Utility of Reading Assignments in Environmental Engineering Education for Effective Learning and Greater Student Engagement in an Era of Innovative Pedagogy and Emerging Technologies

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1.0 Introduction

Since the dawn of education, educators have been looking for ways to make teaching effective and it has been a never-ending pursuit. Engineering education is no exception to this. There have been numerous pedagogical advances such as focusing on students' learning styles, teaching aids, in-class assessments, and use of more hands-on activities and multi-media, which made education more effective. Most engineering majors, some more than others, have dedicated laboratories for hands-on learning of specific concepts and techniques. However, a major portion of teaching still takes places in classroom settings. Educators adopt various pedagogical practices, teaching-aids, and technologies to engage students in learning the course contents effectively within the controlled environment of classrooms. In ideal class settings, an instructor should be able to reach out to all students regardless of their learning styles. These learning styles could be sensory, intuitive, visual, verbal, reflective, active, sequential and global as defined in the Index of Learning Styles (ILS) classification system [1] - [5].

Active and hands-on learning in environmental engineering is not new. More recently, the author has been involved in multiple studies focused on promoting active and hands-on learning among civil engineering undergraduate students [6] - [9]. Introductory environmental engineering (IEE) is not dominated by heavy engineering analysis or complicated algorithms. Some variation is found in IEE courses taught at various universities. However, despite some variations, most of IEE courses are designed to introduce students to sources and effects of pollution; basic methods to control pollution; introduction of environmental laws and regulations; roles of environmental engineers and the problems that they face; the concept of sustainability; and the concept of risk assessment. Conventional class lectures barely cover fundamentals under the imposed time constraints, making additional out-of-class assignments necessary. These assignments could be online interactive modules where students can read brief summaries and then participate in short answer types questions. Alternately, readily available videos from technical societies (AWWA, ASCE. WEF, etc.) could be used. The availability and quality of supplementary material have improved with time but the material is not comprehensive and still lack variety. Educators have limited options for finding appropriate multi-media substitutes for reading assignments because not every lesson or concept is available in video/interactive format.

Additional resources are available on websites of federal environmental agencies such as the United States Environmental Protection Agency (USEPA), the United States Geological Survey (USGS), and state agencies such as the Texas Commission on Environmental Quality, and Department of Natural Resources of multiple states do a good job in providing helpful and relevant information for IEE courses. Despite the availability of supplemental material, the utility of a good textbook cannot be disputed. Textbooks have improved significantly with every edition. Authors have presented theoretical information supported by real-life examples complimented with pictorial aids. In many cases, helpful video clips are available on publishers' websites.

Reading, especially long texts, usually is not the top priority for typical engineering students for various reasons [10]. Students are always short of time. They are taking a high number of credit hours, have budding social relationships, personal lifestyle requiring time out from studies, and in many cases, students work part-time or full-time. Students would have to read in order to fill in the knowledge gaps even after attending class lectures. Generally, the amount of reading required in IEE courses is more than other engineering courses and it creates a unique challenge for educators because engineering students are not too excited about reading assignments. Reading is a declining skill among students in this era of instant availability of information and emerging technology. The lower percentage of students completing the assignments could be remediated by various means such as giving pop quizzes, awarding extra discussion points, providing questions that need to be answered. However, it takes away a significant amount of class time over the entire term and may end up affecting students' overall course grade, and more importantly, quizzes come off as a punitive measure to force them to "compliance" and students do not like it. They would let you know about it either in mid-term evaluations or if you do not do them, in end-of-term teaching evaluations.

While there is a lot of information available about the importance of reading assignments in general, there is a significant lack of similar information in the context of engineering students, especially environmental engineering students. This paper tries to fill in this gap with this study conducted on a small group of students. This paper presents data collected as a part of this study focused on students' performance in an IEE course with and without reading assignments for students to go through required "academic rigor". It also summarizes and analyzes students' experiences and responses to various types of reading assignments (too short, too long, too theoretical or too close to real-life situations). The author shares his experiences and lesson learned as a part of this study.

