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Effective Application of One Minute Paper and Muddiest Point Technique to Enhance Students' Active Engagement: A Case Study

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Abstract: Outcome based education involves a student centric approach. Active participation of students in the classroom plays a significant role in the Outcome Based Education model. This paper explains the use of two active learning techniques viz. 1) Muddiest Point Technique 2) One Minute Paper for three courses taught to third year Mechanical Engineering undergraduate program. The Muddiest Point Technique was used for the course Computer Oriented Numerical Methods (CONM) by using Padlet as a tool to record the conceptual difficulties. One Minute Paper (OMP) was applied to the two courses, Analysis and Synthesis of Mechanisms (ASM) using traditional One Minute Paper and to another course namely Automation and Control Engineering (ACE) using goggle form. Students' responses to the survey questionnaire showed that implementation of these techniques improved overall understanding of the course content. It gives students a chance to communicate their conceptual difficulties without any hesitation.

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1. Introduction

In the active learning techniques students work individually or in the groups during the class and the teacher play the role of facilitator. It is a student centric approach which helps students in achieving learning goals. Jenny Lloyd-Strovas (2015) observed that implementing active learning techniques for the large classes is a challenging task due to logistical concerns which forces teachers to follow a traditional lecture based approach which leads to very little student-teacher interaction. To overcome the logistical challenges step by step introduction of in-class active learning techniques are recommended by leading engineering educators in Guide provided by Richard M. Felder. Also recent Covid 19 pandemic situations forced the teachers to conduct classes online.

It is observed that in the online mode of teaching, few active students ask doubts during sessions or post queries in the chat box of google meet but many students tend to remain quiet. Such students should get the opportunity to communicate their doubts to the course instructor without any hesitation. If the students' doubts remain unaddressed, there is a possibility that students lose interest in the course.

To engage these students actively in the learning

process is a challenge and emphasizes the importance of implementation of active learning strategies to undergraduate students. Classroom Assessment Techniques (CAT) has been utilized as one method of bridging the teaching learning gap. As per Angelo and Cross (1993) formative assessment techniques are identified as Classroom Assessment Techniques (CAT). Various CATs include the Minute paper, Memory Matrix, Concept Maps and Muddiest Point. This paper aims to discuss two active learning techniques viz. 1. Muddiest point 2 One Minute Paper which provides students a very good opportunity to reflect upon the knowledge gained during the lecture.

2. Literature Survey

Outcome based education involves a student centric approach. Active participation of students in the classroom plays a significant role in the Outcome Based Education model. Qiaohui Wu (2010) has explored the various features of active learning and studied the various causes of lack of active learning such as absence of learning objectives, dearth of willpower, examination oriented education system, etc. To enhance the active learning, Wu has suggested some methods such as setting of goals, formation of study groups, delivering the state of the art content, etc. Wu has concluded that teachers should employ reforms in the teaching methods so as to help the students, develop the concept of self-study. Gleason et al. (2011) have summarized that active learning practices gradually develop higher order thinking skills among students. It is very important that teachers should employ reformation in teaching methodology and help students to develop the ability of self-study. As per Sasikumar (2014) good teacher must have technical competency but along with that teacher must employ various techniques to involve the students in learning process and make the learning a fruitful experience for both slow and advanced learners. Sasikumar has discussed various active learning techniques such as Think-pair-Share, class discussion, student debate, etc. He has also summarized the typical problems encountered while implementing these techniques and remedial measures for the same.

