Assessment of Learning: Student Teams Achievement Division Technique for Empowering Students in Problem-Solving Courses

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***Abstract*— Nowadays, there is a growing interest in group activities as interdisciplinary and teamwork raises effective learning among the students than the conventional teaching methodology. It has become a huge challenge to foster learning interest among students and engage them during long hours of problem-solving courses. This study explores the effects of Student Teams Achievement Divisions (STAD) as a cooperative learning technique in classroom teaching, on student learning experiences focusing on engineering students' learning experiences within team dynamics. Through an online survey question, (n=89) responses were collected that included four main categorical questions. The questions were divided into the following four input attributes such as 'Student – Professor Interaction', 'Student – Team Interaction', 'Learning Tool' and 'Assessment Methodology' and each of these inputs were further divided into sub attributes. Regression analysis and correlation was examined to analyze the association between the inputs and the Student Learning Experience as the output for the purpose of this research. The findings indicate that STAD promoted positive correlation with (R2 = 0.71) on student learning experience for the input attributes like 'Student – Team Interaction' and (R2 = 0.77) for 'Assessment' respectively where the students exhibited problem solving skills particularly in the context of the control systems course, suggesting that STAD methodology fosters a conducive environment for active learning and motivation within engineering education.**

***Keywords*— Student Teams Achievement Division, collaborative learning, Student engagement, Student satisfaction, correlation coefficient.**

ICTIEE* Track*: Assessment of Effective Learning

ICTIEE Sub-Track: Assessment for Learning: Empowering Students through effective Assessment Practices

I. INTRODUCTION

Technical expertise and knowledge do not automatically guarantee a student a job. The demands of today's industries are multidisciplinary. By conversing and working in teams with students from other disciplines, an engineering student from one field can learn from another. In this regard, teachers have a big responsibility to create student-cantered approaches in the content delivery techniques and to implement effective teaching and learning tools to evolve the students in such team-based activities (Laal, 2013). In today's classrooms, collaborative learning is a well-known active-based teaching tool. The performance of a collaborative activity is more impressive than an individual contribution (Li et al., 2021; Yurtseven Avci et al., 2022). In general, group work fosters strong teamwork, communication, problem-solving, idea sharing, emotional intelligence, and stress management abilities that the student can use throughout their life. Several academic studies have shown that, regardless of the students' limitations, collaborative learning is directly related to student motivation and interest in learning (Yang, 2023; Zabolotna et al., 2023). Due to this, educators all over the world have employed a variety of collaborative learning strategies, including think-pair-share, the jigsaw method, tournaments for teams, student teams' achievement division (STAD), and many others.

Out of the many collaborative learning approaches, STAD is one that has been widely employed by numerous teachers in a variety of educational organizations to improve the abilities of the learners. The term STAD, which stands for Student Teams Achievement Division, is mostly used in the curriculum to

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enhance student performance on group tasks. With this approach, teams of four to five people usually work together in heterogeneous groups with members of various genders and education level (Mendo-Lázaro et al., 2022). The primary goal of STAD is to aid team members in improving one another's reasoning ability. The teacher teaches a topic and then provides necessary materials to learn within the team. The teacher makes sure that the team communicates with one another, gains knowledge from one another, and understands the idea. Before and after the teamwork, individual quizzes are given; the results

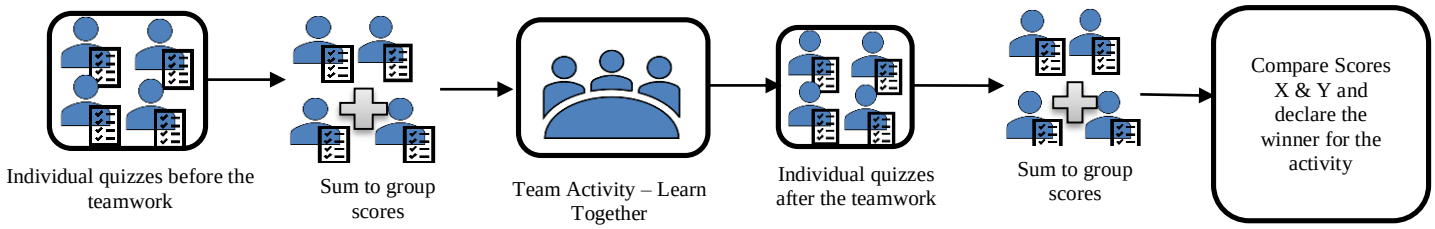

Fig. 1. Student Teams Achievement Division (STAD) Assessment Methodology

are recorded and compared. The team score is calculated by adding the individual participants' total points. The STAD assessment methodology is depicted in figure 1.

