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Improving the Performance and Knowledge Retention of Aircraft Maintenance Engineering Students in the Theory of Flight through STAD Cooperative Learning

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ABSTRACTS

This study used a mixed-method design and an action research approach to investigate the effectiveness of the Student Teams Achievement Division (STAD) in improving 11 TVET students' performance in the theory of flight. The results of the paired sample t-test revealed that students' performance improved and were able to retain their knowledge after the STAD intervention. The students reported positive perceptions about STAD cooperative learning after the interview analysis. It encouraged student-centered and active learning, participation, and the development of teamwork skills. The discussion and practical and collaborative activities helped the students to retain their knowledge since they formed mental images of what they learned. This study concluded that STAD cooperative learning can be a helpful tool in improving TVET students' performance in the theory of flight. This is more achievable when it is conducted in a teacher-friendly and well-prepared classroom environment. Implications of the findings in TVET and suggestions of effective ways to implement STAD cooperative learning are discussed.

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1. INTRODUCTION

The competitive nature of today's job market does not only require job seekers with certificates but also those who have the soft skills and expertise in their fields of work. Therefore, educational sectors have emphasized Technical and Vocational Education and Training (TVET) to produce competent and skillful human resources. Like any part of the world, most countries in Southeast Asia have prioritized TVET and have inculcated several TVET courses into their curriculum to support their socio-economic development. As one of the countries in Southeast Asia, the Bruneian education system has also recognized the relevance of TVET and has established the Institute of Brunei Technical Education (IBTE). It is mandated to support the country's vision 2035, which seeks to produce job-ready graduates with the relevant skills and knowledge required to meet the current ever-changing job market in the country.

Given that having the right technical skills and knowledge alone is not enough to be successful in today's world of work, industries and companies are using multidisciplinary group work to promote the generation of ideas between peers and colleagues. As such, students are required to be critical thinkers, creative, possess effective communication skills, and should be able to collaborate to work as a team. To achieve this goal, teachers have a great responsibility to develop and apply effective teaching and learning methods that can improve the participation and understanding of students (Margono & Arianto, 2021; Hamdan *et al*., 2022). In response to this responsibility, many educators, researchers, and think tanks in education have called for student-centered teaching since it is the best approach to cultivating creative and innovative students with unique ideas (Li *et al*., 2021).

The literature indicates that cooperative learning is one of the best student-centered learning approaches (Listiadi *et al*., 2019; Li *et al*., 2021). As a teaching and learning approach that brings students together in groups to execute a shared goal or task, when implemented well, it can contribute to higher performance and retention compared to when students work individually (Johnson & Johnson, 1999; Tran, 2014; Yussop *et al*., 2021). It has the potential to build communication and social interaction skills, emotional intelligence, and teamwork skills, as well as lifelong learning skills, and limits victimization, bullying, stress, and emotional problems (van Ryzin & Roseth, 2018).

There is a significant body of knowledge that indicates that cooperative learning is associated with high student performance across subjects (Kent *et al*., 2015; Yapici, 2016; Munawar & Chaudhary, 2019; Anwar *et al*., 2020; Rivera-Perez *et al*., 2020; Vernon *et al*., 2020), and has a positive impact on student learning regardless of the achievement level or disabilities of students (Kent *et al*., 2015). For this reason, teachers continue to use several types of cooperative learning in different educational contexts. These include but are not limited to think-pair-share, numbered heads together, jigsaw method, team games tournament, and Student Teams Achievement Division (STAD) (Tran, 2014; Kani & Shahrill, 2015; Jainal & Shahrill, 2021).

Wang and Wu (2022) in their study justified the ability of cooperative learning to improve student problem-solving skills. They surveyed 360 college students in Fuji and found a significant positive correlation between online cooperative learning and problem-solving abilities of students, indicating that the more students are engaged in cooperative learning, they are likely to improve their problem-solving skills. In an experiential pre-test and post-test study in Spain, Mendo-Lazro *et al*. (2022) found from a sample of university students that cooperative learning encouraged students to set academic and learning goals and helped develop the skills and knowledge to achieve these goals. Cooperative learning has also been

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used to teach and improve the oral proficiency skills of learners and other English courses (Zhou, 2017; Hong *et al*., 2022), mathematics (Lim *et al*., 2016; Nurhayati & Hartono, 2016; Chan & Idris, 2017), and assess values and soft skills among TVET students (Khalid, 2016), where the kinds of cooperative learning activities such as total numbered heads, think-pair-share and theme games have been used (Kani & Shahrill, 2015; Listiadi *et al*., 2019).

