2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
Paper ID #37974

Adoption of CACPLA Pedagogy Collaborate Approach to Improve Peer-Facilitated Tutorials in Material Science

Dr. David Olubiyi Obada, Africa Centre of Excellence on New Pedagogies in Engineering Education, Ahmadu Bello University, Zaria, Nigeria

David O. Obada holds a Ph.D. degree in mechanical engineering from the Ahmadu Bello University, Zaria, Nigeria, specializing in production/industrial engineering. His research interests include fracture mechanics, advanced materials, and condensed matter physics. Before joining the Atlantic Technological University, Ireland, David was a research fellow at the University of Ghana, National Environmental Engineering Research Institute, Nagpur, India, and the University of Birmingham, UK. Also, David was a research and teaching fellow at the Massachusetts Institute of Technology (MIT), USA, and holds a Kaufmann Teaching Certificate from MIT.

Adrian Oshioname Eberemu
Mr. Kazeem A. Salami, Ahmadu Bello University
Ayodeji Nathaniel Oyedeji, Ahmadu Bello University
Akinlolu Akande
Fatai Olukayode Anafi, Ahmadu Bello University
Abdulkarim Salawu Ahmed

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David O. Obada[1,5.6,7], Raymond B. Bako[2,5], Abdulkarim S. Ahmed[3,5], Fatai O. Anafi[1,5], Adrian O. Eberemu[4,5], Ayodeji N. Oyedeji[1,5,6], Kazeem A. Salami[1,6], Akinlolu Akande[7], David Dodoo-Arhin[8]

[1]Department of Mechanical Engineering, Ahmadu Bello University, Zaria, Nigeria
[2]Department of Educational Foundations and Curriculum, Ahmadu Bello University, Zaria, Nigeria
[3]Department of Chemical Engineering, Ahmadu Bello University, Zaria, Nigeria
[4]Department of Civil Engineering, Ahmadu Bello University, Zaria, Nigeria
[5]Africa Centre of Excellence on New Pedagogies in Engineering Education, Ahmadu Bello University, Zaria, Nigeria
[6]Multifunctional Materials Laboratory, Shell Office Complex, Department of Mechanical Engineering, Ahmadu Bello University, Zaria, Nigeria
[7]School of Science, Atlantic Technological University, Ash Lane, Ballytivnan, Sligo, Ireland
[8]Department of Materials Science and Engineering, University of Ghana, Legon, Ghana
Corresponding author: David O. Obada (doobada@abu.edu.ng)

ABSTRACT

Group project forms an integral part of engineering education because creating connections between the course modules and its applications can be a difficult task. Therefore, team dynamics/cooperative learning can play a major role in determining the success rate of learners, with new pedagogies and think-pair-share sessions in the forefront of achieving this. For example, the jigsaw approach in the context of engineering education creates expert teams from a group of students by bringing together sub-sets of a group, with each team saddled with the responsibility of studying a specific module and discussing the outcomes with peers. In this study, the jigsaw method is abstracted from the collaborate section of the new pedagogy- CACPLA (Communicate, Active, Collaborate, Problem-based Solving, Learning and Assessment), and assisted with tutorials and peer facilitated studies on elasticity of materials. The broad subject was sub-divided into subsections such as: stress and strain in engineering materials, elasticity hysteresis, Hooke's law, stress tensors, bulk modulus, modulus of elasticity, and young modulus. Based on these subtopics, each of the 7 sub-groups were entrusted with creating scenarios for solving actual problems and these groups were further streamlined to form a core group for the study. We present case-studies on how the collated jigsaw pieces were useful to support the students and create in-depth knowledge on the subject matter.

1. Introduction

Since engineering practitioners mostly work in teams, cooperative learning and the competencies generated from the participating teams are especially relevant for students in areas like materials science. Materials science refers to a multidisciplinary subject which cuts across the physics and chemistry of matter, and their engineering applications.

