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AN INNOVATIVE ACTIVE LEARNING APPROACH IN CIVIL ENGINEERING EDUCATION

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Abstract

Active learning is an essential tool in STEM education to enhance in-depth knowledge. However, most civil engineering students learn reflectively. These students show lack of interests in lecture and remain less interactive. Hence, they neglect many fundamental concepts which are difficult to learn effectively through self-study. In this paper, a step-by-step effective active learning method will be introduced which will encourage active learners to become more attentive as well as will motivate the reflective learners to learn actively. Through the proposed method, guided handouts are supplied to the students before the classes with blank spaces. Students must attend the lecture carefully to fill up those spaces with the guidance of the instructor. In some instances, a pre-recorded video lecture to view could be uploaded prior to the class with instructions. Once in a week at the end of the lecture, the classroom is broken into small group of students to work on a task for about fifteen minutes. Additionally, a short quiz paper is provided to the students based on that lecture and the group task. Students work together on that task and then they submit the quiz paper individually. These quizzes are considered as high-stakes in-class exercise and are graded. This two-step method encourages the students to attend classes timely and to follow the instructions attentively. Moreover, students remain interactive with the instructor through completing the guided notes. As a result, students receive clear basic concepts, attend classes regularly, and enjoy the course. Additionally, students' homework load is reduced which saves their co-curricular activity time. On the other hand, instructors have access to students' class performance records from the quizzes. In summary, this method motivates engineering students to actively attend classes with accomplishment.

Introduction

Learning style varies from person to person. The instructor is the person who facilitates the students to learn effectively. Active learning engages students to learn through taking the responsibility of their own learning experience [1]. This process requires meaningful and thorough learning activities [2] which increases students' involvement [3]. Though some of the students like to learn actively, most students study by themselves [4] through solving the assignments and preparing for exams. They are called as reflective learners. Active learners like experiments and team works, while reflective learners like theories and individual workspaces [5]. Though both learning techniques are acceptable, reflective learners require more study time which takes their co-curricular activity, leisure, and family time. There are different active learning techniques utilized by the instructors such as flipped classroom, guided notes, one minute paper, peer discussion, interactive quizzes, preparing artifacts, collaborative learning, educational trips, problem-based learning, and group projects [3, 6]. However, most of these active learning techniques seem difficult to keep students engaged throughout the lecture. Additionally, some of these techniques require a lot of preparation and excess class-time. With some innovative techniques, active learning could become interesting to the students through engaging them [7]. Two or multiple styles could be merged to effectively utilize these methods.

In this study two active learning styles: guided notes and interactive quizzes are merged into a comprehensive two-step method. The class size is considered as thirty for the effectiveness of this pedagogy. This pedagogy is currently being utilized in a few lectures of elements strength of materials and civil engineering materials courses of civil engineering technology program. Anonymous student-surveys will be conducted in this semester and in the following semester and based on their evaluations; this two-step method might be implemented in future. Additionally, the exam performance of the semesters implemented with active learning will be compared with semesters when no active learning was implemented. These criteria will evaluate the effectiveness of this method.

Significance of study

To evaluate students' performances, often instructors provide an in-class group exercise at the end of a lecture. Students often fail to pay attention throughout the lecture and face challenges in solving those problems. These in-class exercises are conducted in groups consisting of two to three students, and only one or two of them actively participate. Therefore, group exercises are inadequate to evaluate individual's performance. Homework assignments are also considered insufficient when same problems are assigned for an entire class. Through the proposed method, each individual student's performance is evaluated from the beginning of the semester, students extra-curricular time is saved, and their study load reduces. Additionally, inactive students receive advantages from this learning method. This pedagogy involves all students in an interactive teaching and learning environment which is beneficial for their future endeavor in civil engineering profession. Proper initiatives could be applied by the instructor after a few initial class performance evaluations.