2.0 Importance of Reading

Long-term benefits of consistent reading are profound and students are not always aware of them. On the contrary, the effects of too little reading are equally serious and unfortunately, most of the students are not aware of them [11]. There is a lack of published research focused on the role of reading assignments in engineering education and especially in civil and environmental engineering education.

Textbooks and assigned reading materials, in addition to in-class discussion, remain the main source of significant information. An engineering student must be able to read them with an intent to learn, to locate specific information, to understand difficult ideas and to gain an overview of the concept. Moreover, environmental engineering students should prepare themselves for reading technical manuals, reports, and manuscripts once they graduate with an undergraduate degree and enter the next stage as either a graduate student or a professional of environmental engineering. If students are not sold on the long-term benefits of reading, they must be made aware of the immediate benefit of coming to class prepared with some background knowledge of topics to be discussed and their transformation from passive to active learners.

Improvement of self-confidence from reading assignments is one of the chief benefits that is usually not talked about in engineering classes. Background knowledge gained from pre-class reading assignments prepares students for active class discussion and helps them transform from a passive to an active learner. Within a positive and supportive class environment, it

could help students earn more recognition and respect from their peers. It boosts students' self-confidence, which results in better student engagement and performance in class. This brings us to a question – are we assigning enough reading assignments or too much?

3.0 Course Description and Background of Students

The course used in this study is offered as a required course for a civil engineering degree at Missouri University of Science & Technology. The title of the course is "Introduction of Environmental Engineering and Science". Multiple instructors teach the course in multiple semesters and at multiple campuses including Cooperative Engineering Program in association with Missouri State University in Springfield, MO.

Students were provided with standard definitions of traditional and non-traditional students. The class had about an equal number of self-declared traditional as well as non-traditional students. Students were asked to choose a category to identify themselves in the context of their learning styles. The details of the survey are provided in the results and discussion section.

4.0 Methodology

At the start of the semester, students were not informed about the author's plan to collect the data for this study. Students were assigned many out-of-class assignments over the duration of the semester as a part of the course activities. They were assigned with a good mix of required and optional (extra) assignments. The author included a wide variety of assignments such as videos, audios, news articles, textbook reading, search-it-yourself assignments on certain topics, and certain USEPA/USGS webpages. The textbook assignments were sometimes assigned as a specific sub-section of a chapter or as specified pages. In other cases, textbook assignments were based on topics and students were asked to refer to the index of the textbook to find corresponding information to read.

Towards the end of the semester, students were informed about the author's intention to collect information on their experience and opinion on various types of assignments of the course for this publication. Students were also informed that the paper-based survey will be anonymous and will only have multiple-choice type questions. They were asked to not write any identifying information in their responses. Participation in the survey was not required as it was optional. Students were not awarded any credit for their participation either. The author informed students that the anonymous data collected from this survey will also be used to make the course better in the future. The author made sure that students were aware of the fact that the survey for this study was not related in any way to the anonymous end-of-term teaching evaluation that they usually do online. The author followed the standard departmental protocol for this study.

5.0 Results and Discussion

There were a total of 16 students enrolled in the class. All of them participated in the post-activity survey. The first part of the survey asked students to identify themselves based on brief definitions and a series of questions. Each of these standard definitions, taken directly from previously published work, is presented here without any change. The corresponding

responses to each survey question are presented separately for traditional (T), non-traditional (NT) and combined class (Combined).

5.1 Traditional vs Non-Traditional Learners

Non-traditional students

- A nontraditional student is one who has any of the following characteristics:
- Delays enrollment (does not enter postsecondary education in the same calendar year that he or she finished high school);
- Attends part time for at least part of the academic year;
- Works full time (35 hours or more per week) while enrolled;
- Is considered financially independent for purposes of determining eligibility for financial aid;
- Has dependents other than a spouse (usually children, but sometimes others);
- Is a single parent (either not married or married but separated and has dependents).

Traditional students

A traditional undergraduate student is one who is between the ages of 18 and 22, who live on or near campus, is a full-time student, and/or receives financial support from parents. In addition, a traditional student usually would not have a break between high school and college, and/or during college.

