Effective Application and Impact Assessment of STAD in Engineering Education

[1]Nathgosavi Kiran M., [2]Kumbhar Sachin S.
[1,2] Assistant Professor, Department of Electrical Engineering, Rajarambapu Institute of Technology, Sakharale, MS-415414, India
[1] kiran.nathgosavi@ritindia.edu
[2] sachin.kumbhar@ritindia.edu

***Abstract*— Students Team Achievement Division (STAD) is a group-based learning method that encourages students to work together and share knowledge. In this method, every student's contribution is valued and helps the team achieve its goal. This paper discusses how the STAD technique was effectively applied in an important engineering programming subject. The main aim of this paper is to show how STAD improved both student performance and classroom participation. The paper also highlights a detailed assessment of STAD's impact, which is done in three ways. The performance of 48 students before and after using STAD was analyzed by calculating the percentage improvement and conducting a paired t-test to check statistical significance. Apart from this, feedback from students was collected to understand their views and overall experience of this activity. The results clearly show a significant improvement in student performance, as seen in the increased marks and positive findings from the t-test analysis. Additionally, students' feedback highlighted better engagement in class and improved understanding of programming concepts through this method.**

***Keywords*— Students Team Achievement Division (STAD), Paired t-test analysis, Percentage improvement, programming subjects.**

***ICTIEE* Track*:* Pedagogy of Teaching & Learning**

ICTIEE Sub-Track: Pedagogy for the Modern Classroom – Strategies for Engaging Students thorough AI

I. INTRODUCTION

EDUCATION plays an important role in the development of country. Curriculum, delivery, and assessment are the three main aspects of the education system. Indian government invests more in the education sector as it acts as the backbone of the country. Nowadays it is essential to have an education system that focuses on the overall development of students. In a traditional education system, students used to memorize content delivered by the teacher. In addition to that teachers also focus on subject content only. To become successful in the 21st century, the education system must have active teaching and learning which can be possible by increasing students' attention, practical skills, and participation.

In technical education social and intellectual development of students happens through teamwork to make them lifelong learners (Motwani et al., 2022). Peer-assisted cooperative learning (PACL) is a way to conduct various group activities during lectures for students such as discussions, presentations, and mini-projects. The PACL activities enhance the active participation of students and help to achieve cognitive, emotional, and psychomotor growth. In addition to that, there will be improvement in skills required to work effectively in a team (Bugaj TJ et al. 2019; Guraya SY et al. 2020).

Student Team Achievement Division (STAD) is an effective collaborative learning technique that helps to achieve the academic, and social development of students. In STAD activity students need to work together in a small group to achieve holistic development of each group member as well as team. STAD implementation for an important subject civic in a school is presented in (Yulianda et al., 2023) to enhance the critical thinking of students. The author carried out qualitative descriptive research on data collected through observations and interview questions. The author faced various difficulties in implementing STAD for civic courses such as a lack of motivation, and time to give guidelines and rewards to students. The application of STAD to enhance the English speaking of students in a high school for XI class is presented in (siti et al., 2023). The author mentioned that the pandemic affects communication because of a lack of practice and collaboration. After the implementation of STAD, it was observed that students' communication and confidence improved in English public speaking. Carrying out STAD in medical education is presented in (Kusuma et al., 2023). The author selected dental keychains as a topic of this activity and showed impact through increased knowledge about dental and oral health. Impact analysis carried out by the author in both descriptive and statistical ways has been effectively presented.

To improve affection and cognition about mathematics STAD plays an important role (Gaikwad P. et al., 2024; Rachna, 2024; S. Kep et al., 2024). The author effectively presents a step-by-step implementation of STAD in a blended form with Problem-Based Learning (PBL). It has been claimed that the blended mode activity helps to improve results from 73.54% to 87.07%. Reference (Lilis et al., 2022) presents how STAD enhanced course outcomes in an economics subject. The study was conducted in two steps to collect data from annotations and tests. Analysis shows that STAD impacted improvement in average marks. Effective lesson plans, proper selection of learning media, and optimum evolution planning

Mr. Nathgosavi Kiran M.
Assistant Professor, Department of Electrical Engineering, Rajarambapu Institute of Technology, Sakharale. MS-415414, India
kiran.nathgosavi@ritindia.edu

can enhance the implementation of STAD is a key finding of this article.

