International Journal of Engineering Education Vol. 40, No. 1, pp. 144–153, 2024
Printed in Great Britain

0949-149X/91 $3.00+0.00

Group Quizzing to Improve Attendance and Performance in a Civil Engineering Classroom – A Case Study*

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During the post-COVID years, higher education sectors across the globe are having difficulties keeping students motivated, engaged, and regularly attending classes. Poor attendance is one of the key reasons for inferior course performance, and thus many concerns are raised about the social and economic impacts of this level of disengagement. In this case study, the effectiveness of using in-class group quizzes to improve students' attendance and performance was assessed for a civil engineering course entitled CIVE 378 Materials of Construction, which is a required three-credit course for senior and junior students at the Department of Civil and Environmental Engineering at the University of Nebraska-Lincoln. In the semesters of Spring 2021 and Spring 2023, when the case study was conducted, 54 and 47 students were enrolled in the course, respectively. The classes are taught early in the mornings on Mondays and typically have very poor attendance. A series of in-class group quizzes were purposefully designed and implemented in the classes. Students' attendance rates, course performance data, and anonymous survey results were analyzed to evaluate the effectiveness. The results suggested that several design principles should be applied when using this method, which could lead to significantly improved attendance, engagement, and teamwork.

Keywords: attendance; group quizzing; collaborative testing; post-COVID education; engineering education

1. Introduction

Perhaps the most significant question in universities and colleges right now is "Where the heck are the students?" Higher education sectors across the globe are having difficulties keeping students motivated, engaged, and regularly attending classes, especially during the post-COVID years. Some classrooms are completely empty except for the presence of the instructor [1, 2]. Many concerns are raised about the social and economic impacts of this level of disengagement.

Class attendance is closely tied to students' course performance [3], in terms of both individual class grades and college grade point average (GPA) [4]. The more the students attend lectures and seminars, the higher the likelihood for them to acquire information, and thus the better they do in exams and quizzes. Important as it is, instructors in various disciplines still deal with students that are absent from the classroom due to all kinds of reasons [5], including commuting, concurring assignments, low motivation, inconvenient timing of the classes, and poor teaching quality, etc. The sudden outbreak of COVID pandemic in 2019 added another layer of complexity to classroom attendance. Many students have experienced COVID trauma, including death, illness, insecurity, and missed social experiences, etc. During their lonely times, social media, such as TikTok videos, provided the much-needed connection and joy, but also influenced the way they consume information. Amidst the chaos, educators shifted their entire pedagogical approach to online teaching and many students found it more enjoyable than face-to-face lectures [6-9]. Therefore, as the pandemic is over and teaching goes back to normal classrooms, innovative approaches are urgently needed to improve class attendance of students who are suffering from the aftereffects of the COVID pandemic and may have shorter attention spans and decreased engagement with in-person teaching.

In this case study, the effectiveness of using in-class group quizzes to improve students' attendance was assessed for CIVE 378 Materials of Construction. The CIVE 378 classes are taught early in the mornings on Mondays and Wednesdays and typically have very poor attendance. In this study, a series of in-class group quizzes were carefully designed and implemented in the classes offered in Spring 2021 and Spring 2023. Students' attendance rates, course performance data, and anonymous survey results were analyzed to evaluate the effectiveness. University of Nebraska-Lincoln's Institutional Review Board reviewed and approved the research study under Exempt Category 1 at 45 CFR 46.104. The IRB number is 22974.

* Accepted 30 October 2023.

2. Background

CIVE 378 Materials of Construction is a required three-credit course for senior and junior students at the Department of Civil and Environmental Engineering at the University of Nebraska-Lincoln, which is taught every spring semester. Typically, approximately 50 undergraduate students enroll in this course, predominantly senior (approximately 70%) and junior (approximately 30%) civil engineering majors. In the semesters of Spring 2021 and Spring 2023 when the case study was conducted, 54 and 47 students were enrolled in the course, respectively. The first author of this article served as the instructor for this course when the case study was conducted.

This course covers some basic materials engineering concepts, including elastoplastic behavior, viscoelastic behavior, and phase diagram, and various types of construction materials, including aggregates, cement, concrete, asphalt, steel, alloy, wood, masonry, and composites. For each construction material, its mechanical properties, physical characteristics, characterization methods, and manufacturing processes are systematically taught. Two 50-minute lectures and one two-hour laboratory session are scheduled each week. Laboratory activities are used to enhance lecture materials and provide students with hands-on experience of mechanical testing on construction materials. The book entitled "Materials for Civil and Construction Engineers" by M. S. Mamlouk and J. P. Zaniewski has been used as the textbook for both lectures and laboratory sessions since a decade ago [10].