Weaver and Cottrell first developed the idea of one- minute paper. In 1983, Wilson modified it and later it was popularized by Cross & Angelo in 1988. One minute paper is a quick and effective tool which involves active participation of students in the learning process. David .R. Stead (2005) has surveyed literature related to One Minute Paper and concluded that OMP proves to be beneficial to teachers as well as students and needs modest amount of time and efforts. It has been observed that if OMP is applied continuously for two to three lectures, it can become monotonous and students' response declines. It gives students a chance to reflect on the content covered and ask queries related to it and regular competition of the studies improves students' performance considerably in the tests. Ashakiran S and Deepthi R (2013) implemented One Minute Paper in University sponsored Continuation of Medical Education program for post-graduate students. The lecture was subdivided in to five components and one minute paper was employed at the end of every component. Students' responses were analyzed to check to what extent objectives are achieved and to understand questioning pattern related to the topic. They have concluded that for simple and immediate feedback, One Minute Paper proves to be a versatile technique that can be employed to check if the students have grasped the main concept of the topic. They have found that it is an inexpensive, user friendly platform for the learners to ask questions during the course and gives the learners opportunity of active learning. Karlsson et al. (2018) employed One Minute Paper in the digital format which allows quick analysis of the students' responses as compared to implementing OMP with traditional paper based way. The focus of OMP is posing students with the variations of the following questions.1 What was the most important thing you learned during today's class? 2. Was there something you did not understand that you would like explained more clearly? 3. Was there anything you wanted to find out more about, that was or was not covered? A new technology (YACRS) was applied to collect students' responses to the questions. Responses were in the form of text input and software was developed to analyze key points from the students' input. Bimal Kumar Sahoo and Manish Tayawade (2021) applied the technique of One Minute Paper to a large undergraduate class during online session. The technique was used to assess the students' understanding of the lecture content with respect to the target learning objectives. They have concluded that technique proves to be effective in bridging the gap between teaching and learning. In this activity, the students were asked to put forth their thoughts, perspectives and the particular questions at the end of the online session. Follow up of unanswered and difficult questions was not taken.

Muddiest Point Technique is a simple and efficient Classroom Assessment Technique in which at the end of the lecture session or discussion students respond to one question: "What was the muddiest point in the session? Muddiest points can be collected by using different modes. Traditionally it is collected by using paper slips or index cards (Mud cards). As students have to identify the muddiest point, they tend to pay more attention in the class. But at the same time, the focus on what is not understood can be demotivating. Hence balance should be struck by emphasizing on what is understood in the session as well. Majumdar and Iyer (2013) have proposed a framework, LAMP (Large scale Addressing of Muddy Points) which can be effectively used to address individual student's doubts even in a large classroom environment. It is implemented in three steps viz. collection, addressing the muddiest points and closure. Muddiest points were collected in the classroom, outside classroom during discussion with instructor, via Moodle and using chit. It was observed that students have not preferred any specific mode of collection of muddiest points. Muddiest points collected were analyzed and accordingly instructional strategies were modified. Carberry et al. (2013) have stated that implementation of Muddiest Point Technique is beneficial to both the students and instructor. Students get the opportunity to reflect on what is understood and teachers get direct feedback and accordingly course delivery can be modified. They have demonstrated that muddiest points can be addressed effectively by generating YouTube video tutorials, FAQ resources website, implementing preview problems etc. They have demonstrated that implementation of this active learning strategy makes the course enjoyable and valuable from the students' point of view. Perez et al. (2020) applied the muddiest point to undergraduate computer science courses to capture students' perceptions of difficult concepts and to ensure average passing rate. They have concluded that instead of collecting muddiest points at the end of every lecture, if collected every week, students get enough time to reflect and identify true difficult points which need to be revised

The literature review shows that researchers have applied Muddiest Point Technique and One Minute Paper to the various courses and analyzed its impact in terms of students' perception and results. Researchers have summarized that these techniques work as an excellent feedback tool to understand students' difficulties and plan the subsequent actions accordingly.

Still more experimentation is required related to the implementation of active learning technique such as One Minute Paper and Muddiest Point Technique for various Mechanical Engineering courses in the time of hybrid mode (online lectures and offline laboratory sessions) of teaching. It can be effectively implemented to enhance students' engagement during COVID-19 Pandemic situation. An attempt has been made to implement these techniques for Numerical based subjects like Computer Oriented Numerical Methods, Graphical Approach based subject like Analysis and Synthesis of Mechanisms and Application oriented subject like Automation and Control Engineering for the Third Year undergraduate of Mechanical Engineering.

The objective of this study is to provide comfort level to the students to communicate their conceptual difficulties through various platforms such as Padlet, Google form, paper (hard copy) to the course instructors during the shift from complete online mode to hybrid mode of teaching learning environment.

