I learn from criticism | 63 | Before | 2.87 | 1.508 | .190 | -5.743 | 1.667 |
| | | Now | 4.08 | .903 | .114 | $p < .0001^*$ | |

*$p$ <.05; mean scores for the Growth Mindset Survey questions at Before and Now for participants are statistically different

Table 3. Growth Mindset Survey

## Findings:

### Before/Now

The five before/now questions which all align with characteristics of a growth mindset were analyzed through a paired-samples t-test to evaluate the impact of the intervention on students' understanding of the concept of a growth mindset. Paired-samples t-test with bootstrapped confidence intervals indicated statistical significance and a large effect for everyone before/now questions:

These statistically significant changes from before to now as shown in Table 3 indicate that participants developed the 'attitudes' that aligned with the growth mindset principles. While these findings cannot be generalized beyond the students participating in the Growth Mindset survey, the scope of the data provides implications about the way growth mindset was disseminated across an entire division and the impact of this type of broadening participation approach.

### Understanding of Growth Mindset and Classification

A chi-square test of independence was performed to examine the relationship between classification and understanding of the growth mindset concept. The relation between these variables was statistically significant, $X^2(12, N = 92) = 30.705$, $p = .002$ as presented in Table 4. Freshmen were more likely to choose the appropriate answer to the question: What is a growth mindset? The correct response is "A belief that success comes through hard work and perseverance, and 11 freshmen (61.1%) chose that response. First-year and pre-first-year students represented the target population that participated in the online Scientific Literacy course and Residential Summer Programs, which were significantly the most comprehensive interventions.

## Discussion:

### Exposure Methods

Students who remember being exposed to the growth mindset

| Question: | *A Growth Mindset is:* | | | | |
|---|---|---|---|---|---|
| | The brain's ability to reorganize itself by forming new neural connections throughout life | A belief that success comes through hard work and perseverance* | The natural process of development and maturation of one's mental attitudes over time | The established set of open-minded attitudes held by someone | I don't know |
| **Classification** | | | | | |
| Freshmen | 4 (66.7%) | 11 (61.1%) | 0 (0.0%) | 9 (20.0%) | 4 (57.1%) |
| Sophomore | 0 (0.0%) | 0 (0.0%) | 5 (31.3%) | 7 (15.6%) | 1 (14.3%) |
| Junior | 1 (16.7%) | 5 (27.8%) | 8 (50.0%) | 14 (31.1%) | 0 (0.0%) |
| Senior | 1 (16.7%) | 2 (11.1%) | 3 (18.8%) | 15 (33.3%) | 2 (28.6%) |
| Total (n = 92) | 6 (100%) | 18 (100%) | 16 (100%) | 45 (100%) | 7 (100%) |

*Chi-Square Test, $X^2(12, N = 92) = 30.705, p = .002$*

**Table 4. Classification and Growth Mindset Cross Tabulation**

principles identified the venues they participated in. There was a mix of direct and indirect methods necessary to ensure the dissemination across the division at the Liberal Arts College. However, more students reported being exposed to direct methods (94) compared to indirect methods (37). Majority of students that responded to being exposed to multiple venues were freshmen. This outcome correlates with the fact that freshmen students had likely been recently directly exposed to the multi-faceted intervention. However, it speaks to the effectiveness of implementing and disseminating growth mindset principles among these early STEM learners across multiple venues. These students help disseminate growth mindset principles across the division and potentially increase retention amongst STEM majors.

## Growth Mindset Attitudes and Behaviours

The majority of African American students pursuing STEM degrees do not persist. This could be due to lacking a growth mindset that can promote resiliency and intent to persist (Dweck, 2006; Dweck, 2016). The findings in this study showed that through a multi-faceted intervention approach geared toward disseminating growth mindset principles across a division, students showed statistically significant increases in their attitudes and behaviours associated with growth mindset principles. These results suggest that the growth mindset principles shared with students, directly and indirectly, may impact a student's ability to persist within STEM degree programs.

