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Monica Palomo
California State Polytechnic University - Pomona

Pauline Muljana
Old Dominion University, pmulj001@odu.edu

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Women Students Learning a STEM Subject: An Analysis of Note-Taking Practices in a Civil Engineering Course and the Association with Self-Efficacy, Cognitive Engagement, Test Anxiety, and Course Achievement

Monica Palomo (Professor) (California State Polytechnic University, Pomona)

Dr. Mónica Palomo is a professor in the Department of Civil Engineering at California State Polytechnic University, Pomona, where she teaches senior projects, and environmental and water resources engineering undergraduate and graduate courses. She is the CWEA-AWWA student chapter advisor. Dr. Palomo holds a Civil Engineering degree from the University de Guanajuato, México, and her MS and PhD degrees (both in Civil Engineering with Environmental emphasis) from Kansas State University. Her research interests are in water and wastewater treatment, natural treatment systems for water remediation, sanitation in developing countries, engineering outreach, service learning, and engineering education. Dr. Palomo has served as chair of the student council, ASCE Environmental and Water Resources Institute (EWRI), she served as division chair and is current member of the Board of Directors of the Environmental Engineering Division of the American Society for Engineering Education (ASEE). Dr. Palomo also serves as an ABET Program Evaluator. She is a 2009 fellow and mentor for the ASCE Excellence in Civil Engineering Education (ExCEEd) teaching workshop. Dr. Palomo believes that fostering curiosity and life-long learning skills we can make the world a better place. She believes that an inclusive and equitable learning environment is critical for students to be motivated and enjoy their learning journey.

Pauline Muljana

Pauline Salim Muljana is a PhD candidate in the Instructional Design and Technology (IDT) program at Old Dominion University. Her research interests center on the investigations of how a data-informed analytics approach informs instructional design to foster learning behaviors and strategies associated with successful learning. Before joining the IDT program, she held instructional design responsibilities for 12 years at California State Polytechnic University Pomona, which included designing and developing courses with various delivery modes and multimedia learning objects, as well as facilitating faculty workshops on instructional strategies and effective use of technology. She now works at Lumen Learning as Director of Continuous Improvement, integrating data-driven improvements and community-contributed improvements into courseware with an emphasis on equity-centered design.

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Keywords

"Civil engineering," "cognitive engagement," "women in engineering", "note-taking practice," "pandemic", "persistence," "self-efficacy," "STEM learning,", and "virtual learning"

Introduction

While engineering and science programs across the US have come up with interventions to increase the enrollment and retention of underrepresented students, women students are still underrepresented in STEM (science, technology, engineering, and mathematics) fields [1], [2]. In 2015, more men students graduated with an undergraduate degree in the engineering field than their women peers accounting for only 19.8% among those who earned the engineering degree [1], [3]. By 2021, there was only a 2.4% increase in the total number of women graduating from an undergraduate engineering program [63]. Students of color are also underrepresented in the STEM fields [1], [4], and their attrition in the STEM programs is likely to occur (e.g., Latino/Latina/Latinx, African Americans, and Native Americans) [1], [5].

Existing literature documented that men students' high self-efficacy and low mathematical-related anxiety may be two of the factors driving their persistence in STEM courses [6] - [13]. Self-efficacy, defined as "individual judgments of [one's] capabilities to perform given actions" [14, p. 207], has been associated with learning achievement in STEM programs [15] - [18]. It has been found that women students sometimes have math-related anxiety [7], [9], [11], [19] and that they may fear enrolling in courses entailing quantitative activities [7], [19]. Literature suggests that if women students have high self-efficacy about the STEM subject or field, they are likely to perform better and persist in a STEM class [10].

The COVID-19 pandemic, still occurring today, has brought challenges for students, such as sudden changes in the mode of instruction, loss of employment, family health issues, and others that all together result in difficulties to focus and complete coursework. The COVID-19 pandemic has threatened people's health in the community and led to anxiety and depression [20], [21]. These factors may influence students' learning and cognitive processes [20] - [23]. Numerous studies have displayed an inverse relationship between self-efficacy and test anxiety [24], [25], especially toward quantitative subjects [19]. Additionally, the pandemic situation may distract the students from focusing on their cognitive goals [24], [26]. As a result, students may not be able to concentrate, which can disrupt their cognitive engagement [27]—cognitive engagement is a mental process that allows students to grasp knowledge [27], [28]. This paper includes the results from investigating the pairing of note-taking with how self-efficacy, test anxiety, and cognitive engagement may be related to the course achievement of the women students enrolled in a class offered in a civil engineering program. Student information was collected via two online questionnaires, one given at the beginning and one at the end of the term (IRB-0-218).

The Role of Guided Note-Taking

Facilitating note-taking can help students perform better, particularly because it helps students stay engaged in the learning process [29] - [36]. By taking notes, students can monitor their understanding and reflect on their learning process [37]. This type of understanding and reflection is related to the self-efficacy of learning [38]. When students are listening to the instructor, the information received in the sensory memory is transferred to the working memory, and the transferring process may exert the use of working memory [30], [37]. Facilitating guided note-taking can alleviate this cognitive load [30]. Essentially, note-taking may support the cognitive process; it may promote cognitive engagement and discourage test anxiety. While the benefits of note-taking are known for numerous years, the investigation regarding the role of facilitating note-taking on students' self-efficacy, cognitive engagement, and test anxiety that can potentially help them succeed in learning a STEM subject during the pandemic is still limited. While all the students enrolled in the course under study were guided on how to take notes and were given credit for submitting their notes, only the notes of students that showed changes in the semester, five women students, were included in this study.

Note-Taking as a Mean to Engage Students

Note-taking is a valuable essential skill; the process of making the information one's own (e.g., using writing and/or illustrations) is known to support the learning process in the classroom and throughout life [39]. Note-taking is one of the evidence-based teaching practices used by the Association of College and University Educators (ACUE) to promote student engagement in class and with the material, provide opportunities for deeper learning, and promote career readiness, among others. ACUE offers professional development courses for instructors where the note-taking practice is recommended to evolve the engagement in face-to-face and online learning environments.

Guiding students to take notes is important because the process allows them to internalize what they are reading. They practice how to organize the information for themselves and identify more effective studying practices to prepare for the course assessments. In a sudden situation, e.g., when the traditional face-to-face courses are rapidly converted to remote learning during the pandemic, note-taking can serve as a critical practice for students. When students have to suddenly participate in the class activities remotely, students may not have the environment that provides the right conditions for reflection and engagement with the content. By taking notes, students can focus their attention and thus manage the surrounding distractions. If the learner is distracted, the notes may help students go back to the main train of thought. Another advantage of note-taking is that it engages several senses in the learning process as ideas go from the brain to the hands, and finally, they are captured in the paper/pad. Writing is powerful because one has to focus the attention and involve the whole body.

To make the note-taking process effective ACUE provides the following practices:

- Motivating students' note-taking by:
    - Sharing the evidence-based benefits of note-taking in the learning process.
    - Providing information about the transferability of the skill to other courses and beyond college.