Students are required to complete Calculus, Engineering Statics, and Mechanics of Elastic Bodies prior to taking CIVE 378, whereas CIVE 378 provides the necessary background for students to take higher-level technical elective courses, such as Advanced Construction Materials, Bituminous Materials, Reinforced Concrete Design, Steel Design, Pavement Design, and Materials for Sustainability. Teaching quality of CIVE 378 is crucial for students to develop a systematic understanding of the fundamental theory and application of construction materials.

The two 50-minute lectures, scheduled early in the morning on Mondays and Wednesdays, typically have very poor attendance. Absence in lectures directly affects students' laboratory activities and overall course performance. Some students fail the course. Even for those who pass the course, their poor understanding of the fundamental theory and application of construction materials negatively influences their performance in higher-level technical elective courses, especially Advanced Construction Materials. In the post-COVID years, as many of the civil engineering classrooms experience further declined attendance, effective methods are acutely needed to improve students' attendance.

3. Purpose

The purpose of this case study is to use in-class group quizzes to reduce students' absence in the two 50-minute lectures of CIVE 378 during the post-COVID crisis. The "absence" in this study indicates both unexcused and excused absence, i.e., any student who was not in attendance was considered to be absent. An excused absence is one that has been approved by the instructor, such as in the event of an illness or family emergency. For example, when a student has provided medical appointment notes, the instructor typically approves the student's absence. On the other hand, it is well known to instructors that there exist many internet companies that provide fake medical appointment notes, funeral schedules, and jury duty notifications, etc. [11, 12]. Many even offer it free for the first trial and guarantee "get you out of almost any situation" for only $20. During the post-COVID years, it is even easier for students to be excused, i.e., to maintain safe operations, many schools require that no students should attend any in-person class if they have COVID symptoms. Therefore, the purpose of this case study is to reduce absence, both unexcused and excused, by inspiring students' genuine interest in attending classes using the technique of in-class group quizzing.

In-class group quizzes is one of the collaborative testing methods [13]. Based on the existing literature, collaborative testing has been widely acclaimed in higher education due to its positive effects on students' learning and attitudes [14]. Rao et al. [15] found that physiology students who completed quizzes in groups scored much higher than those who completed them individually and concluded that collaborative testing enhances students' learning and understanding of the class materials. Cortright et al. [16] found that using collaborative testing for the completion of exams not only improved student learning in terms of grades, but also improved the students' retention of course content. Helmericks [17] reported that collaborative testing not only improved students' learning but also exerted an affirmative impact on students' attitudes. It indicated that the collaborative process enhanced the interpersonal bonds among students and produced a sense of mutual confidence that heightens the overall learning experience. Clinton and Kohlmeyer [18] investigated the effect of group quizzing on accounting students' course performance and indicated that cooperative testing favorably increased students'

ratings of the instructor. Although not widely documented in existing literature, the technique of engaging students in group quizzing has also been employed in engineering classes [19]. For example, Desai and Stefanek [20] applied this technique in some of the civil engineering, mechanical engineering, and electrical engineering courses and concluded that it improved students' course performance and reduced the occurrence of plagiarism. It also allowed the instructor and the students to acquire real-time assessment during the classes.

To summarize, based on the existing literature, collaborative testing, e.g., engaging students in group quizzing, generally improves students' learning and increases the possibility that students will develop positive attitudes towards the subject matter, the instructor, and their classmates. However, the research community knows much less about how collaborative testing may influence students' behavior, such as attendance and study habits. Although the exact mechanism is still uncertain, collaborative testing may possibly influence students' behavior thanks to the involvement of classmates. For example, Astin suggested that students tend to spend more time studying the course materials when they are aware that their classmates will evaluate their work [21]. Thus, the focus of this case study is to investigate the effects of collaborative testing on not only students' learning and attitudes but also their behavior.

4. Method

With the aim to improve students' attendance, engagement, and teamwork by using the method of in-class group quizzes, several design principles should be applied. First, the grading scheme should be modified so that the quiz performance accounts for a considerable portion of the total course grade, as shown in Fig. 1(a). Even though in-class quizzes may be categorized as formative assessments, some researchers revealed that formative assessments can be used as ''summative assessments plus feedback'' [22]. Besides group quizzes, students are evaluated by laboratory reports, homework assignments, and three exams, i.e., two midterm exams and a cumulative final exam. The three exams also account for a significant portion of the total grade, because they are important tools to evaluate student learning in a summative and formal setting, during which students are not allowed to work together by any means or have access to external resources. To emphasize the importance of deep learning and understanding rather than surface learning and memorizing, students are allowed to have a double-sided ''cheat sheet'' during all the three exams.