Unfortunately, some students offering engineering subjects focus more on the engineering application side of things without emphasis on the fundamentals of materials physics and chemistry. There is a general belief that calculations from first principles/ab-initio calculations as it relates to the properties of materials can allow students appreciate the importance of understanding the theory of materials and how they evolve before their industrial applications [1]. Recently, lessons in computational materials science have been unpopular among students in Nigeria. This could be ascribed to inadequate computational resources and limited access to several crystallographic databases to advance the teaching of core concepts in materials science. Some preliminary and undocumented efforts have been made in our space to engage students in such a way that they pay attention to the theoretical side of things with a view to enhancing their grasp of the fundamentals of specific materials as it relates to their physical, chemical, and mechanical properties. These scenarios have also been reported in other countries where specific subjects and class groups were highlighted [2,3]. Woest [4] opines that changes in lesson content alone cannot make lessons more attractive to students. It was pointed out that the changes made to the lesson content has to be accompanied by a change in the teaching pedagogies. It has been reported that the use of cooperative learning can improve students' attitudes towards science and in their self-esteem. The Jigsaw classroom embeds the basic elements of cooperative learning and studies have shown that the Jigsaw and cooperative learning techniques have demonstrated positive results which relates to the comprehension of students, satisfaction, and self-esteem [5-7].

In the context of changes in the teaching pedagogies, the jigsaws have been abstracted from the collaborate section of a new pedagogy CACPLA (Communicate, Active, Collaborate, Problem-based Solving, Learning and Assessment) [8,9]. Reports on experiences in terms of the application of the jigsaw method in higher education STEM (science, technology, engineering, and mathematics) disciplines have been scarce, however, there are some research outcomes in recent times with researchers establishing experiential learning outcomes using this method [10-15]. Typically, in a jigsaw classroom, students form groups of 4-6 members and each group is responsible for forming expert opinions in different sections of the same problem. The jigsaw technique can also be beneficial when students with diverse academic standings are distributed homogenously among the groups. The complete picture of the method allows the individual groups to solve the problem cooperatively after taking feedback from expert opinions.

In this study, the jigsaw method is abstracted from the collaborate section of the new pedagogy- CACPLA and assisted with tutorials and peer facilitated studies on elasticity of materials. The broad subject was sub-divided into subsections such as: stress and strain in engineering materials, elasticity hysteresis, Hooke's law, stress tensors, bulk modulus, modulus of elasticity, and Young modulus. Based on these subtopics, each of the 7 sub-groups were entrusted with creating scenarios for solving actual problems and these groups were further streamlined to form a core group for the study. We present case-studies on how the collated jigsaw pieces were useful to support the students and create in-depth knowledge on the subject matter.

2. Methodology

2.1. The population sample and the jigsaw technique

The Africa Centre of Excellence on New Pedagogies in Engineering Education (ACENPEE), Ahmadu Bello University, Zaria, Nigeria has a mandate to fill the gap that exists in the training of engineering professionals where there is over reliance on traditional teaching methods. The Centre hosts four departments viz: Chemical, Civil, Mechanical, and Water Resources and Environmental Engineering Departments. The Centre has 78 students representing these four (4) departments and the subject of materials science cuts across the departments in terms of the academic and research components, hence, the decision to focus on the elasticity of materials as a topic. To cover the topic, the students were asked to watch a video and study the downloadable slides at:

https://compmatphys.epotentia.com/topic/elastic-constants-definition/

Next, the students were split into 7 groups of 10 students (n=70) each to discuss subtopics per the jigsaw strategy, and specific tasks were allotted.

Each group was assigned a subtopic under elasticity as follows:

Group 1: Stress and strain in engineering materials
Group 2: Elastic hysteresis
Group 3: Hooke's law
Group 4: Stress tensors
Group 5: Bulk modulus
Group 6: Modulus of elasticity
Group 7: Young modulus

Each group was expected to come up with three power point slides that summarizes the core concept of the subtopics assigned. This way, when the slides (jigsaw pieces) were put together by the overall champion of all groups, it gives a full picture of elasticity. On the premise of the dynamics noticed during the several learning sessions using participatory actions, it was recommended that some modifications be made to the jigsaw classroom method to fit into the peculiarities. This recommendation was because the typical jigsaw classroom method may be a bit tricky to apply if the subtopics should be divided into the number of members of the home groups. Therefore, the jigsaw classroom was modified as follows:

1. Activities and lesson contents were planned to give the students tasks to lead the home groups initially formed (with a greater number of students n=70) through their work. The teaching materials included videos and slide deck.
2. The jigsaw classes were then divided into 7 home groups as per their participation in a pre-lecture test (n=39). The seven home groups were as homogeneous as possible in terms of their academic achievement in the pre-lecture test. The homogeneous mixture means grouping students based on their test scores so as to have a fair distribution of students with excellent, good, and fair pre-lecture assessment scores in one group.
3. Students meet in their home groups where each participant of the group focuses on the overall concept and discuss in-depth with the home group champions.

