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Effectiveness of Crossword Puzzle as a Revision tool in technical education with Pre-test and post-test Analysis.

Rajendra S. Sargar[1], Pravin A. Desai[2],
[1,2] Lecturer, Department of Automobile Engineering, KESs Rajarambapu Institute of Technology, Rajaramnagar, Shivaji University Kolhapur, Maharashtra, India.
[1]rajendra.sargar@ritindia.edu [2] pravin.desai@ritindia.edu

***Abstract*— The main focus of this paper was to check the effectiveness of the Crossword Puzzle as a revision tool in technical education. This activity was implemented on a total of 70 students with 2nd year and 3rd year diplomas in automobile engineering. Pre-test and post-test analysis models are used to check the effectiveness of the Crossword Puzzle as a revision tool. The majority of students enjoyed this activity and responded to feedback questions in agreed and strongly agreed notes. Pre-test, post-test, and student feedback were conducted using Online Moodle software. Data collected were analyzed using MATLAB. Percentage improvement after every activity was calculated and found that student performance improved for both courses and all 11 units. The range of % improvement is from 10.92% in TMM unit-3 to 92.37% in ATS unit-1. Therefore, the Crossword Puzzle revision tool is recommended to be used in other courses in engineering education.**

***Keywords*— Active Learning; Crossword Puzzle; Improvement; Revision; Student Learning,**

***JEET Category*—Practice**

Rajendra S. Sargar,
Lecturer, Department of Automobile Engineering, KESs Rajarambapu Institute of Technology, Rajaramnagar, Shivaji University Kolhapur, Maharashtra, India.

rajendra.sargar@ritindia.ed

I. INTRODUCTION

HIS, In outcome-based education, "what students learn is more important than what we teach", because poor teaching may lead to reduced interest of the students in learning. The majority of engineering institutes are still using the traditional method for curriculum delivery. The traditional teaching-learning process has a teacher-centric approach and students are just passive listeners. Many researchers have advocated that teaching and learning are mutual procedures that influence each other (Harish Kumar Agarwal, 2020). Learners learn better and retain more when they are directly involved in their learning, not just sitting back and being lectured (Mrs. Piyusha S. Shetgar, 2018).

It has become the teacher's responsibility to teach technical concepts with analytical and attractive teaching strategies to stimulate the critical and creative thinking of learners. (Peyman Zamani, 2021). It may be quite difficult for a teacher to replace the complete traditional teaching approach. He can create a challenging and competitive atmosphere that stimulates peer interaction in the classroom (Joan Bryant, 2016). In response to different styles of learning the use of educational games in the classroom can be an effective tool, especially at the college level. (Tricia M. Davis, 2009)

Many educational researchers have advocated the use of different educational puzzles and games in the classroom as an active learning approach in the teaching-learning process (Runki Saran, 2015). Educational games may be used to excite learners, develop critical thinking, minimize fatigue, easily recall information, retain learning, and sustain their interest in the teaching-learning process (Babayemi, J.O, 2014). The goal of educational puzzles is to first frustrate the solver yet hold out hope for a solution (Nickolas Falkner, 2010). The use of a Crossword Puzzle is one of the strategies that teachers can employ to involve students in breaking clues through peer interaction in a fun environment (Martin C. Njoroge, 2013). Crossword Puzzle are common and are regularly published in newspapers, journals, magazines, etc. and their existence has been documented since 300 AD. (Shilpa Patrick, 2018)

The present study was conducted to test Crossword Puzzle as a revision tool after the completion of each unit of Automotive Transmission Systems and Transport Management and Motor Vehicle Act courses for SY and TY Automobile students respectively. The purpose of this current study was to assess the effectiveness of the Crossword Puzzle as an active learning tool based on student performance in pre-test and post-test analysis using MATLAB.