3. Methodology

Due to Covid 19 pandemic situations, the teaching learning process was conducted in hybrid mode. The lecture sessions were conducted using the online goggle meet platform. In the traditional classroom environment, the course instructor can judge the students' understanding level from their facial expressions. Accordingly the course instructor decides which points are to be repeated and given

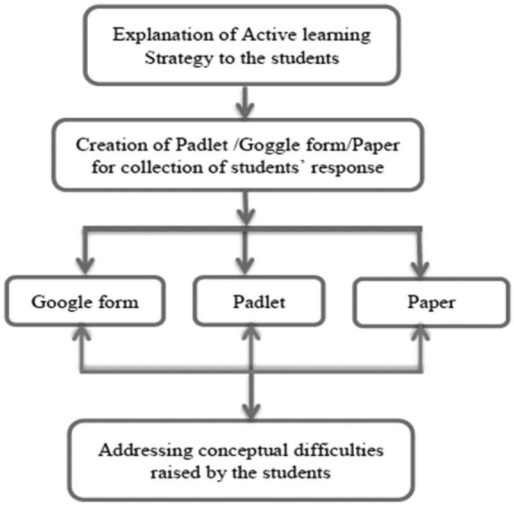

Fig. 1: Procedural Steps for MP/OMP

additional explanation. But in the online mode, this element is completely missed and hence there is possibility that some conceptual difficulties may skip the much required revision. This issue can be addressed by using One Minute Paper and Muddiest Point Technique. Students were briefed about the active learning techniques to be used. A padlet wall, Google form and paper slips were created for the collection of Muddiest Points and responses to One Minute Paper. Evidences of the implementation are presented in the form of screen shot of the padlet wall, Google form and actual photograph of paper slips with students' responses.

4. Implementation

The active learning strategies viz. Muddiest point technique and One minute paper are implemented for three courses of the third year mechanical engineering undergraduate program. The three courses are 1) Computer Oriented Numerical Methods 2) Analysis and Synthesis of Mechanisms 3) Automation and Control Engineering. Due to covid 19 pandemic situation, the teaching learning process was in hybrid mode i.e. theory classes were engaged online and some of the laboratory sessions were conducted in person.

A. Muddiest Point Technique:

The Muddiest point technique was used for the theory course: Computer Oriented Numerical Methods. A padlet was created for collecting and recording the muddiest points of lecture sessions as shown in the figure 2. All the third year mechanical branch students joined the padlet wall. Prior to using this active learning technique, the idea of the muddiest point was explained to the students. Students were also explained how the padlet will be used for anonymous collection of the most difficult point/s of the lecture session. For the first few lectures, a quick recap of the lecture content was taken in the last three or four minutes and students were given a list of probable difficult points from the lecture. Students either chose points from the given list or any other point which they have faced difficulty in thorough understanding. The points which needed revision, difficult concepts were written on the padlet wall by the students. The course instructor used to browse all the points mentioned on the wall and answered the queries on the padlet itself or in the subsequent lecture.