4. The group champions then break up like pieces of a jigsaw puzzle into a group consisting of group champions from the other home groups and form expert opinions. The group champions then discuss the parts based on materials shared in their home groups to ensure that what they discuss with other colleagues in the group corresponds to the topic of interest.
5. Group champions then return to their groups, give feed backs based on the take home messages from the group champions of other home groups, teach the content in their group plus the add-ons to a general class that consists of all the students from the home groups.

Figure 1 shows a schematic of the modified jigsaw classroom method:

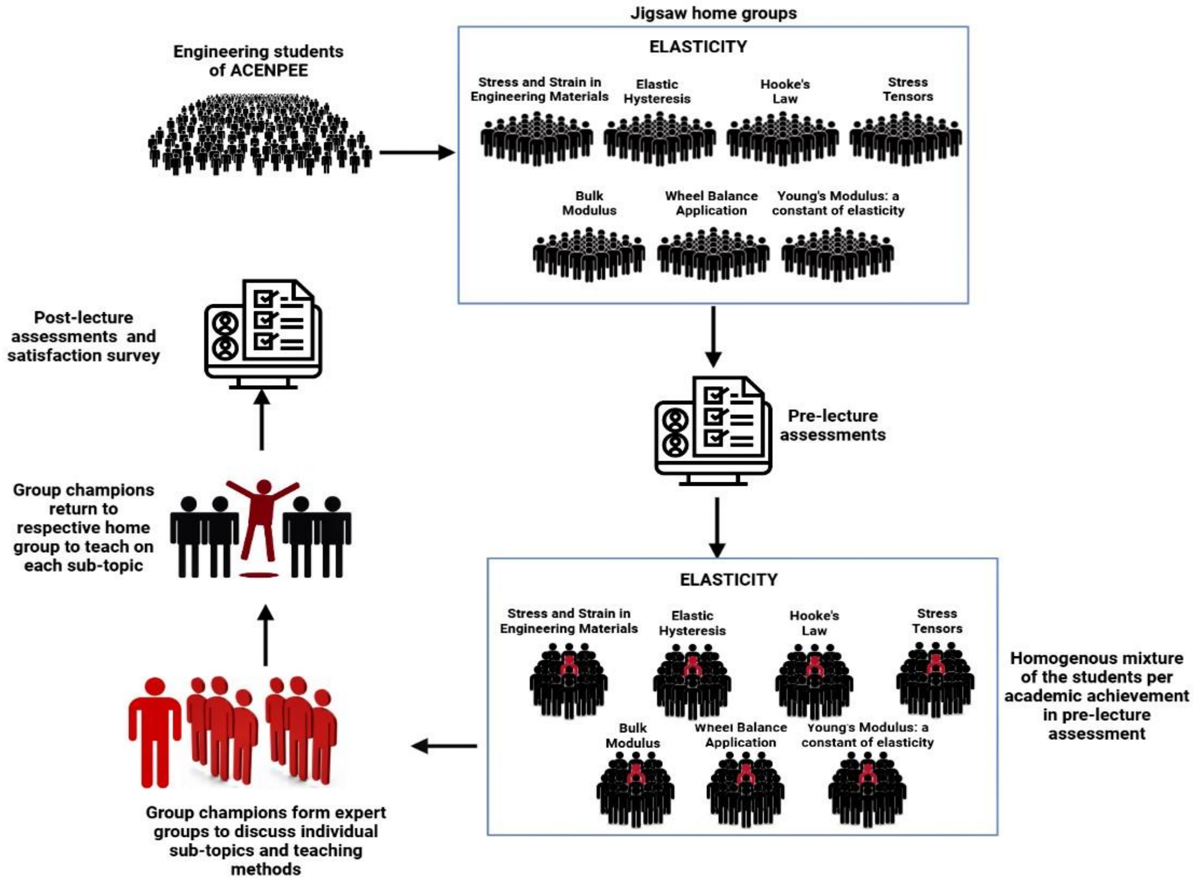


Figure 1: Schematic of the modified jigsaw classroom method

Formulation of the test questions (pre and post lecture tests) was done using a Google Form. Ten (10) questions each were included in the assessment for the pre-lecture, post-lecture and critical thinking assessment, respectively. The same questions were used for the pre and post lecture assessments, while the critical thinking questions were primarily questions based on the application of the materials science concepts. At least one question relating to the seven (7) materials science topics covered in the activity was included in the assessment questions. Before distributing the form to the students, the questions were reviewed to ensure that the questions were clear, and the add-in worked correctly. Monitoring of the assessment process was done using Quilgo (an add-in for Google