But it takes active-based learning, like STAD, for students at all levels to become motivated to tackle analytical problems through conceptual mathematics and hands-on activities (Troussas et al., 2023) . This paper investigates third-year engineering students in the electronics and communication disciplines who are studying control systems as one of their sixth semester courses, which also includes first and second order systems and a conceptual understanding of Laplace transforms. The primary goal of this study was to explore the effect of STAD on students' performance in the course (Nungu et al., 2023). As far the authors know, there is limited research on the effect of STAD on students' involvement.

In the research framework depicted in figure 2, various factors that affect students' performance in the control systems course are examined. The characteristics that were considered to analyse the students' learning experiences were based on interactions between students and professors, students, and team members, learning materials, and STAD assessment methods.

II. Related Works

STAD is renowned for being more effective than conventional lecture-based learning methodologies because it fosters a learner's skills in a variety of areas. Teams of diverse skill levels, including low, moderate, and advanced, are formed as part of STAD. These teams have varying potential to understand a problem and approach its solution from wholly different perspectives. The research has proven characteristics of this form of collaborative learning that can expertly execute the purpose of using technology effectively when applied to many fields of study (Schnaubert & Vogel, 2022). The authors of (Awada et al., 2020) proposed a research model to combine STAD and inquiry-based learning in a collaborative learning technique, and they were successful in teaching argumentative writing to advanced level students. Their findings show how EFL students acquired abilities related to social interaction, teamwork, and authentic materials. They urge that this research be expanded to include students at various levels, such as low-intermediate and advanced-low, as well as students with writing abilities in genres other than argumentative writing. It is difficult to manage collaborative learning among Iranian students, so in a study (Jahanbakhsh et al., 2019) done in that country, the authors examined two collaborative techniques: STAD and Cooperative Integrated Reading and Composition (CIRC). Their findings demonstrate that CIRC is more effective than STAD in lexical collocation usage by learners and gives access for fostering collaborative learning in educational systems. They advise that certain considerations be made while examining the nature of the procedures for the learners, including stress, motivational factors, a lack of effort, classroom dynamics, etc.

The authors advise considering other aspects that are crucial for the interaction between the teacher and the students during the learning process while keeping these factors in mind. In (Schnaubert & Vogel, 2022), the authors tried multiple forms of self-regulation, co-regulation, and socially shared regulation within the same curriculum. Out of these three, socially shared mode performed the task more effectively and helped team members understand the lesson more effectively as a whole.