The before and now questions that were used to gauge students' understanding of growth mindset principles are directly correlated with the attitudes that have been linked to having a growth mindset. Within previous research, growth mindset principles have impacted students' attitudes toward STEM. However, this intervention approach was not multi-faceted and was not implemented over several years (Woods, 2020).

According to the Phenomenological Variant of Ecological Systems Theory (PVEST), students experience risks and protective factors within each environment that they occupy (Spencer Dupree, & Hartmann, 1997). The five components of PVEST include, net vulnerability level, stress engagement, reactive coping methods, emergent identities, and life-stage outcomes (Spencer et al, 1997). There are various risks and protective factors for African American students pursuing STEM degrees within educational contexts. Within this study, the multi-faceted approach of the growth mindset intervention responds as an adaptive coping method. It supports student's persistence in their STEM courses as they encounter the intervention directly and indirectly.

The contextual factors of the students and around the campus environment must be considered when understanding the role of the multi-faceted growth mindset intervention. Due to the varying net vulnerabilities of students and the different ways they learn and interact on campus, there was a need for disseminating the intervention through direct and indirect exposure methods. Spencer and colleagues (1997) designed a framework that shows the bi-directional phases of how the intervention allowed the examination of the results to go beyond impact to understand how each growth mindset exposure method operated as a stable coping mechanism for students to foster positive emergent identities needed to navigate STEM courses and careers.

The multi-faceted intervention also operates within each of the other four components of PVEST as support, protective factor, positive identity association, and productive outcome for students. The hope is that the growth mindset principles acquired by students will continuously inform their identity and the identities of other students as they interact throughout the campus community.

The small sample size limits the generalizability of the study. However, the statistically significant increases in student's positive behaviours and attitudes show the impact of the growth mindset intervention when students have been directly and indirectly exposed. With growth mindset principles, students are experiencing a protective factor that, if used repeatedly, will become a part of who they are and contribute to them accomplishing many things through hard work and resilience. Exposing pre-first year and first-year students to direct growth mindset interventions allowed students to utilize the new skills they learned as they persisted through their STEM major. Additionally, the indirect interventions allowed for the reinforcement of these attitudes and behaviours through the senior year.

Students were asked to define what a growth mindset is, and from their responses, a Chi-square analysis revealed statistically significant results based on classification. Freshmen students were responsible for 61.1% of the correct responses as they represented the target population that most recently participated in the extensive online scientific literacy course and residential summer program. Students that did not select the correct answer either stated that they did not know what a growth mindset was or chose an answer that demonstrated a partial or inaccurate understanding of the definition of a growth mindset. Specifically, they chose answers that either:

- Aligned with the animated hook in the Scientific Literacy course that describes anatomical changes in the brain during growth mindset development
- Defined mindset and not growth mindset
- Described growth mindset as an open-minded attitude, which according to Dweck is a common misconception of a growth mindset (Dweck, 2006)

Since freshmen answered the definition question more accurately, these results could also identify a need to further extend direct growth mindset interventions past the freshman year to ensure adequate understanding for students at every level.

The researchers encountered several limitations while conducting this study, such as limited resources that required convenience sampling in classrooms, dormitories, and the cafeteria. Despite capturing students from each level, classification was not adequately represented, and a larger sample size would have helped generate stronger

statistical data. Future researchers should consider gathering additional contextual information that will provide a more robust understanding of how effective the intervention strategy was at spreading growth mindset principles across all STEM majors. Also, consider conducting longitudinal studies that track students through graduation and post-graduation, comparing pre- and post-intervention implementation rates.

## Conclusion:

Within this case study, the researchers highlighted the significance of disseminating growth mindset principles across a Division of Science and Mathematics at a liberal arts college through direct and indirect exposure methods. This multi-faceted intervention started targeting pre-and-early first-year students with the intent of spreading growth mindset across the division as students matriculated through their majors. The findings showed among the surveyed students a statistically significant positive attitudinal change due to the multiple exposures.

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