STAD is a group-based effective cooperative technique to promise group learning which highlights learning through social discussion where each student's contribution is responsible for his or her learning to achieve team goals as well as helping and motivating others to achieve the same. STAD is an activity that produces change in teaching from knowledge transmission to development. As students work in a team they feel positive about their peers and themselves which indirectly learning outcomes and social skills (Aryanti et al., 2020; Mulyana et al., 2023).

Application of STAD in programming subjects was not done or presented before. However, many articles proved that academic improvement because of STAD activity in school or high-school-level subjects. There are very few articles to present the impact of STAD in core engineering subjects. This paper presents the application of STAD activity in T. Y. B. Tech. Electrical Engineering class for Microprocessor and Microcontroller subject. The main contribution of this paper is to present the application of STAD for programming courses with an effective impact analysis from the academic and social development point of view. The objective of this article is to present an effective way of STAD employment as well as a direct and indirect impact analysis of STAD activity.

II. METHODOLOGY

The simplest, well-researched, and upfront active teaching-learning technique is STAD (Yeung, H. C. H, 2015). It has five components, content delivery by a teacher, team formation, pre & post-assessment, improvement analysis, and team recognition. The step-by-step procedure of STAD implementations is shown in Fig. 1.

1) **Content Delivery**: An appropriate topic has to be selected by a faculty for this activity. The topic should have a moderate difficulty level with the scope of learning from discussion i.e. collaborative learning.
2) **Team Formation**: This is an important step in a STAD activity. The team plays an important role in achieving the objectives of this activity. Hence few guidelines to be followed while forming a team i.e. team should not have more than 4 members, team should be heterogeneous.
3) **Pre & Post Assessment:** After content delivery by the faculty there should be a pretest. Based on the marks of that test heterogeneous groups have to be formed. Appropriate time has to be given to team study and after that post-tests for individuals need to be carried out. To conduct these tests various active teaching learning tools can be used.
4) **Result Analysis**: To validate outcome achievements proper analysis of the results of pre and post-tests needs to be done. The analysis may be manual or software-based. It should be accurate, simple, and measurable. The analysis focused on individual as well as team improvement.
5) **Team Recognition**: From the analysis best team is to be selected and recognized for percentage improvement in pre and post-test scores. Recognition is important to motivate students to be more and more active during a lecture and take part in such active teaching-learning activities.

A. *Actual Implementation & Data Collection:*

STAD activities were planned and implemented for T. Y. B. Tech. Electrical Engineering class for Microprocessor and Microcontroller subject during lecture hour on 27th Sept 2023. From this subject addressing mode of 8051 microcontroller topics were selected. 8051 has 49 mnemonics which can be represented in 255 syntaxes. This means there are 255 instructions available for the 8051 microcontroller.

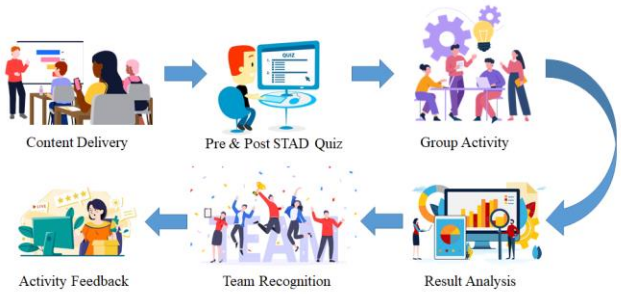

Fig. 1. STAD implementation procedure

It is very difficult to remember all 255 instructions to write a program in assembly language. Hence the best way to address this issue is to understand the addressing mode of instructions. A 15-minute lecture on addressing mode with its examples was delivered at the beginning of the lecture. After that, an online quiz (Pretest) on the same topic was conducted by using Sli.do platform. Fig. 2 shows a quiz on Sli.do platform. Sli.do provide an effective and easy way to conduct quizzes attractively.