II. LITERATURE REVIEW

Harish Kumar Agarwal et al. (2020); In this study, a survey was taken to study the individual performance of undergraduate students in a Forensic medicine course. Researchers found that playing a crossword puzzle can improve the psychomotor skills and knowledge of students.

Mrs. Piyusha S. Shetgar et al. (2018); In this study, they have implemented a crossword puzzle method to increase student interest in solving multiple choice questions. Measurement of student learning is analyzed with pre-test and post-test analysis. They have concluded that this is a unique way to test a student's comprehension of the material.

Peyman Zamani et al. (2021); In this study, the researchers compared the Crossword puzzle method with the regular traditional teaching-learning process with three time points, before, immediately after, and after one month of activity. The result of the study showed that puzzle techniques improve the knowledge of the student as well as the retention of learning.

Joan Bryant (2016). Researchers constructed simple Crossword puzzles and clues were given to the students to solve the Crossword puzzles and feedback was taken both before and after the activity. By using simple games like crossword puzzles, we can improve classroom instructions which will motivate students to improve their performance.

Tricia M. Davis et al. (2009); Researchers tested two sections of the same class to find out whether the Crossword puzzle method affects student exam scores as evidence of student learning. The outcome of the study revealed that students in one class benefited but students in other classes showed a reduction in exam scores.

Runki Saran et al. (2015); Printed copies of Crossword Puzzles were given to students and researchers motivated students to solve Crossword puzzles through group discussions in 20 minutes. Many students think that a Crossword Puzzle can relieve the tedium of traditional lecturing and provide a friendlier and more dynamic atmosphere in the classroom.

Babayemi, J.O et al. (2014); Researchers examined the effect of the Crossword puzzle method and mental ability on the achievement of students through pre-test and post-test experiment models. They found that the Crossword Puzzle was a more effective teaching strategy than a traditional teaching strategy.

Nickolas Falkner et al. (2010); In this study, the researchers focused on educational puzzles which will improve the problem-solving skills and creative thinking of students. They developed this approach with the sample syllabus and course materials for the students.

Martin C. Njoroge et al. (2013); This study focuses on the use of the Crossword Puzzle in the teaching of vocabulary in the English language with pre-test and post-test analysis. This study concludes that the Crossword Puzzle helps students to enlarge their vocabulary and deepen their experience in the English language.

Shilpa Patrick et al. (2018); Research was carried out to check the effectiveness of new active learning strategies like crossword puzzles with formative examinations of participant students. The majority of students replied that crosswords are useful to enhance the learning of the topic. It also motivates students to self-learning and provides a creative break from the traditional teaching-learning process.

Amitkumar Maheshwari et al. (2021); This study compares the effectiveness of Crossword puzzles and traditional teaching based on student performance. The outcome of the study says that the Crossword Puzzle improves the learning of students through recreation, which ultimately helps teachers break the monotony of traditional teaching

III. NOVELTY IMPACT STATEMENT

Many researchers used the Crossword Puzzle to increase the vocabulary of students or to recall key concepts in teaching-learning sessions.

The novelty of this study is that the Crossword Puzzle active learning strategy is used for the first time to take revision of a complete unit in engineering education based on the key technical concept in that particular unit. The effectiveness of the Crossword Puzzle as an active learning tool has been checked with student performance in pre-test and post-test analysis using MATLAB.

IV. MATERIALS AND METHODS

This study was conducted on the 3rd-semester Automobile Transmission System (ATS) course and the 5th-semester Transport Management and Motor Vehicle Act (TMM) course for the students of Diploma Automobile Engineering. The study was implemented in

three stages Crossword puzzle activity implementation, pre-test, and post-test to measure students' understanding before and after the activity.

A. Pre-test

Lectures of both courses, ATS and TMM considered for the study are conducted on the online platform MS-Team as per the teaching plan from September 2021 to December 2021. MCQ-based questions are prepared on the respective units.

