



CodeCube: Active Learning for STEM

Vinothini Kasinathan^{1*}, Aida Mustapha², Heng Chin Yee¹

¹Faculty of Computing, Engineering Science and Technology, Asia Pacific University of Technology and Innovation, Technology Park Malaysia, 57000 Kuala Lumpur, Malaysia, vinothini@apu.edu.my

²Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia, aidam@uthm.edu.my

ABSTRACT

At present, there are many e-learning software but the market is lacking a two-way communication between the system and the users. CodeCube is an online learning website designed based on the concept of active learning. CodeCube introduces the “coin” concept, whereby coins are earned by completing the learning modules as well daily challenge. The earned coins can then be used to unlock new chapter or purchase new course and used at different level in the system. This is to encourage more student to using CodeCube for learning computer programming.

Key words: E-learning, Active learning, STEM, Code cube

1. INTRODUCTION

Active learning is an approach to instruction in which students are engaged to the study material through writing, talking, listening, reading and reflecting. Different from the traditional learning method, active learning requires student to respond more than the instructor. It is a mode of learning which the student is active while the instructor is passive [1]. Active learning is known to be able to increase student’s problem-solving abilities, critical thinking and content knowledge [2]. This is especially useful for subjects related to Science, Technology, Engineering and Mathematics (STEM) because the STEM subjects not only focus on the lecture and laboratories sessions, but also the occasional group problem-solving, worksheets and assignments, personal response without peer instruction and workshop course designs. Traditional lecture and laboratories sessions are insufficient for such subjects.

Active learning also improves student perception towards the information literacy and able to achieve higher learning outcome as compared to traditional lecture-based delivery [3]. Research by [4] used the active learning approaches as one target channel to perform the selection of information samples from students being individual learning. Most recent study on software engineering module has also shown an increased on students’ performance in examination upon using an active learning software for study [5].

Active learning requires the student to engage in higher order thinking tasks, which includes analysis, synthesis and evaluation [6]. Through carrying out these tasks, student can understand well how much they adapted in the subject and what the parts they are not familiar with. [7] applied active learning concept for Computer Science introductory course, which include difficult topic such as algorithms, data structures and programming logic. Survey showed that the approach was more dynamic and motivating to students instead of using traditional methods. Active learning approach had the most positive impact on the student learning and motivation. In [8], a thorough survey was carried out among 550 students studying STEM-related subjects. The investigator compared and analyzed 255 reported data and information about STEM students’ examination results and failure rates under active learning versus traditional lecturing. The purpose of this investigation was to find out the percentage of failure rate with active learning. The result is reproduced in figure 1.

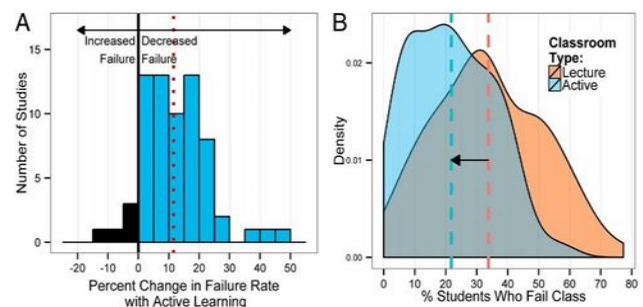


Figure 1: Changes in failure rate for active Learning vs. lecturing learning style [8]

In figure 1, diagram A showed the result of students after having a test. By using active learning, majority students decreased their failure and got improved in their results, where only minority increased rate of failure in the test due to various reasons. Diagram B showed the percentage of student who failed in the class. The dashed line showed the mean of failure rate of active learning student and lecture learning student, which are 21.8% and 33.8% respectively. From Diagram B, the study showed that students learning based on traditional lecture has higher possibility to fail. Another research conducted a massive 6000 students survey to investigate the impact of active learning on student’s education. Result is reproduced in figure 2. The figure shows that the student who used active-learning method score higher

than the student who only go through traditional lecture or lab instruction. The learning gains of active learner are obviously higher than the student study the lecture.