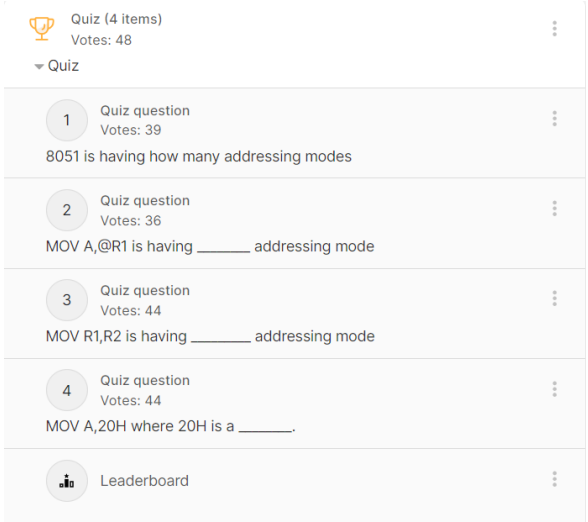

Fig. 2 Quiz on Sli.do

After this pre-test, STAD activity gets announced in a class. The faculty also elaborated to all the students about STAD activity and its implementation procedure. On that day there were 48 students present in a lecture. Faculty appealed to students to form a heterogeneous group of 4 students each. To ensure groups are heterogeneous following conditions were

given to students,

- The group should have at least one girl student.
- The group should have at least one high cumulative performance index (CPI) student
- The group should have at least one low-CPI student

Once student forms their groups and rearrange themselves in a class 10 minutes are given to them to discuss and have peer learning on the same topic. Fig. 3 shows the team study activity. After the allotted time individual quiz has been conducted again on the same topic by using the same platform for same marks.

Fig. 3 Student team study activity

Result analysis done based on individual and team marks percentage improvement. Equation (1) is used to find the percentage improvement. A team having a high percentage improvement in their total marks is considered a winning team.

$$\%\ Improvement = \left[\frac{B}{A} - 1\right] \times 100 \qquad \ldots(1)$$

Where,

A – Pretest Marks

B – Posttest Marks

The winning team was congratulated in front of all the students. In addition to that as the name suggested for this activity i.e. team achievement division special appreciation was also given to students who achieved a high percentage improvement in their marks. At the end of the STAD activity students' feedback has been taken by using Google form. This feedback plays an important role in identifying lacunas in STAD implementation and making improvements in the future. It has been understood that time management plays an important role in the application of STAD during lectures.

III. Results & Discussion

In this section result analysis is done by using three ways,

1. Percentage Improvement Analysis
2. Paired t-test analysis
3. Feedback analysis

A. Percentage Improvement Analysis

STAD activity was first experienced by T. Y. B. Tech. Electrical Engineering students. Result analysis was done based on the collected data through pre & post-tests. Fig. 4 shows quiz results with a % improvement. Based on individual marks of students in both pre and post-test following understandings made,

- 91.67 % of students have improvement in their marks
- 33 % to 200 % individual improvement were there in student performance
- 333% Improvement in the number of students with the highest marks. i.e. in the pretest, only 6 students achieved the highest score but in the posttest 26 students achieved it.

Fig. 5 shows a bar chart of the number of students according to marks in pre and post-tests respectively. It is observed that the number of students improved to get higher marks. From this result, it is claimed that STAD activity is more effective in the case of slow learners. After the STAD activity, none of the students score 1 mark.

STAD is a team activity and hence team results were also analyzed. % improvement in team performance is shown in Fig. 6 by using a bar chart. From Fig. 4 & 6, it is observed that there are groups having improvement from 18 to 86 %.

Roll No.	Before STAD	After STAD	% Improvement
2258004	4	4	0
2108023	2	3	50
2108052	3	4	33
2106073	2	3	50
G1	11	14	27

Roll No.	Before STAD	After STAD	% Improvement
2258005	4	4	0
2258011	2	3	50
2108019	3	4	33
2108027	2	4	100
G4	11	15	36

Roll No.	Before STAD	After STAD	% Improvement
2108072	4	3	-25
2108025	2	4	100
2258007	3	4	33
2108060	1	4	300
G7	10	15	50

Roll No.	Before STAD	After STAD	% Improvement
2108042	3	4	33
2008053	2	4	100
2108043	3	3	0
2108003	1	2	100
G10	9	13	44

Roll No.	Before STAD	After STAD	% Improvement
2108039	4	4	0
2108041	2	4	100
2108062	3	4	33
2258013	2	3	50
G2	11	15	36