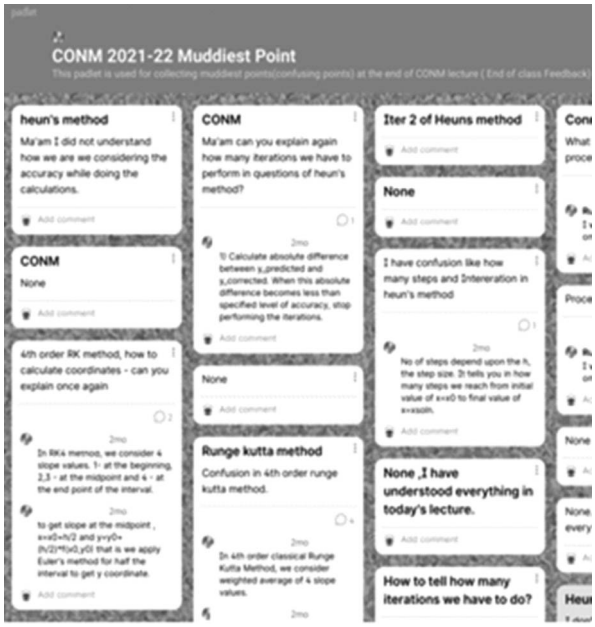

Fig 2: Padlet - Muddiest Point Technique

B. One Minute Paper

The active learning technique of One Minute Paper is used in the classroom for instantaneous feedback. It helps the teacher to check whether students have understood the main points discussed in the class session. Its major advantage is that it provides immediate feedback whether the teacher's main idea and what the students have understood as the main concept are one and the same. The students find it difficult to ask the question during the class session even in online mode. In Implementing OMP technique, it is necessary for each student to concisely write down answers to two questions, generally: (1) what was the most important concept learned in class today? And (2) what are the most uncleared points of the discussion in class today? Anonymous answers are preferred to inspire students to complete the OMP activity. The teacher addresses the most uncleared concept in the next class. Students understand that their course teacher gives importance to their viewpoints and learning needs and this, ultimately improves students' motivation.

The One Minute Paper (OMP) was employed for the two courses 1) Analysis and Synthesis of Mechanisms 2) Automation and Control Engineering for third year Mechanical Engineering students to assess effectiveness of achievement of learning objectives. Students were briefed about the One Minute Paper technique. J. Shaaruddin, M. Mohamad

(2017) has concluded that OMP technique takes about a minute and, generally used at the end of class, also the same technique can be used at the end of small topic discussion.

1) One Minute Paper (Paper Slip)

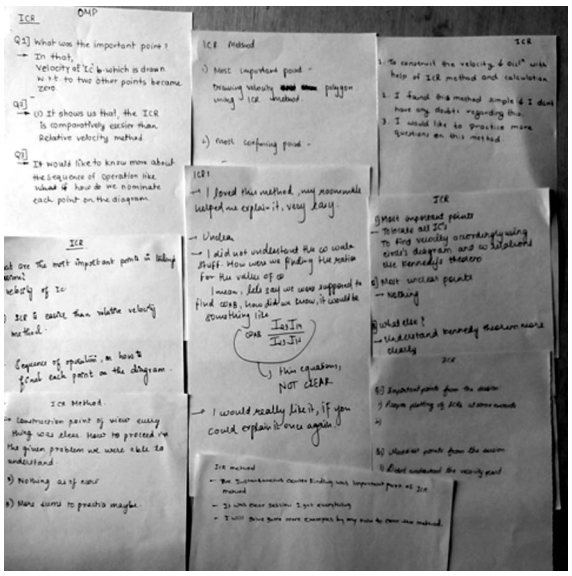

Fig 3: Hard copy (on paper)-One minute paper

For the Analysis and Synthesis of Mechanisms course, OMP technique was implemented in Physical Minute paper during laboratory sessions for velocity analysis of mechanism using Instantaneous Centre (ICR) method. Physical Minute papers were read by the teacher and the uncleared part of the previous session was revised at the beginning of the next class to address the points mentioned by the students.

2) One Minute Paper (Google Form)

For the Automation and Control Engineering course at the end of the class, a google form was floated. The following two questions were asked in the Google form (1) what was the most important concept learned in class today? (2) What are the most uncleared points of the discussion in class today? The teacher studied students' responses of the google form. The Students' understanding of the lecture content was verified and doubts were resolved in the subsequent lectures.

One Minute Paper provided a platform for students to ask questions anonymously with paper slip. In the subsequent session the uncleared points raised by the students (in One minute paper/google form) were revisited and revised, which ultimately helped

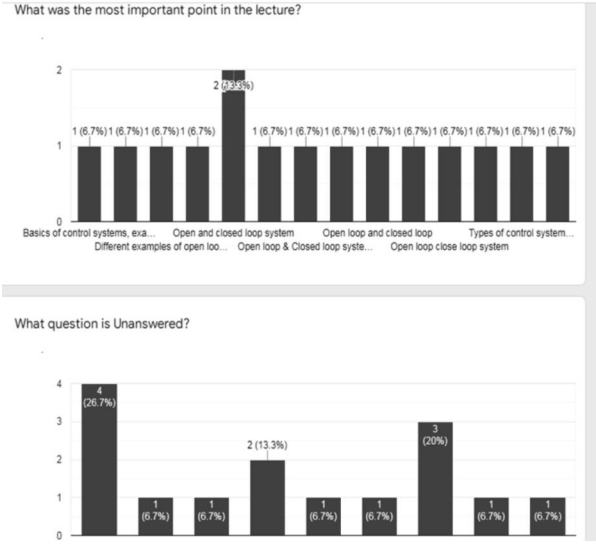

Fig. 4 : Google Form Response– One Minute Paper

students to get their doubts cleared. It is observed that One minute paper is simple to use, and a quick evaluation tool, which reviews the learning objective achievement. For the teacher, the answers of One Minute Paper help to check to what extent the learning objectives of the class have been achieved. Accordingly, a teaching plan can be reframed.