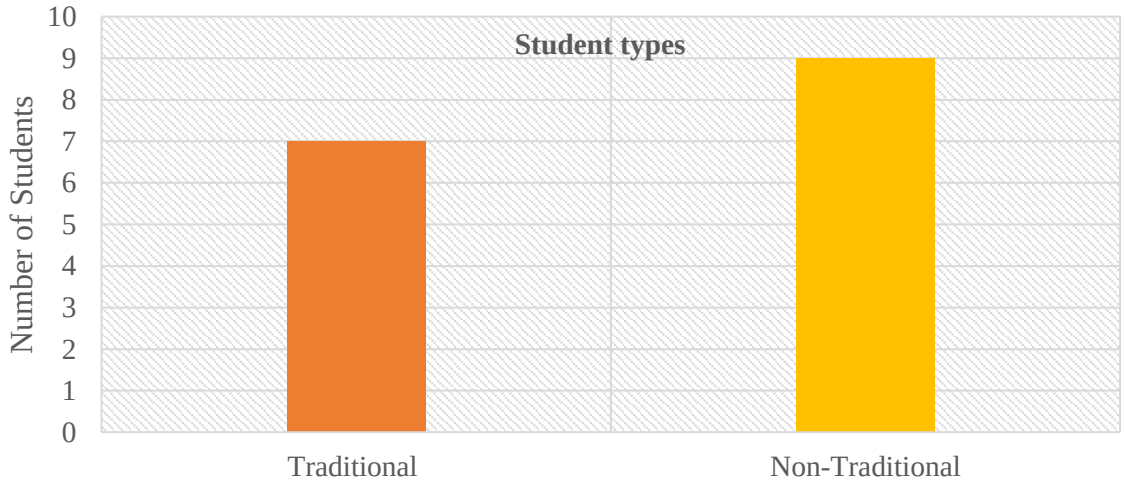

Figure 1. Class composition based on traditional and non-traditional learners.

5.2 Learning Styles

Sensory vs intuitive learners

- Sensory learners tend to like learning facts; intuitive learners often prefer discovering possibilities and relationships.
- Sensory learners often like solving problems by well-established methods and dislike complications and surprises; intuitive learners like innovation and dislike repetition. Sensory learners are more likely than intuitive learners, to resent being tested on material that has not been explicitly covered in class.
- Sensory learners tend to be patient with details and good at memorizing facts and doing hands-on (laboratory) work; intuitive learners may be better at grasping new concepts and are

often more comfortable than sensory learners with abstractions and mathematical formulations.

- Sensory learners tend to be more practical and careful than intuitive learners; intuitive learners tend to work faster and to be more innovative than sensory learners.
- Sensory learners do not like courses that have no apparent connection to the real world; intuitive learners do not like "plug-and-chug" courses that involve many memorization and routine calculations.