Roll No.	Before STAD	After STAD	% Improvement
2108013	4	3	-25
2258009	2	3	50
2108018	3	4	33
2108015	2	3	50
G5	11	13	18

Roll No.	Before STAD	After STAD	% Improvement
2108020	4	3	-25
2258003	2	3	50
2258012	3	4	33
2108067	1	2	100
G8	10	12	20

Roll No.	Before STAD	After STAD	% Improvement
2108033	3	3	0
2108029	2	4	100
2108009	1	3	200
2108037	1	2	100
G11	7	12	71

Roll No.	Before STAD	After STAD	% Improvement
2108053	3	4	33
2108044	2	3	50
2108069	3	4	33
2108028	1	3	200
G3	9	14	56

Roll No.	Before STAD	After STAD	% Improvement
2258015	3	4	33
2108017	2	4	100
2108070	3	3	0
2108005	1	3	200
G6	9	14	56

Roll No.	Before STAD	After STAD	% Improvement
2258006	3	2	-33
2108004	2	4	100
2258002	3	4	33
2102004	1	3	200
G9	9	13	44

Roll No.	Before STAD	After STAD	% Improvement
2108016	3	4	33
2108032	2	4	100
2108030	1	2	100
2108026	1	3	200
G12	7	13	86

Fig. 4 STAD Activity Result

Group number 5 had less % improvement i.e. 18% only on the other hand group number 12 had the highest % improvement

i.e. 86%. As per STAD methodology, a group who is having highest improvement is considered as winning group. In that group, all students have improvement after team activity. Roll number 2108026 achieved 200% improvement as he scored 1 mark in the pretest and 3 marks in the post-test.

B. *Paired t-test Analysis*

In addition to that paired t-test analysis (Kumbhar S et al., 2024) was also presented to validate the impact of STAD activity. This statistical method is ideal for comparing the results of the same group of students on two different quizzes. By using this paired t-test, it can be determined whether the STAD technique had a significant impact on the student's performance or not.

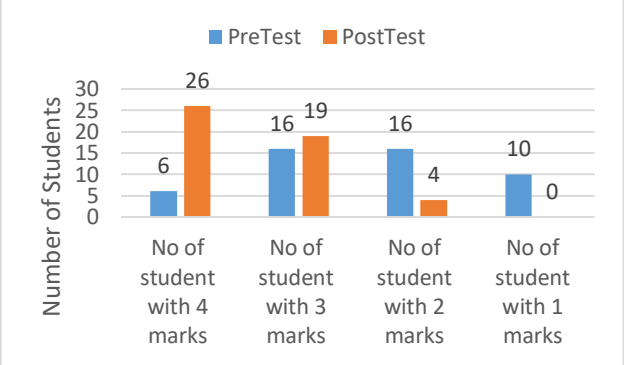

Fig. 5 Student performance in pre & post-test

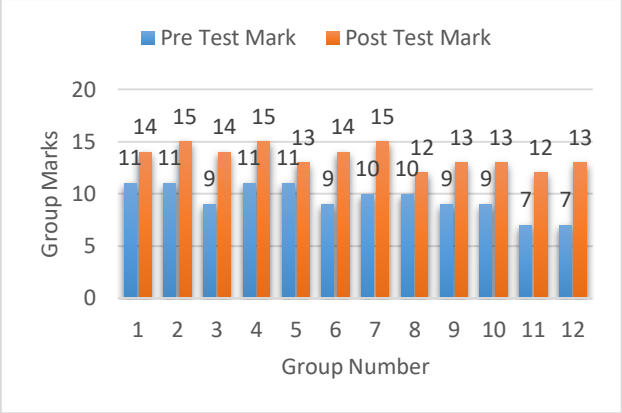

Fig. 6 Group performance in pre & post-test

1) *Hypothesis formulation*

A hypothesis is a statement that provides the suggested explanation for something that has not yet been proven or found. Although anyone can formulate a hypothesis based on the available data, verifying it is the real challenge. The null hypothesis (H_0) and the alternative hypothesis (H_1) are the two primary types of hypotheses considered for the analysis. The null hypothesis assumes that there is no significant difference or effect between the selected variables as given in equation (2). On the other hand, the alternative hypothesis states that there is a significant difference or effect between the selected variables or it disproves the null hypothesis as given in equation (3).

$$H_0 = \cup_1 = \cup_2 \quad \ldots(2)$$

Where,

$\cup_1$ = The marks of the initial quiz conducted before the implementation of the STAD team task.

