# There's a Textbook for this Class? Scaffolding Reading and Note-taking in a Digital Age

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## Abstract

Innovative engineers depend on technical reading as a primary means of lifelong learning. Several scaffolded course activities encourage the practice of reading and notetaking in a collaborative learning environment. In lower-level courses, students receive brief instruction in *How to Read a Book*[1], Cornell notes[2], and Sketchnoting[3]. Student Note assignments require students to take hand-written notes while reading the textbook and post a picture of their reading and class notes to an online discussion board. In later courses, students, well trained in the Student Notes methodology, tackle a more advanced textbook through guided reading activities before class. Though Reading Notes Quizzes proved an unacceptable tax on student-faculty rapport, Group Notes and Student Board Notes show much more promise. In upper-level courses, faculty provided a list of questions connected to specific sections of an advanced textbook. In a third-year course, Group Notes assignments require students to generate answers in groups of two or three and upload a scan of their answers ahead of lecture. In the fourth-year course, the Student Board Notes assignments require students to copy their notes for a specific question onto the board which the faculty then use to facilitate a "just-in-time" clarification of content before application in example problems. Student responses indicate a generally positive outlook on many of these reading and notetaking assignments. Faculty appreciate students who engage with the material before class. Students learn how to expand their understanding through reading even as they gain required technical knowledge.


## Introduction

Western culture, shaped more and more by digital devices, increasingly undermines critical thinking, clear argumentation, and extended focus. For many, on-demand video (YouTube, subscription streaming services, etc.) drives entertainment and education[4]. To the popular American mind, personal development through reading hard books is often either foreign or repulsive. Where text is still the preferred medium, messages truncated by a particular character count result in "discourse" with too little understanding or listening. Rather, ad hominem attacks and warring factions dominate[5] where diplomatic longform debate once reigned[6]. Ubiquitous advertising has shaped a visual medium commonly applied to topics that inspire the most extreme emotions with little concern for nuanced, propositional truth[7]. While intended to maintain remote student engagement, COVID accelerated a transition in education to post-literate teaching methods built on passive video[8].

The K-12 public education system has contributed to the cultural move away from the written word through a focus on specified learning outcomes rather than harder-to-assess, classically-liberal educational goals[9]. The modern educational edifice, built on a Prussian model for training compliant soldiers[10] and Dewey's[11] literalistic reading of Rousseau[12] has suppressed the curiosity of generations of students and left them without the emotional or intellectual fortitude for independent learning or critical evaluation[13], [14]. The ideological capturing of the teaching profession has replaced actual critical thinking with the victimhood of grievance studies[14], [15]. Regurgitation has displaced critical thinking developed through reading, writing, and revising. Educators and students alike can erringly prioritize testable

content over wholistic mastery. The educational institution has become increasingly brazen about its systemic shortcomings with some regions refusing to assess high school graduates for competency in mathematics, reading or writing in the name of DEI [16], [17], [18].

In this milieu, the new engineering professor enters the American university. Alongside the need to research, serve the college and profession, mentor graduate students, and publish, the engineering professor has an ethical responsibility to help shape the next generation of innovative engineers. Meanwhile, many of their students, through no personal fault, enter college without the habits of mind or self-control expected of previous generations of college undergraduates. New educators may find students who struggle to adapt to the model of higher education that produced the educators. Further, college graduates must self-direct their learning and develop the reading comprehension required for their industries documents and policies. The engineering educator is confronted by the fulfillment of the prophecy of over 80 years ago:

> "We continue to clamor for those very qualities we are rendering impossible... In a sort of ghastly simplicity, we remove the organ and demand the function. We make men without chests and expect of them virtue and enterprise. We laugh at honor and are shocked to find traitors in our midst. We castrate and bid the geldings be fruitful."[19]

Too many have believed a lie that "promised … innovation without study"[20], [21]. Engineering educators must take an authoritative role in helping students learn to study the world around them and build on the *written* knowledge of prior generations.

Practicing engineers must have fluency in the languages of engineering; they must to use writing, math, and sketching to "paint in another's mind the mental picture in one's own"[22]. Engineers must engage with the world curiously, aligning their mental model with the true nature of God's created world as reliably described in published literature[23], [24]. How will the engineering field advance without knowing where it came from? In educating future practitioners, educators must cover technical engineering concepts, but engineering students desperately need a recovery of those lifelong learning habits of observation, understanding, affection, evaluation, application, and expression working in harmony[25]. The written word drives lifelong and multi-generational continuous development in engineering. The current moment needs engineers trained by the "democracy of the dead"[26] to become "good, old-fashioned engineering students"[27] and then the professional engineering leaders of tomorrow. Course assignments should re-incorporate reading and notetaking into the skill set of the engineering student and future engineer; engineering students are best "supported when learning is scaffolded through… reading and notetaking"[27].

**The Need**

Practicing engineers work on complex problems that require submission to the wisdom of the past and regulations of the present to exercise dominion over the world of the future. Engineers solve problems through technical knowledge acquired through many generations of study, trial, error, and documentation; such knowledge is generally accessible only through meaningful, focused reading. Students and educators should not assume or desire that all historic technical knowledge will be converted to video formats in their lifetimes. Rather, they must dialogue with

the written word, increase their understanding, synthesize information, evaluate alternatives, and develop innovative and efficient applications founded on an understanding learned from the written word. Only then will engineers be equipped to solve their own technical problems and holistically benefit their communities. Fortunately, the means are as straight forward and common as they are unfamiliar to many modern students: critical reading and active notetaking.