- Giving credit for taking notes.
- Allowing the use of the notes for quizzes and assessments to promote extensive use of the notes (repetition is the key: writing of notes, reviewing of notes, preparation of a study guide from notes, use of notes in assessment, etc.)
- Providing structure by using skeletal notes with blank spaces for students to complete ideas, including prompts to focus on important content and opportunities for reflection. Additionally, skeletal notes provide structure for students to further organize and classify the information received. In engineering, skeletal notes could promote the addition of extra information, illustrations, or sketches as needed to add context, and help the learner make connections and remember ideas later.
- Providing tips or a guide on how to take notes.
- Providing examples of notes, e.g., using students' notes from past terms or instructor modeling how to take notes [40].

Note-taking is further effective if the learners have the time to write the information down as it is delivered in class. It allows them to reflect on the information and add additional information relevant to the topic (e.g., applications, experiences, observations, reminders, reflections from discussions, links to past knowledge or courses, etc.), thereby resulting in personalized and nonlinear notes. When a course is based on the use of pre-prepared, content-based materials using presentation software delivered at a fast pace, the student experiences difficulty making connections and will not have time to write their own notes. In such conditions, the learner is limited to reading, highlighting and/or commenting on the already existing course notes. Thus, using the note-taking strategy requires the class instruction to be developed to include adequate pacing and time for their production.

The instructor modeling the note-taking process is one of the practices recommended by ACUE to guide students [40]. The idea of the professor modeling a specific behavior in the classroom as an effective learning practice is not exclusive of ACUE. The American Society of Civil Engineering (ASCE) Excellence in Civil Engineering Education (ExCEEd) teaching model [41] suggests that good teaching includes the modeling of different behaviors (e.g., clear written and oral communication, problem-solving, use of physical demonstrations, among others). [41] – [43]. Since 1998, the ExCEEd Teaching Workshop (ETW) has provided effective writing practices for instructors to make the information-sharing process effective [41]. [42]. This study expanded the ETW's faculty writing practices to develop a student note-taking (SNT) guide and a SNT rubric. The intent of this study was to support student engagement with the content, by focusing kinesthetically and cognitively during the synchronous learning period due to the pandemic. Thus, note-taking was used as an intervention that supported students with preparing personalized, comprehensive, and organized records of the class materials that could be used as a reference to prepare for quizzes, exams, or other senior-level or graduate-level courses.

The overall principles of the ETW writing practices were adapted to prepare a note-taking guide for students. The instructor that taught the CE 4201 Water and wastewater engineering course demonstrated note-taking using the ETW writing practices while writing on an electronic whiteboard. The student SNT guide contained five main elements that were included in the rubric used to score students' notes. The elements of the note-taking guide are listed below.

A. Writing quality:

1. Shape and clarity—this item refers to the legibility of the writing, well-defined letters, consistent case and format, and space between words.
2. Writing bold—item that refers to the strength of the writing (dark enough to have good contrast with paper/tablet).
3. Writing in an organized manner and in a straight line.

B. Organization of ideas:
4. Organization and emphasis of ideas—use of indentation, grouping, underlining, clouds to classify information.
5. Stressing the importance of ideas—showing the hierarchy of ideas, adding visuals to notes, use of drawings to enhance the clarity of ideas.
6. Consistency of the format along with the notes (use of color, way to emphasize, font type, and shape).

C. Notes appearance:
7. Notes look harmonic (organized and visually pleasant).
8. Ideas look flowing in a sequential way and are coherent.

D. Use of technical drawings**:**
9. Drawings are complete, detailed, accurate, colorful.

E. Use of equations and calculations:
10. Equations are complete and clear.
11. Calculations are legible.
12. Calculations are organized.
13. Intermediate results are easily identified.
14. Final answers are identifiable.

The Purpose of the Study

The present study was aimed to investigate the note-taking practices of women students with increased self-efficacy and cognitive engagement, and decreased test anxiety. The following research questions guided the present study:

1. Among the women students, was there any increase in self-efficacy and cognitive engagement, and any decrease in text anxiety?
2. Regarding the women students with an increase in self-efficacy or cognitive engagement, or a decrease in test anxiety, what were the scores of their note-taking practices when evaluated using the SNT rubric?
3. Regarding the women students with increased self-efficacy or cognitive engagement, or decreased in test anxiety, were their note-taking practices correlated with the course grades?
4. What were the women students' reflections on their learning strategies and challenges?

Method

Context and Participants

The course selected to conduct this study was a junior/senior level design course of the Civil Engineering program at Cal Poly Pomona (CPP). The course was offered in the fully synchronous mode due to COVID-19 rapid transmission at the time. The course was designed

with the note-taking intervention as a required learning experience for all students enrolled and had a weight of ~6.6% of the overall course grade. A total of 24 students were enrolled in the spring of 2021, when the pandemic and remote learning still occurred. While 19 students gave consent to participate in the study; only 18 consented students completed the study. Out of the total participants, 61% and 39% reported being women and men, respectively. The ethnic background distribution was 26.32% Asian, 15.79% Caucasian, 47.37% Hispanic or Latino/a or Latinx, and 10.53% other. While 15.79% were juniors, 84.21% were seniors. About half of the participants (52.63%) reported that they did not work for pay. The students' course load varied from 3 to 4 courses (21.05%) to 4 to 6 (36.84%), with the majority of students taking seven or more courses (42.11%). Approximately 47.37% were full-time students (enrolled in more than 12 units); 47.37% were full-time students (enrolled in more than 12 units) and working part-time; and only 5.26% were part-time students (enrolled in less than 12 units per semester) and working full time

The methods were used to report self-efficacy, cognitive engagement, test anxiety, and how these variables relate to course achievement, all in the context of note-taking. To achieve the research purpose, among all students, only the five women students that showed changes are discussed in this paper. However, it is worth noting that all responses were carefully considered to inform the instructor regarding the course redesign of the next cohort. In addition, when analyzing the responses of all 18 consented students who completed the study, it was found that the mean score for all students in the class did not seem to change in the three aforementioned variables. For all 18 students, self-efficacy changed from $M = 3.761$ ($SD = 0.469$) to $M = 3.329$ ($SD = 0.682$); cognitive engagement changed from $M = 4.091$ ($SD = 0.405$) to $M = 3.980$ ($SD = 0.313$); test anxiety changed from $M = 3.567$ ($SD = 0.430$) to $M = 3.661$ ($SD = 0.781$)

The authors delved deeper to analyze any differences in the three variables among the women students. When analyzing all women participants (a total of seven women students consented to participate in the study), the changes from pre- to post-surveys did not seem to indicate an improvement as well. For example, self-efficacy changed from $M = 3.796$ ($SD = 0.471$) to $M = 3.178$ ($SD = 0.838$); cognitive engagement changed from $M = 4.026$ ($SD = 0.256$) to $M = 3.922$ ($SD = 0.312$); test anxiety changed from $M = 3.598$ ($SD = 0.118$) to $M = 3.829$ ($SD = 0.820$) for all the seven women students. Therefore, the authors further explored whom among the seven women students improved self-efficacy, cognitive engagement, and/or test anxiety. As a result, the investigation was narrowed down to five women students who reported an improvement in self-efficacy, cognitive engagement, and/or test anxiety. These five students represented 20.83% of the total students in the class or 26.31 % of the students that consented to be part of the study. Two of the five women students were juniors, and three were senior civil engineering students. Three of them were students of color. The study occurred during spring 2021 in a course that was taught fully synchronous due to the pandemic. Table 1 displays the demographic information of the five women students participating in this study.