5. Survey Questionnaire

To study and analyze the effectiveness of active learning strategies viz. Muddiest Point Technique and One Minute paper, a survey questionnaire was prepared. During the process of preparing the questionnaire, the survey questions related to active learning strategies prepared by Carberry et al. (2013) and H. A. Seneviratne et al.(2021) were referred. The objectives of the survey were to measure 1) the enhancement of students' engagement in the teaching learning process 2) the enhancement of conceptual understanding 3) the enhancement of interest developed in the courses. Survey was conducted using Google form.

There were ten questions in the questionnaire. Students' responses were recorded on a four point scale [A) Strongly Agree B) Agree C) Disagree D) Strongly Disagree.] The survey Questionnaire is as shown in the figure below. (Number of students participated in the survey = 51).

6. Results And Discussion

Effect of Implementation of MPT and OMP is

Table 1: Active learning Survey Questionnaire

Sr. No.	Statement	Strongly Agree	Agree	Disagree	Strongly Disagree
1	I got opportunity to communicate the most confusing point/unclear concept to the course instructor through MuddiestPoint Technique and One Minute Paper without hesitation.				
2	Raising query through Muddiest Point Technique and One Minute Paper does not consume a lot of time.				
3	Muddiest Points and One Minute Paper were addressed by the course instructor in the class (next session).				
4	After the course instructor explained the uncleared point, the overall understanding of the topic is improved.				
5	Muddiest Point and One Minute Paper Techniques helped me to improve my self-learning ability.				
6	The Muddiest Point and One Minute Paper has benefited me with self - reflection of the topic.				
7	Myclassroom engagement is enhan ced with Muddiest Point and OneMinutePaper activity.				
8	I would like to raise doubts through Muddiest Point Technique and One Minute Paper for other courses as well.				
9	I am more comfortable with the following way of collecting Muddiest Point and One Minute Paper.	Padlet		Hard Copy (on paper)	Google Form
10	Explain briefly the reason behind your comfort for the chosen method of collectingMuddiest Point.				

studied in terms of the following two points

- Attainment levels of Course outcomes
- Students' Perception of Active Leaning Techniques

A: Attainment levels of Course outcomes

Course Evaluation is done in the form of ISE (In-Semester Examination) and ESE (End Semester Examination) ISE has two components viz. T1 and T2. T2 and ESE are conducted by Paper and Pen mode. T1 is continuous evaluation which can be done using various modes such as assignments, quizzes, crosswords, etc.

Course Chairman and Course Instructor define course outcomes using appropriate action verbs as per revised Bloom' Taxonomy. For every event of evaluation, questions are mapped with the course outcomes and based on students' performance; attainment levels of the course outcomes are calculated.

For the course CONM, Active learning Technique MPT was applied for CO6. For the course ASM the active Leaning OMP was implemented for CO2. For the course ACE OMP was employed for CO4. Table 2 shows the comparison of Attainment levels with and without implement of active learning techniques for respective Course outcomes.

Table 2: Statements of the Course Outcomes

SR. NO	COURSE NAME	PARTICULAR COURSE OUTCOME STATEMENT
1	CONM	**CO6:** Obtain approximate solution of ordinary and partial differential equations applying numerical techniques.
2	ASM	**CO2:** Construct and analyze velocity and acceleration of links in four bar and slider crank mechanisms.
3	ACE	**CO4:** Justify selected component(s)/system from given catalogue(s) for automation application under study.