Forms). This add-in has features such as easy import of questions, randomization of questions, timing, automated grading, confidence level monitoring of students, and ensuring that the students do not open any new tab. All these features were employed in the pre-lecture and post-lecture assessments. As students completed the tests and survey assignments, their responses were automatically collected in a Google Sheet and analyzed. The R software and the “tm” package were used to analyze the open-ended feedback section. This generates a word cloud which highlights the most popular search terms in the survey’s feedback to provide a visual representation of the data.

3.Results and discussion

The results for the pre and post lecture tests are shown in Figure 2. The pre-lecture assessment was administered to the students with the aim of assessing the students’ concept inventory of the subject matter based on the learning materials shared hitherto, and to enable the formation of new home groups. The post-lecture test was administered after the teaching sessions facilitated by the group champions (experts) after the jigsaws. It was found that integrating the jigsaw classroom into the materials science lessons was positive as reflected in the performance of the student’s post-lecture. The results showed that all the students that participated in the post lecture tests scored above 50% of the total score as compared to scores reported during the pre-lecture assessment. The increase in test scores post-lecture can be ascribed to the improvement in learning methods based on the activities in the jigsaw groups proving the effectiveness of cooperative learning. Tucker [16] Bergmann et al., [17], and Nerantzi [18] in previous studies have reported that the influence of the collaborative aspect in the learning process cannot be overemphasized. It can be inferred that the jigsaw classroom method was useful as it promoted experiential learning.

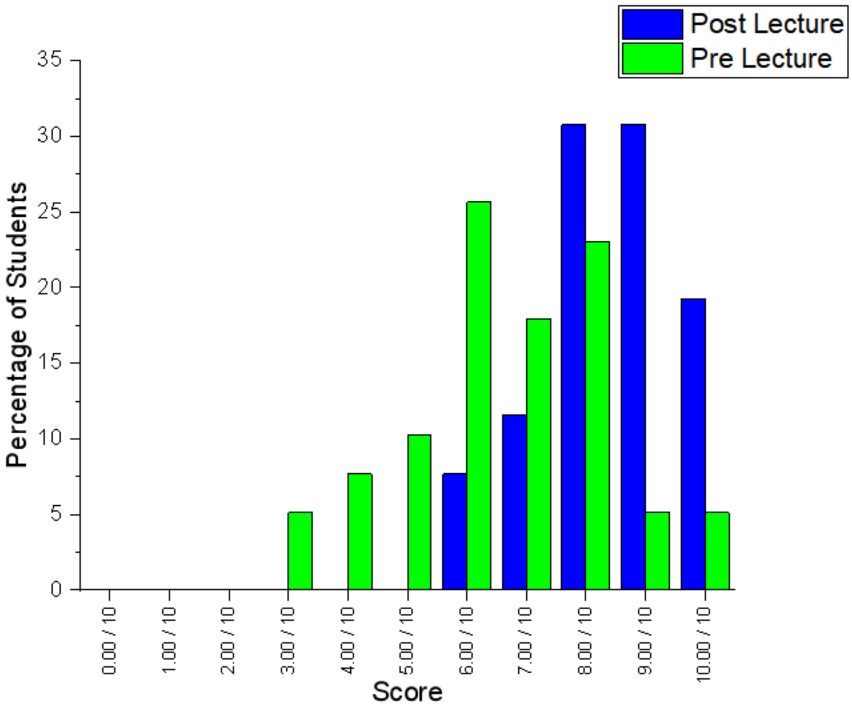


Figure 2: Comparison of students score for post-lecture and pre-lecture assessments.