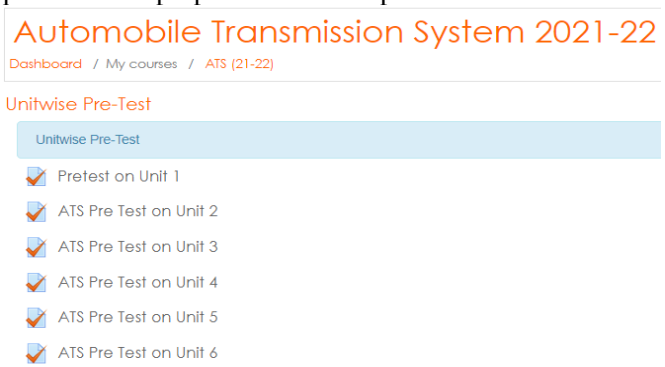

Fig. 1: Sample Unit-wise Pre-test of ATS on Moodle Software

This pre-test comprising of 5 MCQ questions was uploaded on the online Moodle software as shown in Figure Students were asked to solve it within 20 minutes. MCQ-based pre-tests are taken after the completion of every unit in teaching-learning sessions.

B. Crossword puzzle activity implementation

Important technical concepts from units were shortlisted. Its answers and clues were created at moderate and high difficulty levels. These clues and answers were fed to software to create a crossword puzzle. Then 'across' and 'down' clues were recorded and given to students during the revision session.

TABLE 1
SAMPLE CLUES AND ANSWERS FOR CROSSWORD PUZZLES

Across Words		
Sr.	Clue	Answer
2-a	Meaning of "D" in Semi-automatic transmission.	Drive
4	The gearbox in which gears were engaged by sliding them on their shafts.	Sliding mesh
6	Which device is used to vary the torque & and speed of the vehicle as per requirement?	Gearbox
8	Which of the components is absent in semi-automatic transmission cars?	Clutch
11	The gearbox in which all the gears are always in mesh.	Constant-mesh
12	Which gear is engaged to move a vehicle in a back direction	Reverse
13	A transmission in which various speeds are obtained automatically is known as_____ transmission.	Automatic
14	Which types of gears are used in the Sliding mesh gearbox?	Spur gear
19	The auxiliary gearbox used in a four-wheel drive vehicle is called a transfer_____.	Case
Down Words		
1	The shaft gives output power from the gearbox.	Main shaft
2-d	Which element is used to transfer power in the sliding mesh gearbox?	Dog clutch
3	The dog clutch couples the lay shaft and main shaft by _____.	Interference
5	Which type of gearbox removes the clutch pedal from the driver's reach and completes its function electronically?	Semiautomatic
7	An intermediate shaft within a gearbox that always rotates.	Lay shaft
9	Which types of gears are used in a constant mesh gearbox?	Helical gear
10	Which type of gearbox is widely used in a present automobile?	Synchromesh
15	It is a Continuously Variable Transmission.	CVT

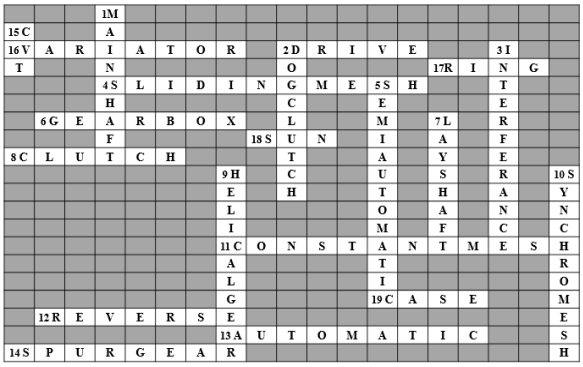

Fig. 2: Sample Crossword Puzzle on ATS Unit 3: Automotive Gear Boxes

These crossword puzzles were created on all units of both ATS and TMM courses by using freely available online websites as shown in Figure 2.