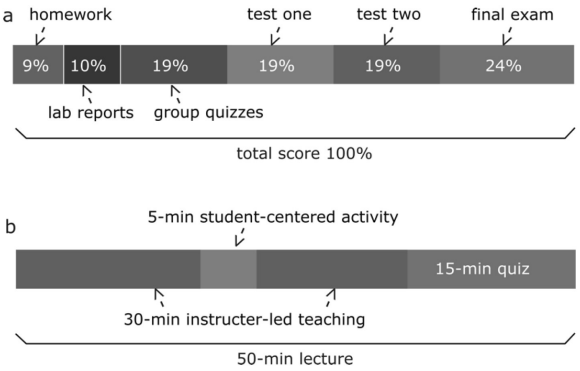

Fig. 1. (a) Grading scheme and (b) lecture structure used in CIVE 378 in the semesters of Spring 2021 and Spring 2023 when the case study was performed.

Second, the 50-minute lecture should be well structured so that students have sufficient time to work collaboratively to solve the quiz problem, as shown in Fig. 1(b). The most significant portion of the lecture is still instructor-centered teaching, which is interspersed with one or two 5-minute student-centered activities to keep students stay focused. A 15-minute group quiz is held at the end of each class as a post-lecture comprehension check. The rationale of this structure is to ensure that the students in attendance are engaged in learning by making them aware that they will be tested at the end of each class. The 15-minute time duration was determined through a trial-and-error process in the beginning of the semester of Spring 2021, i.e., when it was shorter, many students reported that they did not have sufficient time to discuss with their peers, and when it was longer, the instructor felt rushed to cover all the materials to meet the learning objectives. In particular, all the materials essential for the students to complete the quiz problems should be delivered in a timely and effective manner within the first 35 minutes of the class.

Third, the importance of attendance, the grading scheme, and the lecture structure should be included in the syllabus and elaborated by the instructor on the first day of class. While it is well known that the attendance policy, as well as its potential impacts on student grades, should be clearly and distinctly presented in the course syllabus [23], the COVID pandemic has made us strongly aware of the seriousness of health and safety and that no students should attend any in-person class if they have COVID symptoms. The pandemic also raised awareness of other stressors that students may face, such as financial issues, housing, and mental health. To make a balance, the following sentences are used in the syllabus: ''A 15-minute group quiz is held at the end of each class as a post-lecture comprehension check. This team-based learning activity accounts for 19% of your

total course grade. Because of that, I expect you to attend all the classes unless you are ill or have other valid reasons for missing. If you are ill or have other valid reasons for missing, please contact the instructor by email in advance of the absence.''

Fourth, the quiz questions should be designed to be not only interesting but also challenging. Creating time for students to be engaged in solving complex problems is highly valued in cooperative learning environments [24]. It is essentially the philosophy and foundation of blended and flipped learning, in which a significant portion of class time is dedicated to complex topics and real-time assessment of students' learning [25]. When quiz questions are challenging, students believe that he/she cannot solve the quiz by himself/herself, and thus they know that their individual performance and success are connected to everybody else's within the group. Group members are forced to actively seek help from each other, which eventually strengthens interpersonal ties and helps building a sense of mutual trust. On the other hand, the instructor should make sure that the quiz question can be completely solved based on the materials just taught during the lecture. As long as the students are actively engaged in learning, they are equipped with all the essential tools to solve the quiz problem. Three examples of the quiz questions are shown in Appendix A. The quiz questions, designed by the instructor and thus cannot be found on any textbook, require the students to show not only knowledge of content but also an in-depth understanding of fundamental concepts.

Finally, although groups are formed by student self-selection, the instructor should work as a facilitator to make sure the group size is not too large or too small. For collaborative groups to be productive, the group size must be sufficiently small to allow for face-to-face interaction so that each student has the opportunity to participate in the group discussion. In addition, in large groups, ''free-riding'' or ''social-loafing'' often appears, when some group members evade doing their fair share of the task and expect others to pick up the slack [26]. For these reasons, some researchers recommended the group size to be less than five [27]. On the other hand, when faced with a challenging task, small groups may not have sufficient intellectual horsepower to resolve the problem. For this reason, some researchers recommended the group size to be between five and seven [28]. As a result, the course requires the group size to be four or five.

To assess the effectiveness of in-class group quizzing, instructor's observation, attendance rates, scores in three exams, and course survey results are analyzed. The course survey is the anonymous survey uniformly conducted for each course by the University of Nebraska-Lincoln at the end of each semester [29]. It is an in-depth survey designed to collect the ideas and comments from the students on their learning experience.