## Literature Review

Reading and notetaking are two sides of the same coin. When serious learning needs to take place, the best students will read *and* take notes as a means of synthesis and future reference[28]. The value of reading as an essential lifelong learning skill is readily observable; the learning environment markedly improves where students have exposed themselves to the material through reading before class[29], [30]. "Author-directed" learning is the most readily accessible way to expand understanding and is encouraged by many professional societies[1], [31]. Responsible faculty will direct, guide, and monitor their students' skills in independently increasing understanding through reading and notetaking.

Faculty face a number of obstacles to developing fully literate students[32]. The greatest obstacle may be the explicit student perspective on textbooks. Textbooks continue to increase in price presenting students with a significant financial hurdle[33]. Free online resources can reduce the barrier to student entry[34]; however, the development of good online resources places more demand on the faculty teaching the course and/or an academic field willing to invest time and financial resources for free text development[35]. Regardless of the source, class time must emphasize written resources to drive and inspire to earnest reading[36], [37]. Far too often, students do not perceive the textbook as useful[38], particularly when previous courses have left the textbook unused or poorly leveraged[39]. In some cases, students have grown so accustomed to courses without textbooks, they are surprised when faculty assign one.

Motivating student reading is also a significant challenge. Faculty and well-prepared students may find forced pre-class reading condescending. Yet K-12 education anticipates limited preparation outside of class[40]; therefore, students often lack reasonable expectations for reading and notetaking. Students voluntarily engage with the text primarily when cramming for a test or struggling with homework[41], [42]. Though many students only complete learning activities for a grade, graded reading assignments may only slightly increase student reading[43].

Instructors have implemented various methods for encouraging and/or assessing reading before class. Whether a pop-quiz at the beginning of class[39], a pre-reading quiz on the learning management system (LMS), or interactive questions incorporated into a digital textbook[43], [44], the common reading quiz drives some engagement with the content before class. Yet, appropriately scaled questions are difficult to develop: easy quizzes might be answered without reading; difficult quizzes can frustrate students and damage rapport[39]. Though some students value interactive online textbooks[45], particularly interactive example problems[44], [46], evaluating earnest engagement has unique challenges[36], [47]. Though easy to grade, quiz-based reading verification may not develop lifelong learning skills.

Alternatively, the flipped classroom presupposes interaction with the content before class. Whether using videos, faculty notes, textbook readings, or a combination, students study

assigned topics before class so that class time can be spent solving problems under the guidance of the faculty. Interactive textbooks with integrated video and questions can be a great resource for the flipped classroom[47], though not all topics have quality interactive textbooks. Non-traditional students typically respond better to the flipped classroom while many traditional college students may simply come to class unprepared and unbothered[41]. Depending on the pre-class resources, faculty may inadvertently reinforce dependence on videos or curated information. Flipping a classroom requires significant effort, even as faculty may abdicate necessary authority[13], [22] and still struggle to inspire lifelong learning habits.

Some textbooks attempt to driving reading and critical thinking by complementing the typical litany of homework problems with writing prompts and conceptual problems. Such writing prompts direct student notetaking and inspire the critical thinking required to write[48]. “Class preparation activities” (CPAs) can fill a similar roll; students provide handwritten responses to guided reading questions. Completion grading effectively motivated students resulting in wide-spread engagement with the reading[49]. For lower-level courses, CPAs can train students to identify and prioritize the most relevant information in the textbook, though hopefully upper-level students have largely developed this lifelong learning skill as they approach graduation. A “progressive reading log” can develop student notetaking abilities through one semester: early in the semester the log provides directed reading responses (like a CPA) with increasingly open-ended prompts toward the end of the semester (like a Structure Reading Guide (SRG))[32]. SRGs adapt Cornell Notes[2] for STEM studies by creating worksheets with spaces for definitions, examples, proofs, analysis, reflections, and summaries[50]. SRGs may be generalized for a particular course, requiring far less development effort for the faculty; however, SRGs often require excessive student time [32].

Open-ended assignments may also encourage reading. The minute paper concept encourages students in lifelong learning through reflection, synthesis and documentation of learning from the reading[51], [52]. One variation asked students to “mind dump”[49] their learning from the reading during the first few minutes of class, creating an open note resource for exams. Though intended to inspire multiple interactions with the content, faculty encountered low student participation with less than a third of students generating useful mind dumps[49]. Mind dumps and minute papers may inadvertently encourage rapid regurgitation, rather than deep learning.

Perhaps more than assessment, students require instruction in lifelong learning skills including reading and notetaking. Survey tools, like the Metacognitive Awareness of Reading Strategies Inventory (MARSI), may increase reading strategy awareness[53], [54]. The lifelong learning skills learned through instruction in reading[1], notetaking[2], and sketching[3] can have significant impact on student learning and academic trajectory. Students may also develop meaningful lifelong learning skills through interactive activities [55] such as developing reading strategies on class discussion boards[56].

The literature suggests much can be done to encourage students to develop lifelong learning skills. Faculty can emphasize important concepts by leveraging the textbook, pursuing the “irreducible minimum”, and resisting the urge to recreate the textbook resource[57]. Valuable and high-quality textbooks may provide students the internal motivation to read even as graded assignments supply external motivation. Assignments should seek to develop deep learning and lifelong learning skills through reading, notetaking, collaboration, and synthesis while avoiding

temptations to short-term regurgitation, nominal content interactions, or dependence on sub-optimal learning resources. Students should question and think critically through writing as they develop more and more skill in increasing their understanding through reading. Faculty must consider the time commitment required for reading to avoid overwhelming the student, degrading rapport, or causing the student to give up on reading all together. Finally, faculty can initiate students on the path of lifelong learning through direct training in reading and notetaking. Faculty have an opportunity to win students over to reading through direct instruction on the *how* and *why* of reading, meaningful use of the textbook, clear expectation management around student reading and notetaking, and scaffolded collaborative assignments that encourage lifelong learning practices. The development of reading and note taking skill should be scaffolded across all four years of the engineering curriculum.