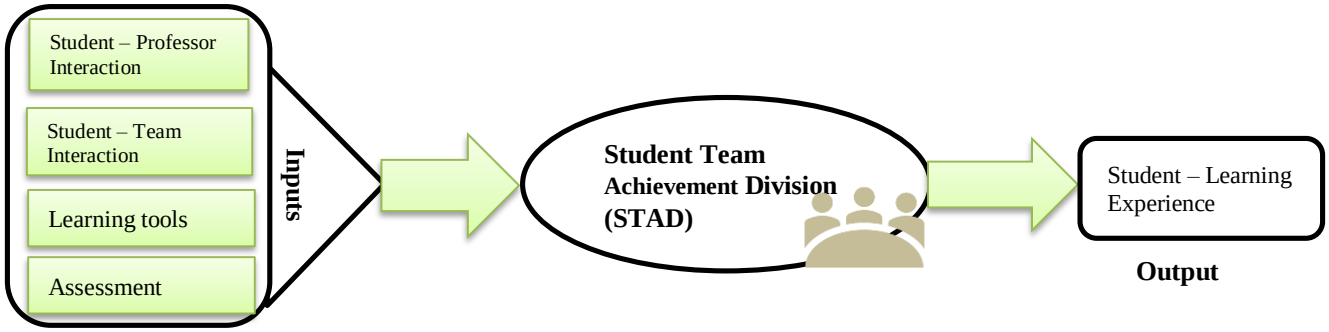

Fig. 2. Research Framework

Their research was successful in encouraging the less capable students to gradually assume responsibility for understanding the lecture. In a different integrated approach proposed by the authors in (Shafiee Rad et al., 2022), it was suggested that advanced EFL students may use flipped learning to explore expository writing skills. Although they were able to successfully apply the flipped technique in a STAD mode for the advanced EFL students, their recommendations for future research include taking account a larger dataset using random

TABLE 1
ATTRIBUTE AND SUB ATTRIBUTES DETAILS OF THE SURVEY

I / O	Attribute No.	Attributes	No.	Sub Attributes (Likert Scale 5) 5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Slightly disagree, 1 = Strongly Disagree
Inputs	SPI	Student – Professor Interaction	SPI-1	The professor guided me to develop teamwork skills that enabled me to work in team effectively
			SPI-2	The professor allowed individual team members to express his / her opinions
			SPI-3	The professor guided team members to form collaborative groups
	STI	Student – Team Interaction	STI-1	There was an effective team management and organization within the team
			STI-2	The interaction among the team members favoured the development of teamwork skills
			STI-3	I am able to develop new skills and knowledge from other members in my group
			STI-4	I am able to develop problem solving skills through peer collaboration
	LT	Learning tools	LT-1	The learning materials provided by the professor helped me in applying the skills during the team activity
			LT-2	The hands – on laboratory session allotted for this course helped me to apply the problem-solving skills during the team activity
			LT-3	The professor provided relevant links and resources to the books for learning this concept.
	AT	Assessment	AT-1	The quiz questions correctly assessed my problem-solving knowledge learnt during the collaborative activity
			AT-2	I am able to apply the knowledge gained through the group activity in answering the quiz questions
Output	SLE	Student – Learning Experience	SLE-1	The collaborative learning is fun
			SLE-2	I enjoyed working out the problem with my team members
			SLE-3	I am satisfied with this style of group collaboration learning for analytic problem-solving.

sampling techniques. Additionally, the study recommends including different genres and female students in the dataset as their current study only considered writing abilities for male students into account. The authors suggested (Ng et al., 2022) a model in which they investigated online collaborative learning (OCL) for student engagement and to foster peer interaction in a Chinese context. Concept generating, idea organizing, and intellectual convergences were investigated as part of their OCL activities, and it was demonstrated that these factors had a substantial impact on the student involvement. Future research by the authors intends to include cross-sectional survey data gathered from different other neighboring nations.

According to earlier research, which has been observed, STAD has had a significant impact on several genres for teaching a variety of courses with the aim of encouraging team-based learning. However, the authors have done a few studies on the relationships and effects of the variables that affect a student's success in the experiences brought on by STAD while learning a particular course's lesson (Tiantong & Teemuangsai, 2013). Furthermore, this study attempts to investigate how learning materials, evaluation procedures, student-peer interactions, and student-professor interaction affect students' experiences in STAD. The following research objectives will be addressed by this study.

H1. Is there a significant impact of student – professor interaction on student performance through STAD?

H2. Is there a significant impact of student – team interaction on student performance through STAD?

H3. Do the learning materials used in the STAD help in promoting student learning experience?

H4. Does an assessment methodology for STAD have an impact on student learning experience?

The structure of the paper is as follows; section 3 describes the methodology of this research work. This section talks about collection and analysis of the data and the responses. Section 4 elaborates results obtained through statistical analysis. Section 5 concludes the paper with limitations and the findings in this research study.

III. METHODOLOGY

A total of (n=89) third-year engineering students participated in the STAD-based problem-solving teamwork activity inside the classroom, with (n=75) male students accounting for 84.27 % and (n=14) female students accounting for 15.7 %. They were randomly assigned to teams of one female and the remaining male students. It was also made certain that the team included at least one advanced learner. Before and after the group activity, the students completed individual quizzes, and their results were compared to evaluate their performance. Student-Professor Interaction (SPI), Student-Team Interaction (STI), Learning Tools (LT), and Assessment (AT) were the attributes used for the survey. Each of these attributes was further subdivided into sub attributes, which were then represented in the questionnaires via surveys. Google Forms were used to deliver surveys online. The survey links were distributed to student groups.