5. Results

According to the instructor's classroom observation, group quizzing had a substantial positive effect, and most students received prompt feedback from classmates on their understanding as well as the opportunities to revise and restate their grasp of central concepts. Students appeared to be engaged more intensely with the course material, and classroom discussions were more frequent. In addition, many students expressed their satisfaction with the teaching approach via email or office hour visits at some point during the semester. On the other hand, the instructor also observed that some students could not participate in group discussions as confidently as others due to various issues. For example, some students were still trying to understand the quiz question when a classmate jumped in with a possible solution. In addition, some students expressed uneasiness associated with the daily quizzes, and a few felt very stressful to be quizzed on the materials just taught on the same day.

The most striking success of this case study is the significant increase in students' attendance rate, as shown in Table 1. In the semesters of Spring 2021

Table 1. Attendance rate in Spring 2021 and Spring 2023. Any student who was not in attendance was considered absent, whether or not being excused

Semester	**Quiz 1**	**Quiz 2**	**Quiz 3**	**Quiz 4**	**Quiz 5**	**Quiz 6**	**Quiz 7**	**Quiz 8**
Spring 2021	98.2%	96.3%	100%	100%	100%	100%	94.4%	98.2%
Spring 2023	95.7%	97.9%	97.9%	100%	100%	100%	100%	100%
Semester	**Quiz 9**	**Quiz 10**	**Quiz 11**	**Quiz 12**	**Quiz 13**	**Quiz 14**	**Quiz 15**	**Quiz 16**
Spring 2021	96.3%	96.3%	96.3%	96.3%	98.2%	98.2%	98.2%	100%
Spring 2023	97.9%	100%	100%	95.7%	100%	100%	83.0%	91.5%
Semester	**Quiz 17**	**Quiz 18**	**Quiz 19**	**Quiz 20**	**Quiz 21**	**Quiz 22**		
Spring 2021	92.6%	94.4%	96.3%	94.4%	100%	100%		
Spring 2023	95.7%	91.5%	95.7%	91.5%	100%	100%		

Table 2. A comparison of the students' scores in test one, test two, and final exam

Test One				
Semester	**Minimum [%]**	**Maximum [%]**	**Median [%]**	**Mean [%]**
Spring 2020	69	98	88	87
Spring 2021	70	100	96	94
Spring 2023	60	100	90	90
Test Two				
Semester	**Minimum [%]**	**Maximum [%]**	**Median [%]**	**Mean [%]**
Spring 2020	70	100	84	86
Spring 2021	72	100	92	90
Spring 2023	80	98	90	90
Final Exam				
Semester	**Minimum [%]**	**Maximum [%]**	**Median [%]**	**Mean [%]**
Spring 2020	55	100	80	84
Spring 2021	51	100	84	85
Spring 2023	80	100	93	93

and Spring 2023, the average attendance rate reached 97.5% and 97.0%, respectively, which are much higher than the average attendance rate of other courses within the College of Engineering at the University of Nebraska-Lincoln. Many instructors within the college also set up the grading scheme in a way that the in-class quiz performance accounted for a considerable portion of the total course grade, but still had significant amounts of excused absences due to various reasons, such as COVID symptoms and mental health issues. This indicates that only working on the grading scheme cannot guarantee improved attendance or engagement.

Compared with the semester of Spring 2020 when the same instructor taught the course without systematically using in-class group quizzing, the students' performance in the three exams became much better. The exam questions used every year are not the same but with approximately the same level of difficulty. A comparison of the students' scores is presented in Table 2.

Compared with the semester of Spring 2020, the students' feedback in the anonymous end-of-the-semester survey became more positive. A comparison of the students' rating to the most relevant questions is presented in Table 3. Since this course survey is the end-of-semester survey uniformly conducted by the university for each course, it does not contain questions specifically related to group quizzing.

In the anonymous end-of-the-semester survey, many students commented that the group quizzes had a favorable effect on their learning and understanding of the course material. All the text data containing either ''quiz'' or ''quizzes'' were selected for analysis. When the method of qualitatively coding recommended by Creswell [30] was used to analyze the data, three strong themes emerged, i.e., the placement of quiz at the end of the class, the group approach to creating a collaborative learning environment, and the real-time self-assessment.

Theme #1 The following representative comments showed that the placement of the quiz at the end of the class resonated very well with the students.