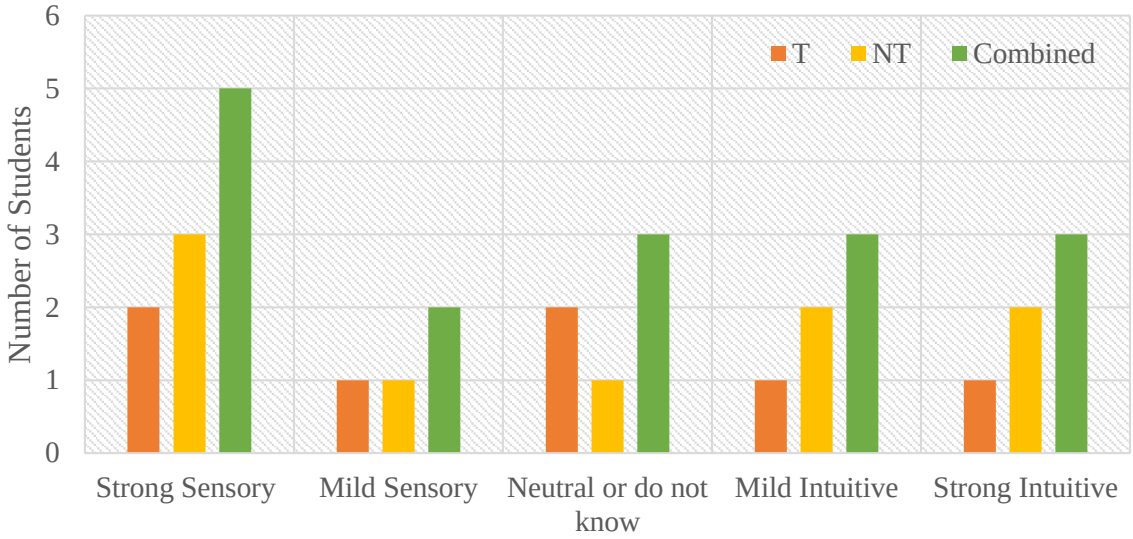

Figure 2. Class composition based on sensory and intuitive learning styles of students.

Active vs reflective learners

- Active learners tend to retain and understand information best by doing something active with it--discussing or applying it or explaining it to others. Reflective learners prefer to think about it quietly first.
- "Let's try it out and see how it works" is an active learner's phrase; "Let's think it through first" is the reflective learner's response.
- Active learners tend to like group work more than reflective learners, who prefer working alone.
- Sitting through lectures without getting to do anything physical but take notes is hard for both learning types, but particularly hard for active learners.

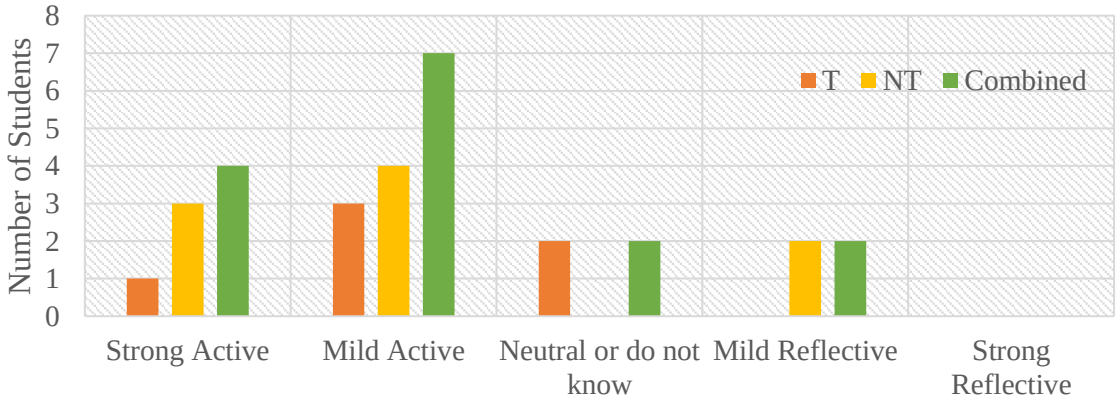

Figure 3. Class composition based on active and reflective learning styles of students.

Visual vs verbal learners

Visual learners remember best what they see - pictures, diagrams, flow charts, timelines, films, and demonstrations. Verbal learners get more out of words--written and spoken explanations.