The students were expected to respond with a total of 89 responses. Each question was presented to the students on a 5-point Likert scale, with 5 representing Strongly Agree, 4 representing Agree, 3 representing Neutral, 2 representing Slightly Disagree, and 1 representing Strongly Disagree. There were totally 15 sub attributes in the survey (Nair et al., n.d.). Table I lists the sub-attributes that students were asked about in the survey.

The mean and standard deviation of the various input responses collected for the individual factors are shown in Table II. The third sub attribute (LT-3) of the learning materials received the highest rating with a mean of 4.54, indicating that students were satisfied with the resources provided to prepare for teamwork during the STAD and to solve the problems assigned by the professor. Likewise, the mean and standard deviation of the output response of the student experiences were statistically examined. Table III displays the statistics for the sub-attributes used to assess students' learning experiences. Students showed high satisfaction in accepting this type of group collaboration for problem – solving (SLE-3) as indicated by the mean value 4.60.

Table IV shows the Cronbach coefficient, which was calculated to test the survey's reliability. The correlation and consistency between survey results were found to be adequate, as all values were greater than 0.9.

TABLE II
STATISTICS FOR INPUT ATTRIBUTES USED IN THE SURVEY

Attribute No. (inputs)	Sub No.	No. of responses	Mean	SD
SPI	SPI-1	89	4.46	0.64
	SPI-2	89	4.39	0.80
	SPI-3	89	4.40	0.69
STI	STI-1	89	4.43	0.69
	STI-2	89	4.39	0.71
	STI-3	89	4.43	0.64
	STI-4	89	4.44	0.62
LT	LT-1	89	4.47	0.71
	LT-2	89	4.33	0.81
	LT-3	89	4.54	0.60
AT	AT-1	89	4.51	0.64
	AT-2	89	4.47	0.62

TABLE III
STATISTICS FOR OUTPUT ATTRIBUTES USED IN THE SURVEY

Attribute No. (Output)	Sub No.	No. of responses	Mean	SD
SLE	SLE-1	89	4.44	0.69
	SLE-2	89	4.41	0.74
	SLE-3	89	4.60	0.59

TABLE IV
RELIABILITY TEST OF THE RESPONSES

Attributes	α value
SPI	0.96
STI	0.95
LT	0.97
AT	0.96
SLE	0.95

IV. RESULTS AND DISCUSSION

An overall analysis was done between the output attribute, the Student Learning Experience, and their correlation with the input attributes such as Student Professor Interaction, Student – Team Interaction, Learning Tools provided, and the Assessment methods. Figure. 3 shows the correlation between the SPI and the SLE using scatter plot. The best fit shows (R2 = 0.66) where the correlation coefficient equation is given as in equation (1).

$$SLE = 0.7955SPI + 0.9751 \quad (1)$$

Figure. 4 shows the correlation between the STI and the SLE using scatter plot. The best fit shows (R2 = 0.71) where the correlation coefficient equation is given as in equation (2).

$$SLE = 0.8531STI + 0.7211 \quad (2)$$

Figure. 5 shows the correlation between the LT and the SLE using scatter plot. The best fit shows (R2 = 0.62) where the correlation coefficient equation is given as in equation (3).