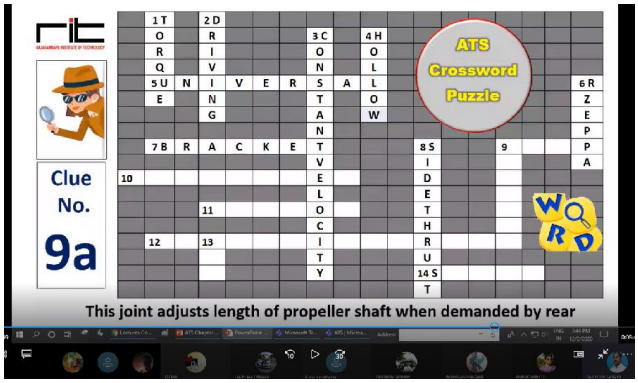

Fig. 3: Sample Crossword Puzzle Clue showing.

Then the one-hour online session was conducted to take revision of each unit by using the Crossword Puzzle strategy. In this strategy, the first clue and number of letters in answers were disclosed to students with the help of a PowerPoint Presentation as shown in Figure.

Fig. 4: Sample Answers of clues in the MS-Team chat box.

After clues and the number of letters in answers were disclosed to students, they were asked to answer the clue in the MS-Team chat box as shown in figure-4 sometimes students are unmuted randomly by a teacher and they have to answer.

C. Post-test

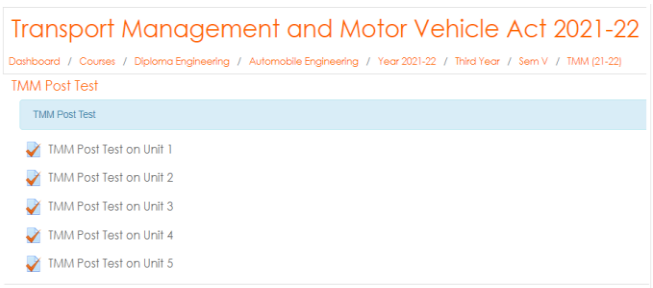

Fig. 5: Sample Unit-wise Post-test of TMM on Moodle Software

After the revision of the Crossword Puzzle strategy, MCQ-based questions are prepared for the respective units. This post-test comprising of 5 MCQ questions was uploaded on the online Moodle software as shown in figure-5 Students were asked to solve it within 20-minute time. MCQ-based post-tests were taken for each unit of both ATS and TMM courses.

Student performance in the pre-test and post-test was analyzed using MATLAB to check the effectiveness of the crossword puzzles strategy for revision of all units. At last feedback on the crossword, puzzle strategy was taken from students. Pre-test, Post-test, and feedback of students were conducted on online Moodle software.

V. STUDENT FEEDBACK

At the beginning of the semester and activity, the student feedback questionnaire and marking scheme (1= Strongly Disagree, 2 =Disagree, 3=Neutral, 4= Agree, 5= Strongly Agree) were discussed with students. Student feedback questionnaires for the Crossword Puzzle activity are shown in Table 2.

TABLE 2
FEEDBACK QUESTIONNAIRE OF CROSSWORD PUZZLE ACTIVITY

Sr. No.	Feedback Question	1	2	3	4	5
1	Did you like and enjoy solving crossword puzzles?					
2	Did the Crossword Puzzle help you to improve your understanding of technical concepts?					
3	Were the clues of the Crossword Puzzle challenging to solve?					
4	Does the Crossword Puzzle promote an active learning environment in classroom sessions?					
5	Do you think that this is a useful tool for taking revision of units?					
6	Do you recommend this tool to be used for other courses?					

After completion of the Crossword Puzzle activity, student feedback was made available on the online Moodle platform from 30th December 2021 to 6th

January 2022. A total of 66 (ATS-30 and TMM-36) submitted feedback on the Moodle platform.