## Lower-level Course Activities

In the first and second years, engineering students are adjusting to life away from home and the new intellectual requirements of college. Given common K-12 training, many students seem unaware that reading and notetaking are expected in college classes. For the eager engineering professor, ill-prepared students are both a challenge and an opportunity.

### *Training*

Introduced at the beginning of each semester, students confront required reading and notetaking assignments. As students are frequently uninitiated in good study habits, they are asked to read and take notes on excerpts from *How to Read a Book*[1], hopefully developing a vision for their moral responsibility to understand the author's words and only then pass thoughtful judgement on read content. During the first or second class, students are guided in an inspectional reading of the course textbook, to understand what the book is about and to identify the author's intended goals. The first exposure to any new concept mainly creates confusion; initial reading assignments are about creating that confusion *before* class rather than *during* class. Ideally, reading the textbook will "raise new questions while it answers old ones"[22].

As students read the assigned textbook sections, they also take notes. As few students have any training in notetaking, each of the first four reading assignments is accompanied by a brief video introduction to Cornell Notes[2] or Sketchnotes[3], with encouragement to try each method while reading[58]. Again, the goal is helping students start taking notes and giving them a vision for improving their notetaking skill.

Finally, students are asked to share their notes using an LMS discussion board. By sharing their notes, students engage in interactive learning, receiving informal constructive criticism for their notetaking, and learning from other students about how to identify important information and arrange it in a useful form. Appendix A.1 contains a syllabus excerpt describing these Student Note learning activities.

### *Student Note Assignments*

Student Note assignments enforce the reading schedule included in the syllabus. Appendix A.2 contains an example LMS assignment description for a Student Note assignment. The assignment title includes the chapter and/or subchapters assigned for the reading. Each assignment description starts with learning objectives as used in class the following day.

The next section describes the instructions in three parts. First, students read the book while taking notes and then post a picture of their notes to the discussion board before class. Students should spend no more than 20-30 minutes exploring the learning objectives through the text. The readings are typically no more than three to five pages of text (plus example problems, homework problems, etc.). The goal of the reading is *not* comprehensive mastery of the content; rather, students are introducing the topic to their minds, generating questions, and generally establishing a context of mild confusion that class time can clarify.

Second, students expand on their notes during class based on the lecture content. Effectively, students have generated their own lecture guide in the reading notes and might now annotate it: highlighting important ideas, adding instructor summaries based on board notes, capturing details from the instructor's lecture that might be missed if the student was trying to understand visual presentation (PowerPoint, board notes, demonstrations, etc.) without having considered the topics, even incompletely, before class. Where students have had little experience creating notes from reading, they often simply extend their notes based on the instructor's board notes and in-class examples. As they improve, lecture notes look far more individualized, as lecture notetaking becomes more annotation-based rather than copying. After class, students revisit the Student Note assignment on the LMS and post a response to their reading notes with a picture of their lecture notes.

Finally, students can earn extra credit through additional interaction on the Student Note discussion board. Where the action of creating the reading and lecture notes was a constructive learning activity, the discussion board elevates the assignment to an interactive activity[55]. Though students sometimes discuss the actual content or the related homework, typically students comment on the quality of the notetaking, complementing order and color coding or critiquing the need for a figure to fully capture a concept. This is the strongest indication that students are learning, not only the technical content of the course, but also how to effectively read, take notes, and synthesize their thoughts as they glean ideas from others.

Grading for the assignments is completion based. Beyond meeting formatting requirements, the rubric asks the faculty to evaluate the number (not the quality) of student submissions. Students receive 50%-70% credit for a single image post before class; the faculty functionally assumes these are the reading notes. They receive 100% credit for two image posts, again assuming the first post is after reading and second post is after class. Students may then receive an extra 10% credit for additional comments and posts on the discussion board. Appendix A.3 contains a typical LMS rubric for Student Note assignments.

***Student Response***

Student response has been largely positive. Most students see the value of the Student Note assignments. Student participation has been very high. Figure 1 shows the Student Note and overall course grades for 263 students who took a Statics course featuring Student Note assignments between 2021 and 2023. The Student Notes assignments were worth 8%-10% of the overall grade. The average Student Note grade was a 77%, certainly passing. The median Student Note grade was 88% with nearly half the students earning an A in the category. Approximately 70% of students earned a passing grade for the Student Note assignments. This level of participation in reading and notetaking far exceeds that documented in the literature.

Due to the completion grading, overall course performance is only loosely correlated to Student Note grades. Of the 17% of students who failed the course, the average and median Student Note assignment grades were 51% and 48%. Around 65% of students who failed the course also failed their Student Note assignments. However, this likely aligns with student intention to pass the course and does not indicate the direct influence of reading and notetaking.

