Creating an Effective Learning Environment in Engineering Graphics Course for First Year Engineering Students

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Abstract: Thinking and learning are irresistible for human but they differ on individual's cognitive abilities. Engineering education demands active and experiential learning for experiencing demonstrable technical and professional skills. The practice of active learning strategies is gaining momentum in Indian engineering education. Engaging today's learners i.e. Millennial learners, in learning activities, is a challenging task for a teacher in a constrained physical learning environment. The responsibility of the teacher is to create an effective learning environment to promote students' intended learning. The learning environment is characterized by the learners, learning activities and learning outcomes. This paper presents a different kind of an experience gained in creating an effective learning environment in Engineering Graphics course for the first year (freshman) engineering students for improving their spatial visualization. This also portrays a variety of blended learning activities employed in building confidence amongst students. The learning strategies have been developed to overcome the challenges so as to create an effective learning environment among students. While employing such learning approaches, the factors like engaging students, using appropriate strategies, balancing the content length with the level of learning, managing time and infrastructure, and measuring the of success of activity should be considered. These well-structured activities are executed with the appropriate supportive learning resources. The impact of blended teaching strategies and their sequence on improving students' learning in this course has also been assessed through structured feedback and informal interactions. The results demonstrate a significant improvement in students' learning experience through a set of active learning strategies.

Keywords: Learning Environment, Active Learning, Engineering Graphics, Students' Learning, Paper Modelling, TAPPS, Note Check

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1. Introduction

Thinking and learning are unstoppable for human but they differ on individual's cognitive abilities. Learning is the result of neural connections, caused during course of time and it would result in concrete experience. True learning results from doing things and reflecting on the outcomes (Felder and Brent 2016). Engineering education demands active and experiential learning for gaining essential technical and professional competencies. Teaching is a purposeful intervention that causes students' learning. Traditional teacher-centered teaching has been gradually transforming into learner-centred approach in Indian context. Active learning is a learner-centered teaching approach that encompasses active participation of students in doing things in a class room rather than simply watching and listening to the instructor and taking notes. Active learning reduces cognitive level of working memory, making retention and storage of new information more likely (Felder and Brent 2016). In the learner-centric approach, students are expected to experience active and deep learning during their course of study.

The practice of active learning strategies is gaining momentum in Indian engineering education. Because active learning strategies are learner-centered, students take more responsibility in their own learning. The responsibility of the teacher is to create an effective learning environment to promote students' intended learning. Each individual has unique learning preferences which lead to distinct learning experience. Engaging today's learners i.e. Millennials in learning activities, is really a challenging task. They learn differently, when compared to teachers. Therefore, a variety of teaching strategies has to be customized for engaging the millennials. Besides, they diverge in thinking, interacting, using technologies, and leading their life. The responsibility of the teachers is to understand the composition of students in his/her class and to devise suitable a sequence of variety of technology-enabled activities for achieving the intended students' learning.

Learning environment is defined as the diverse physical locations, contexts and cluster in which students learn (Abualrub et al. 2013). Koper (2014) defined learning environment as the set of physical and digital locations, contexts and cultures in which students learn. Classrooms, laboratories and workspaces are some of the examples of a learning environment. Even natural sites and industries may also be a learning environment, based on the context of learning. Learning environments are arranged to stimulate towards learning outcomes through learning materials, tasks, tests, quizzes, feedback and support. Besides, the learning environment is characterized by the learners, learning activities, and learning outcomes. One or more learning activities are employed to address the intended learning outcome. Moreover, learning environment also facilitates the integrated learning to address more than two learning outcomes. Koper (2014) categorised learning environment, based on composition of physical and digital methodologies into five cases:

1. Zero case - Only cognitive representation without any physical and digital locations
2. Digital case - Physical environment with digital learning devices without non-digital stimuli to the learner
3. Embedded case – Physical environment provides relevant stimuli to the learner and digital devices augments cognitive representation
4. Side-by-side case - Digital devices are added to a physical environment to support additional learning function. All information about the physical environment will be added to digital device by the learner
5. Classical case – Physical environment provides relevant stimuli and no additional digital interactions

On the consideration of the above, the effectiveness of students' learning lies on the way of planning, designing, implementing, and reflecting learning activities in physical and/or digital environment. Choosing appropriate strategies needs a careful design and implementation of the plan combined with the appropriate technology.

An attempt was made to create an effective learning environment of a course on Engineering Graphics for the first year (freshman) engineering graduates in alignment of the above discussed aspects. The intention of this research study is to know: *How well the blended teaching strategies and their sequence improve students' learning in Engineering Graphics course for freshman engineering students.*

This paper presents the reflection on the experience, gained in creating an effective learning environment in a course on Engineering Graphics for the first year engineering graduates. The paper is organised into five sections as detailed here. Section 2 describes the challenges and strategies for creating an effective learning environment, Section 3 explains the learning activities employed in the Engineering Graphics course for first year students. Section 4 presents the results of the activities in terms of students' learning and discussion and section 5 leads to the significant conclusion of this work.