- *I really loved having the quizzes at the end of each class, a good check in to go over material right away.*
- *Taking quizzes after every class made students pay attention and learn the material immediately without requiring an abundant amount of time dedicated to work outside of the class.*
- *Quizzes at the end of each lecture were extremely helpful in immediately testing understanding and highlighting the most important points of the lecture.*
- *Having the quizzes after each lecture and having the ability to work with other students on those quizzes really helped me learn and understand the material better.*
- *I really liked the having the quizzes at the end of class especially the fact that we could work in groups on them. It really helped us get familiar with that day's topics.*
- *The quizzes at the end of each class are super helpful and convenient, allowing students to work with the material and ask questions.*
- *The quizzes at the end of lecture were very helpful with promoting my knowledge of the class material.*
- *The quizzes at the end of each lecture made sure that each student was paying attention. If they paid attention in the lecture, the quiz was easy and a good way to practice concepts learned in the lecture.*
- *I enjoy how we have quizzes at the end of each class*

Table 3. A comparison of the students' rating according to end-of-the-semester course survey

	Response Rate	Mean	Median
I feel welcome and respected. The class has a positive learning environment.			
Spring 2020	92.06%	4.56	5.00
Spring 2021	90.74%	4.67	5.00
Spring 2023	87.23%	4.83	5.00
I understand course expectations and how my performance is evaluated.			
Spring 2020	92.06%	4.39	4.00
Spring 2021	90.74%	4.59	5.00
Spring 2023	87.23%	4.71	5.00
The learning tools (e.g., course texts, notes, slides, videos, exams, projects, etc.) support my learning.			
Spring 2020	92.06%	4.22	4.00
Spring 2021	90.74%	4.69	5.00
Spring 2023	87.23%	4.47	5.00
I know where to go for help in this course if, and when, I need it.			
Spring 2020	92.06%	4.20	4.00
Spring 2021	90.74%	4.65	5.00
Spring 2023	87.23%	4.39	4.00
Course activities effectively promote my learning and interest in the subject.			
Spring 2020	92.06%	4.19	4.00
Spring 2021	90.74%	4.47	5.00
Spring 2023	87.23%	4.47	5.00
I feel challenged to learn a lot in this course.			
Spring 2020	92.06%	4.20	4.00
Spring 2021	90.74%	4.39	5.00
Spring 2023	87.23%	4.17	4.00
I find communication with the instructor (e.g., office hours, email, Canvas, etc.) effectively supports my learning.			
Spring 2020	92.06%	4.20	4.00
Spring 2021	90.74%	4.65	5.00
Spring 2023	87.23%	4.34	4.00
I have opportunities to learn with and from other students in this course.			
Spring 2020	92.06%	4.36	4.50
Spring 2021	90.74%	4.71	5.00
Spring 2023	87.23%	4.61	5.00

because it makes me focus during class and it provides me with an example problem of the information we just learned.

- *Having a quiz at the end of every class was extremely beneficial as it forced us to immediately understand the concepts from that class.*
- *The professor had a very good setup for the class where every day there was a quiz at the end of class. This helped to apply the ideas and topics that we had learned in class that day to verify what we should have learned.*

Theme #2 The following representative comments showed how the group quizzes had a favorable effect on their learning by creating a collaborative learning environment.

- *I think that the daily quizzes are extremely beneficial to my learning. Being able to work with the people around me on these quizzes also helped accelerate my learning.*
- *Being able to consult other students during lecture quizzes was helpful to my understanding of the material. If I got an answer that was different than another student, we were able to figure out what went wrong and fix it. That was the best learning for me.*
- *Collaborative quizzes helped me to learn a lot in the course.*
- *Group quizzes helped a lot to grasp material.*
- *I believe that the reason that I was successful in this class was due to being able to collaborate with other students for assignments. This was the first class I had in which I really appreciated the group work aspect of the class. For the quizzes, it was very nice to be able to collaborate with other students, and it was able to supplement my learning as well.*
- *The fact that the quizzes were collaborative allowed me to interact with other students and further expand my knowledge on the subject.*
- *Even if we didn't do a sample problem just like it, the fact that we had to solve the quiz problem with our neighbors was much more effective than watching a professor solve a problem.*
- *In each class, the student works together to solve the quizzes, which enhanced our interaction, and we were able to make friends even in the classroom.*

Theme #3 The following representative comments reported how the group quizzes had a favorable effect on their learning by allowing them to have real-time self-assessment.

- *The daily quizzes really helped me know what we learned that day.*
- *The quizzes helped anchor my learning and showed me where I had misunderstandings.*
- *The class was set up perfectly for a person like me who best learns by doing examples. The quizzes at the end of each lecture were those examples.*
- *Loved the quizzes. We were expected to do difficult things, but we were given all the tools to do everything successfully.*
- *I liked that we had a quiz in each class, which kept everyone paying attention and it helped to immediately apply the skills we just learned.*
- *The quizzes helped to apply the ideas and topics that we had learned in class that day to verify what we should have learned.*
- *The quizzes were very helpful for testing my*

knowledge on the information that I just learned in class.
- *Doing the in-class quizzes is extremely helpful for learning. I feel like I've learned everything I've needed to in this class through the quizzes.*
- *I felt that the quizzes are really a fantastic tool in this class to measure understanding.*

More importantly, besides its impact on learning, the group quizzing also exerted a positive impact on students' attitude towards the subject matter, the instructor, and their classmates, as well as students' behavior, such as attendance and study habits. Some representative comments are shown below.