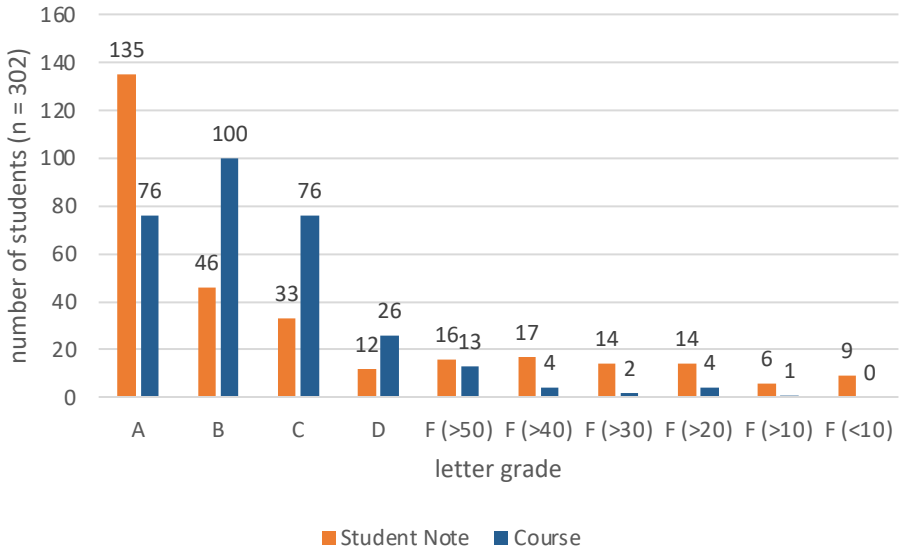


Figure 1. Student Note assignments and overall course grade distribution for 302 students enrolled in Statics courses between Spring 2021 and Spring 2024.

Nevertheless, course exit surveys from a range of lower-level courses (Figure 2 and Figure 3) corroborate a level of high engagement with reading and notetaking through the Student Notes assignments. Nearly 90% of students positively agreed that the reading assignments helped their engagement in the class with 50% strongly agreeing! Not only did students identify an increase in their own engagement, but students also felt the reading and notetaking supported their content mastery with nearly 90% either agreeing or strongly agreeing. When asked if the discussion boards were helpful, support was less enthusiastic with slightly less than 75% of students answering in the affirmative. For the vast majority of students, the reading and notetaking assignments were perceived as helpful, consistent with a constructive learning activity, though only slightly fewer students perceived the value of the interactive parts of the assignments[55].

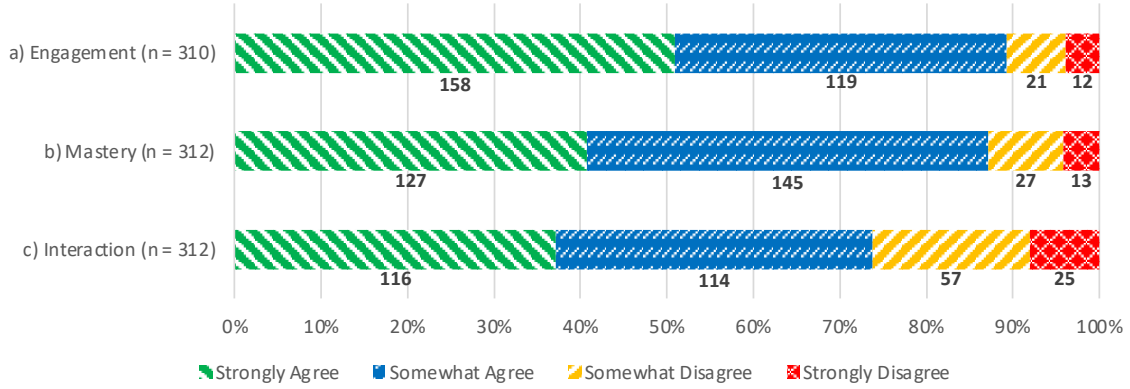


Figure 2. Student survey results from first and second year engineering courses stating agreement with the statements:
a) Engagement (n = 310): "Taking notes for the Student Notes helped my engagement in class."
b) Mastery (n=312): "Taking notes for the Student Notes helped me master the class content."
c) Interaction (n = 312): "Seeing and engaging with other students through the Student Note discussion boards was helpful."

Students also develop an appreciation for reading and notetaking as a lifelong learning skill. Figure 3 shows survey responses to statements about the future. Over 80% of students said they planned to take notes from the reading in future courses. This is a tremendous outcome; four out of five students embrace reading and note taking as crucial learning activities. Slightly less than 80% of students hope that other professors will implement similar assignments in their courses, again, an overwhelmingly positive response. It may be too optimistic to credit students with self-awareness about their need for external motivation to continue reading; more likely, students appreciate the high degree of agency they can exercise over a portion of their course grade.

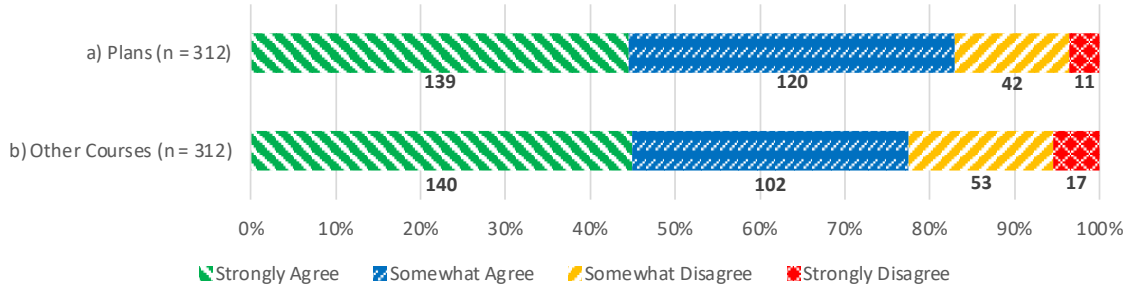


Figure 3. Student survey results stating agreement with the statements:
a) Plans (n = 312): "I plan to take notes from the reading in future courses, whether or not the professor offers credit or a discussion board."
b) Other Courses (n=312): "I hope more professors will implement Student Note discussion board assignments in their classes."

### *Faculty Perspective*

Faculty also appreciate the outcomes of the Student Notes learning assignments. Anecdotally, classes run smoother, students are more engaged, and questions are on topic when students have read before class. Many students sub-optimize their learning experiences aiming to invest the minimum effort to achieve the desired results such that average overall grades have not noticeably changed in the courses. However, student rapport is strong, and students seem to take greater ownership of their learning. When students miss class, faculty are no longer asked for notes or what was covered in class; twenty classmates have posted their class notes for review and synthesis.