2. Effective Learning Environment

One of the arguments of Bowden & Marton (1998) is that *the 'best' approach to teaching will vary both with the nature of the learning being undertaken and the context in which it takes place, and above all with the object of learning*. As per this statement, the following aspects are to be considered in developing an effective learning environment.

- Engaging the students in the activity
- Using appropriate strategies
- Balancing content length and level of learning
- Time management in performing the activity
- Managing infrastructure in executing the activity
- Measurement of success of activity

Koper (2014) defined an effective smart learning environment where physical environments are augmented with digital, context-aware and adaptive devices to promote better and faster learning. He introduced a new theoretical concept named as Human Leaning Interfaces (HLI), a set of interaction mechanisms which are used to control, stimulate and facilitate the learning process. Three basic HLIs represent three types of learning: learning to deal with new situations (identification), learning to behave social group (socialization) and learning by creating something (creation). These HLIs result in the change of cognitive representations and behaviour which develop skills. The performance of task is enhanced by Practice HLI which is characterised by repetition of activities to improve the quality of result and to prepare for a high performance for forthcoming tasks. Moreover, another HLI named as Reflection has been proposed for the meta-cognitive development. Ohelsson (2011) defined this reflection HLI as a result of prevailing past experience, exploring new ideas, creative insight, adaptation of cognitive skills by learning from errors, and conversion from one belief to another compatible belief. Based on literature, the inference has been presented in the form of a concept map on learning environment which is presented in fig. 1.

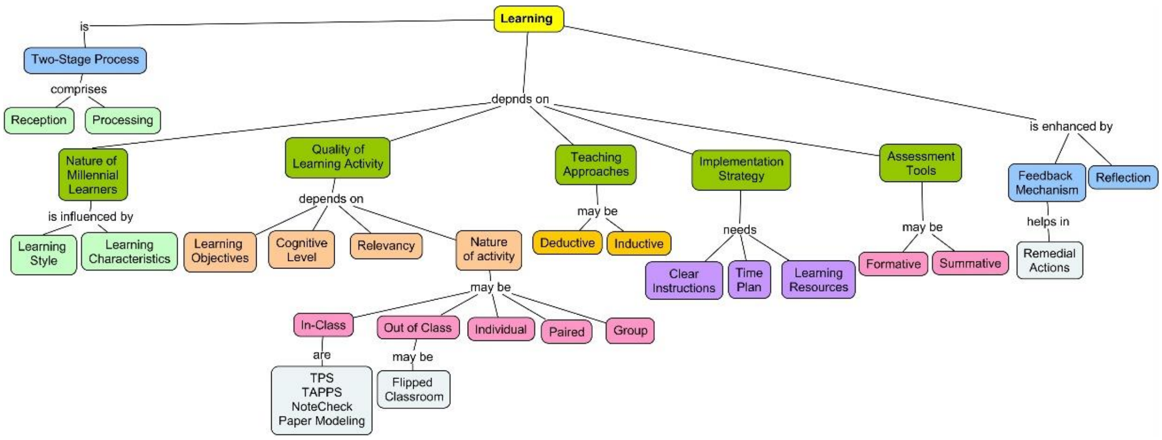

Fig. 1 Concept map of constituents of learning environment

TABLE 1. CHALLENGES AND STRATEGIES IN CREATING EFFECTIVE LEARNING ENVIRONMENT

Challenges	Strategies
Engaging the students	
• Lack of students' awareness on the benefits of the activity • Lack of realisation to the relevancy of activity and the syllabus content • Difficulty in managing students' diversity in terms of learning styles, level of knowledge, level of understanding, interest, expectations in learning and experience of learning • Lack of Students' cooperation due to unassigned group activity • Lack of reflection of students' learning experience on the activity • Managing more number of groups in a large class room	• Explaining the outcome of the activity and its relevance to course outcome • Educating them the importance of the activity before the start of the activity • Showcasing the real time applications on the topic of the activity • Establishing a connection of previous learning and explain its role in future learning • Obtaining the learning preferences of all the students in class and • Identifying the major class of learning preferences • Designing and executing variety of activities addressing all possible learners • Assigning the groups based on the level of knowledge to enable the peer learning opportunities • Assigning the group/pair with logic like random numbering, birth date/month. • Obtaining the oral/written feedback about the learning experience
Balancing content length and level of learning	
• Students' attitude towards surface level of learning and their mind-set on non-coverage of syllabus content	• Designing an activity for students' deep learning experience • Implementing Flipped classroom activities in lower cognitive levels • Conducting in-class activity in higher cognitive levels for the competency demonstrating course outcome
Time management	
• Activity time exceeds the expected execution time which affects successive teaching plan	• Execution of well-designed/ structured activity with the specified time-lines • Remedial plan in case of exceeding the stipulated time
Managing infrastructure	
• Difficulty in implementing activities in a rigid classroom structure • Non-availability of reconfigurable class room for implementing group activity	• Planning the activity by ensuring the availability of the reconfigurable classroom • Implementing with an alternate plan for the same activity in rigid classroom structure
Measurement of success of activity	
• Difficulty in ensuring the success of the learning activity	• Devising a mechanism for students feedback • Assessing the students' performance • Revealing the success of learning in the same/successive class

A. Challenges and strategies in creating an effective learning environment

The effectiveness of teaching intervention and availability of supportive conditions for learning will stimulate the learning process. However, the challenges have to be faced by devising appropriate strategies to build an effective learning environment. The challenges and strategies in developing an effective learning environment are summarised in the table 1 in terms of engagement of students, use of appropriate strategies, balancing content length and level of learning, time management, managing infrastructure and measurement of success of activity.