There should be a transition from teacher-centered to student-centered teaching and learning, and that is why cooperative learning should be encouraged in the classroom. It is important to emphasize that the collaboration between students is necessary for them to direct their learning and develop the cognitive and practical skills that are necessary for them to apply in their future fields of work. Despite that the Bruneian education system prioritizes TVET and has established its IBTE to train students for that purpose, our experience tells us that the teaching and learning in TVET remain teacher-centered, limiting students' knowledge and retention in several TVET courses including aircraft maintenance engineering. On the basis that little is known about the instructional approaches how to improving teaching, learning, performance, and retention of TVET students in Brunei (Ebil *et al*., 2020; Salleh *et al*., 2021; Hamdan *et al*., 2022), this study is conducted to access the effectiveness of STAD cooperative learning in improving the performance and knowledge retention of aircraft maintenance engineering students in the theory of flight.

We intended to conduct STAD intervention for this group of students for several reasons. First, STAD is one of the kinds of cooperative learning that is associated with high student performance, collaboration, and retention regardless of the ability levels of the students (Sirisrimangkorn & Suwanthep, 2013; Rahmatika, 2019; Rachmawati *et al*., 2019). It is the simplest cooperative learning strategy that accommodates two to five groups of students of different learning abilities (Wyk, 2012). It is also new to Bruneian contexts and especially in TVET instructions. Second, the TVET students who majored in aircraft maintenance engineering were convenient for us to assess the efficacy of our intervention. Furthermore, our observations and teaching experiences informed us that most of the TVET students had difficulties retaining the concepts taught in the theory of flight, affecting their performance. Taking up these gaps, this study investigated the effectiveness and the perceptions of TVET students of STAD cooperative learning. The following research questions guided this study: What is the effectiveness of STAD cooperative learning in improving the performance and knowledge retention of TVET students in the theory of flight? And how do TVET students perceive STAD cooperative learning as an instructional approach in the theory of flight?

2. METHODS

For this study, a mixed-method design with an action research approach was adopted. This was because both quantitative (pre- post- and retention scores) and qualitative data (interviews) were collected sequentially (Creswell & Creswell, 2017). Additionally, the action approach was considered appropriate since we provided STAD cooperative learning intervention to the same group of students, in the same class to assess its efficacy in addressing student performance and knowledge retention challenges in the theory of flight (Avison *et al*., 1999; Mertler, 2013).

2.1. Sample and instruments

We used convenience sampling to select 11 participants who were Higher National Technical Education Certificate (HNTec) students in one of the IBTE campuses in Brunei. Since these TVET students were readily available and the theory of flight was taught at this level, they were suitable for this study. The participants involved one female and ten males. Their

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ages ranged from 18 to 20 years, and they were of different learning and performance abilities.

Data were collected through structured tests and interviews. The tests involved a pre-test, post-test, and retention test. The pre-test was conducted to assess the entry behavior of students on the theory of flight before the intervention. The post-test was used to determine the performance of the students after the intervention, while the retention test was conducted to determine how well the students could retain what they were taught after the post-test. The same test was used for the pre, post, and retention tests. There were 18 multiple choice questions in the tests with a maximum and minimum score of 18 and 0 marks, respectively. Various concepts in the theory of flight such as speed of sound, aircraft surfaces, transonic flights and range, skin friction, and critical Mach number of aircraft, among others were covered in the tests.

For the interview data, six participants were asked about their perceptions of STAD intervention. Some of the questions we asked are: '*How has STAD cooperative learning improved your academic performance and knowledge retention in flight energy?*' and "*How do you perceive STAD cooperative learning in the teaching and learning of the theory of flight?*' Six participants were used in the interview because we discovered a redundancy in the information we gathered after the six participants. Therefore, we ended the interview after the sixth participant, since the information we gathered was in-depth enough for our analysis.

The reliability and validity of all the instruments were checked by three experts in aircraft maintenance. These experts were teachers of TVET with more than 15 years of teaching experience. Their suggestions and comments were used to refine the questions in the tests and interview guide. In addition, all questions in the test were developed based on well-structured lesson objectives to make sure that the questions represented the concepts that were taught (Asamoah *et al*., 2019).