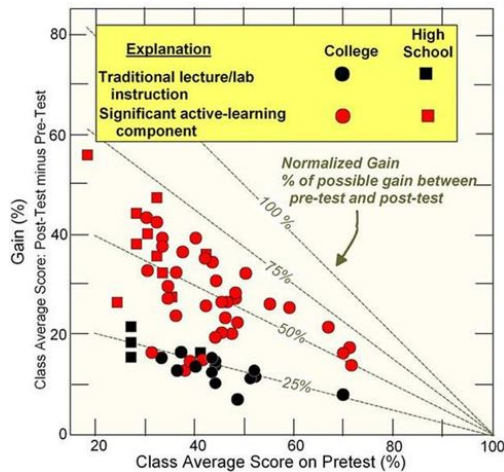


Figure 2: Impact of active learning on student’s education [9]

Based on these evidences, this study proposes the “Code Cube”, a massive open online learning platform that provides technology courses for user. It is developed using computer language PHP as both of the front end and background. This project is inspired based on the idea of active learning. The targeted user of the website includes student who are interested in learning technology. In this website, the courses are listed based on the degree of difficulties. It begins with the fundamental concept to ensure user learns from the basic. To progress to next chapter, the user needs to complete the fundamental chapters. To check the user’s understanding, an end-of-chapter quiz will be given to the user.

To promote active learning, the CodeCube includes the elements of active learning and aim to encourage student to learn more in participating. Among STEM, the development team selected Technologies as the main teaching subject of the website. The targeted user of the website includes student who are interested in learning technology. In this website, the courses are listed based on the degree of difficulty. It will first start with the fundamentals concept to make sure user learnt from basic. To progress to next chapter, the user needs to complete the fundamental chapters. To check the user’s understanding, an end-of-chapter quiz will be given to the user.

The remaining of this paper proceeds as follows. Section 2 presents related works to CodeCube, Section 3 presents the CodeCube online system, Section 4 discusses the results and finally Section 5 concludes the paper with plans for future works.

2. RELATED WORK

There are some similarity systems with CodeCube. In this section comparison is discuss in the table format. The developed website is having similar features with few online

websites, including Duolingo and w3schools. The comparison tables are shown in table 1 and table 2.

Duolingo is a language learning website which offers different language courses. It has majority features that is similar to CodeCube. Both websites implement gamification throughout their teaching process. User of Duolingo can earn extra hearts by begin a daily login strike whilst user of CodeCube can earn extra coins by doing so. However, it does not provide a calendar for user to set learning plans. Moreover, Duolingo does not have exercises that allow students to do practise during learning process. In CodeCube, the code editor is being provided for user to do code-testing while learning. Besides, CodeCube contains an active learning planner for user to pre-set their learning plan and they can view their pending tasks.

Table 1: Comparison between Duolingo and Codecube

Features	Duolingo	CodeCube
Does not contain advertisement	No	Yes
Keep user learning progress	Yes	Yes
Exercise using hands on tools	No	Yes
Active learning planner	No	Yes
End-of-module quiz	Yes	Yes
Achievement	Yes	Yes
Gamification	Yes	Yes
Login	Yes	Yes

Codecube has similar functionalities with w3schools.com. W3schools is a website for student to learn free web technologies. Although it does not have much similar features with CodeCube, the subject taught by both websites are the same. The modules in two websites are being categorized in the similar way and both contain the code editor for the user to test their code. However, differ with CodeCube, w3schools does not provide guidance along with gamification and end-of-module quiz. Besides, w3schools allows guest viewing and does not require user to login. In that case, it does not contain a database to store user account thus it will not keep user learning progress, store user achievement and provide active learning planner to user.

Table 1: Comparison between w3schools and CodeCube

Features	w3schools	CodeCube
Does not contain advertisement	No	Yes
Keep user learning progress	No	Yes
Exercise using hands on tools	Yes	Yes
Active learning planner	No	Yes
End-of-module quiz	Yes	Yes
Achievement	No	Yes
Gamification	No	Yes
Login	No	Yes

3. CODECUBE

To develop a more thorough computer language learning website, the Codecube combined the features of Duolingo and w3schools with further enhancement. CodeCube offers gamification throughout the whole learning process, as well as professional teaching materials to the user. As enhancement, the CodeCube contains a planner for user to preset their future learning plan, and also an end-of-module-quiz for user to have better understanding on how well do they understand the module. After completed all module in one course, user will be awarded with a badge, showing that he or she has unlocked the achievement.