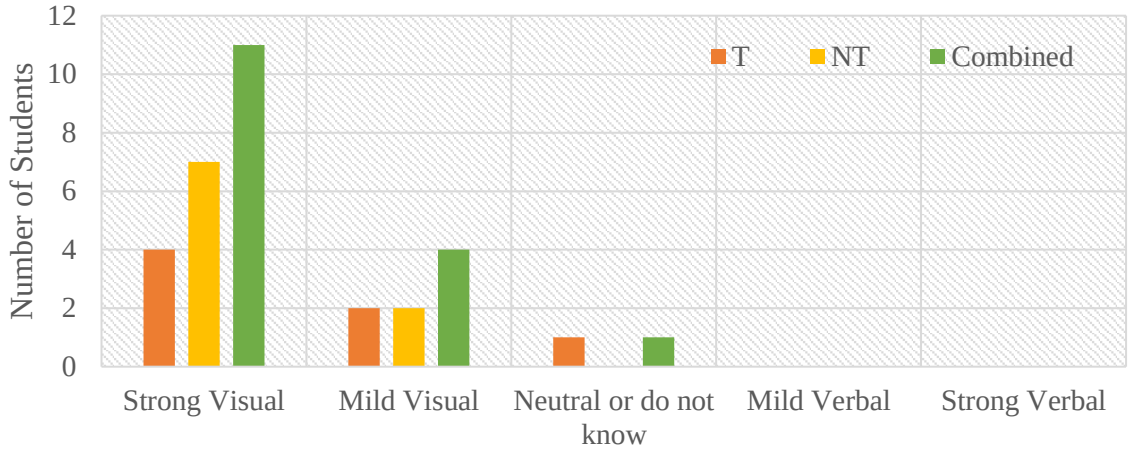

Figure 4. Class composition based on visual and verbal learning styles of students.

Sequential vs global learners

Sequential learners tend to gain understanding in linear steps, with each step following logically from the previous one. Global learners tend to learn in large jumps, absorbing material almost randomly without seeing connections, and then suddenly "getting it."

Sequential learners tend to follow logical stepwise paths in finding solutions; global learners may be able to solve complex problems quickly or put things together in novel ways once they have grasped the big picture, but they may have difficulty explaining how they did it.

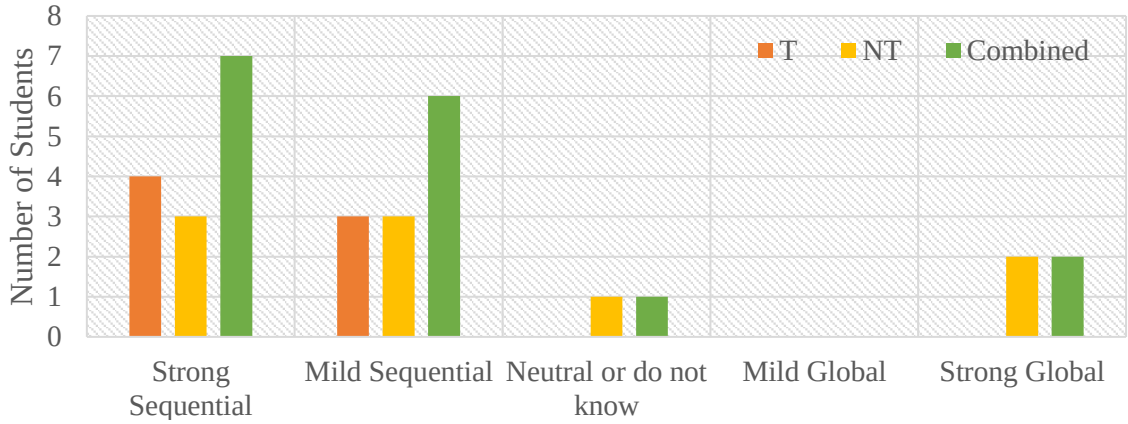

Figure 5. Class composition based on sequential and global learning styles of students.

The class had about the same numbers of students with sensory and intuitive learning styles as shown in Figure 1 and the same was the case for students with sensory and intuitive learning styles as shown in Figure 2. It being an engineering class, the author was expecting more students having sensory than intuitive learning style. The trend was similar for traditional and non-traditional students. However, this even distribution disappeared for

active versus reflective (Figure 3), visual versus verbal (Figure 4), and sequential versus global (Figure 5) learning styles. Engineering students tend to be active, visual and sequential and it was supported by the data in this study.

5.3 Assignments

Assignments types

Students were assigned various kinds of assignments in this course. These assignments could be classified mainly in five categories – audio/video without writing components, writing assignments (including lab reports and critique of audios/videos), work out problems, reading assignments, and presentations. Students were asked to choose one type of assignment that they really liked. However, a couple of students marked more than one options and thus the total number of responses are more than 16 for this particular question. The responses are presented in Figure 6. As expected, being engineering students most of the students really liked workout problems followed by audio/video assignments with no writing component. Not a single student liked writing assignments and only one response out of total 21 responses was in favor of reading assignments. This equates to a little less than 5% and presents a challenge to educators who are trying to expose more engineering students to "academic rigor" with reading assignments.