Methodology

The lesson plan is divided into two parts. In *part 1*, students receive the guided style notes through Brightspace or through printouts provided by the instructor prior to the lecture. During the lecture, they complete the handouts with the guidance of the instructor. In *part 2*, once in a week, at the end of the lecture, students solve problems in group and then attend an individual quiz. The procedure is described below:

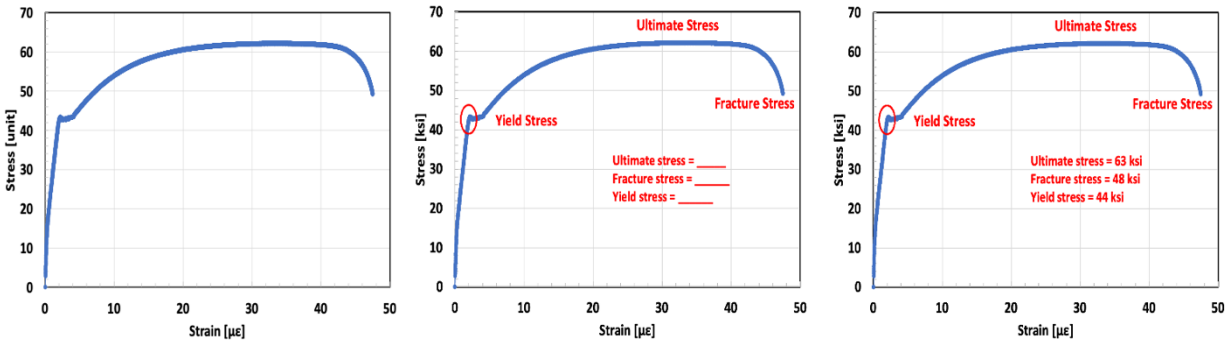
Part 1(guided notes)

The handouts are prepared in skeleton style [8] with blank spaces. Additionally, sketches are required to complete or occasionally to plot during the class. Students receive instructions on how to complete the handouts with the assistance of the instructor. Sometimes problem sets are provided in skeleton style too. The instructor uses animated PowerPoint slides to help students solving the problems. Additionally, instructors often utilize whiteboard to show the steps manually. Some instances, a wireless and portable personal computer with a touchscreen interface could be utilized by the instructor to electronically solve these problems. Generally, the instructor uploads the handouts in Brightspace prior to the class. As per electronic device policy of mentioned courses: "*electronic devices may be used in the class to look up materials through Brightspace*", students are encouraged to use their electronic devices in classroom. In some instances, the printouts are supplied by the instructor at the beginning of the lecture. Often a pre-

recorded video lecture with instructions is posted in Brightspace to watch before beginning of the class.

Part 2 (Breakout classroom and individual quizzes)

Weekly at the end of a lecture, a worksheet containing a problem set is provided to the students. Student-groups of two to three work on those problems. Fifteen minutes time limit is provided for the groupwork and then students attend an individual quiz for an additional five to ten minutes. These quizzes are considered as high-stakes assessments. A few times, instead of a regular quiz, students are asked to submit a one-minute paper [9] to summarize whatever they learnt. The weakest points [9] in that lecture could be asked to summarize too. These activities will be considered as low-stakes assessments. The instructor evaluates individual's weekly performance from the quizzes. The graded quizzes are returned to the students and a brief discussion is conducted based on the common misconceptions. For the low-stakes assessments, instructors may re-explain the challenging parts of that lecture.



(a) (b) (c)

Figure 1: Stress-strain relationship of a mild steel specimen

Illustrations of this method

Sample of guided notes and group works utilized in an elements strength of materials course:

An example of a handout utilized in the elements strength of materials course is shown in **Figure 1**. In this course, students identify mechanical properties of materials from the stress-strain diagram of metal specimens subjected to a tensile strength experiment. The handouts contain only **Figure 1(a)**, which is the stress-strain response of a mild steel specimen subjected to a uniaxial tensile strength test. During the lecture on stress and strain, students identify yield stress, ultimate stress and fracture stress of this metal and label the points as shown in **Figure 1 (b).** Then they are asked to fill up the blank spaces in that same plot to obtain the values. Students try to complete it and, finally, the instructor shows **Figure 1 (c)** and students revise their results if necessary. At the end of the lecture, the classroom is divided into small groups consisting of two to three students. Force-displacement data of multiple specimens are provided per group as shown in **Figure 2**. Each student-group works on these data to determine selected properties of these specimens. After the group discussion, students attend an individual quiz based on this exercise.