Before data collection, we obtained ethical approval from all the relevant departments and institutions. The participants also consented to participate in the study and were well informed of the purpose of the study. They were told of the decision to voluntarily participate in this study, and their right to leave the study at any time they wanted. They were also assured of the confidentiality of the information they provided and the anonymity of their identities. Taking this into account, the names or any information to trace the identity of the participants or the information they provided have not been included in this report.

2.2. Intervention processes

The STAD intervention consisted of five parts: lesson presentation, collaborative /teamwork, quizzes, individual progress score, and team score. We presented a 50-minute lesson on the theory of flight in the classroom, telling the participants the intended objectives and the relevance of the lesson. The lecture-discussion method was used to present the lesson. We also encouraged students to pay attention to the demands and objectives of the lesson so that they would be able to perform the next tasks. After this stage, the participants were put into groups of two with different abilities and gender to work cooperatively with their peers. Work and answer sheets on the theory of flight were provided to the students based on the lesson objectives. After this stage, each of the students in each of the groups was assessed individually by taking a quiz on the theory of flight. We recorded the scores of each of the students obtained in the quiz. In addition, the average of the individual student scores was used to determine the score of each of the groups. The team with the highest score was recognized and awarded. The awards we provided were pens and story books that were related to the concepts we taught.

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2.3. Data collection and analysis

The entire data collection lasted for five weeks. The pre-test was collected on an agreed date with the students, while the post-test was conducted six days after the STAD cooperative learning intervention. The retention test was also conducted three weeks after the post-test. Haynie (1997) suggested that a retention test should be administered two or more weeks after the intervention. Therefore, it was considered appropriate to conduct the retention test three weeks after our intervention. We scheduled an interview time with all the participants who agreed to be interviewed. Tests and interviews were conducted in a laboratory facility on the selected IBTE campus, ensuring a peaceful environment, and appropriate testing conditions. Each of the tests lasted for 25 minutes, while the interviews lasted for 45 minutes. For the quantitative data, the pre, post, and retention tests were coded into SPSS for statistical analysis. Data were cleaned to address all missing values and outliers. For the research question that aimed to assess the effectiveness of STAD intervention, a paired sample t-test was performed to compare the mean differences in the pre, post, and retention scores. The statistical tool was considered appropriate because the scores were analyzed to check the mean differences of the same group of students (Coman *et al*., 2013), and especially when we observed that the data met normality assumptions: pre-test ($p=0.88>0.05$), post-test ($p=0.09>0.05$) and retention test ($p=0.12>0.05$) (Fisher & Marshall, 2009). The six phases of thematic analysis used to analyze the interview data. We transcribed and thoroughly read each of the responses from the participants. This helped us to familiarize ourselves with the data. Initial codes were developed, and potential themes were searched and reviewed before producing the interview report.

3. RESULTS AND DISCUSSION

3.1. Effectiveness of STAD cooperative learning

Table 1 and **Table 2** provide the overall results that show the impact of STAD cooperative learning on students' performance. **Table 1** provides a summary of the mean difference between the pre-test and post-test scores, while **Table** 2 provides a summary of the mean difference between the post-test and retention scores.

Table 1. Paired sampled t-test between pre and post-test.

	Mean	SD	Mean difference	t	df	Sig (2-tailed)	Cohen d
Pre-test	39.27	13.09	31.55	7.8053	10	0.000	0.85
Post-test	70.82	8.93					

N=11, SD=standard deviation, mean difference is significant if sig<0.05

The results of the paired sample t-test show that the performance of the TVET students in the post-test (mean=70.82, SD=8.93) is significantly higher than in the pre-test (mean=39.27, SD=13.09); $t(10)=7.8053$, with a mean difference of 31.55 (see **Table 1**). This indicates the performance of students improved after the STAD cooperative learning intervention. The Cohen's d value of 0.85 signifies a large effect size, suggesting that about 85% of the performance of students is explained by the intervention we provided. The paired sample t-test for the post-test and retention test is shown in **Table 2**.

As shown in **Table 2**, TVET students' performance in the post-test (mean =70.82, SD=8.93) does not significantly differ from their retention performance (mean=69.91, SD=8.26); $t(10)=0.6386$, with a mean difference of 0.91. This provides evidence to prove that the students were able to retain what they learned within the three-week interval after the

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intervention. From Cohen's d value of 0.04, it can be observed that the knowledge the students gained after the post-test only explains 4% of their retention performance. **Table 3** and **Figure 1** present the descriptive statistics and graphical comparison of individual students' pre, post, and retention scores.