$$SLE = 0.7939LT + 0.9556 \quad (3)$$

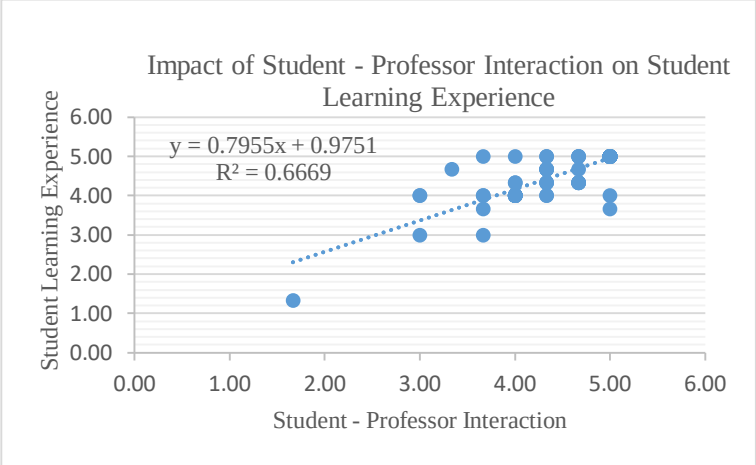

Fig. 3. Correlation coefficient between Student Professor Interaction and Student Learning Experience

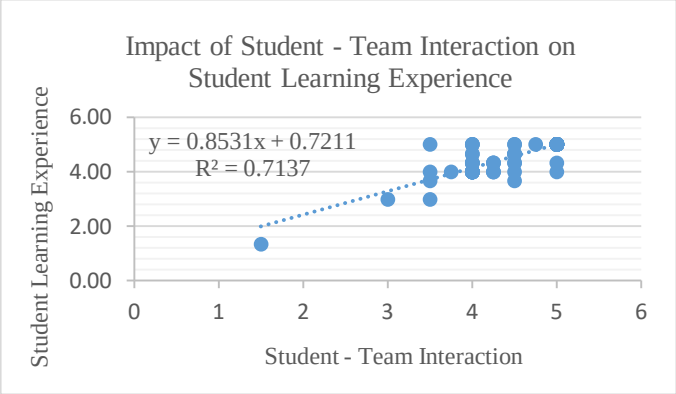

Fig. 4. Correlation coefficient between Student Team Interaction and Student Learning Experience

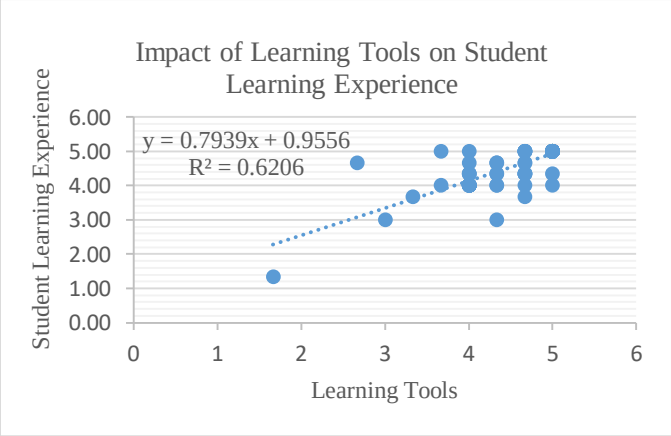

Fig. 5. Correlation coefficient between Learning Tools and Student Learning Experience

Figure. 6 shows the correlation between the AT and the SLE using scatter plot. The best fit shows (R2 = 0.77) where the correlation coefficient equation is given as in equation (4).

SLE= 0.917AT + 0.3878 (4)

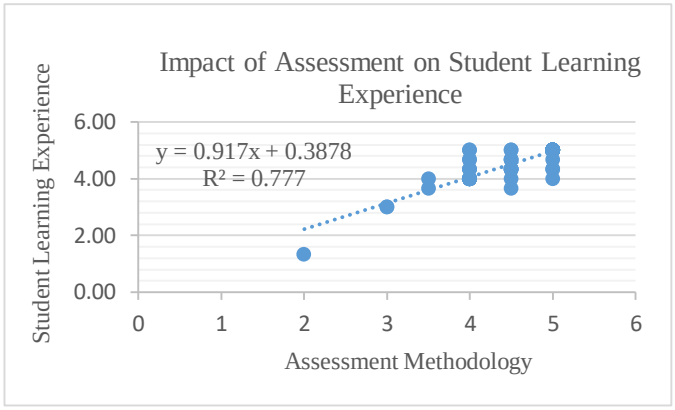

Figure 6. Correlation coefficient between Assessment methodology and Student Learning Experience

The R2 values were used to validate the coefficient correlation between all the attributes and their impact on student learning experiences. Positive correlations are shown by the student - Team Interaction and Assessment Methodology input attributes in the above regression models. These two are observed to have a positive impact on student learning experiences, as evidenced by high satisfaction in survey responses in these aspects.