Table 3: Comparison of Attainment levels of respective Course Outcomes

SR. NO	COURSE NAME	PARTICULAR COURSE OUTCOME	ATTAINMENT LEVEL			
			PREVIOUS YEAR (WITHOUT IMPLEMENTATION OF MPT AND OMP)		CURRENT YEAR (WITH IMPLEMENTATION OF MPT AND OMP)	
			ISE	ESE	ISE	ESE
1	CONM	CO6	3	3	3	2
2	ASM	CO2	2	3	2	3
3	ACE	CO4	1	2	-	3

B: Students' Perception of Active Leaning Techniques

In this part of the paper, the students' responses to the survey questionnaire are presented. The responses are analyzed to understand students' perception about the implementation and effectiveness of the Active

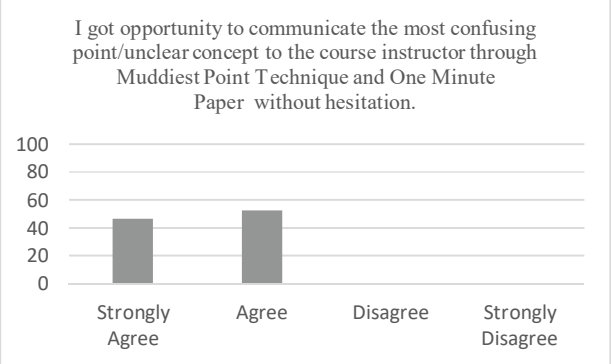

Fig. 5 : Communication of the unclear concept

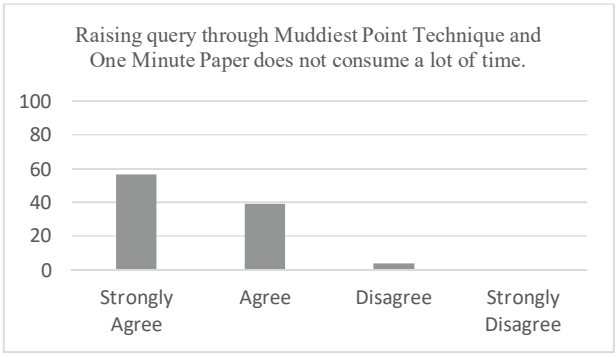

Fig. 6: Activity Time