Faculty grading load is minimal. By grading for completion, each assignment can be graded in about the time it takes for the discussion board posts to load in the LMS. Students need only remember to revisit the discussion boards after class to get full credit on the assignment. The student work itself is often of high quality (see Appendix A.4). Because students have received feedback on their reading notes through the instructor's class notes, students gain all the benefit from the assignment before grading. One student marveled that something that took so little time to grade had generated such significant learning in him.

Faculty also benefit from straightforward assignment preparation. Each assignment is essentially identical only requiring changes in chapter sections, learning objectives and due dates. Creating a full semester of Student Note assignments is repetitive, but the instructor does not need to create thought provoking prompts. Rather, learning objectives, the textbook author and the lecture notes can drive thoughtful content interaction.

Ultimately, the Student Note activities force structured engagement with content, encourage interaction, train students in lifelong self-directed learning skills, drive curious engagement with the wisdom of previous generations, and communicate through math, writing, and sketches [27]. By mastering this level of reading and notetaking in the lower-level course, students are well prepared for more challenging reading in upper-level courses.

## Upper-Level Course Activities

With several semesters of reading and notetaking practice, upper-level students should be ready to tackle more difficult texts and broader reading assignments. Where the textual difficulty, length, and complexity increases faster than student ability, faculty provide additional reading guidance and more opportunities for interactive refinement while learning.

### *Training*

Upper-level students enroll in a sequence of two environmental engineering courses in their third and fourth years. The same textbook is used in both courses. The textbook's intended audience is "an advanced undergraduate course or a first-semester graduate course in environmental engineering" and, while very good, may be at the edge of comprehension for most undergraduate civil engineering students taking their first environmental engineering courses[59]. To focus student reading and scaffold their engagement with this significantly harder text, students receive a list of notetaking prompts with associated sections from the textbook.

### *Group Note Assignments*

In the third-year course, Group Note reading assignments occur weekly with a list of 10 to 30 prompts as seen in the example in Appendix B.1. The number of prompts depends on the topic and include both simple definition-based questions and more critical thinking prompts. Students comprehensively document their responses working in groups of two or three. Grading is based solely on completion using rubrics like that seen in Appendix B.2. The prompts provide a guide to make the difficult text more manageable. By working in groups, students engage in interactive learning that also reduces the time commitment and workload for any single student while preparing them for more independent reading in the same textbook the fourth year.

When concepts and vocabulary terms from the reading emerge during class, students look for definitions in their notes. Students are directed to use their reading notes rather than the textbook itself as a study resource for exams. Reading assignments make up 10% of the course grade to externally motivate formative activities without undermining the role of summative assessment in passing the course.

### *Reading Note Quizzes*

In the fourth-year environmental engineering design course, assessment methodology has varied with time. During the first semester with the new textbook, in-class Reading Note Quizzes were employed and graded for accuracy. Students knew which textbook sections a reading quiz would cover but did not receive a list of prompts. Both open and closed note quizzes were given at the start of each new topic in the course, based on one to two sections from the book (generally 10-20 pages). Quizzes were graded for accuracy, though complete but incorrect answers received minor partial credit. A subset of questions from the reading quizzes were repeated on the exams. Though intended to motivate and reward quality independent reading and notetaking, student reactions required modification to the methodology.

### *Student Board Note Assignments*

In the next iteration of the fourth-year course, a list of prompts to guide student preparation of Student Board Notes returned. These guides were previously the basis of the course lecture outline and feature larger conceptual prompts connected to sections of the textbook. Students uploaded a scan of their notes for each prompt to the LMS and received grades based on completion. Prompts were broken into weekly uploads with standard weekly reminders, though topics sometimes spanned across weeks.

At the start of each class, three to six students went to the board and copied their response to a Student Board Note prompt. Through the semester each student copied notes to the board four times. Students were given credit toward their course grade based on their board responses: full credit for complete and accurate, partial credit for complete but with inaccuracies, no credit for a lack of response or when the assignment is substantially incorrect. During lecture, the instructor used the Student Board Notes as a starting point for discussion, helping all students in the class correct and improve their own notes. Amended notes were not submitted for a grade.

The Student Board Notes in many ways build on the Student Notes methodology but provided additional scaffolding for an advanced text and supported interaction as students present their work on the board. The use of more conceptual prompts helped students move beyond the Group

Notes' more narrowly focused guides. Students are now responsible for their own reading but benefit from practicing additional lifelong learning skills including presentation and discussion.

### *Student Response*

Based on candid verbal student feedback and the end of semester course evaluation surveys, student response to the third-year Group Note assignments has been neutral to positive. Some students felt that the Group Note utility was undermined by the ability to "divide and conquer" the reading prompts between members of their group. However, as an example of the classical model of education, most students expressed appreciation for the clear connection between the lecture content and the reading assignments (grammar), especially when the connection is further drawn between example problems from the textbook or class (dialectic)[60].

The student feedback on the Reading Notes Quizzes in the fourth-year course prompted the modality change. Students simultaneously described the Reading Notes Quizzes as a "waste of class time" and "too difficult". Even when a quiz allowed open notes, students were frustrated that so much of their notes seemed unnecessary for the quiz. Some students reported hours spent reading and taking notes to earn only 50% on the reading quiz. Rather than feeling more prepared for the exams when quiz questions were repeated on the tests, one student felt "penalized twice" for not knowing the information. Overall, the Reading Notes Quizzes resulted in too much negative impact on student-teacher rapport and student learning.