Figure 6. Students' preferences for assignment types in this IEE course.

Reading assignments

Students preferred referring textbooks for solved examples of workout problems and understand the derivation of formulae and models. When asked specifically about interest in reading a textbook, almost 69% (11 out of 16) said that they have little or very little interest and only about 6% of the class (1 out of 16) responded with a strong interest in reading a textbook. These results are shown in Figure 7. Students' little or very little interest in reading a textbook could have been one of the reasons behind some of them not buying/renting the required textbook of this IEE course. Students were asked if they owned/rented the textbook (paper or electronic). If they did not have access to the textbook, they were asked to share the reason behind it. As the access to textbooks is one of the factors that could have an influence on students' performance in a course. A little fraction over 81% (13 out of 16) of the students had access to the textbook. There were a little over 28% (2 out of 7) traditional students and a little over 11% (1 out of 9) non-traditional students who did not have access to the textbook for various reasons. However, every student who did not have access to the textbook responded affirmatively when asked if they have access to alternate or supplementary course material.

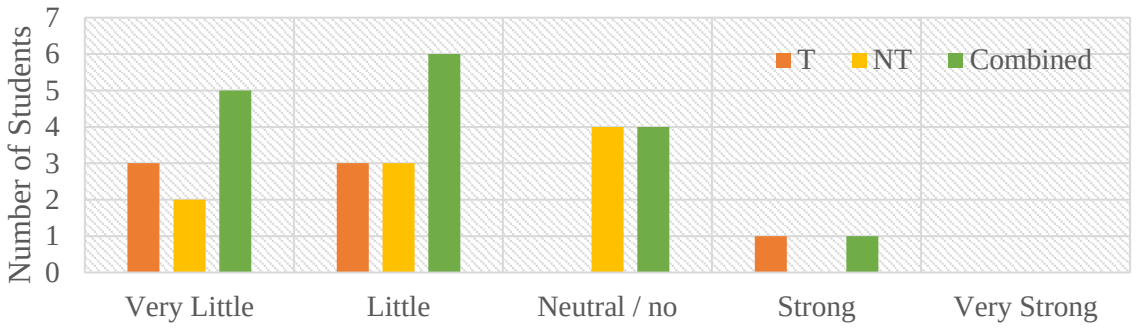

Figure 7. Participating students' interest in reading a textbook.

The reading assignments used in this study can be classified in five categories - 1) looking up the assigned topics in the index of the textbook and reading about them, 2) reading assigned sections of a chapter in the textbook, 3) assigned online articles, 4) reading major points/definition put together by the instructor as HW solution or PowerPoint slides, and 5) researching the topic online without referring to the textbook. The data presented in Figure 8 show that students preferred textbooks or specifically assigned online articles over researching on a topic that was not available in the textbook. One possible reason behind this could be time invested in this research and lack of certainty of getting the right kind and reliable information from online sources. Summary and major points provided by the instructor were of limited help as compared to going over detailed text.

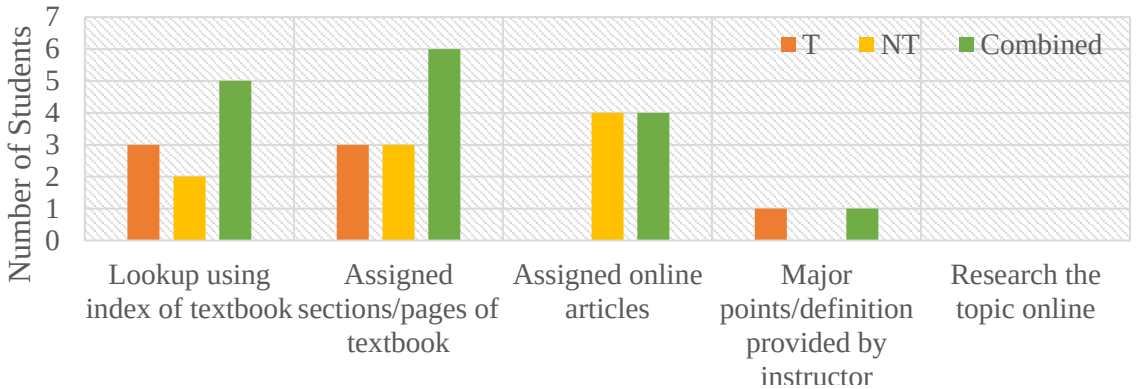

Figure 8. Students' preference for various types of reading assignments used in this study.