Table 1: Demographic Information of the Participants

Demographic Information/ Student ID	Student 1	Student 2	Student 3	Student 4	Student 5
Race or Ethnicity	White	Hispanic	White	Biracial	Hispanic
Class	Senior	Junior	Senior	Senior	Junior
Enrollment Status	Full-time	Full-time	Full-time	Full-time	Full-time
Enrolled Courses	7 or more	3 to 4	5 to 6	5 to 6	5 to 6
Type of Enrolled Units (Eng-Lec/Eng-Lab/Non-Eng)	12/2/3	12/2/0	8/1/1	9/1/0	14/2/0
Total Units Enrolled	17	14	10	10	16

Note. Eng-Lec is engineering lecture course, Eng-Lab is engineering laboratory course, Non-Eng is non-engineering course.

Teaching Strategies or Procedures

The syllabus of the selected course included 13 different topics. Students had a set of skeletal notes provided for each topic. The skeletal notes included the lesson learning objectives, relevant pre-positioned information, questions to complete during class, reflection prompts, figures, and diagrams. While the skeletal notes included the content organized sequentially, the class presentation used images, videos, textbook tables, group and individual activities, and other materials not in the notes that needed to be captured or integrated by each student. Notes were graded, and 6.6 % of the final grade was assigned to them. Students who took notes and submitted them were given credit to encourage the note-taking practices and help them stay focused during the synchronous class. While notes were required and skeletal notes provided, students could opt out of using the skeletal notes and organize their notes differently. Notes were graded based on their completeness, organization, use of units in calculations, and completion of the problems solved in class or assigned in class. No credit was given to notes that consisted of screenshots of writing or drawings made and displayed by the instructor on the screen. A significant part of the curriculum included design; thus, screenshots of complex diagrams, tables, or images to supplement the notes were encouraged and received credit if relevant. Either handwritten or electronic notes were accepted. Notes were due on Saturdays to allow students to consult with classmates and submit full notes even if students missed a class or got distracted during class. The note-taking guidelines, which included the five elements of good note-taking, were available in the course Learning Management System (LMS). The instructor introduced it to the students in the first week of class. The instructor used an electronic whiteboard in every class and followed the ETW instructor writing guidelines to demonstrate the note-taking process.

Data Collection and Analysis

Data were collected from online surveys, pre- and post-surveys, and students' submitted notes (IRB-0-218). The pre-survey included several demographics, contextual-related items, open-ended questions, and several items from previously validated scales. These scales were: (1) two items of study environment items from Pintrich et al.'s [44] Motivated Strategies for Learning Questionnaire (MSLQ); (2) eight items of self-efficacy for learning and performance scale from MSLQ; (3) 11 items of cognitive engagement (i.e., deep processing and shallow processing) from Greene and Miller [45]; and (4) five items of test anxiety scale from MSLQ. The post-survey included the same items from the pre-survey; however, some demographic items were

excluded. The pre- and post-survey responses were analyzed to recognize any increase in self-efficacy and cognitive engagement and any decrease in test anxiety. The open-ended responses were analyzed to detect any themes regarding their perceptions of the learning experiences.

A rubric based on principles of writing practices from the ETW was developed. The principles of note-taking guidelines were captured, and further transformed into a rubric to score students' notes. The authors met to discuss the rubric items and calibrated the use of the rubric. Each author scored students' notes independently. The scores from each author were then averaged. In the Results section, Table 3 displays the rubric used to score each students' weekly notes and the scores of the five women students.

Results

When the results of each pre- and post-survey for all 18 students were analyzed, no changes were detected. For example, self-efficacy changed from $M = 3.761$ ($SD = 0.469$) to $M = 3.329$ ($SD = 0.682$); cognitive engagement changed from $M = 4.091$ ($SD = 0.405$) to $M = 3.980$ ($SD = 0.313$); test anxiety changed from $M = 3.567$ ($SD = 0.430$) to $M = 3.661$ ($SD = 0.781$). To emphasize, only the women students (N = 5) that reported an improvement in self-efficacy, cognitive engagement, and/or test anxiety are discussed in this paper to align with the research purpose. In the results below, these five women students were also analyzed against all women students who consented to participate in the present study.

RQ1: Among the Women students, Was There Any Increase in Self-Efficacy and Cognitive Engagement, and Any Decrease in Text Anxiety?

We conducted pre- and post-surveys, allowing students to self-rate their self-efficacy, cognitive engagement, and text anxiety at the beginning and end of the semester. We detected an increase in either self-efficacy or cognitive engagement or a decrease in test anxiety.

Table 2 includes the results of the survey for the Likert-scale items. For self-efficacy, Student 2 and Student 5 results reported an increase (respectively $M_{difference} = 0.375$ and $M_{difference} = 0.429$). For cognitive engagement, results from three students reported an increase: Student 1 ($M_{difference} = 0.182$), Student 4 ($M_{difference} = 0.186$), and Student 5 ($M_{difference} = 0.091$). As far as the test anxiety, two students reported a slight decrease: Student 3 ($M_{difference} = 0.400$) and Student 4 $M_{difference} = 0.200$).

Student 2, who was initially below the self-efficacy pre-survey class mean ($M = 3.761$), increased from $M = 3.125$ to $M = 3.500$, becoming higher than post-survey class mean ($M = 3.329$) and higher than all women participants' post-survey mean ($M = 3.178$). Similarly, Student 5, initially below the class mean, increased the self-efficacy to $M = 4.000$, higher than the post-survey class mean, and higher than all women participants' who consented to participate in the study.

In terms of cognitive engagement, Student 1's mean increased to be $M = 4.364$, which made her be above post-survey class mean ($M = 4.091$), above all women participants' in class ($M = 3.922$) and the third-highest score in the class at the end of the semester. Students 4 and 5 ($M = 3.723$ and $M = 3.818$, respectively) started the term with a score below the class pre-survey average ($M = 4.091$) and women participants pre-survey mean ($M = 4.026$), and their post-survey ($M = 3.909$

each) indicated that they reached close to the class mean (M = 3.980) and close to the mean of all women participants who consented (M = 3.922).