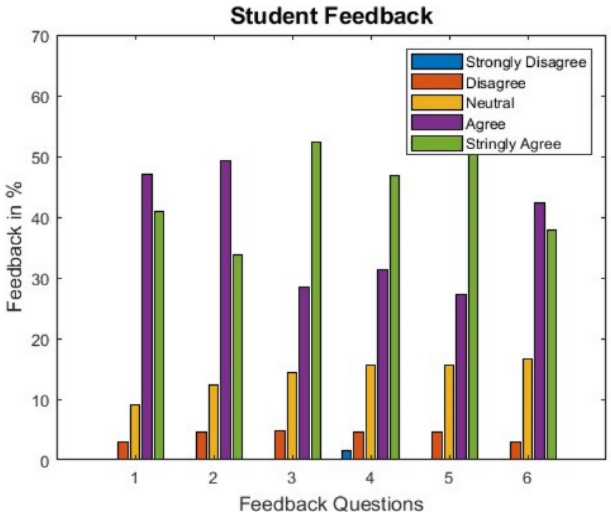

Fig. 6: Student Feedback Analysis (N= 66)

While evaluating student feedback, we found that the majority of students enjoyed this activity and responded to feedback questions in agreed and strongly agreed notes. Student feedback analysis is done in MATLAB and the results are shown in figure- 6.

88% of students agreed that they enjoyed and liked to solve Crossword Puzzles. 83% of students felt that Crossword Puzzle helped them to improve their understanding of technical concepts. 81% of students agreed that the rules of the Crossword Puzzle were challenging to solve. 78% of students said that the Crossword Puzzle strategy promotes an active learning environment in classroom sessions. 81% of students favored the Crossword Puzzle strategy as a revision tool in technical education. 81% of students recommended that this Crossword Puzzle tool be used for other courses. Thus we can say that proper implementation of Crossword Puzzle activities can impact students' learning and involvement in classroom sessions.

VI. RESULTS AND DISCUSSION

A total average of 29 students have solved all pre-tests and post-tests of the ATS course and a total average of 33 students have solved all pre-tests and post-tests of the TMM course. It is observed that out of 70 students, a total average of 62 students actively participated in this Crossword Puzzle activity. It is important to measure the learning received by students during the Crossword Puzzle activity. Comparison of understanding of students before and after Crossword Puzzle activity is measured by pre-test and post-test analysis after every unit of ATS and TMM course by using MATLAB.

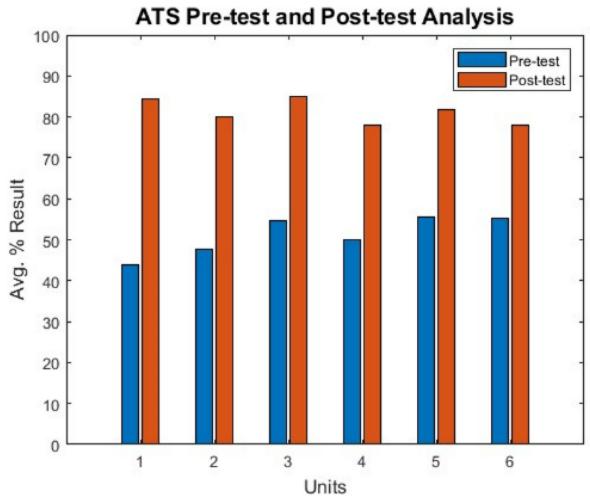

Fig. 7: Average % marks obtained by students in ATS course. (Avg. N= 29)

In the ATS course, students have scored marks in pre-test ranges from 43.85% for unit 1 to 55.48 % for unit 5 and their performance is improved marks scored in post-test ranges from 73.93% for unit 4 to 85.00% in unit 3 as shown in Figure-7.