CodeCube mainly focuses on online course learning, which enable the user to choose the course based on their preference after they had completed the basic course. This website will have own database to store user's account and keep data of user activity. With this, user can sign in to their account and continue with their progress in different places using different devices. In this website, an active learning planner is provided to user which allow the user to make future study plans. Besides user can earn game coins through learning and use it in the CodeCube website. The user can earn coins as part of rewards for performed daily login, finished one course chapter and gave review to each chapter. The coins earn can be used to purchase new course and buy hints during the end-of-chapter quiz. User needs to unlock the chapter by paying game coins. The purpose of developing this website is the support and promote the idea of active learning in a web-based application. Besides, this website act as an online learning platform for student to explore new skills and allows student to learn new things in an interactive way. With this website, more student can approach to active learning and the student's average learning outcome will be improved.

In CodeCube, all webpages will have similar layout design. The logo and menu button will be on the top of each page. A footer will be shown on the bottom of each page. When guest first enters the website, the index page is displayed. It is a long scroll page which introduce the features about the CodeCube website. It can be accessed without logging in. Figure 3 shows the user interface of CodeCube.

From figure 3, a big background image is shown and a clickable button 'Get Started' is displayed. When guest clicks on the 'Get Started' button, he or she will be redirected to the sign-up page, which will be discussed in the section afterwards. When guest scrolls down the page, it displays the 'Explore all Courses' section, which shown in figure 3. This section contains three clickable buttons which will redirect the guest to the corresponding webpage introducing the course details. Guest can view the course details, however, if he or she tries to proceed with the course learning, a pop-up message will appear, informing the guest to login first before proceeding with other step. After clicking the 'OK' button, he or she will be redirected to the login and sign-up page. In the below session of the index page, it introduced the features of the website.



Figure 3: Index page of CodeCube

3.1 Dashboard Page

After the user login to the website, he or she will be redirected to the dashboard page. A pop up will appear in the middle of the page. Figure 4 shows the webpage and the pop up message after the user login.

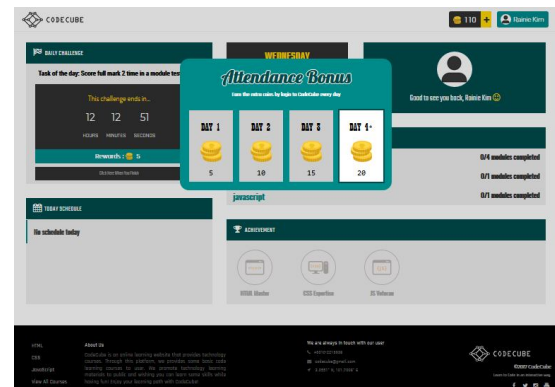


Figure 4: Dashboard display

The pop up message shows the user's attendance bonus. If the user login consecutively, he or she can get the corresponding rewards shown in the pop up message. The reward, which is the coin amount, will be automatically added to the user's coin. Figure 5 shows the example of pop up message. In this case the user had logged in to the website continuously for four days.

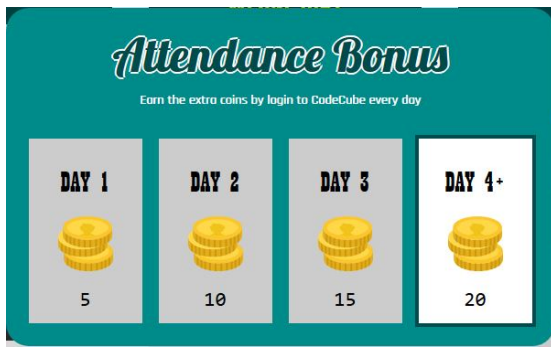


Figure 5: Attendance bonus pop-out message

3.2 Daily challenge

In this page, it shows the daily challenge. The user can earn coins as reward if he or she manage to complete the challenge within the day. A timer is shown in the box, showing the remaining time for user to complete the challenge, which is shown in figure 6. Once the user completed the challenge, he or she can click on the 'Click Here When You Finish' button and claim the rewards.

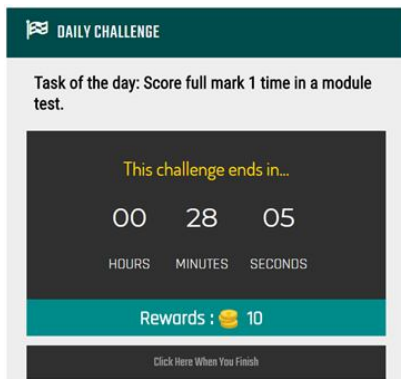


Figure 6: Daily challenge task timer

After the user clicks the button, he or she will be redirected to a page with a pop up message in the middle. This pop-up message informs the status of user claiming reward and if the user tries to claim reward without completing the challenge, a pop up message will be shown user will not be able to get reward. After the user completed the challenge and claimed the reward, the timer will not be showed and replaced with a 'Completed' icon as shown in figure 7. New challenge will be appeared after 24 hours.