Table 2: Results of the Pre- and Post-Surveys of the Likert-scale Items

Participants	Self-Efficacy		Cognitive Engagement		Test Anxiety	
	Pre-Survey	Post-Survey	Pre-Survey	Post-Survey	Pre-Survey	Post-Survey
Student 1	3.875 (0.641)	3.5 (0.463)	**4.182** (0.751)	**4.364** (0.674)	3.000 (1.000)	4.200 (1.304)
Student 2	**3.125** (0.354)	**3.500** (0.756)	4.273 (0.786)	3.909 (1.375)	3.600 (0.895)	3.800 (1.095)
Student 3	4.625 (0.518)	4.000 (0)	4.273 (1.009)	4.182 (1.168)	**2.600** (0.548)	**2.200** (1.095)
Student 4	4.000 (0.535)	2.750 (0.707)	**3.723** (0.467)	**3.909** (0.944)	**4.000** (0)	**3.800** (0.447)
Student 5	**3.571** (0.535)	**4.000** (0.756)	**3.818** (0.405)	**3.909** (0.539)	3.400 (0.548)	3.600 (1.140)
All seven women participants who consented	3.796 (0.471)	3.178 (0.838)	4.026 (0.256)	3.922 (0.312)	3.598 (0.118)	3.829 (0.820)
All 18 participants who consented	3.761 (0.469)	3.329 (0.682)	4.091 (0.405)	3.980 (0.313)	3.567 (0.430)	3.661 (0.781)

Note. The cases included in this study were women students with increased self-efficacy or cognitive engagement or decreased test anxiety. The values in bold text are either (a) increase in self-efficacy, (b) increase in cognitive engagement, or (c) decrease in test anxiety. *M* is mean; *SD* is standard deviation.

As far as the test anxiety, Student 3 initially had a low score (M = 2.600) and decreased at the end of the semester (M = 2.200), which was lower than the post-survey class mean (M = 3.661) and all fwomen participants' post-survey average (M = 3.829). While Student 4, whose initial test anxiety level was M = 4.000, which is above the pre-survey class mean and all women participants' pre-survey mean, showed a decrease to M = 3.800 in the post-survey. No correlation was found to suggest that the decrease in test anxiety resulted in increased self-efficacy and cognitive engagement or vice versa.

RQ2: What Were the Scores of Women Students' Note-Taking Practices When Evaluated Using the NST Rubric?

For the weekly notes, Student 2 received the highest score ($M = 4.38$, $SD = 0.51$), followed by Student 1 ($M = 3.90$, $SD = 0.71$), Student 5 ($M = 3.49$, $SD = 0.60$), Student 4 ($M = 3.11$, $SD = 1.21$), and Student 3 ($M = 3.03$, $SD = 0.65$). Table 3 lists the mean scores of individual rubric items.

Table 3: The Mean Score of Students' Notes When Evaluated Using SNT Rubric

Metrics	Student 1	Student 2	Student 3	Student 4	Student 5
1- Writing is legible					
a.Use consistent format and case	4.68	4.43	3.14	4.18	3.73
b.Put space between words	4.57	4.64	4.21	4.73	4.07
2- Writing is bold					
a.Press hard on the paper or electronic page (clear)	4.43	4.52	4.25	4.82	4.43
b.Letters well defined.	4.54	4.50	3.61	4.82	3.80
3- Writing is on a straight line	5.00	5.00	3.43	5.00	4.40
4-Ideas are organized					
a.Indentation	4.82	4.96	2.94	4.37	3.56
b.Grouping	4.21	4.64	3.15	3.35	3.59
c.Underlining	2.88	3.83	1.79	1	2.83
d.Clouds	2.20	2.27	1.34	1	1.27
5-The importance of ideas are stressed					
a.Showing the hierarchy of ideas	3.37	4.04	2.59	2.31	3.14
b.Adding visual life to material	3.36	4.67	2.25	1.92	3.30
c.Enhancing clarity with drawings	3.61	4.55	2.45	1.82	3.14
6-The notes have consistent format throughout the topic notes					
a.Same font type (lower case, upper case, etc.)	4.62	4.54	3.57	4.56	4.07
b.Similar organization	4.11	4.46	2.79	3.36	3.31
c. Similar way to emphasize ideas.	3.96	4.42	2.57	2.70	3.38

d.Similar use of color	3.57	4.26	2.71	1.94	3.51
7-The notes look harmonic (pleasing to see)	3.86	4.57	2.46	2.91	3.00
8- Ideas look to be flowing in a sequential way	3.86	4.38	3.04	2.82	3.18
9-Technical drawings used					
a.Clear and complete	3.88	4.17	3.17	2.57	3.88
b.Colorful	2.225	4.54	2.69	2.64	3.55
c.Detailed	3.46	4.38	3.02	2.64	3.57
d.Accurate	4.58	4.64	3.50	3.43	3.75
10-Equations and calculations used					
a.Equations are clearly written	4.65	4.84	3.77	4.31	4.22
b.Calculations look ordered	3.88	4.33	3.45	3.54	3.48
c.Calculations look legible	4.16	4.75	3.59	4.53	3.85
d.Calculations are organized using steps (steps easy to be identified)	3.60	4.09	2.98	2.56	3.21
e.Intermediate results are easily identified	3.56	4.14	3.21	1.80	3.13
f.Final answer clearly identified	3.55	4.10	3.15	1.53	3.21
***M* and *SD* of each student**	**3.90 (0.71)**	**4.38 (0.51)**	**3.03 (0.65)**	**3.11 (1.21)**	**3.49 (0.60)**

Note. The rubric includes the five elements of the note-taking guide that was developed based on the principles of writing practices and introduced by ETW for instructors. Items 1, 2, and 3 are related to the writing element. Items 4, 5, and 6 are related to the ideas elements. Items 7 and 8 are related to the note appearances element. Item 9 is related to the use of technical drawings. Lastly, item 10 is related to the equations and calculations element. *M* is mean; in parenthesis, *SD* is standard deviation.

It is important to note that Students 1 and 2 had the highest note-taking scores. Both wrote their notes by hand and opted out of the skeletal notes. Their notes included information from different sources used in class, personal reflections, references to other sources, and relevant graphics, and they seemed to develop their personalized note-taking style (Figure 1).