Table 2. The paired-sampled t-test between post and retention test.

	Mean	SD	Mean difference	t	df	Sig (2-tailed)	Cohen d
Post-test	70.82	8.93	0.91	0.6386	10	0.000	0.04
Retention	69.91	8.26					

Table 3. Individual student's test scores.

Group	Student ID	Pre-test (%)	Post-test (%)	Pre-post-test difference	Retention-test (%)	Post-retention difference
Group A	A1	50	61	+11	61	0
	A2	33	67	+34	67	0
	A3	44	78	+34	78	0
	A4	22	56	+34	56	0
Group B	B1	67	78	+11	83	+5
	B2	33	61	+28	67	+6
	B3	44	67	+23	67	0
	B4	28	72	+44	67	-5
Group C	C1	50	78	+28	67	-11
	C2	33	83	+50	78	-5
	C3	28	78	+50	78	0

Key:

Selected High Achiever for Interview	High Achiever Score >75
Selected Middle Achiever for Interview	Middle Achiever Score 65 to 74
Selected Low Achiever for Interview	Low Achiever Score < 64

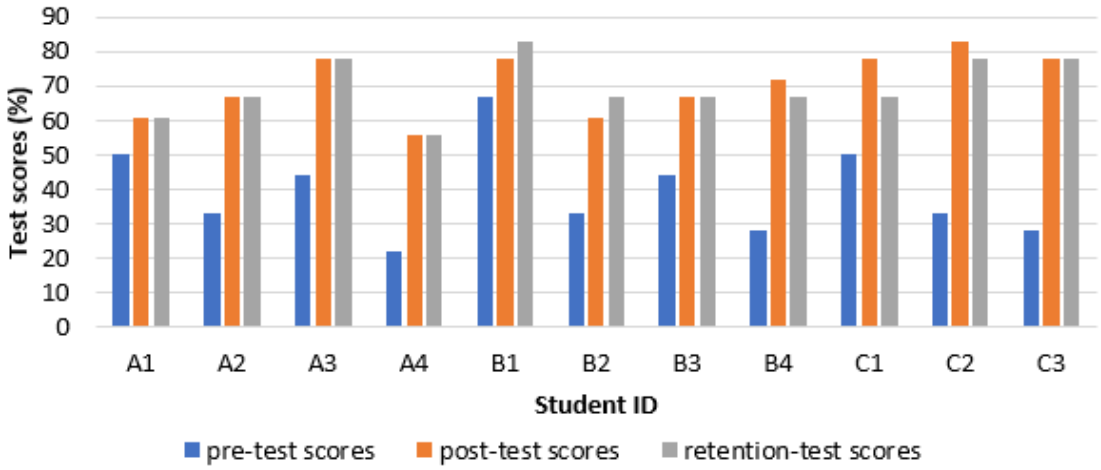

Figure 1. A graphical comparison of the individual student's pre, post, and retention scores.

Referring to the pre-post difference column, it is observed that all students obtained positive differences, suggesting that they improved their performance in the post-test, with the lowest and highest improvement scores of 11 and 50%, respectively (see **Table 3**). On the other hand, in the post-retention difference column, it is observed that two students (B1 and

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p- ISSN 2775-6793 e- ISSN 2775-6815

B2) recorded positive differences, adding 5 and 6%, respectively. Six students recorded zero differences in their retention scores, while three obtained negative differences. This confirms that the post-retention scores of the students on the theory of flight remained about the same. A graphical comparison of the pre, post, and retention scores is shown in **Figure 1**.

Figure 1 confirms that all the students improved their post-test scores after the intervention, as we have found. A wide difference exists between the pre-test and post-test, however, there are no observed differences between the post-test and retention scores. This confirms that the students after improving their post-test scores were able to retain what they learned in theory of flight, as our findings have shown.

3.2. Students' perceptions of STAD cooperative learning as an instructional approach

Six themes emerged from the interview responses of the participants. These are their general experiences about the intervention, their interests, and dislikes about the intervention, their participation, their views about their performance and knowledge retention, and recommendations on STAD cooperative learning.