The critical thinking ability of the students was assessed as shown in Figure 3 as the learning capacities of the students in comprehending concepts differ. The questions in this assessment were based on the discussion in the lecture sessions considering all the expert opinion formed, and a summary of the outcomes based on the feedback from the group champions to their home groups. The results showed a relatively good critical thinking skill among the students as a larger percentage of the students scored more than the average of 50%. One of the factors that may have been responsible for a more than average critical thinking skill is the ability of the students to keep pace with the synchronous sessions (teaching session).

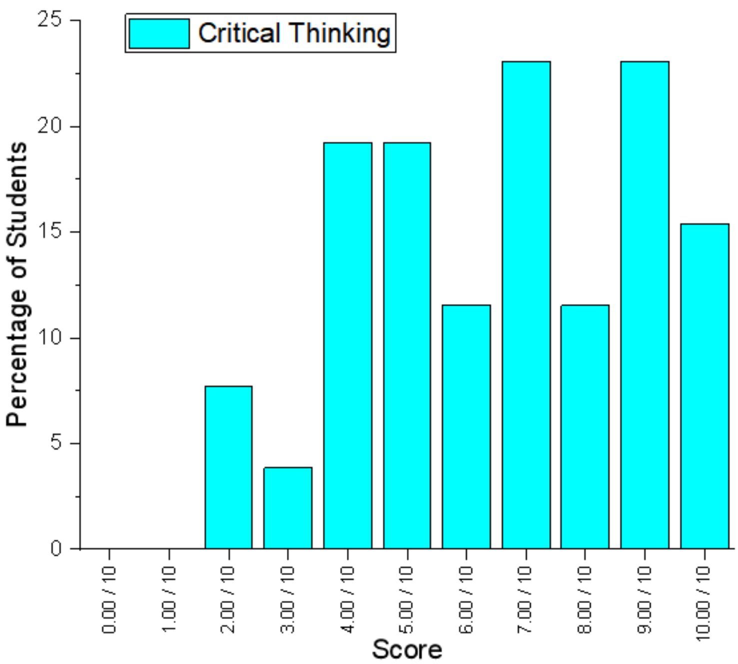
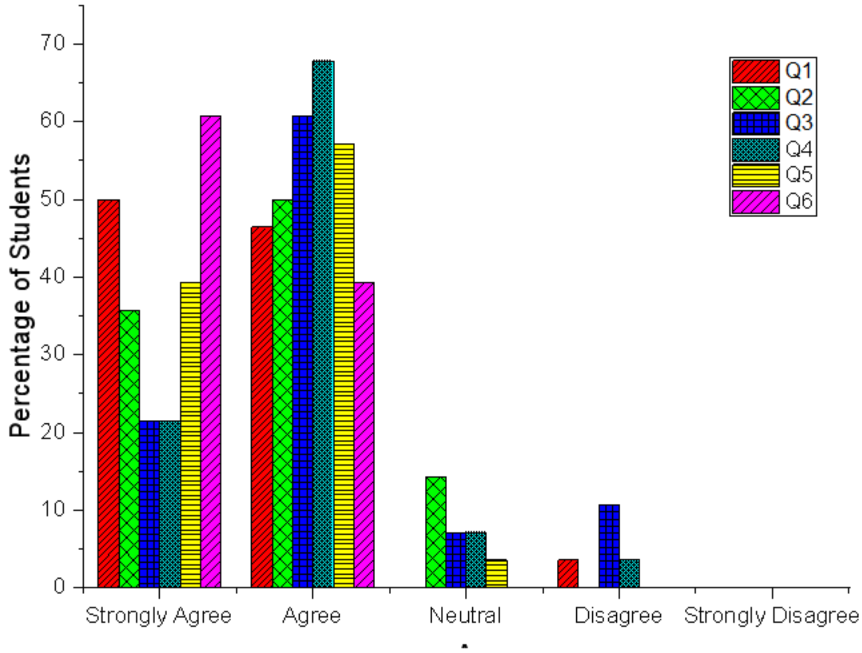


Figure 3: Distribution of students test scores for the critical thinking assessment.