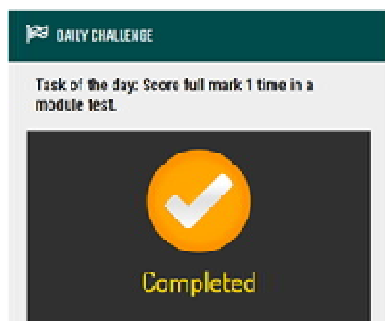


Figure 7: Daily challenge completed

3.3 Today Schedule

Today Schedule shows the user schedule of the day. To set a schedule, user needs to go to the 'Planner' page. From there, the today schedule filtered the schedule planned on the day and display it on the dashboard page, which is shown in figure 8 and if there is no schedule set on the day, it will display the today schedule, planned on the day and display it on the dashboard page, which is shown in figure 8 and if there is no schedule set on the day, it will display the today schedule.

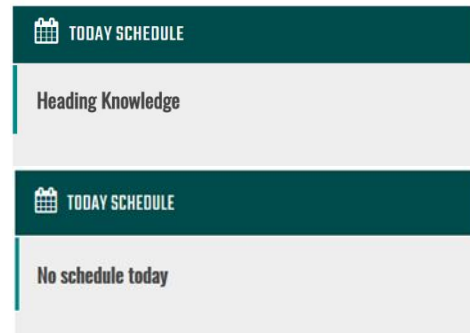


Figure 8: Sample of today schedule task

3.4 Progress Summary

In progress summary, it listed the module completed by user in each course, which is shown in figure 9.



Figure 9: Progress summary of the students overall on all modules

3.5 Achievements

The achievement section will display the achievement badges. Figure 10 shows the badge that user earned will be displayed with blue border, whilst others will be displayed in grey. To unlock achievement and earn the badge, user needs to complete all the modules in the particular course.



Figure 10: students track their achievements

When the user hover over the badge, a message will be shown, telling the user about the badge details. Figure 11 shows the example when user hover over an earned badge shows the example when user hover over a badge that have not being unlocked.



Figure 11: Mouse over comments

User’s coin amount and the username will be displayed at the top right corner of the header as shown in figure 12. Each user also has their own user interface. Figure 13 shows an example.

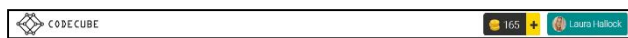


Figure 12: Coin amount and user name

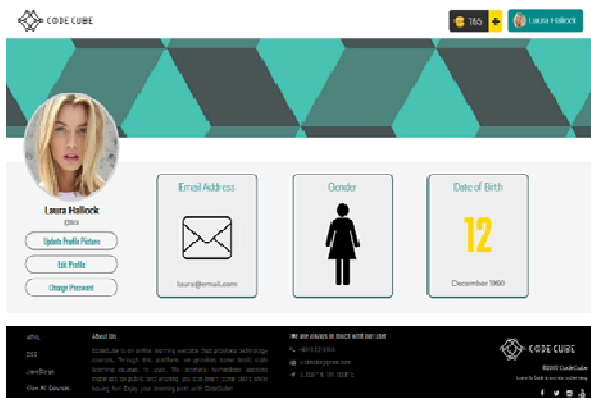


Figure 13: User profile page

From the menu bar, user can click on the ‘My Profile’ icon to go to the User Profile page. In the User Profile Page, it shows the user personal details. On the left, it shows the user’s profile pictures and username. On the right, three boxes displaying user’s email address, gender and date of birth. Upon completing the course, the following menu as shown in figure 14 will pop up and users can decide which task they want to continue.

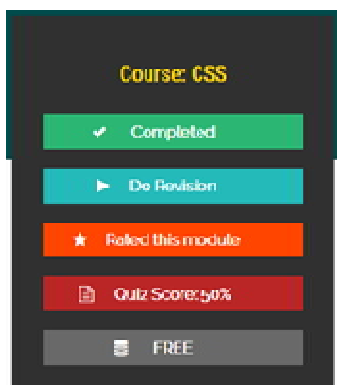


Figure 14: Course on CSS and other options to choose

4. RESULTS AND DISCUSSION

User acceptance testing was carried out for CodeCube system, Questionnaire about the website is being prepared as to collect user feedback and responses after using the CodeCube website. In the questionnaire, it contains four simple questions where the interviewee is able to answer it without any guidance. The interviewee of this questionnaire are the students who currently studying at Asia Pacific University. Since the questionnaire is prepared using google form, the hyperlink is sent to the interviewee and the feedback collected are being analyzed by Google form. A total of 33 responds answered the acceptance testing.