Students responded better to the Student Board Notes method. In the course evaluations, students reported feeling overwhelmed by the homework load including the Student Board Notes assignments and the standard quantitative-based homework. One student remarked, "Class could feel redundant due to some classes only going over notes." No students volunteered that the Student Board Notes aided their learning, though they did acknowledge the value when prompted to reflect on why the instructor opted for that methodology. Consistent with the literature, non-traditional students (working adults attending college classes in the evenings) tended to be better prepared and were able to use in-class time more effectively to move into quantitative elements of treatment system design[41]. During class, some students, instead of annotating their own notes, would instead copy the board content or simply take a picture of the board at the end of class, offering minimal-to-no engagement during lecture. As a design-oriented fourth-year course, several students longed for more class time spent on numerical problem solving (via in class example calculations) and less on conceptual understanding (via the Student Board Notes).

### *Faculty Perspective*

Both Group Note and Student Board Note reading assignments in upper-level courses largely depend on the instructor creating prompts to direct student attention to specific content in the text. While this requires a significant instructor time to prepare, once complete, faculty can re-use the prompts across multiple years so long as they use the same textbook. The process of prompt creation also supports new faculty familiarizing themselves with the textbook content. Alternatively, new faculty with lecture-level learning objectives may direct students to generate notes for each learning objective ensuring alignment between notes and class content.

When completing Group Note assignments, students will tend to "divide and conquer" to complete the assignment more quickly. Negatively, Group Notes may mitigate the individual knowledge gains from reading and notetaking. Positively, Group Notes might provide an opportunity for student-to-student interaction. The perceived reduction in time outside of class by spreading the reading load across multiple people improved faculty-student rapport.

As seen in the literature, the Reading Notes Quizzes may not support learning. The time required to prepare reading quizzes was comparable to that of the reading prompts. When combined with the negative effects on rapport, new faculty should probably avoid reading quizzes, opting instead for active learning strategies like peer-instruction[61].

The instructor hopes to improve the reception of the Student Board Notes by more firmly committing no more than a quarter of lecture time (15 minutes) to (a) students writing their notes on the board and (b) reviewing and correcting those notes, with the remaining class time devoted to example problems and quantitative homework problems. Due to poor student preparation seen via either insufficient or incorrect notes, in-class time spent on Student Board Notes in the first year of implementation often took over half of the class. Overall, faculty agree with students about the imbalance in class time between conceptual understanding and quantitative elements and look forward to addressing this shortcoming in the next iteration of the course.

### *Future Work*

Continued development of the Student Board Notes methodology poses several options utilizing elements from the lower-level Student Notes method as well as those in literature. Students may be asked to submit both original and annotated notes to ensure that students continue to engage with their notes appropriately during lectures.

A second option under consideration mirrors the "peer learning" elements of the Student Notes discussion boards by having students check the reading notes of their classmates either in-class or on an LMS discussion board. Though quality and accuracy of the Student Board Notes varied highly, the better examples demonstrated that at least some students effectively practiced acquiring information from the textbook, identifying the correct content, and synthesizing the findings. If students evaluated one another for accuracy, the correct answers might be identified via group consensus.

Finally, faculty could more fully "flip" the classroom by supplying pre-class video lectures to provide the otherwise in-class correction to the students' expected reading notes content. This would be the most time-intensive option for the faculty and may be beyond the time commitment many new faculty can spend on preparing material for a single course. While flipped classroom techniques have shown some learning gains, they also often result in lower course evaluation scores as students feel like they must do more work.

## Conclusion

The scaffolded sequence of training on reading and notetaking, followed by Student Note, Group Note and Student Board Note assignments show great promise for helping underprepared students develop the lifelong learning skills of reading and notetaking required of the practicing engineer. Engineering educators can easily complain about the underprepared students, but

engineering students likely had low agency in their college preparation. By embracing the challenge of shaping future engineers with technical knowledge and lifelong learning skills, faculty have a tremendous opportunity to recover the lost learning tools of reading and notetaking[60]. The engineering educators' authoritative role can help shape the world of tomorrow through their students, one informed and equipped mind at a time.

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## Appendix A. Student Notes Discussion Board Assignments

### Appendix A.1. Syllabus Excerpt

Engineers must have the skill to increase their understanding, most frequently through reading. In the professional world, an engineer must read, interpret, and apply various policy documents and codes. The professor will expect students to have read the narrative and summaries from the assigned reading before class and to have posted their notes from the reading on the LMS. Prior preparation and an attempt at author-directed learning will make class time and professor-directed learning more effective. The assigned reading may address additional topics not covered in class.

Please consult the following books on author-directed learning:

Adler, M. J., and Doren, C. V. (1972). *How to Read a Book: The Classic Guide to Intelligent Reading*. Touchstone, New York.[1]

Piper, J., and Noll, M. A. (2011). *Think.* Crossway, Wheaton, Ill.[62]

Good notetaking can take many forms including the Cornell Notes [63] and Sketchnotes [3]. Students should experiment with different note taking methods while reading the textbook, watching video lectures, and participating in class. The best notes will synthesize *(1)* major concepts from the reading, *(2) everything* the professor wrote on the white boards, *and (3)* additional annotations based on classroom discussion. Typically, class presentations including example problems will be made available before class (at the bottom of each Module in the LMS); students may find these handouts useful for notetaking. Notetaking requires having the right tools (https://rb.gy/xm4eqp) and/or the right application (OneNote, Notability, etc.) during reading sessions and class.

Discussion boards provide students the opportunity to share notes, discuss concepts and homework assignments and support each other's learning.

Each Student Notes activity on Canvas requires two discussion board posts:

1. *Reading Notes*

   An initial post of useful notes taken from the assigned reading. Complete notes posted as an image will receive 60% credit.