In response to additional questions included in the post-activity survey, a little more than 62% of the students did not think that length of reading assignments was not long or too long, while about 37% students thought it was the opposite case as shown in Figure 9A. However, more than 81% of the students agreed that the reading load in this IEE course was more than average load in other engineering courses they had taken (Figure 9B). It was evident that student did not favor an increase of reading load in this course (Figure 9C). It is not surprising considering that only less than 5% of students liked reading assignments (Figure 6). There is a possibility that students thought that the reading assignments were either not needed or were time-consuming. Students mentioned in feedback that the reading assignments were needed to be shorter and the number of assignments was needed to to be reduced. Students said that they were already short on time and could not afford to complete all reading assignments. However, if this was the case student should have liked the concise/summary of major points provided by the instructor (Figure 8).

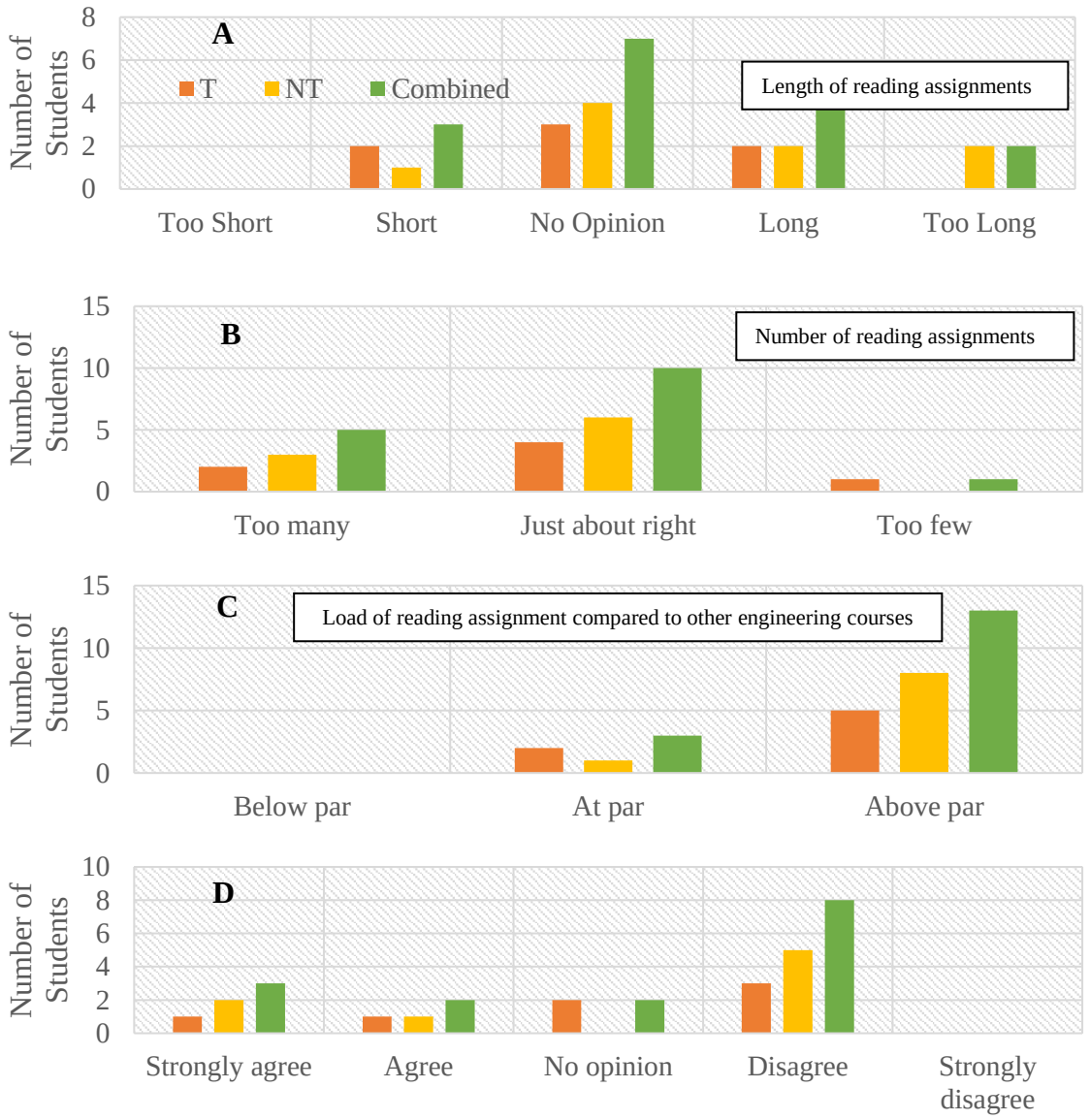

Figure 9. A) Length of reading assignments in this study. B) Number of reading assignments as compared to other engineering courses. C) Load of reading assignment as compared to other engineering courses student have taken. D) Increasing either length or number of assignments would result in broader knowledge of the course material.

6.0 Conclusion and Lessons Learned

Generally, engineering students are not too excited about reading assignments. Civil engineering students taking this IEE course are no exception. However, a small percentage of the class really liked reading assignments. In a course where students have to be made aware of contemporary issues related to the environment, various environmental laws/regulations and their background, reading environmental impact statements and many other reports, how can educators make students suddenly excited about reading assignments? It is not going to happen suddenly just because now students are in a course that requires more than other engineering courses, especially not in an IEE course. However, we can increase participation or compliance by taking many small steps. The author has already made some of the changes in another higher-level environmental engineering course that he is currently teaching in the Spring of 2019. So far, the students are responding well to the assigned reading assignments.

The author plans to collect anonymous data at the end of the current semester and plans to expand this study to other courses in multiple majors taught by fellow faculty of the Cooperative Engineering Program of the Missouri State University.