The first question was on this is to investigate the study field of the interviewee thus further analyze in which field the interviewee will have what response.

Please select your field of study

33 responses

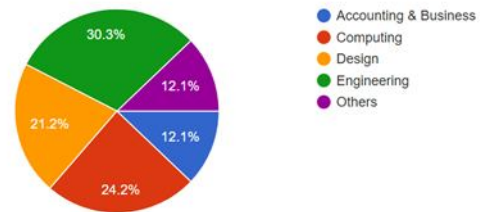


Figure 15: Demographic information on students background

The result for question 1 is being displayed in a pie chart shown in above. From this chart, it shows that the questionnaire has most interviewee who studying in Engineering course (30.3%), followed by Computing course (24.2%) and Design (21.2%). Among all field of study listed in the questions, least interviewee is currently studying the Accounting & Business course and Other courses which are not in the list (12.1%) as shown in figure 15

For the second question ask was a simply true or false question. This question asks the interviewee about does the quiz matches with the teaching material. This is to know whether the syllabus of the module content having the same standard with the level of the end-of-module quiz.

From your opinion, is the end-of-module quiz relevant to the teaching material?

33 responses

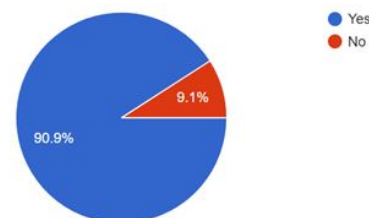


Figure 16: Results by user on the Yes or No question.

The result is being displayed in a pie chart shows that majority of the interviewee (90.6%) thinks that the end-of-module quiz matches with the module content. Only 1 user (9.1%) disagree with the statement. From the result shown, only one user does not think that the end-of-module quiz is relevant to the teaching material. Thus, the CodeCube website may adjust the degree of difficulty of the quiz or implement a more suitable module content as shown in figure 16.

The third question asks the interviewee about which part of the website function can be improved based on their personal opinion. It allows user to select more than one check box. This is to get feedback from user about which function of the website can be further improved. The result is being displayed in a bar chart shown in figure 17.

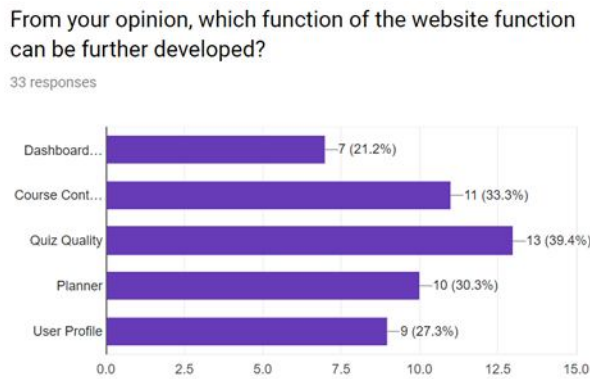


Figure 17: Users respond on which components they are not satisfied

From the chart, among all website function, the function which most interviewee voted to be further developed is the Quiz Quality (39.4%), followed by the Course Content (33.3%), Planner (30.3%) and User Profile (27.3%). Dashboard Arrangement received least votes, which is only 21.2%. From the result, the website function which should be further improved is the Quiz Quality. Thus, evaluation and improvement should be made as to make users to have better experience.

From the scale of 1 to 5, how satisfy are you with the website in general?
33 responses

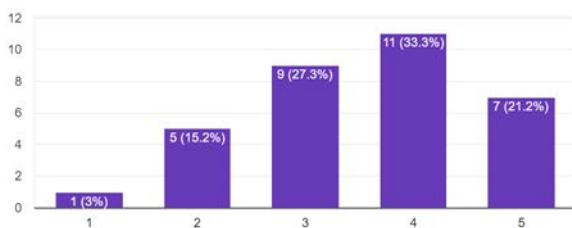


Figure 18: Level of satisfactory on the overall CodeCube system

The last question was on the satisfaction of using the website based on their experience. They can rate from 1 to 5, which 1 refers to totally not user-friendly, and 5 refers to extremely

user-friendly. This is to understand the interviewee’s experience while using the website. The result is being displayed in a bar chart shown in figure 18.