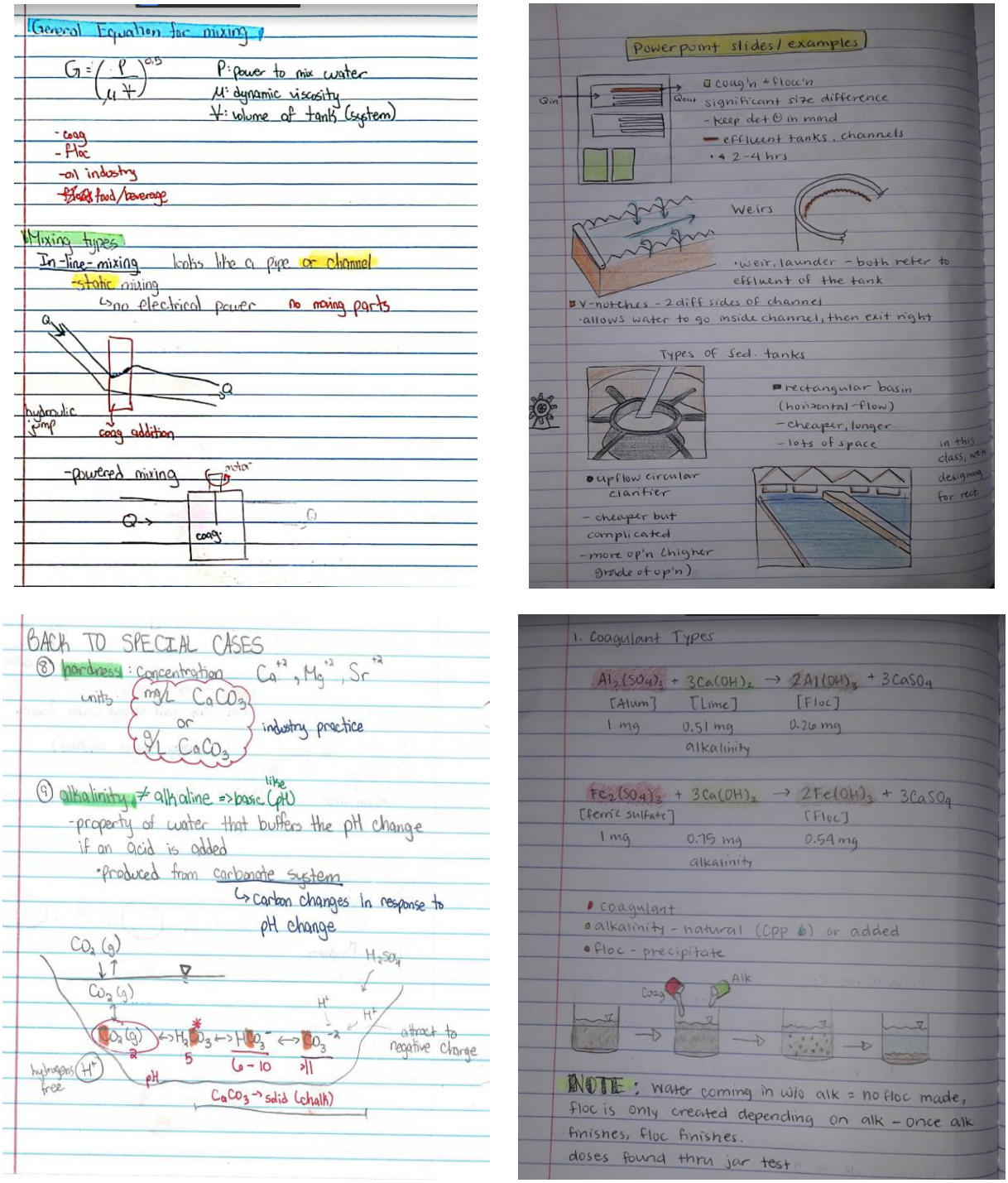

Figure 1: Left: Student 1 Sample Notes; Right: Student 2 Sample Notes

Samples of students' notes that used the skeletal notes provided are shown in Figure 2. The quantity and quality of the information recorded in the same skeletal note varied significantly across all five students. It was evident that the students who did not use the skeletal notes developed their own note-taking style consistently, showing more creativity. By contrasting the notes shown in Figure 1 and Figure 2, it seemed that all students engaged cognitively. However,

the notes from Student 1 and Student 2 suggested that they were more deeply engaged with the content by identifying their own way to organize the ideas (bullet points, colors, among others) and adding some information from the textbook or mentioned in class but not written on the board. The class sessions were not recorded, so students had to capture the information as the class progressed. One of the objectives of the note-taking intervention was to encourage students to stay focused while attending the synchronous virtual course. Such an objective was achieved since most students in the class submitted full sets of complete notes.

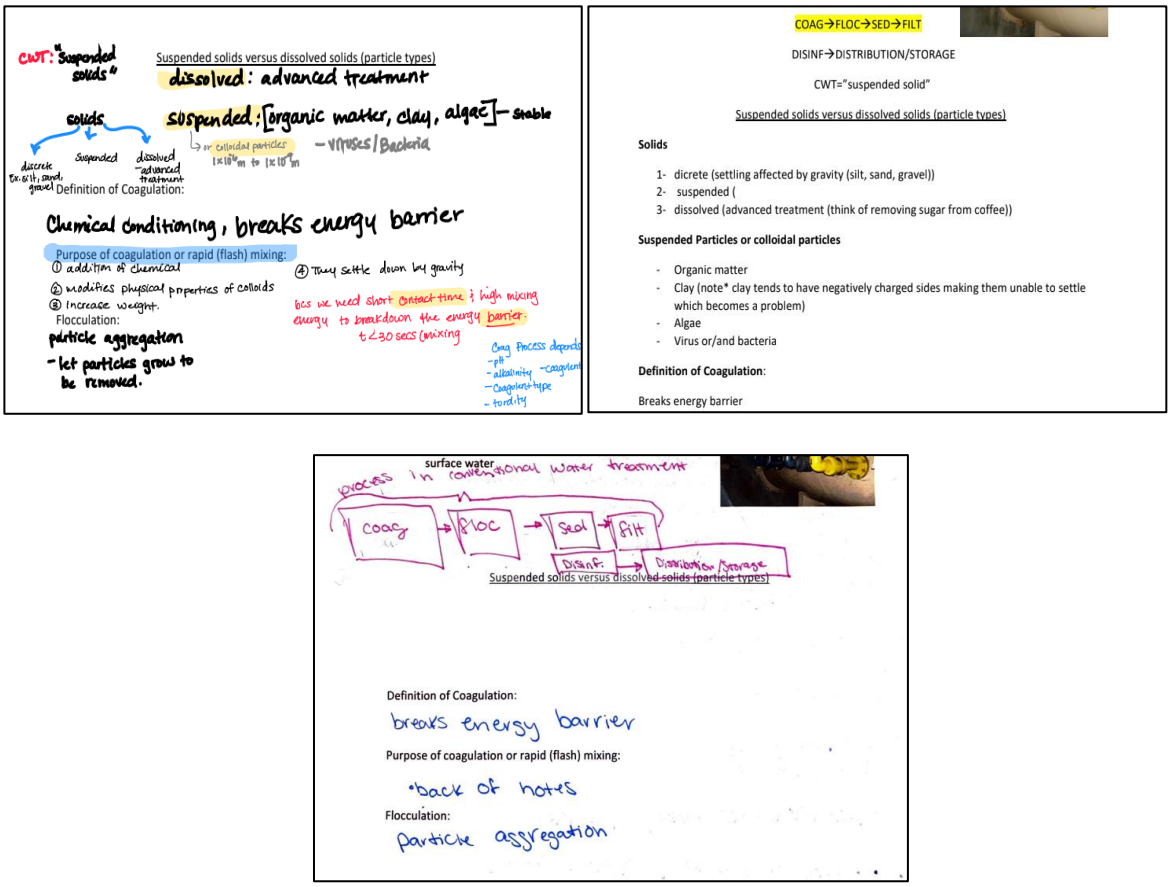

Figure 2: Samples of skeletal notes completed by Student 5 (first image), Student 4 (second image), and Student 3 (third image). The figure shows the same skeletal note completed by different students.