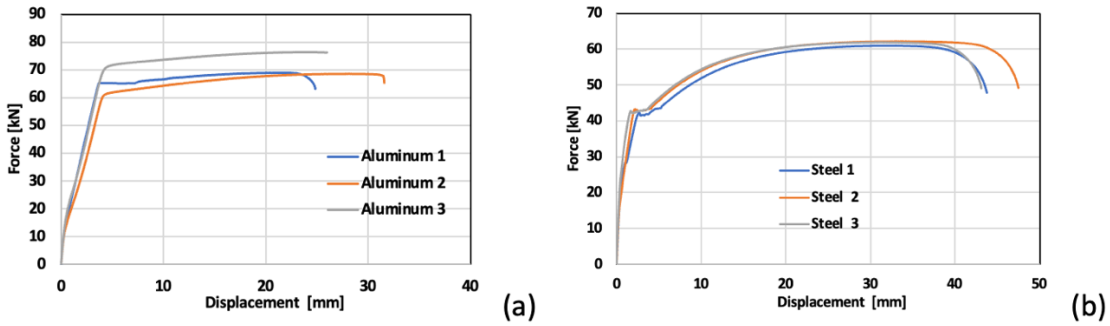


Figure 2: Force-displacement diagrams of different metal specimens

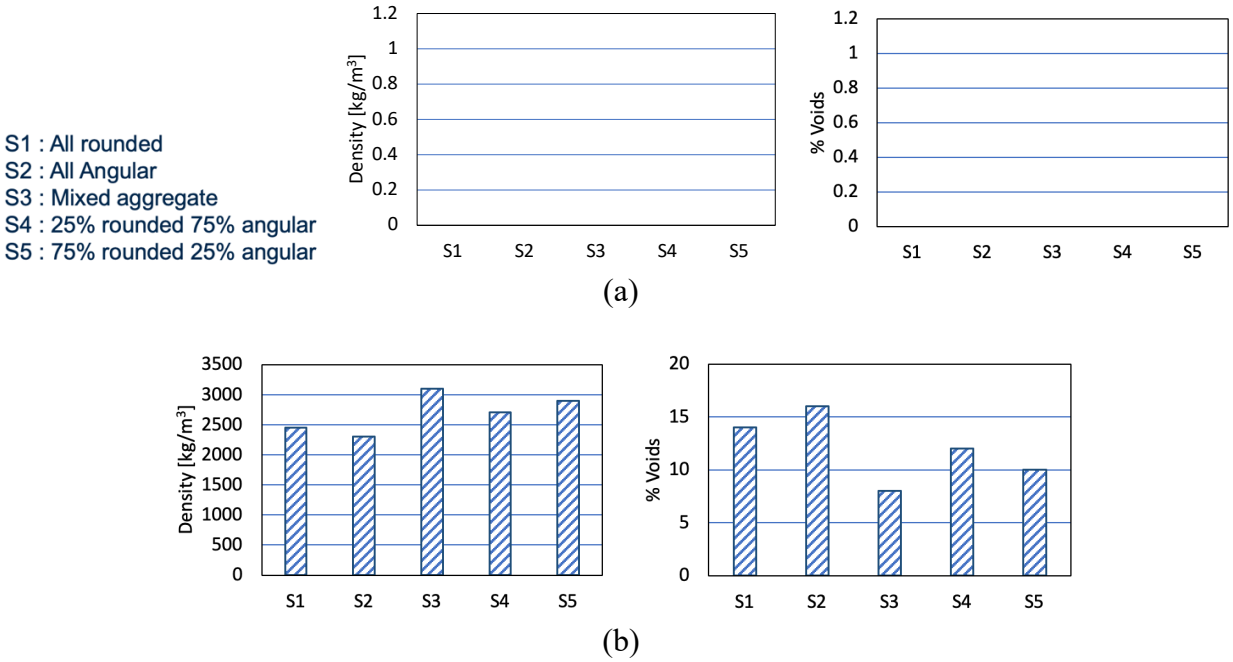


Figure 3: Effect of particle shape and gradation on density and voids of a mix

Sample of group works utilized in a civil engineering materials course:

Another example of a group work utilized in the civil engineering materials course is shown in **Figure 3**. In this course, students learn what a well-graded aggregate sample is, and why it is essential to manufacture a dense concrete. This class exercise gives them an idea on the effect of aggregate shape and gradation on density and voids of a mix. After the skeleton style lecture on grain size distribution and aggregate properties, the classroom is divided into five groups. Each group receives a worksheet with the sketches as shown in **Figure 3 (a)**, and one aggregate sample such as S1. Small containers, tamping rods, measuring tapes and scales are provided per group. Each group runs a dry density and void analysis on their sample and estimates density and voids. After the experiment, student groups share their results in the whiteboard and complete the bar charts as shown in **Figure 3 (b)**. Finally, each individual student attends a quiz based on the analysis and interpretation of these experimental results.