$\cup_2$ = The marks of the final quiz conducted after the implementation of the STAD team task.

The given null hypothesis for this case tells that the results are unchanged, indicating that there is no significant difference between the two results with and without the implementation of the STAD technique. This scenario is unbiased.

$$H_1 = \cup_1 \neq \cup_2 \quad \ldots(3)$$

The alternative hypothesis states that the test marks before and after applying the STAD are not the same. It is safe to say that the null hypothesis has failed when the alternative hypothesis stands, after analyzing the results. Also, one can say that there is a significant difference between the results of the two quizzes taken before and after the implementation of STAD if the alternative hypothesis stands.

2) *IBM SPSS for paired t-test*

The IBM SPSS software is used for the analysis of results using the paired t-test method. In a paired t-test analysis, the p-value helps to determine whether there is a significant difference between two variables or not. A low p-value (typically less than 0.05 or 5%) indicates that there is a statistically significant difference, or they are not similar to each other.

Confidence levels are always expressed as percentages (such as 95% or 99%). For example, a 95% confidence level means that if the test is repeated many times, the results will fall within the same range 95% of the time. In other words, there is a 5% chance that the observed difference is due to random variation rather than a true effect. This analysis is based on the 95% confidence theory. It means that if the p-value or the significance value is less than 5% then the null hypothesis is rejected and the alternative hypothesis stands.

The results can be calculated by hand but due to complex calculation, it is effective to use the IBM SPSS software for the analysis of the results. This software is easy to use and will get results on a single click, but it is paid. In this software, two columns are used. In one column the marks obtained before the STAD team activity are added i.e. "Pretest". The other columns consist of the marks obtained after the STAD team activity test i.e. "Posttest"

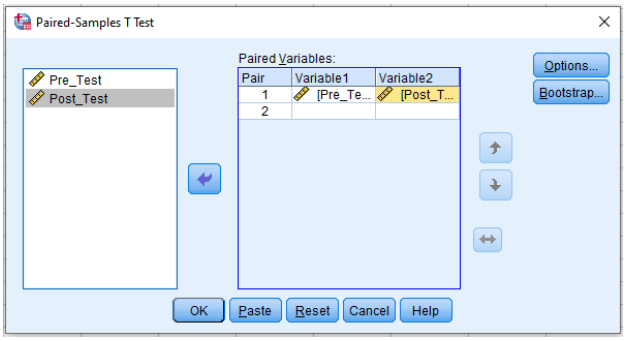

Fig. 7 Paired t-test block in SPSS

The total 48 students' marks data is added in two columns in the software. The maximum mark for both tests is 4. The paired t-test block in IBM SPSS software is shown in Fig. 7. This tool is easy to use as compared to the ANOVA which is also present in the same software. In this, variable 1 is considered a "Pretest" and variable 2 is considered a "Posttest" and added in the paired variable section from the left section as shown in Fig. 7. After adding up the variables and clicking the OK will display the results.

Table I shows the descriptive paired sampled statistics. The

table shows that N= 48 for both the tests as the total number of students count was 48. The mean plot between the two variables (Pretest and Posttest) is shown in Fig. 8.

TABLE I
PAIRED SAMPLED STATISTICS

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest	2.38	48	0.959	0.138
	Posttest	3.40	48	0.676	0.098

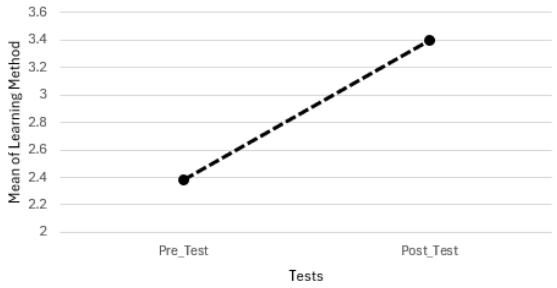

Fig. 8 Mean plot of analysis.