The author has reduced the number of the reading assignment and reduced the size of each of them. Additionally, the first couple of weeks instead of simply giving pop-quizzes, the author has started asking students individually to share their opinion about the assigned topic with the class without penalizing students for not completing the reading assignment. Students who did not complete the reading assignment or did it with cursory scans were not able to share anything with the class. In the author's opinion, it is the biggest penalty you could impose on students without hurting their grades. This has resulted in greater participation. The next step in this process will involve informing students that random names will be drawn in each class and the selected student will be the discussion facilitator. This process of quick discussion based on reading assignment is being done at the start of the class and only lasts for a few minutes. This technique is effective for smaller class sizes. This may not be effective for bigger class sizes. The author also plans to ask students to take lead on various reading assignments and come up with questions that they think would address the content of the assignments.

So far, there are signs of positive progress in this course. However, the current course is not a required course for civil engineering students and usually, only students who want to gain in-depth knowledge in the field of environmental engineering end up taking this class. Since these students are already interested in this topic, perhaps that is why there is a better response to reading assignments. The author suspects that students who are interested in other areas (structures, materials, transportation, and geotech) of Civil Engineering already are not excited about environmental engineering and related assigned reading. These students probably take the IEE class as it is a required class. It would be interesting to investigate if the majority of these students do not like reading assignments. More in-depth data collected over the next couple of semesters would help in better understanding of the utility of reading assignments in environmental engineering courses. The data will be collected from multiple environmental courses (proving a larger pool of students). The results from the collected data will be compared with similar data from other courses in civil engineering, and electrical engineering (only other engineering major offered by the program). The small sample size posed a challenge. Hopefully, this will be rectified when the study is conducted over multiple semesters for the same course.

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