TABLE V
STATISTICS OF STUDENT – TEAM INTERACTION ATTRIBUTE

Sub Attributes		STI_1	STI_2	STI_3	STI_4
No.	Valid	89	89	89	89
	Missing	0	0	0	0
Mean		4.50	4.47	4.48	4.49
Std. Deviation		0.69	0.70	0.64	0.62
Variance		0.48	0.50	0.41	0.38

To determine the relationship between the STI sub attributes and the SLE, a stepwise regression analysis of STI is performed. The effect of STI on SLE is investigated further here using analysis of variance, and the results are displayed in Table V using the SPSS tool. The table shows effective time management and organizing skills (STI_1, mean=4.50) among students are the factors that have the greatest impact on satisfaction, allowing students to engage in the discussion and achieve effective results in the group activity. The overall Student Learning Experience equation as a representation of the sub attributes of Student – Team Interaction is shown in the equation (5) developed from stepwise regression.

Overall SLE = 0.7211 + 0.707 STI_1+ 0.668 STI_2 + 0.708 STI_3 + 0.752STI_4 (5)

Similarly, assessments play an important role in students' learning experiences and were thus considered in the analysis. Prior to the group activity, a quiz was administered in the classroom, and individual grades were recorded. Following the group activity, another quiz-based assessment was given, and the results were compared. The grades were higher than the previous quiz-based assessment. As a result, the students recognized the importance of group discussions, and the

activities were effectively used during the STAD (Wyk, 2012). The effect of assessment on SLE is further investigated here using analysis of variance, and the results are shown in Table VI using the SPSS tool. According to the table, students were significantly satisfied and responded with a high mean value of (AT, mean = 4.51).

The overall Student Learning Experience equation as a representation of the sub attributes of assessment is shown in the equation (6) developed from stepwise regression.

$$\text{Overall SLE} = 0.3878 + 0.767AT\_1 + 0.837AT\_2 \quad (6)$$

This demonstrates that the quiz questions correctly assessed their competency level prior to and following the group activity, as well as their problem-solving knowledge gained during the collaborative activity (Nakata et al., 2022). The assessment allowed them to apply their knowledge from the group activity to the quiz questions.

TABLE VI
STATISTICS OF ASSESSMENT METHODOLOGY ATTRIBUTE

Sub Attributes		AT_1	AT_2
No.	Valid	89	89
	Missing	0	0
Mean		4.56	4.51
Std. Deviation		0.63	0.62
Variance		0.40	0.38

CONCLUSION

A study was carried out to determine the impact of Student Team Achievement Division (STAD) on students' learning experiences. The survey questions were developed with our university's teaching environment in mind. The input attributes that influenced the student learning experience during group activities were student professor interaction, student team interaction, learning materials, and assessment. The attributes were subdivided further to investigate the impact of individual sub attributes on the 'Student Learning Experience' (SLE). Among all the attributes, it was discovered that 'Student Team Interaction' and 'Assessment' had the greatest impact on the 'Student Learning Experience'. Further investigation revealed that the STAD methodology instilled a process in the students to develop managerial skills in terms of time and problem-solving. Similarly, all the sub-attributes in 'Assessment' had the highest correlation with the 'Student Learning Experience,' indicating that the students were satisfied with the assessment methodology. The obtained results were validated using correlation analysis, stepwise regression analysis, and Pareto plots. Some of the study's limitations must be acknowledged. The sample size must first be increased. Inadequate data may lead to more serious conclusions. Second, to analyse generalized datasets, STAD can be combined with other collaborative tools such as flipped learning and inquiry-based learning. Third, both qualitative and quantitative analysis can be used to correlate student performance in various assessments due to STAD.

Based on observations, STAD is a promising and interactive tool that can be used in a dynamic classroom. Given the established correlations between collaborative learning and these outcomes, as well as the positive correlation with student learning experiences discovered in this study, professors and universities who want to improve their students' chances of achieving these outcomes should consider incorporating STAD as one of the pedagogical tools that can benefit both students and institutions.

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