RQ3: Regarding the Women students with Increased Self-Efficacy or Cognitive Engagement, or Decreased Test Anxiety, were Their Note-Taking Scores Correlated with the Course Grades? Student 2, who received the highest score for her note-taking strategies, earned 87.17% (B+) at the end of the semester. She was followed by Student 1, who received the second-highest note-taking score and earned 77.75% (C+) at the end of the semester. They were followed by Student 5 and Student 4, who earned 76.70% (C) and 66.86% (D), respectively. In contrast, Student 3, who earned 91.99% (A-) at the end of the semester, received the lowest note-taking score. It is important to mention that per the SNT scores (Table 3), Student 3's notes lacked some effective organization elements but still captured the information provided during the synchronous class.

Table 4 listed both the score of note-taking strategies and the course grade of the five women students.

Table 4: The Score of Note-Taking Strategies and Course Grades.

Variables	Student 1	Student 2	Student 3	Student 4	Student 5
Note-taking mean (*M*) score and standard deviation (*SD*)	3.90 (0.71)	4.38 (0.51)	3.03 (0.65)	3.11 (1.21)	3.49 (0.60)
Hours spent for employment per week	None	None	21-30	21-30	11-20
Hours planned for studying per week	2-4	5-7	2-4	2-4	5-7
Course grade (in % and letter)	77.75 (C+)	87.17 (B+)	91.99 (A-)	66.86 (D)	76.70 (C)
Spring 2021 GPA	2.94	3.40	3.58	1.89	3.41
Overall CPP GPA	3.18	3.34	2.97	2.65	3.02

Note. *M* is mean; (*SD*) is standard deviation.

Figure 3 shows the grades for Midterm 1, Midterm 2, and the final course grades. Student 1, with notes scoring the second highest ($M = 3.90$), improved the grade the most as the class progressed from a 45.5 in Midterm 1 to a 77. 75 in the final course grade (~32% increase). Moreover, Student 1's cognitive engagement also increased ($M_{difference} = 0.182$); she did not work and reported only 2 to 4 hours of study per week; she was the one student among the five taking the most units during spring 2021, 17 units. Student 2 had the highest score for note-taking ($M = 4.38$), and the grade improved from 70 in Midterm 1 to 87.17 in the final course grade (~17% increase). Her self-efficacy increased by $M_{difference} = 0.375$. She took 14 units, did not work for exmployment, and dedicated 5 to 7 hours per week to study.

Student 3 received the lowest score for note-taking ($M = 3.03$). Notes were complete and just partially met the rubric guidelines. Student 3 improved her grade from a 77 in the Midterm 1 to 91.99 in the final course grade (~15% increase). The anxiety decreased ($M_{difference} = 0.400$) even though she had to work 21 to 30 hours for employment and only studied 2 to 4 hours per week. Student 4 received $M = 3.11$ for the notes, a score of 66 in Midterm 1, a 36.67 for Midterm 2, and the final course grade was 66.86. Student 4 faced many personal struggles that put her behind in the course, but she made considerable efforts to complete all the notes. She took ten semester units, worked 21 to 30 hours, and studied 2 to 4 hours per week. Despite the challenges, her cognitive engagement increased ($M_{difference} = 0.186$), and interestingly her anxiety decreased ($M_{difference} = 0.200$). While her notes were typed, she did not develop a particular style or follow

the note-taking guidelines; the notes were complete and seemed adequate to help her prepare for exams and quizzes. It is believed that the notes helped Student 4 focus her attention on the class topic; as a result, she had a good set of notes that she could consult later even if she did not have time to study them. Results suggested that the note-taking intervention might have helped the struggling student be engaged with the material, possibly leading to increased cognitive engagement and decreased test anxiety.

Lastly, Student 5 note-taking score was 3.49, and her grade increased from 50 in Midterm 1 to 76. 7 in the final course grade (improved by ~ 26%). Regarding self-efficacy, Student 5 reported an increase ($M_{difference}$ = 0.429), and the cognitive engagement increased too ($M_{difference}$ = 0.091). Student 5 was enrolled in 16 units, worked 11 to 20 hours, and dedicated 5-7 hours/week to study.

The three highest note-taking scores correlate with the highest improvement among the five students through the term, 32.25%, 26.7%, and 17.17% of grade improvement for Student 1, Student 5, and Student 2, respectively (Figure 3). All students but Student 4 improved their grades. However, Student 4 persisted and improved cognitive engagement and decreased test anxiety, $M_{difference}$ = 0.186, and $M_{difference}$ = 0.200, respectively. Moreover, her notes were complete, suggesting that she might have been focused during the synchronous class. Her notes seemed to have served as a good resource of information during quizzes, exams, and while solving the assigned practice problems.

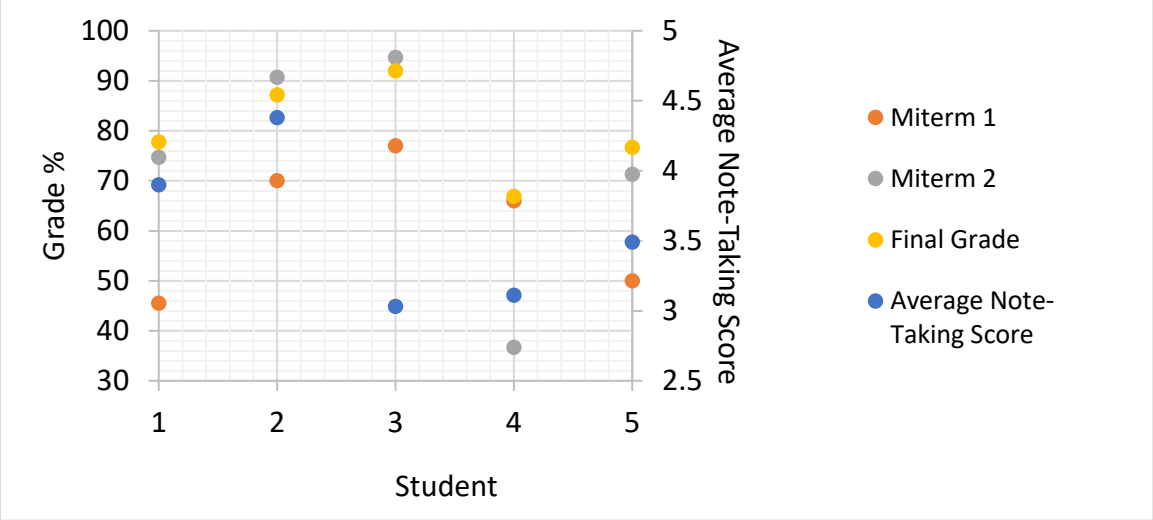

Figure 3: Midterm 1, Midterm 2, and the Final Course Grades for the Five Women students

Figure 3 shows that Student 3, with the highest final grade, received a note-taking score similar to the score of Student 4, who received the lowest final grade. This suggested that note-taking kept all students engaged, but it was more impactful and critical for the student who struggled the most. Interventions like note-taking may especially help engage students at-risk or those who experience non-school-related worries or stress, or those who face personal or health-related

issues. Furthermore, providing guidelines to produce high-quality notes may overall support the engagement and improvement of all students.