The learner's satisfaction survey was administered to the students using a five-point Likert scale as shown in Figure 4 with the questions Q1-Q6 as addendum. Regarding the item Q1, it can be concluded that the jigsaw method was sufficient to achieve the learning outcomes as students mostly agreed that there were positive learning outcomes. Item Q2 showed that most of the students could easily answer the questions after the lecture sessions. Most students (Q3) agreed that there was enough time to work on the learning materials and the questions asked were sufficient to assess their understanding of the subject (Q4). Some students didn't agree that enough time was allotted for them to study materials because they may be slow learners. It has been advised that tolerance be given to these students to allow for more positive outcomes of the jigsaws generally. Items Q5 and Q6 show that the student's problem-solving skills were developed, and that the teaching methods can be applied to engineering courses. On this basis, it can be concluded that the students favoured the cooperative learning approach. Most of them commented that the method has improved their grasp of the subject and their communicative and social skills. This result is supported by the word cloud of the feedback received from the students as shown in Figure 5. The words "learning" and "method" were mentioned frequently because the students felt that the learning method can be adopted with a view to enhancing their learning outcomes.



Q1	The jigsaw learning method used was sufficient to achieve the learning outcomes
Q2	I could easily answer the post-lecture questions after homogeneous mixing and participating in the lecture session delivered by the group champions
Q3	There was enough time to work on the learning materials at my own pace
Q4	The number of questions administered during the assessments was sufficient to assess my understanding of the subject
Q5	The time frame of assessment was helpful in developing my problem-solving and analysis skills
Q6	This teaching method should be applied to engineering courses

Figure 4: Students satisfaction survey

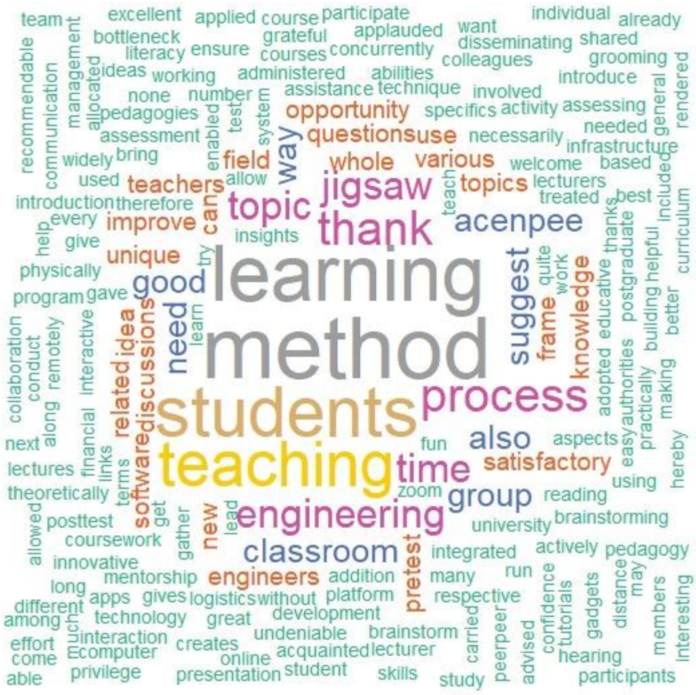


Figure 5: Word cloud analysis on the open-ended feedback section

4. Conclusion

This study provides a modified jigsaw classroom method that resonates with the peculiarities of the learning environment. Assessing the intervention of the modified jigsaw method as it relates to the academic performance of the students and the acceptability by the students (satisfaction survey), it was established that the modified jigsaw method enhanced the understanding of the students per the subject matter. The enhanced motivation of the students and progressive participation through the process resulted in an improved academic performance as the scores recorded post-lecture outweighed the scores pre-lecture. The data presented in this study will allow the adoption of the modified jigsaw method (subject to improvements) which will help in consolidating on the gains of the adoption of the CACPLA pedagogy.

Acknowledgements

The authors acknowledge the Africa Centre of Excellence on New Pedagogies in Engineering Education, Ahmadu Bello University, Zaria, Nigeria for providing financial resources to carry out this study. Also, the Tertiary Education Trust Fund (TETFund) in Nigeria is acknowledged for funding this study under the National Research Fund category with grant reference: NRF_SETI_HSW_00714, 2020, and the Irish Research Council for funding granted to DOO with Project ID GOIPD/2021/28. The discussion with Prof. Steefan Cottenier on the use of the online teaching resources available at https://beta.compmatphys.org/, which was adopted in this study is well appreciated.

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