The mean of the two Pretest and Posttest are 2.38 and 3.40 respectively. The mean of the post-test is higher than the Pretest as the overall marks are greater in the post-test. This reading and understanding of the mean are the primary observations of the statistics. It is not safe to comment on the hypothesis according to the mean values of both tests only.

TABLE II
FINAL PAIRED T-TEST ANALYSIS

Mean	Std. Deviation	Std. Error Mean	95% confidence interval of difference		T	df	Sig (2 Tailed)
			Lower	Upper			
-1.02	0.911	0.131	-1.28	-0.75	-7.7	47	0.00

The final paired t-test result is given in Table II. The t value is negative and equal to -7.766, it shows there are significant differences in the two variables and the STAD is more efficient. If the t value comes in positive, then the pretest performance is more efficient than the posttest. The significance value that is present at the end of the table is 0.000 or nearly equal to the 5.7008E-10 obtained. As discussed in the earlier section this analysis is based on the 95% confidence theory. According to the said theory, the alternative hypothesis stands, and the null hypothesis is rejected if the significance value comes below 5%. As the value is below 5%, the H_1stands and H_0rejected which is given in equation (4) and i.e.

$$H_1 = \cup_1 \neq \cup_2 \quad \ldots(4)$$

The overall conclusion from the results is that there is a significant difference between the two variables. It means the STAD technique is efficient in producing an impact on pre and post-test marks.

C. Feedback Analysis

Student feedback on this activity was taken by using Google Forms. This feedback shows the effectiveness of STAD activity from actual stakeholders i.e. students.

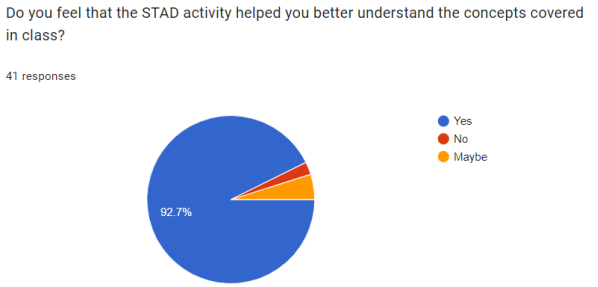

Fig. 9 (a)

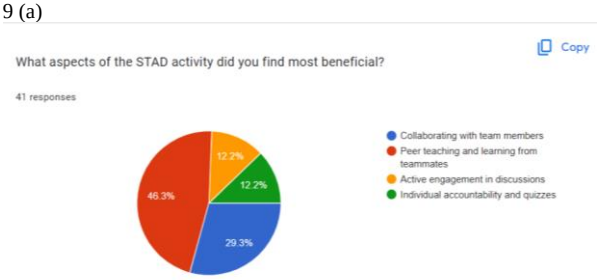

Fig. 9 (b)

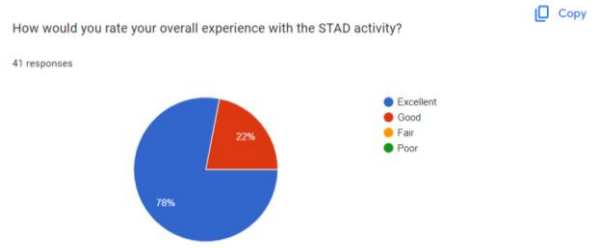

Fig. 9 (c)

Fig. 9 Feedback of (a) concept understanding, (b) STAD activity, and (c) overall STAD experience

Students have also given their valuable comments regarding this activity. A few comments are: *"More such activities should be taken", "Very nice concept from learning concepts from a teammate", and "Activity is good but it consumes more time".* Apart from the comments, it is easily found from Fig. 9 (a), (b), (c) that the STAD activity was liked by all students. During the lecture, while conducting the STAD activity it was observed that students' involvement in the lecture improved, and their interaction with peers was enhanced which will result in the transformation in behavior as an enhancement of self-esteem.

It is found that there are benefits of STAD activity beyond academics. Such as enlightening meaningful social collaboration in a team, and collectively subsidizing to augment and improve cooperative learning.