- *I think Dr. Jin's way to set up the course is extremely useful in the fact that we are learning from each other every single class. The opportunity to have a quiz to test our knowledge over the content just learned is very beneficial.*
- *I believe that Dr. Jin's teaching style is the one that allows students to gain the most knowledge in a concise and organized manner.*
- *Dr. Jin's class is well put together and allows for students to learn. Nothing in regard to her class, grading methods, or teaching style needs to be altered.*
- *I feel satisfied with how the class went this semester. Professor Jin was able to teach very well, and I didn't feel that the class was missing anything or that anything needed to be changed.*
- *Class is enjoyable and I feel like I have learned a lot.*
- *Easy to find interest in the subject when we get to do things with other students.*
- *The in-class quizzes were a motivator to attend class every day. It also was a good tool to reinforce the material from that day's class and a good tool to help integrate the previous material with what we currently learned. I feel like I learned the most from this class of all my classes this semester and it was the most fun to attend.*
- *Each class is engaging and productive. The lessons are very organized, thought out, and easy to follow. The professor makes sure each student understands the material. This is the class that interact most with the other students. The quizzes and tests feel like interesting challenges that can be overcome with the tools the professor gives us. This semester, I have looked forward to each class session. Thank you!*
- *In each class, the student works together to solve the quizzes, which enhanced our interaction, and we were able to make friends even in the classroom.*
- *The daily quizzes were, by far, the most effective attendance tool I've seen.*
- *I like that this class is just quiz based because I have to show up to class and learn along with other students.*

On the other hand, students expressed different opinions about whether the quiz problems were actually challenging. Some students also pointed out that some quiz problems were poorly correlated with the lecture material. These survey results revealed that designing the most appropriate quiz problem for each lecture remains the most challenging task for this practice.

- *I often felt like the information we covered in lecture was not enough for the quizzes.*
- *At times quizzes did not correlate heavily with what was covered that day in class.*
- *I have had to rely heavily on my peers on some occasions to be able to connect what the quiz question was asking for to the material we had just learned. Sometimes the material being taught seemed straightforward, but the quizzes were unnecessarily difficult.*
- *The challenge of the course was perfect, and it made the class enjoyable.*
- *I feel like I haven't been challenged too hard in this class. I don't know if that's because the class being set up really well and learning coming easily.*

6. Discussion

In this case study, the effectiveness of using in-class group quizzes to improve students' attendance and performance was assessed for CIVE 378 Materials of Construction. The most striking success of this case study was the significant increase in students' attendance rate. In the semesters of Spring 2021 and Spring 2023, the average attendance rate reached 97.5% and 97.0%, respectively, which are much higher than the average attendance rate of other courses within the College of Engineering. Many instructors within the college also set up the grading scheme in a way that the in-class quiz performance accounted for a considerable portion of the total course grade, but still had significant amounts of excused absences, indicating that only working on the grading scheme cannot guarantee improved attendance or engagement. Compared with the semester of Spring 2020 when the same instructor taught the course but without systematically using group quizzes, the students' performance in the three exams became much better, and the students' feedback in the anonymous course survey became more positive. In the anonymous course survey, many students stated that the group quizzing had a positive impact on their learning due to three reasons, i.e., the placement of quiz at the end of the class, the group approach to creating a collaborative learning environment, and the real-time

self-assessment. Many students also stated that the group quizzing exerted a positive impact on their attitude towards the subject matter, the instructor, their classmates, and most importantly, their behavior, such as attendance and study habits. This research finding has the potential to improve student-faculty satisfaction and exert a favorable societal impact by proffering strategies that enhance retention rate and graduation rate.

7. Conclusions

During the post-COVID years, higher education sectors across the globe are having difficulties keeping students motivated, engaged, and regularly attending classes. In this case study, the effectiveness of using in-class group quizzes to improve students' attendance and performance was assessed for a civil engineering course. In the semesters of Spring 2021 and Spring 2023, when the case study was conducted, 54 and 47 students were enrolled in the course, respectively. The classes are taught early in the mornings on Mondays and typically have very poor attendance. A series of in-class group quizzes were purposefully designed and implemented in the classes. Students' attendance rates, course performance data, and anonymous survey results were analyzed to evaluate the effectiveness. The results suggested that several design principles, such as the placement of quiz at the end of the class, the group approach to creating a collaborative learning environment, and the real-time self-assessment, should be applied when using this method, which could lead to significantly improved attendance, engagement, and teamwork.