RQ4: What Were the Women Students' Reflections on their Learning Strategies and Challenges?

The Learning Strategy Used

Student 1 listed her learning strategies, such as memorizing the problem-solving steps, reviewing class notes, and using calm music in the background to help her concentrate. Student 1 also shared a unique strategy to help her engage cognitively:

> *"If possible, I like to have music at hand because it really helps my concentration and calms my nerves. Though this can't be used when classes were in-person. [For in-person class], gum helps me focus on the one problem at hand, since my mind tends to wander very easily, and hard candies help me remember what to do when I'm stuck at a problem."*

A strategy that both Student 1 and Student 2 shared was using highlighters and colors to emphasize important points, especially when reading and taking notes. Student 2 commented:

> *"This notes-project was fun. Lots of colors and drawings. I think it helped me because I actually had to read through the notes instead of skim like I usually do."*

Both Student 1 and Student 2 additionally shared a similar strategy for managing the study environment to promote cognitive engagement. Student 1 liked to study in a quiet place at home, such as in "*a room that is separated to work in peace,"* especially if there was a mandatory social distancing. However, Student 1 ideally would prefer to study in the library or a small group. Student 2 preferred to work in *"a neat and clutter-free zone"* in order to help concentrate.

In terms of preparing for an exam, Student 2 described that staying calm and focusing on the problems could help her alleviate test anxiety. However, she believed her good feeling might not always lead to a good course achievement. Below is her experience:

> *"I took a deep breath and told myself to not worry, to do my best, to read the problems, and that it was on the quality of the work I put out, not how many problems I went through. I also told myself not to focus on the problems I couldn't solve. [… .] I was able to finish the exam with a very good feeling. [… .] Despite feeling great, I was convinced I had failed."*

Challenges Encountered by Students

All three students, who provided open responses, admitted they encountered challenges. One challenge revolved around maintaining proper time management. Both Student 1 and Student 2 mentioned a large amount of classwork that consumed time. Student 1 commented, *"It has been manageable, but very difficult for […] having to spend with family and relax."* However, despite the workload, Student 2 felt that she retained the information and was able to *"understand it [our*

course topic] for the most part and my notes are thorough." It seemed that the time spent for studying and her thorough notes might have played a role in her perceived learning.

Another challenge was related to finding a suitable study place to help concentrate. Student 2 admitted that it tended to be loud in her house. She tried to study in her car, but unfortunately, she noted, *"I'm not as productive in the car as I would be in my room."* This Student 2, who preferred to work in an organized and tidy room, additionally encountered a challenge regarding finding the time to tidy up her room. This might be related to a time management challenge above.

As far as the third challenge, there seemed to be an issue related to self-efficacy. Student 2 initially thought she performed better than she expected. During a difficult exam, Student 2 was able to alleviate her test anxiety and *"finish the exam with a very good feeling."* Unfortunately, in the end, she believed *"a good feeling at the end of the exam doesn't mean a good grade."*

The last challenges were related to the technical issues on the campus Learning Management LMS and emergency family circumstances. Student 4 brought up a technical issue she encountered while completing her test. She exclaimed, *"It would have been nice if Blackboard didn't crash during my test."* Had the class been in-person, she would have taken a paper test and would not have dealt with a disruptive technical issue. In addition, she admitted she was unable to do well for the semester due to emergency family obligations (e.g., taking care of a family member with medical issues).

Discussion

Engendering guidelines for students to take notes in class allowed us to reveal students' successful use of note-taking strategies. Notably, the note-taking strategies potentially assist the women and at-risk students to increase their self-efficacy and cognitive engagement, decrease test anxiety, and improve grades if the intent is to support their persistence in engineering and, in general, in STEM learning.

The three highest note-taking scores resulted in the highest improvement in the class through the term, 32.25%, 26.7%, and 17.17% of grade improvement for Student 1, Student 5, and Student 2, respectively. All students but Student 4 improved their grades. However, Student 4, who faced significant personal challenges, improved cognitive engagement and test anxiety, $M_{\text{difference}} = 0.186$, and $M_{\text{difference}} = 0.200$, respectively. This finding is aligned with previous studies. Note-taking allows students to concentrate, allowing them to use their cognitive energy and simultaneously connect the new knowledge with their prior knowledge [30], [46] – [48].

Regarding Student 3, who earned A-, she did not receive the highest average score on note-taking strategies, but she improved her performance by 15% during the term. It is important to note that her self-efficacy and cognitive engagement were the ones with the highest values among all the students in this study, and her level of anxiety showed a decrease. In addition, there may be other factors not captured in this study. Perhaps, Student 3 executed specific learning strategies beyond note-taking. For example, existing literature has documented the imperative role of conducting metacognitive reading strategies wherein students deliberately monitor and evaluate their understanding during the reading activities [49] - [52]. Unfortunately,

Student 3 did not include her reflection in the open-ended questions, and there is a lack of information to make more inferences. Such a topic deserves a future investigation.

Three students shared that they faced personal issues (e.g., medical emergencies, issues with learning space, anxiety, etc.). Each of these students faced different situations of different magnitudes, and each responded in different ways depending on their resources and support. All the challenges in the students' lives influenced their academic achievement and engagement. However, the present findings suggest that the note-taking strategy has supported the improvement of academic performance during the term for four women students (two Hispanic, two White). As shown in the results, some students only improved in one or two areas. This was expected because each student had a different personal situation. Each student started at a different academic level, resulting in a varied impact of the note-taking intervention among participants. Overall, the results suggest a trend of improvement. This finding resonates with Biggers and Luo's [30] systematic review; assigning students to take notes by providing the skeletal structure as guidance potentially promotes self-regulated learning [e.g., 53], wherein self-efficacy and test anxiety are just two of the sub-constructs. In addition, it also assists students in focusing on the fundamental key points from the lecture (e.g., [48], [53], [54]). As a result, students are likely able to connect the new information with their existing knowledge (e.g., [30], [46]– [48]). In turn, it potentially helps them achieve a better grade in their quizzes and/or exams (e.g., [48], [55] - [60]).

While still discussing self-regulated learning, it is worth providing a reminder that students will not automatically develop self-regulated learning skills without appropriate training, guidance, and opportunities to practice [19]. This also indirectly presents a limitation of the present study that deserves a future exploration; the students in the study who have not received training in self-regulated learning could possibly have misunderstood the questionnaire statements and unintentionally misrated themselves. As abovementioned, because the pandemic and emergency remote learning still occurred during the study, students possibly experienced other types of anxieties related to personal, familial, and/or work matters that might have influenced the three variables (i.e., self-efficacy, cognitive engagement, and test anxiety), or other constraints not allowing them to concentrate during class or while studying. Such factors deserve an in-depth investigation in the future.