3.2.1. General experiences with the intervention

We found that most of the participants (n=10) perceived STAD cooperative learning positively. They saw the lessons and associated activities as enjoyable, and more effective compared to using conventional teaching methods. Most of them, especially high achievers, shared that discussing and sharing opinions with their group members enabled them to understand the topic and completed the worksheet given. They generally perceived the lessons to be more practical and were able to work in a group to support themselves in the teaching and learning process. Reflecting on his experience, one of the participants shared:

> *I think it is a very good technique because we can share a lot of ideas with the group during discussion and then create a better answer in the end. Learning using this method is more effective than when the instructor is teaching the lesson for a long time - traditional teaching and learning* (Student B2).

Similarly, another student said:

> *We can relate our experiences and what we have learned to our work in the future once we go to the field for our placement, where we must work in groups. So, it is a good experience for me* (Student A4).

The participants believed that as students, practical experiences, and collaboration matter. Therefore, they saw the STAD cooperative learning as essential to help them in their future fields of work because it exposed them to teamwork, support for one another, and the ability to apply knowledge in practical situations. They believed that STAD cooperative learning experiences have the potential to shape their teamwork and collaboration skills, as well as how to put knowledge into practical use.

3.2.2. Interests and dislikes about the intervention

Most of the participants (n=8) were interested in the intervention because they expressed that it promotes active learning. According to them, they were actively engaged with the lesson contents through discussion and liked all the group discussion activities the most. They shared that when they had the opportunity to discuss learning contents with their peers, they understood the lesson more and improved their answering method in completing their tests, and this was more interesting when higher achievers explain the concepts to them. On the

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other hand, most of them (n=7) was not happy when one of the instructors looked a bit aggressive and questioned them in the middle of the lesson and their discussion. For example, one of the participants commented:

> *…Of course, I liked the discussion because it helped me and my colleagues to improve our answering method, our skills, and so on…* (Student A4).

When we asked another student about her dislike and likes of the intervention, she had this to say:

> *… I liked the activity because although the lesson was quite complicated at first, we managed to understand it better after the group discussion. What I disliked was that there was a particular instructor who kind of caused us to panic. He kept on questioning us while we are still discussing the topics* (Student C2).

We observe from the responses of Student C2 that the students prefer collaborative learning in a more relaxed and friendlier environment, making the nature of the teaching and learning environment quintessential. Students should have enough time to discuss before questions are asked. They should also be given adequate time to think about the questions. Teachers should ask questions in friendly and a more professional way devoid of aggression to engage students and sustain their interests. This emphasizes that when conducting cooperative learning activities, students should be allowed to take the center stage of their learning.

3.2.3. Participation in teaching and learning

Most of the participants (n=9) reported that the STAD cooperative strategy encouraged student participation and contribution. The higher achievers said that they were about to explain concepts to their lower achieving counterparts since they (higher achievers) understood most of the concepts. All students reported that they researched the topics and shared their knowledge with their group members. According to one of the students, they debated, disagree, and agree on a particular topic/answer especially when they had different opinions. The following excerpts represent the views of the participants:

> *I think I did quite well in contributing and teaching my friends. I remember I shared lots of strong reasons and strong answers for some of the descriptions for answering the worksheet. Sometimes, we debate our answers before we agree on the correct answer...* (Student B1).

Similarly, another participant indicated:

> *"… I contributed by researching some topics on Google, and then discussed my opinions when answering questions in the worksheet. My friends also explained the lesson well to me and I understood them. However, I did not just accept what my friends taught me, but I also ask questions.* (Student C1).

It can be inferred that students tend to contribute and engage in teaching and learning when STAD cooperative earning is used, making teaching, and learning student-centered. What struck us is that the students did not just accept the answers their peers provided; they probed to understand better. This provides an appropriate platform for student-centered learning including student-to-student dialogues in the classroom.

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3.2.4. Views about performance and knowledge retention

Students were asked to rate (on a scale of 10) how likely they have improved their performance and knowledge retention after the intervention. They were also asked to explain their choice of rating. **Figure 2** and **Figure 3** illustrate the student ratings regarding their performance and knowledge retention.