2. *Lecture Notes*

   Students will provide a second response post with updated notes synthesizing information from brief theory videos (posted to the discussion boards) and/or live lectures. Complete notes posted as an image in response to the student's initial post will receive 40% credit.

Additional content-related posts (comments, feedback, questions, answers, etc.) on the discussion boards may earn extra credit.

## Appendix A.2 Example LMS Assignment

***Student Notes: Chap 3.1-3***

***Learning Objectives:***

2. Interpret and solve 2-D and 3-D particle equilibrium problems using vector algebra.
    2.1 Define…
        2.1.1 The Equations of Equilibrium (EoE) for a concurrent force system.
        2.1.2 A Free Body Diagram (FBD).
        2.1.3 A force reaction (RXN).
    2.2 For a concurrent force system in equilibrium…
        2.2.1 Draw a FBD.
        2.2.2 Write the EoE from the FBD.
        2.2.3 Calculate force RXNs in…
            2.2.3.1 2D.

***Instructions:***

Use the "Upload Image" tool. Do NOT use the "Attach" button. Only posts that are visible without clicking an additional link will receive full credit.

*1. Reading Notes (20min)*

- *Read* the chapter sections listed in the assignment title from Hibbeler's *Engineering Mechanics: Statics[64]* while *taking notes*.
- *Optional: Read the associated sections from Baker and Haynes engineeringstatics.org. See the Appendix C in the Syllabus for details.*
- *Post* a picture of useful notes from the reading.

*2. Lecture Notes (20min)*

- *Attend* class and/or *watch* the theory video(s) in the discussion *taking notes*.
- *Post*a reply to your own initial post with an updated picture of synthesized notes from the reading and lecture.

*Extra Credit Discussion*

- *Post* or *reply* with meaningful comments, questions, answers, or interactions related to the reading, the lecture, or homework for extra credit.

## Appendix A.3 Example LMS Rubric

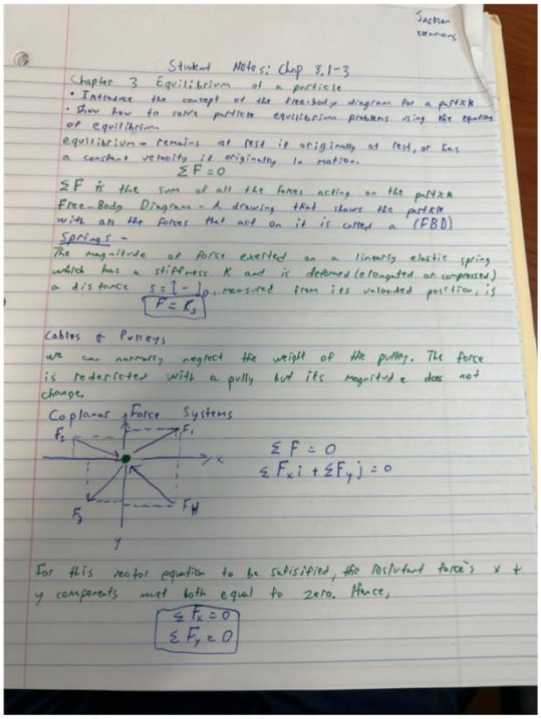
**Student Notes**

| Criteria | Ratings | | | | Pts |
|---|---|---|---|---|---|
| Reading Notes<br>Initial discussion board post most show notes from the reading without clicking a link. | **6 pts**<br>**Excellent Synthesis**<br>All topics from the reading covered succinctly, completely, and accurately. | **4 pts**<br>**Inadaquate Synthesis**<br>Topics from the reading only partial captured. | **2 pts**<br>**Not Image Upload**<br>Submission by text or "Attach File" rather than "Upload Image". | **0 pts**<br>**No Submission** | 6 pts |
| Lecture Notes<br>Reply to initial discussion board post most show notes from the lecture without clicking a link. | **4 pts**<br>**Excellent Synthesis**<br>All topics from the lecture covered succinctly, completely, and accurately. | **2 pts**<br>**Inadaquate Synthesis**<br>Topics from the lecture only partial captured. | **1 pts**<br>**Not Image Upload**<br>Submission by text or "Attach File" rather than "Upload Image". | **0 pts**<br>**No Submission** | 4 pts |
| Post, Comments, and/or Questions<br>Additional discussion board interaction supports student learning. | **1 pts**<br>**Competent Engagement**<br>Meaningful posts or replies about reading, lecture, and/or homework. | | | **0 pts**<br>**No Engagement** | 1 pts |
| | | | | | Total Points: 11 |