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Appendix A

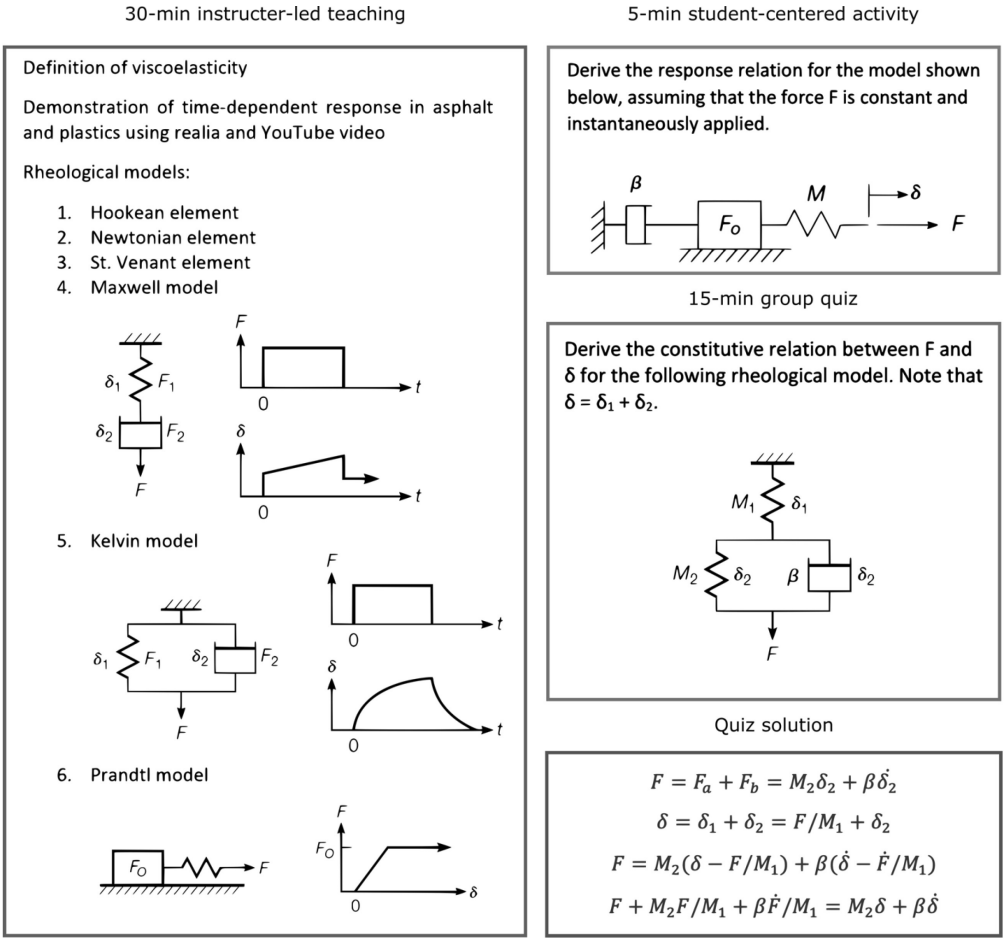
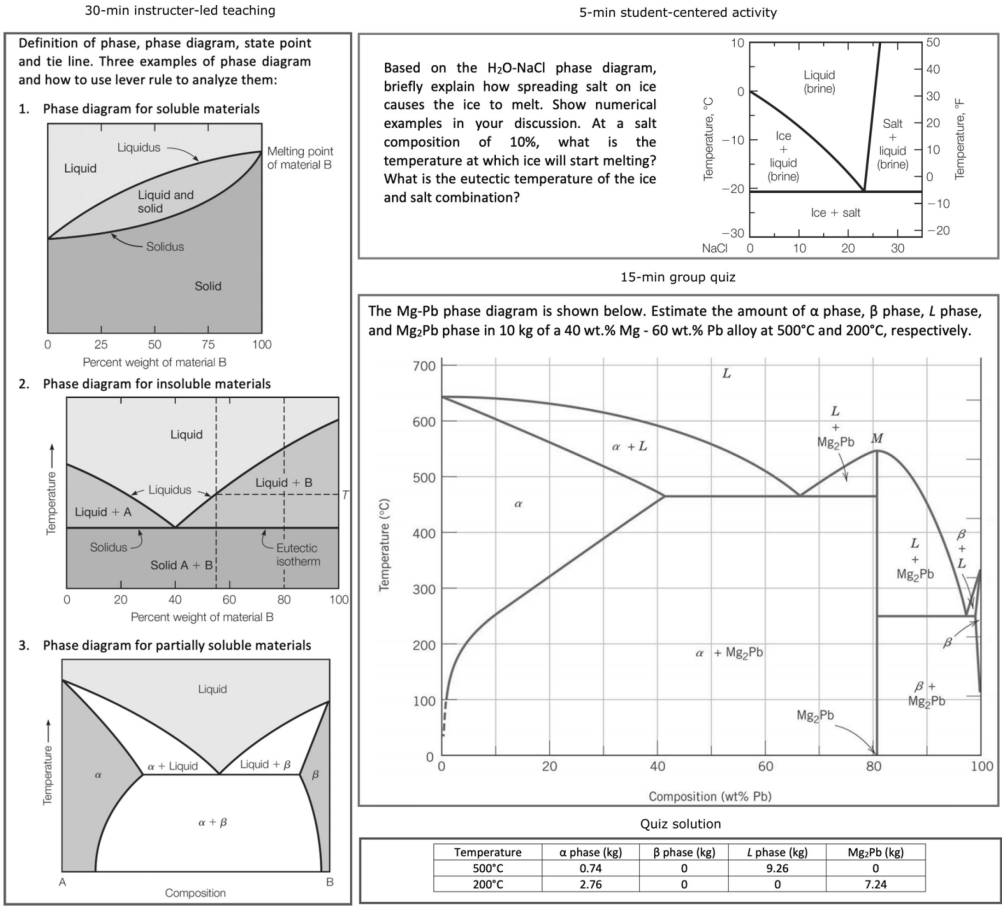