From the chart, it shows that majority interviewee (33.5%) rated ‘4’ for the website, which means fairly user-friendly. The second highest result is ‘3’, which means somewhat satisfied (27.3%), and the third highest is ‘5’, which is extremely user-friendly (21.2%). Among 5 scales, least interviewee voted ‘1’, which is totally not user-friendly (3%). In this question, only 1 user vote for the totally not user friendly. Through evaluation, majority user has a fairly good experience while using the website, however this website still has the space of improvement.

5. CONCLUSION

Future enhancement of this CodeCube online website could add new platform for users like forum. A new function which is the Online Class Group will be added. User can add other user as friend and create an online class study group in the website. Other than admin and user, a new user type, which is the instructor will be added to the website. Instructor needs to be registered with qualified certificates as evidence of an educator. He or she can upload new teaching material, start online and start online class group. Users will be able to retrieve their password in future. A ‘forget password’ button will be added in the login page. The website will send email to users if they have not been signed in to the website in the over past 14 days. It helps to remind the users to continue their learning progress. User will be able to purchase coin with online transaction system. User can see a ‘Add’ symbol beside the coin amount displayed on the header, after clicking on the button, a user is able to purchase different coin amount according to his or her preference To enable user to purchase coins, this website needs to collaborate with the banking system. As conclusion CodeCube Online System has its limitations but the acceptance by users is good. With more add on future and testing, this system could be used by more universities.

ACKNOWLEDGEMENT

This project is sponsored by Asia Pacific University of Technology and Innovation. The authors would like to credit Pauline Chon Zee Hui, Heng Chin Yee, Ngo Hui Ann in the development of the system.

REFERENCES

- [1] University of Minnesota, 2017. cei.umn.edu: “**what is active learning**” [Online] Available at: <https://cei.umn.edu/support-services/tutorials/what-activ-e-learning>
- [2] Anderson, W. L., Mitchell, S. & Osgood, M. P., 2005. “OnlineLibrary.com: **Comparison of Student Performance in Cooperative Learning and Traditional Lecture-Based Biochemistry Classes**”. [Online] Available at: <http://onlinelibrary.wiley.com/doi/10.1002/bmb.2005.49403306387/full>

- <https://doi.org/10.1002/bmb.2005.49403306387>
- [3] Brian, D., Lorne, B., Alexander Serenki & Heidi , J., 2012. **“Student Perceptions of Information Literacy Instruction: The Importance of Active Learning”**. [Online] Available at: <https://eric.ed.gov/?id=EJ1001900>
- [4] Thiam, P., Meudt, S., Palm, G. and Schwenker, F., 2017. **“A Temporal Dependency Based Multi-modal Active Learning Approach for Audiovisual Event Detection”**. Neural Processing Letters, pp.1-24. <https://doi.org/10.1007/s11063-017-9719-y>
- [5] García-Holgado, A., García-Peñalvo, F.J. and Rodríguez-Conde, M.J., 2018, April. **“Pilot experience applying an active learning methodology in a Software Engineering classroom”**. In Global Engineering Education Conference (EDUCON), 2018 IEEE (pp. 940-947). IEEE.
- [6] Eison, J. A. & Bonwell, C. C., 1991. **“Active Learning: Creating Excitement in the Classroom”**. [Online] Available at: <http://ericae.net/db/edo/ED340272.htm>
- [7] Caceffo, R., Gama, G. and Azevedo, R., 2018, February. **“Exploring Active Learning Approaches to Computer Science Classes”**. In Proceedings of the 49th ACM Technical Symposium on Computer Science Education (pp. 922-927). ACM. <https://doi.org/10.1145/3159450.3159585>
- [8] Freeman, S., 2003. **“Active Learning increases Student Performance in Science, Technologies, Engineering and Mathematics. Study of Active Learning”**, 111(23), pp. 8410-8415. <https://doi.org/10.1073/pnas.1319030111>
- [9] Richard, H., 1998. **“Interactive-engagement versus traditional methods. A 6,000 student survey of mechanics test data for introductory physics courses”**, 66(7), pp. 64-74. The PHP Group, 2018. [Online]Available at: <http://php.net/manual/en/function.mktime.php>. <https://doi.org/10.1119/1.18809>