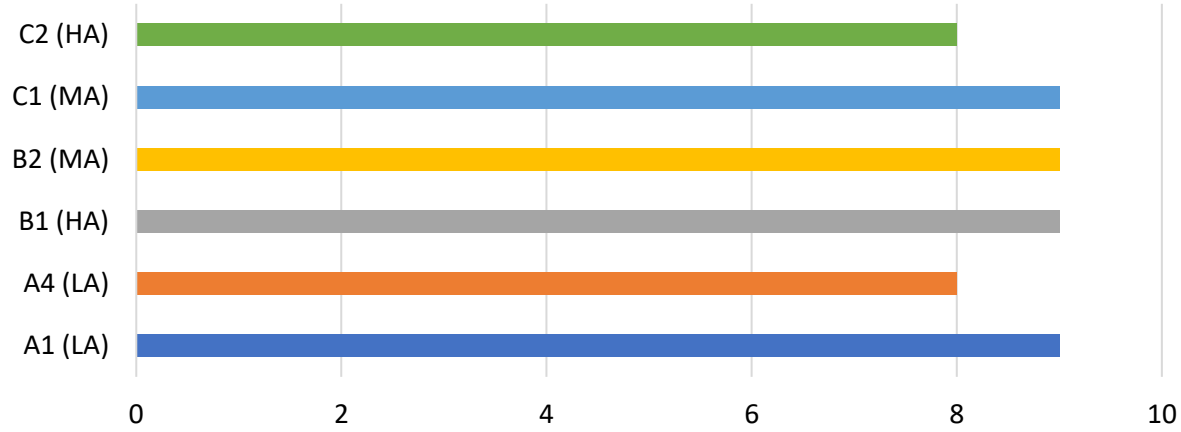

Figure 2. Ratings on students' academic performance.

Concerning students' views on how they have improved their performance in theory of flight, they gave a rating of 8 to 9 to indicate the extent of their improvement. This confirms our previous results on improving students' post-test scores. According to most of the students, they improved their performance because they were able to understand the content of the lesson. This was due to the teamwork and collaboration, as well as the practicality of the lessons they were involved with.

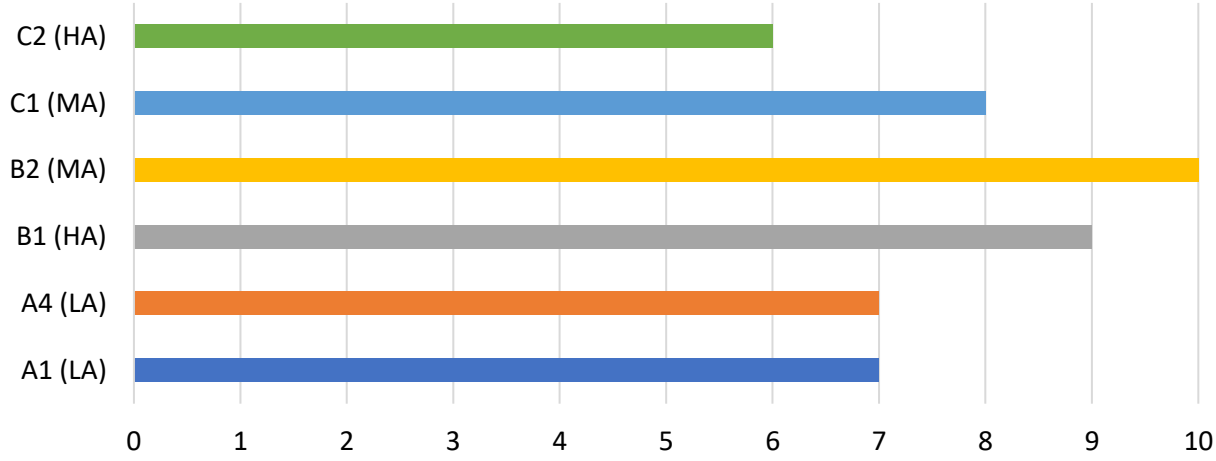

Figure 3. Ratings on students' knowledge retention.

Most students believed that they were able to retain their knowledge of the theory of flight (rating score of 6 to 8). They believed that they retained the knowledge because they had a memory of discussing it with their group members and the kind of activity they went through, making it easier for them to recall the knowledge. Student B2 gave a rating of 10 points out of 10 (see **Figure 3**) and mentioned that he retained the knowledge longer, as he understood the contents more compared to just memorizing it. It is not surprising that he scored the highest positive differences in post-retention difference (see **Table 3**). Meanwhile, student C2

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gave a rating of six, which is slightly lower than the other students. Regardless of this, she stated that she retained the knowledge more compared to when the lesson was delivered in traditional teaching and learning.