Overall, it is essential to remark that note-taking can engage students and help them persist (e.g., Student 4 earned D, but persisted—she submitted notes that received scores comparable to those of the student with the higher final grade). Another interesting finding worth future exploration is that all students who showed the highest grade improvement wrote their notes by hand using paper or a tablet. In contrast, Student 4, who had the lowest grade, typed the notes using a computer, which limited the flexibility and creativity to prepare the notes.

Good note-taking strategies can help students perform better over time; in this study, all students but one increased their performance over time. Other factors, such as student's commitment, study environment, family responsibilities, job or employment responsibilities, health (i.e., mental and physical), support and resources from campus and family, among others, that are not considered in this paper are of great importance [61] because they may affect the performance and achievement of underrepresented, minoritized (URM) students. Such factors should also be studied in-depth in a future study. These factors occur outside the classroom, and faculty have no

control over them. Student 4's struggles were evident in the Spring 2020 GPA of 1.89 and the overall GPA of 2.65; however, she persisted regardless of the personal and familiar challenging circumstances. Thus, closing the gap of URM students can be alleviated to a certain degree through classroom instruction that uses high-impact teaching practices. High-impact practices are research-based teaching and learning strategies that are positively associated with student academic achievement, especially the academic achievement of underrepresented students [62]. It is essential to acknowledge that URM students' lives may also influence their class achievement level. The results suggest that interventions like note-taking can help engage students at-risk or those who experience non-academic-related worries or stress or face personal or health-related issues.

Implications

Many high-impact teaching practices are available for faculty to engage students in class with the content, providing an active learning experience that allows students to reflect on the content and make connections to previous knowledge. Incorporating more than one type of high-impact teaching practice is recommended because every student is different and has different needs. The positive impact obtained from using a mix of high-impact teaching practices will be influenced by the students' personal and academic circumstances. In this study, it was observed that the note-taking scores were related to the improvement in academic performance and that the final grade was not the same for all participants. Results of self-efficacy, cognitive engagement, and anxiety suggested that students' own circumstances at the beginning of the class and through the semester also influenced their performance and persistence (e.g., the number of hours of work, the course load, the perceptions of oneself, the prerequisite preparation, among others.). Thus, in addition to using high-impact practices to support student learning creating a more inclusive learning environment, students need support outside the classroom. Closing GPA's gaps and academic achievement requires a whole support system (i.e., inside and outside of the classroom), as well as the commitment and drive of the learner [61].

In this study, the note-taking intervention was beneficial for all participants. For an instructor who is planning to use the note-taking strategy as part of their course, there are some recommendations that ACUE has already mentioned, and that have been confirmed or drawn from the experience this present study:

- It is crucial to motivate students to take notes by explaining the future professional benefits of the note-taking skill and the benefits of the notes that will be produced.
- Providing pre-prepared notes (or ACUE skeletal notes) can help students maintain the organization of the information, provide moments for reflection, and concentrate on important ideas.
- Providing a clear guide on how to take notes will help students learn how to take good notes. Instructors may want to clearly establish what should be included and what should not.
- Allowing flexibility for the way the notes are taken is essential so that students can decide on their own whether they handwrite, type, use paper, or an electronic device.
- While the skeletal notes have a finite length, instructors should allow long notes; some students need to include information that will help them connect to previous knowledge.

- If students receive credit for submitting notes, the instructor can give them an opportunity for students to redo notes; this will provide the opportunity of having more time in direct contact with the class content.
- If students receive a grade for the notes taken, instructors may want to provide meaningful and motivating feedback.
- Instructor may consider modeling how to take good notes.
- Information about the high-impact teaching practices used in class by an instructor should be shared with the students. Students will be happy to know that the techniques used have successfully supported the learning process of other students.
- Instructors may consider asking students for feedback representing their learning experiences so that the intervention can be modified and improved in future terms.
- Instructors may not want to expect that one intervention will provide the same results for all students. Using multiple high-impact teaching practices potentially engages many students at different degrees, creating a more inclusive learning environment.

Conclusion

Because of the forced transition to virtual learning due to the pandemic, it was assumed that students would not start the course with high confidence levels and that they would need support engaging cognitively in the virtual classroom. Contrary to what was expected, the results indicated that overall all students arrived and ended the course with high self-efficacy and high cognitive engagement (M = 3.3 or higher). This positive finding suggests that most students might have slowly started to adapt to the virtual learning environment. Also, many were probably able to find a better study space at home to join the class synchronously, had a reliable Wi-Fi connection, and had adequate technology. However, the present study found that most students experienced high anxiety during remote learning. The class mean for the anxiety was 3.5 out of 5 and practically remained the same throughout. This anxiety level could be associated with the lack of peer interaction, personal-life stress, and the volatility of the social environment due to the pandemic, among other factors.

It was hypothesized that note-taking would aid students in focusing and increasing their cognitive engagement. The students were given credit for submitting class notes to motivate them to concentrate and engage. Even more, exams were open-materials, meaning students were allowed to refer to their class notes and textbook. The intention of the open-materials exams was to encourage students to put an effort into preparing notes and spend a significant amount of time using the notes for practicing problems and preparing for exams. Therefore, such an effort may consequently help them increase their self-confidence. The majority of the students that consented to be part of the study submitted all class notes throughout the semester. Only the results for five women students indicated some variations in the self-efficacy, cognitive engagement, and anxiety mean scores. Thus, the study focused on those five women and related their class performance to the quality of notes taken.

It was observed that Students 1 and Student 2 followed the note-taking guidelines; Students 3 and 5 adopted and adapted the guidelines to an extent; Student 4 used the skeletal notes and did not fully follow the guidelines. Such a situation resulted in varied quality of the notes produced.

Results suggested a positive correlation between the high score of the notes and the grade improvement (e.g., higher for Student 1, Student 2 and less pronounced for Student 3 and Student 5). Although Student 4 did not follow the note-taking guidelines, her notes were clear and complete, so they might have supported her while studying and during exams. This may suggest that note-taking is potentially one reason for the decreased test anxiety score of Student 4. Thus, the study results showed that the note-taking intervention positively impacted all five students, but the benefit was of major impact for the student who struggled the most. The findings suggest that high-impact interventions, like note-taking, can especially help engage at-risk or those who experience non-school related worries or stress or face personal or health-related issues. Furthermore, providing guidelines to produce high-quality notes could further support the overall cognitive engagement and grade improvement of all students. Lastly, the project brought up critical attention regarding students' self-regulated learning skills and other study strategies that are important to increase the effectiveness of learning interventions to engage students, especially when the intent is to close the GPA gap of the URM students. Thus, the current study and the newly developed SNT guidelines could be used as a pilot for a large-scale funded project where note-taking can be used as an intervention beyond the pandemic.

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