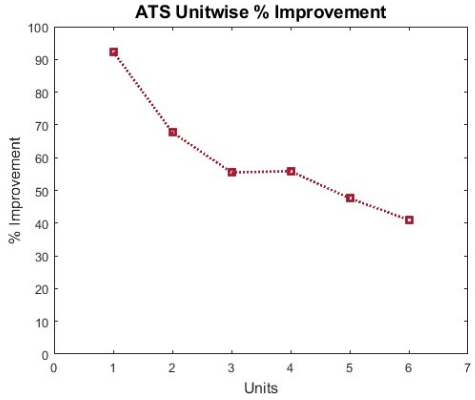

Fig. 8: Unit-wise % improvement in the ATS course.

For the ATS course, it is observed that the average percentage of students in post-tests compared to pre-tests increased in all units; it ranges from 40.96% improvement for unit-6 to 92.37% improvement in unit-1 as shown in Figure 8.

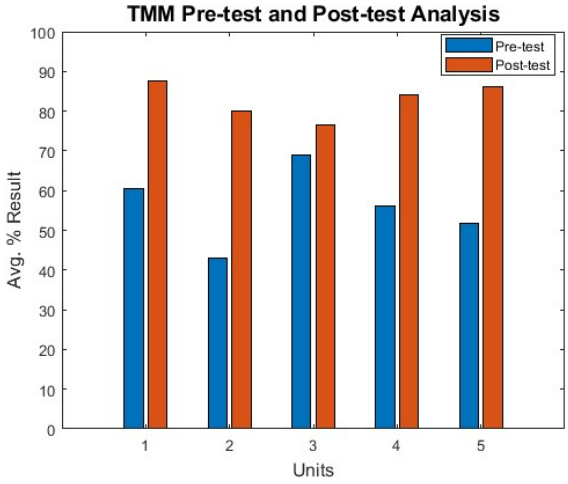

Fig. 9: Average % marks obtained by students in the TMM course.
(Avg. N= 33)

In the TMM course, students have scored marks in pre-test ranges from 43.13% for unit 2 to 69.03% for unit 3 and their performance is improved marks scored in post-test ranges from 77.93% for unit 4 to 87.59% in unit 1 as shown in Figure-9.

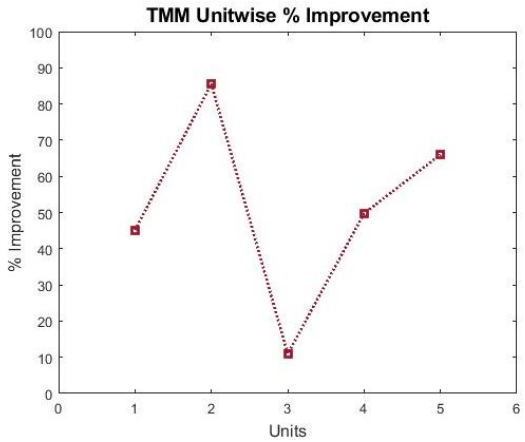

Fig. 10: Unit-wise % improvement in the TMM course.

For the TMM course, it is also observed that the average percentage of students in post-tests compared to pre-tests increased in all five units; it ranges from 10.92% improvement for unit 3 to 85.51% improvement in unit 2 as shown in Figure 10.

VII. CONCLUSION

Crossword puzzle provides excitement to students in the classroom and encourages learning by playing puzzle games. This makes the teaching-learning process more and more productive. This strategy can be used to improve student understanding as well as to provide them the opportunity to evaluate self-knowledge and find areas to improve.

The Crossword Puzzle strategy is used for the first time to revise of complete unit in engineering education and the majority of student found that crossword puzzle enhances their technical knowledge uniquely and enjoyably. In this study student performance is compared with pre-test and post-test analysis. It is found that student performance is improved for both courses (ATS and TMM) and all 11 units. The range of % improvement is from 10.92% to 92.37% which is positive and motivating for the teacher.

Thus we can say that proper implementation of the Crossword Puzzle strategy can impact positively students' learning and their involvement in classroom sessions. Therefore, this Crossword puzzle strategy is recommended to be used in other courses of engineering education.

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