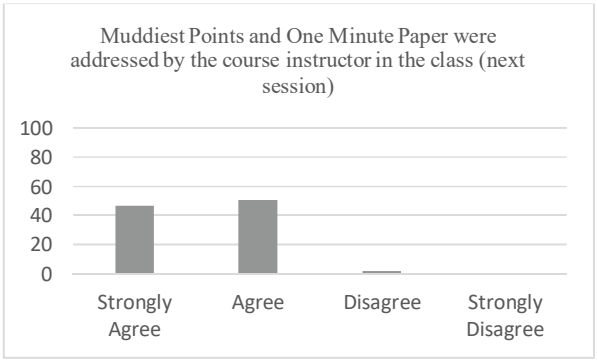

Fig. 7: Addressing of the unclear concepts

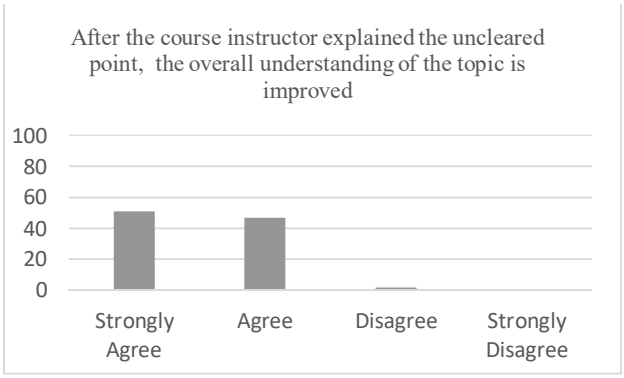

Fig. 8 Improved understanding of the topic

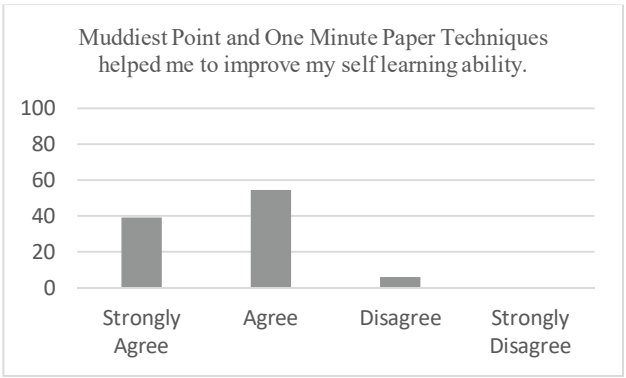

Fig. 9: Self learning Ability

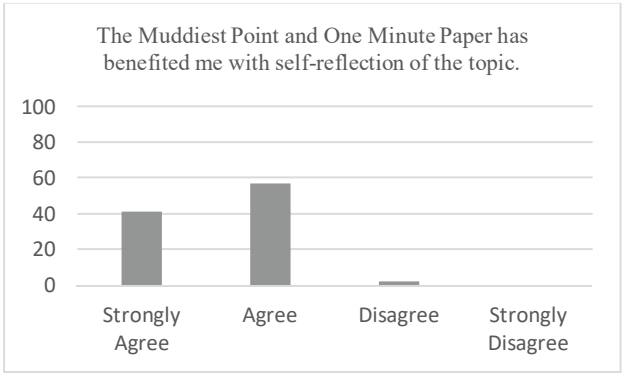

Fig. 10: Self-reflection of the topic

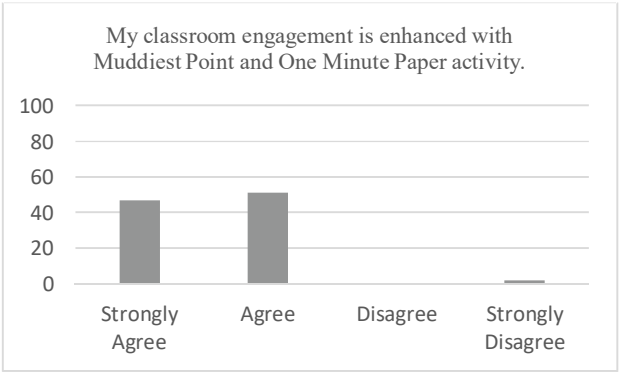

Fig.11: Enhancement of classroom engagement

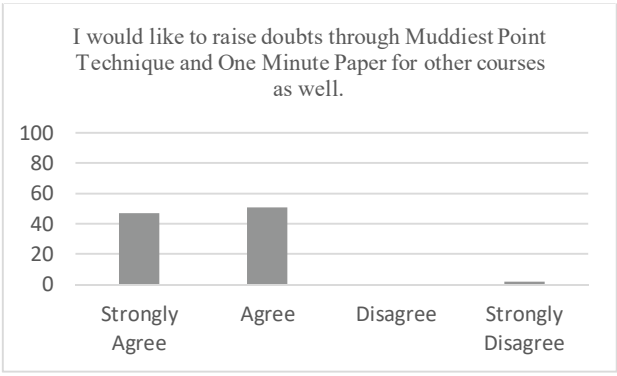

Fig.12: Use of Muddiest Point/OMP Technique

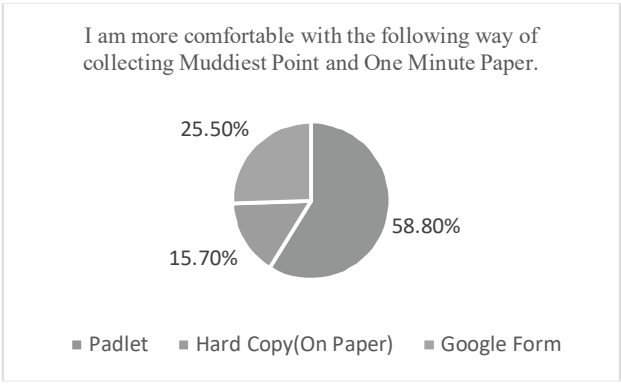

Fig. 13: Comfort level w.r.t. mode of collection

learning strategies viz. Muddiest Point Technique and One Minute Paper.

The Analysis of the students' responses is as follows.