## Appendix A.4 Example Student Submissions

JC Student A

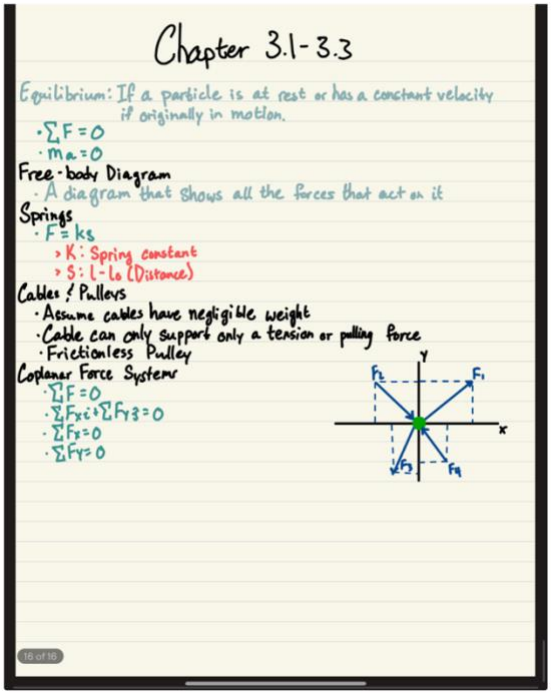
Jan 29 9:56pm Last reply Jan 29 9:57pm




Reply | | 1 Reply, 1 Unread

CW Student B

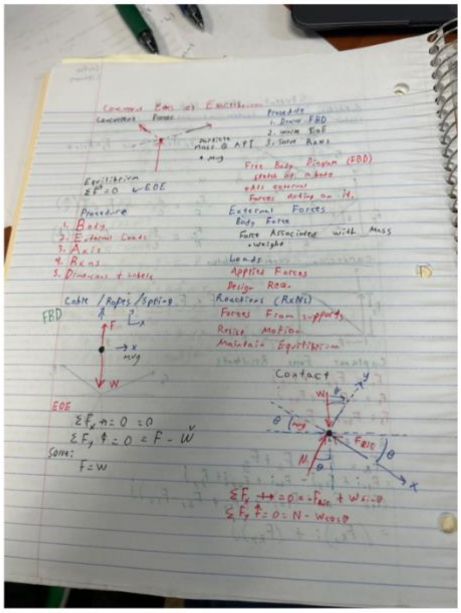
Jan 28 12:09pm Last reply Jan 29 8:53am




Reply | | 1 Reply, 1 Unread

JC Student A

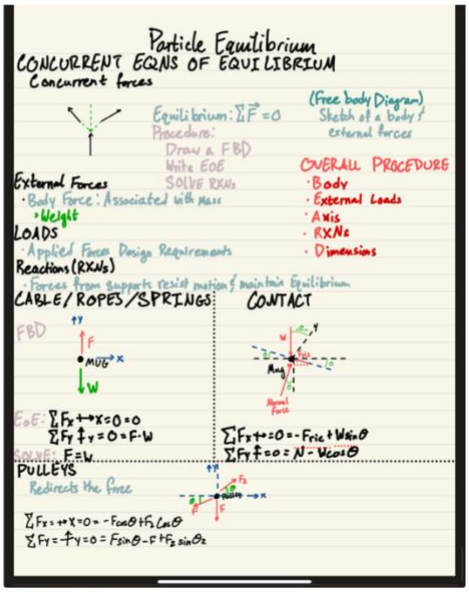
Jan 29 9:57pm




Reply |

CW Student B

Jan 29 8:53am




Reply |

## Appendix B. Reading Questions and Board Notes Assignments

### Appendix B.1. Sample Reading Question List

These questions are from third-year Introduction to Environmental Engineering Course. Note each problem is started with a number corresponding to the section of the textbook where the solution can be found.

***Reading 2: (22 questions)***

1) 4.8.1.2: List the exponential growth equation (4.5.1) and define all terms.
2) 4.8.1.3: Why is the logistic growth model more accurate to "real world" scenarios compared to exponential growth? List the equation (4.58) and define all variables
3) 4.8.2: List equation 4.75 and define all terms.
4) 4.5.1: What is the rule of thumb for energy conversion to biomass?
5) Example 4.2: Review the problem and solution. Make notes regarding the general steps to determine energy efficiency through a food chain.
6) 10.2.1: What are the "constant" variables that affect climate?
7) 10.2.1.1: What is the greenhouse effect? How is feedback phenomena observed in climate studies?
8) 10.2.1.4: What numerical trends have been observed with respect to temperature and sea level?
9) 10.2.1.5: Why are changes in land cover and changes in atmospheric composition tied to climate change?
10) 10.2.2: What is environmental degradation? What are examples of unsustainable land use that degrade the environment?
11) 10.2.3: What is an ecological footprint?
12) 10.3.6: What are the 4 stages of carbon sequestration?
13) 2.2: What are the four fundamental dimensions considered in environmental engineering?
14) 2.2.1: What is the formula for density?
15) 2.2.2: What is the formula for specific gravity?
16) Example 2.3: Read through the example and make notes on the steps used to complete concentration unit conversion.
17) Example 2.5: Read through the example and make notes on the steps used to calculate a mass flow rate.
18) 2.2.5: What is the formula for detention time?
19) 5.2: What are the three potential "fates" of a substance entering a control volume?
20) Example 5.1: Review this example and list the general steps to follow to characterize flows in and out of a control volume.
21) 5.2.1: What simplifications/assumptions can be made for steady-state (aka equilibrium) conditions?
22) Example 5.3: Review this example and list the general steps to follow to characterize an unknown flow in and out of a control volume.

## Appendix B.2. Sample LMS Assignment and Rubric

Sample of reading assignment instructions and grading rubric provided in LMS for third-year Introduction to Environmental Engineering course.

### Reading Assignment 4

Published | Edit

Complete the questions under this reading assignment number in the document: Reading Assignment Question Master List.docx

All group members should participate in the completion of the questions, but groups are allowed to assign work as they see fit.

Once work has been completed for this reading assignment, upload your file to the assignment. You should be able to do that directly from the Office 365 option on Canvas if you are working in a shared OneDrive document.

Points will be assigned per the rubric on this assignment.

**Points** 3
**Submitting** a file upload

| Due | For | Available from | Until |
|---|---|---|---|
| Feb 4 | Everyone | - | - |

**Reading Assignments**
You've already rated students with this rubric. Any major changes could affect their assessment results.

| Criteria | Ratings | | | Pts |
|---|---|---|---|---|
| Completion of Questions | **2 pts**<br>**All questions completed** | **1 pts**<br>**Not all but some questions completed** | **0 pts**<br>**Less than 30% of questions completed** | 2 pts |
| Individual Contribution | **1 pts**<br>**Full Marks** | **0 pts**<br>**No Marks** | | 1 pts |
| | | | | Total Points: 3 |