Fig. A. The quiz question on viscoelastic behavior used in CIVE 378. This lecture focuses on rheological models that are often used to model time-dependent behavior of materials. This part of knowledge is in Chapter 1.2.5 of the textbook [10].



Temperature	α phase (kg)	β phase (kg)	*L* phase (kg)	Mg_2Pb (kg)
500°C	0.74	0	9.26	0
200°C	2.76	0	0	7.24

Fig. B. The quiz question on phase diagram used in CIVE 378. This lecture focuses on how to use lever rule to calculate the relationship between the percentage of materials and the transition temperatures based on a phase diagram. This part of knowledge is in Chapter 2.2.5 of the textbook [10].

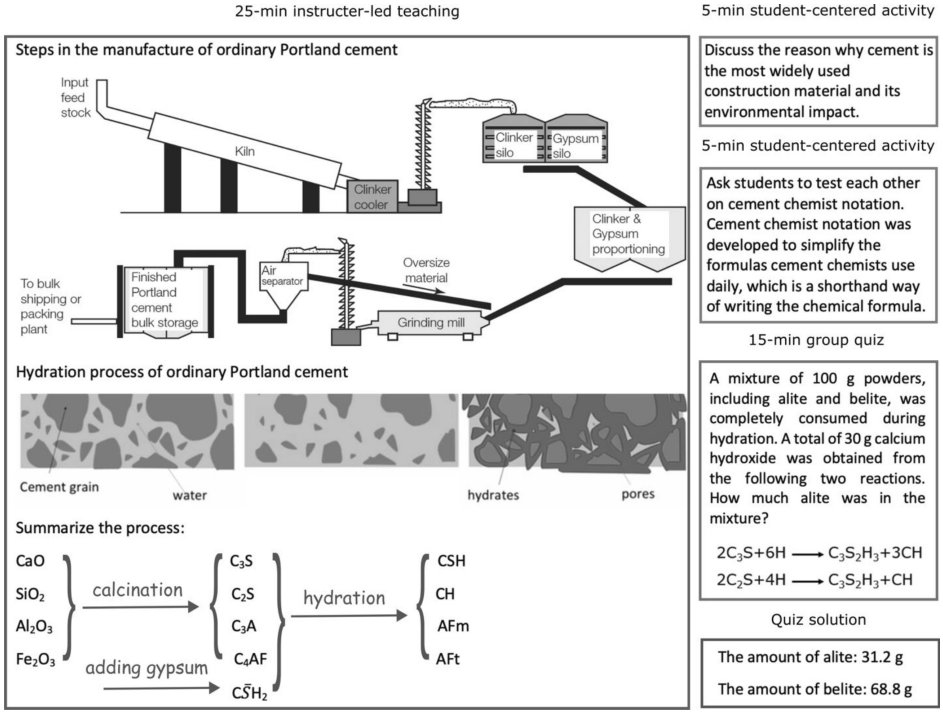


Fig. C. The quiz question on ordinary Portland cement used in CIVE 378. This lecture focuses on the chemical reactions during the hydration process. This part of knowledge is in Chapter 6.1 to 6.5 of the textbook [10].