- All the students are of the opinion that they can share their doubts and difficulties to the course instructors without any hesitation using these active learning techniques.
- 96% students have opined that using Muddiest Point Technique and One Minute Paper, they can raise the doubts without spending lot of time.
- 98% students believe that the doubts raised by them are addressed by the course instructors in the subsequent sessions.
- 98% students agree to the point that, once their doubts get cleared by the course instructors, the overall understanding of the topic is improved.
- Around 94% of the students believe that implementation of the Muddiest Point Technique and One Minute Paper has inculcated in them the self-learning ability.
- 98% students have expressed that application of the Muddiest Point Technique and One Minute Paper has helped students with self-reflection of the topic.
- 98% students have stated that use of active learning strategies have helped to increase classroom engagement.
- 98% students have expressed the opinion that they would like if these active learning strategies are employed for the other courses as well.
- Around 60% students have shown comfort with the use of padlet wall for Muddiest Point Technique. Around 16% students have shown comfort with the use of paper slip for One Minute Paper. Students can express their doubts and difficulties anonymously on the padlet wall as well as using paper slip. They can communicate their doubts to the course instructors without any hesitation by these two modes.
- Around 25% of the students have shown their inclination towards the use of goggle form for one minute paper.
- Due to ease in accessibility and convenience students have shown liking towards active learning strategies implemented.

Munna et al. (2021) have done the impact analysis of active learning strategy on student's engagement. They have used peer learning, experimental learning, and game-based learning as active learning strategies. They observed that majority of students (82%) got the opportunity to express their viewpoints on the contents learned. Authors observations is in line with the literature, that almost 100% of the students have expressed that they got opportunity to communicate the most confusing point/unclear concept to the course instructor through Muddiest Point Technique and One Minute Paper without hesitation.

Mohti (2011) has studied impact of using One-Minute Paper in civil engineering courses. The author has compared the course outcome evaluation results with and without implementation of OMP and observed that this technique is effective in increasing student's involvement in the course contents. The author has observed a noticeable improvement in the evaluation rating after implementation of OMP. In the present study the effect of MPT and OMP on the attainment levels of the course outcomes is studied and authors' findings are in agreement with above literature.

Desai (2022) has applied various active learning strategies for the course of Hydraulics and Pneumatics and summarized that implementation of active learning strategies helps to create supportive environment for self-learning of the students. Authors' finding in this study is that 94% students believe that self -learning habit is developed is in agreement with the literature

Existing literature suggests that active learning strategies are beneficial in increasing the student's involvement in the course content which ultimately results in the improvement of academic performance and better achievement of expected course outcomes. Authors' findings are in line with these observations. Implementation of active learning strategies has helped the students in the transition phase from complete online to hybrid mode. Authors have observed that, timely addressal of the doubts helps students connect with the course content. It leads to better conceptual understanding and enhancement in the academic performance and thus establishes virtuous cycle. After the application of OMP,

improvement was recorded in the attainment level of the course ACE.

7. Conclusions

Active learning strategies viz. Muddiest Point Technique and One Minute Paper were implemented for three courses of the third year undergraduate Mechanical Engineering program. Muddiest Point Technique was employed for the course Computer Oriented Numerical Methods using the padlet wall. One Minute Paper strategy was used for Analysis and Synthesis of Mechanisms using paper slip. Google form was the mode applied for the course Automation and Control Engineering for the technique of One Minute paper. Based on the analysis of the students' responses to the survey questionnaire the following conclusions are drawn.

- Overall it can be summarized that identifying the concepts which are not clear is a prominent step towards better learning. These active learning techniques help students in developing higher thinking skills, so that they can convey their conceptual understanding of the lecture content as well as difficulties at the end of the session. As the doubts are timely addressed by the course instructors, students are immensely benefitted.

- The cross-sectional study constitutes the effect of active learning strategies on active engagement of the students leading towards conceptual clarity and in turn improving their academic performance.

- The active learning strategies help students develop interest in the course content.

- As the course instructors respond to the doubts either in the subsequent session or prior to that, doubts are not piled up. It leads to the better understanding of the concepts.

- With the use of padlet wall to collect the Muddiest Points, students can check the conceptual difficulties faced by their fellow classmates as well. Hence the padlet wall works as repository of important points related to the course.

- With Google form as the mode of compiling important points and doubts, the course instructor can address the difficulties of the entire class.

- By using traditional paper chits, every student has to jot down the conceptual difficulties at the end of the sessions. This mode encourages and ensures active learning during the session on students' part.

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