CONCLUSION

The use of STAD in programming lectures has shown a positive impact on students' academic and social performance. Quantitative assessments revealed that 91.67% of students improved their academic performance, with a paired t-test showing a t-value of -7.766 and a significance value of 0.00, confirming STAD's effectiveness in enhancing learning outcomes. Student feedback highlighted active participation, motivation, and enjoyment during lectures, leading to better understanding of programming concepts. Along with academic improvement, STAD also promotes teamwork, helping students

develop better social behavior, feel positive about themselves, and build stronger connections with their peers.

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REFERENCES

Motwani R, Kaliappan A, Chandrupatla M. (2022) Student Team Achievement Division as a tool for peer-assisted co-operative learning in neuroanatomy. AnatCellBiol 2022; 55: 452-458. https://doi.org/10.5115/acb.22.122

Bugaj TJ, Blohm M, Schmid C, Koehl N, Huber J, Huhn D, Herzog W, Krautter M, Nikendei C. (2019) Peer-assisted learning (PAL): skills lab tutors' experiences and motivation. BMC Med Educ

Guraya SY, Abdalla ME. (2020) Determining the effectiveness of peer-assisted learning in medical education: a systematic review and meta-analysis. J Taibah Univ Med Sci.

Yulianda, Putri., Ranti, Nazmi., Budi, Juliardi. (2023). Implementation of the Cooperative Learning Learning Model Type Student Teams Achievement Division in Enhancing Students' Critical Thinking. Jurnal Pendidikan Amartha, 2(2):88-95. doi: 10.57235/jpa.v2i2.608

Siti, Rubaeah., Muhammad, Andriana, Gaffar. (2023). Implementation of The Student Team Achievement Division (STAD) to Develop Student Skills in Explaining Orally Natural Phenomena. JIIP (Jurnal Ilmiah Ilmu Pendidikan), 6(8):5687-5697. doi: 10.54371/jiip.v6i8.2560

Ika, Kusuma, Wardani., Deby, Kania, Tri, Putri., Nurul, Fitriyani, Dewi., Fatma, Kirana., Aulia, Rahimah., Fatimah, Maulideya., Jamilatun, Nisa. (2023). Educational Dental Keychains Application in Student Team Achievement Division: Implementation of Dental and Oral Health Promotion. Jurnal Kreativitas Pengabdian kepada Masyarakat, doi: 10.33024/jkpm.v6i10.11496

Gaikwad, P., Bobalade, D. D., Mandale, M. B., Bhujakkanavar, U., Patange, S., & Sabale, S. R. (2024). Enactment and impact analysis of active learning strategies utilized for the basic science courses in the evaluation of engineering students. Journal of Engineering Education Transformations, 37(Special Issue 2).

Rachna Desai (2024). Using STAD as an Assessment for Learning (AfL) in Mathematics. Journal of Engineering Education Transformations. 37(2):993-997 DOI: 10.16920/jeet/2024/v37is2/24150

S.Kep., Dewi, Suryandari. (2024). Student Team Achievement Division for Underachiever in Learning Mathematics among Indonesia Public Senior High School Students. Journal of Education Research, doi: 10.37985/jer.v5i2.1181

Lilis, Setiyo, Rini., Sridiyatmiko, Gunawan., Palupi, Sri, Wijayanti., Fitri, Jamilah. (2022). Efforts to Increase Motivation and Outcomes of Learning About Economic Activities Through Implementing the STAD Cooperative Learning Model. KnE Social Sciences, doi: 10.18502/kss.v7i14.12035

Aryanti, Y., & Widodo, E. (2020). The effectiveness of Student Team Achiement Divisions (STAD) cooperative learning in science learning on analysis skills and social skills. Journal of Science Education Research, 4(1), 22-27

Mulyana, F. R., Juniar, D. T., Malik, A. A., Mulyana, D., & Hanief, Y. N. (2023) The Influence of Cooperative Learning Models and Learning Styles on Social Skills in University Student. International Journal of Disabilities Sports and Health Sciences, 7(Special Issue 1): International Conference on Sport Science and Health (ICSSH, 2023)), 9-18.

Yeung, H. C. H. (2015). Literature review of the cooperative learning strategy-student team achievement division (STAD). International Journal of Education, 7(1), 29-43.

Kumbhar, S. S., & Kalkhambkar, V. N. (2024). Student Learning Improvement using Collaborative Presentations and Knowledge Sharing. Journal of Engineering Education Transformations, 37(Special Issue 2).