Evaluations of effectiveness

The effectiveness of this active learning will be evaluated at the end of the semester based on a few anonymous surveys and exam performances. For each course, two to three surveys will be conducted. Sample of survey questions are: "*was this activity helpful to comprehend you the theory, did it enhance your teamwork skill, was it helpful to analyze the results quickly, and do you recommend it for the future students*". Their evaluations will be analyzed statistically in the end of the current semester and in the next semester. In addition, students' performances in the mid-term exam and final exams of the semesters implemented with active learning will be compared with the semesters when active learning was not implemented. If more than 80% of the students respond optimistically in the surveys and if exam grades improve, this active learning will be implemented in future in those two mentioned courses by the same instructor. Moreover, this active learning method could be implemented in some other civil engineering technology courses such as statics.

Potential issues and solutions

Preparing guided style notes is considered as an outstanding task for the instructors for the foremost time. However, these handouts could be utilized in the subsequent semesters. Additionally, reduction in homework assignments reduces instructor's workload for grading. Time management is also challenging for a large class size. However, the groupwork and quizzes are scheduled once in a week which is manageable. Nevertheless, this method is highly effective for a class size of thirty students.

Summary and conclusions

Active learning is required in civil engineering as well as in STEM education. The proposed two-step method helps the students to remain interactive during the class and to grasp the fundamentals through gratification. The group exercises enhance their teamwork capability and leadership skills. Finally, this pedagogy enhances the student-teacher interactions.

The outcomes of this pedagogy are:

1. Students learn effectively without the sense of stress of active learning.
2. The study load reduces as students learn actively during the classes.
3. Number of homework reduces as the quizzes are considered as high-stakes assessments.
4. The homework load reduces as students can solve problems quickly.
5. Teamwork skills and leadership skills are developed.
6. Based on the results of weekly quizzes, instructions could be upgraded immediately.

References

1. J.D. Bransford, A.L. Brown, and R.R. Cocking, *How People Learn: Brain, Mind, Experience, and School*, Washington, D.C.: National Academy Press, 2000.

2. C.C. Bonwell and J.A. Eison, *Active Learning: Creating Excitement in the Classroom*. ASHE-ERIC Higher Education Report No. 1, Washington, D.C.: The George Washington University, School of Education and Human Development, 1991.
3. M. Prince, "Does Active Learning Work? A Review of the Research," *Journal of Engineering Education*, vol. 93, no. 3, pp. 223-231, 2004.
4. Z. Zhan, F. Xu, H. Ye, "Effects of an online learning community on active and reflective learners' learning performance and attitudes in a face-to-face undergraduate course", *Computers & Education*, vol. 56, pp. 961–968, 2011.
5. R.M. Felder, L.K. Silverman, "Learning and Teaching Styles in Engineering Education", *Journal of Engineering Education*, vol. 78, no. 7, pp. 674-681, 1988.
6. M. Hernandez-de-Menendez, A.V. Guevara, J.C.T. Martinez, D.H. Alcantara, R. Morales-Menendez, "Active learning in engineering education. A review of fundamentals, best practices and experiences", *International Journal on Interactive Design and Manufacturing*, vol. 13, pp. 909–922, 2019.
7. B. McCoy, "Active and Reflective Learning to Engage All Students", *Universal Journal of Educational Research*, vol. 1, no. 3, pp. 146-153, 2013.
8. C.L. Sidman, D. Jones, "Addressing Students' Learning Styles through Skeletal PowerPoint Slides: A Case Study", *MERLOT Journal of Online Learning and Teaching*, vol. 3, no.4, 2007.
9. D. R. Stead, "A review of the one-minute paper", *Active Learning in Higher Education*, vol.6, no. 2, pp. 118–131, 2005.