3.3.5. Participants' recommendations on using STAD cooperative learning

All the students (n=11) reported that they would like to experience cooperative learning in their future lessons. They suggested that the strategy is suitable for their learning of theoretical and practical modules in TVET. These include materials and hardware, air legislation, aircraft maintenance practices theory, and the theory of flight. For example, one of the participants commented:

> *I think this method is best for theoretical and practical topics such as air legislation, maintenance practices theory, and materials and hardware. It is suitable when learning types of tools and corrosions. We can remember more if we discuss the contents rather than just learning them* (Student A1).

Similarly, another participant had this to say:

> *I think when learning theoretical and practical modules, we need to experience and visualize in a good laboratory… classroom exercises after every lesson would also be good…* (Student B2).

It can be inferred that the students preferred to be assessed frequently. Formative assessment, for example, can be administered to monitor student learning and provide feedback to students (Asamoah *et al*., 2022). Inculcating visualization when teaching theoretical and practical models was also emphasized by the students. Most of them acknowledged that they learn better in groups when they visualize the object that they are learning and discussing. They also believed that there should be a good and well-prepared laboratory for convenient practical and group activities to occur.

Generally, our findings show that STAD cooperative learning has the potential to improve TVET students' performance and knowledge retention in the theory of flight. The teamwork and collaboration that are associated with this method of teaching and learning encourage not only student-centered learning (Duraman *et al*., 2015; Li *et al*., 2021) but also student dialogues in the classroom. It allows students to discover knowledge for themselves and encourages them to apply the knowledge in a similar situation, which is important in improving the practical skills needed in TVET.

The findings of this study are consistent with the literature that has found that cooperative learning is positively associated with high student performance and understanding (Anwar *et al*., 2020; Mendo-Lazro *et al*., 2022; Rivera-Perez *et al*., 2020; Wang & Wu, 2022). The high involvement of students, cooperative and peer teaching, and learning, and sharing of ideas among students, contribute to higher performance compared to traditional teaching and learning (Tran, 2014; Khun-Inkeeree *et al*., 2018; Jainal & Shahrill, 2021; Yussop *et al*., 2021; Hamdan *et al*., 2022).

As we have shown, students were able to improve their academic performance and knowledge retention regardless of ability level, which is one of the strengths of STAD cooperative learning (Sirisrimangkorn & Suwanthep, 2013; Kent *et al*., 2015; Lim *et al*., 2016; Rahmatika, 2019) Forming groups of students with different abilities and engaging them in discussion help complement each other. It is, therefore, not surprising that the students expressed positive views about the intervention provided and saw STAD instructional

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activities as enjoying, effective, collaborative, practical, and participative compared to conventional teaching and learning, which confirm existing studies (e.g., Ghaith, 2001).

4. CONCLUSION

This study assessed the effectiveness of STAD cooperative learning in improving aircraft maintenance engineering students' academic performance and retention in the theory of flight. The findings show that STAD cooperative learning has the potential to improve students' performance and knowledge retention in the theory of flight. The students expressed positive perceptions about STAD cooperative learning as it encouraged student-centered learning and teamwork stills. This approach to teaching and learning supported enjoyable and effective learning compared to traditional methods. The students liked STAD intervention because it promotes active learning and student participation especially when it is conducted in a more relaxed and friendlier environment. Notably, the students retained their knowledge because they formed mental images of the discussion and collaborative activities in the classroom. This suggests that STAD cooperative learning can be a helpful tool for improving the performance of students and retaining their knowledge.

This research draws our attention to some important insights. Given that TVET carefully emphasizes the acquisition of practical skills, involving students in teaching and learning, collaboration, teamwork, and motivating them to learn in a practically controlled and stimulating environment are important to improve their performance. When implementing STAD cooperative learning in TVET, teachers should be aware that a well-prepared instructional environment is quintessential and that this should be coupled with enough visualization to represent abstract concepts. Its implementation should also come with a frequent assessment plan, including timely and focused questions to engage and monitor student learning. Teachers should also be friendly and play the role of a guide compared than being aggressive with students when implementing STAD cooperative learning. Future researchers are encouraged to investigate the effectiveness of STAD cooperative learning and students' perception of this teaching approach in other local and international educational contexts. Given the effectiveness of STAD cooperative learning to improve the performance of students in the theory of flight, this study also recommends that it is implemented in other theoretical and practical topic areas in TVET.

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6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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