3. Teaching and Learning strategies for Engineering Graphics course

Engineering Graphics course is offered to all branches of engineering in almost all universities/colleges regardless of their geographical location. This course is one of the fundamental courses for engineering students to build spatial visualization abilities professionally. Pucha and Utschig (2012) employed series of learning strategies to improve students' engagement in one of the courses of freshman engineering students, ME/CEE 1770 Introduction to Engineering Graphics and Visualizations which is offered in spring, summer and fall at Georgia Tech. Peer assisted learning in lectures, collaborative learning in lab activities, problem-based learning in tests/exams and assigning real-world case studies or team projects for integrative thinking are the different types of learning strategies employed in this course. The students' engagement is assessed qualitatively through interactions and quantitatively through questionaries with rating scale. The results indicate a noticeable improvement in their learning attitude and enhanced the levels of student engagement.

A. Nature of the course

The course 14ME170 -Engineering Graphics is offered for the first year engineering students of all branches at Thiagarajar College of Engineering, Madurai. This course is one of the challenging courses for faculty as well as students due to its mode of learning that is totally different from students' learning experience in school. Though millennial learners are smart and predominately visual learners, they lack in spatial visualization ability. This requires a kind of an intensive practice and training in visualization and drawing. They are performing remarkably well in solving similar kind of problems but they find some difficulty in attempting new kind of problems. It has generally been perceived that there is a need to train them differently and inculcate the attitude for learning new things.

B. Activity 1: Paper Modelling

A series of learning activities for the course, 14ME170 – Engineering Graphics has been implemented for the entry level engineering students of Computer Science and Engineering Students on topic of Development of Surfaces for solids. A batch of 52 students has participated in this activity in the odd semester of academic year 2016-17.

The students are engaged in drawing the projections of different solids monotonously during practice sessions and it is found that most of the students are not interested in this approach. In order to break the monotonous traditional experience, a model building exercise is planned for execution in a practice session.

Millennials are generally inquisitive in performing things differently instead of doing it in a tedious way which they have been practicing since childhood. A variety of learning activities in a sequential manner is explored and examined to address almost all possible components of learning preferences (Sensory, Intuitive, Visual, Verbal, Active, Reflective, Sequential and Global).

On the considerations of the above, the objective of the activity is set as: *At the end of the activity, students will be able*

- To develop a paper cut model of a hexagonal prism using development of surfaces
- To recognize the characteristics of solid based on the number of surfaces, edges and corners

The students are expected to construct the unfold drawing on a paper, based on the nature of the solid i.e. a hexagonal prism which comprises two hexagon for the base and top faces, and six rectangles for lateral surfaces. After the construction of the unfolded drawing, it is detached from the paper. The surfaces are labelled and folded in a particular fashion to obtain a hexagonal prism. Joining of appropriate faces completes the required paper model. The students would experience the method of developing surfaces for a solid and understand how it is used for making a solid.

In order to address the different learning styles of the students and to engage active learning, the following activities are executed sequentially in order to ensure the expected outcome in the paper modelling activity to demonstrate higher bloom's cognitive abilities.

1. Flipped Mode Video - Outside Class activity (A day before the activity)
    - Video of paper model for making of pyramids (Relating new materials for future topic) – Weblink: http://www.korthalsaltes.com/model.php?name_en=multi%20side%20base%20pyramids
2. Think-Pair-Share (TPS) activity (Time for self-reflection & Brainstorming) -In-class activity (before start of task) – 5 minutes
3. **Paper Modelling** (Balance between problem solving and understanding & Assigning practice) - In-class activity: 35 minutes
4. Self-assessment and Feedback (Problem requiring analysis) - In-class activity - 5 minutes (After the paper modelling)

Efforts made to complete in time:

The following steps were taken to complete the activity within stipulated time.

- Instruction sheet, self-assessment forms, and rubrics for the activity as shown in fig. 2 and fig. 3, are prepared and distributed before the start of the task. Hand-outs with a description, rough sketches, instructions for performing the activity in different stages, and their timelines is formulated and issued. The estimated time is 3 minutes.

14ME170 – Engineering Graphics – I sem – CSE II Academic Year 2016-17

Paper Modeling – Instruction Sheet

- **Expected Outcome of Paper Modeling (06.10.16)**
  At the end of the activity, students will be able
  To develop a paper cut model of a hexagonal pyramid using development of surfaces
  To recognize the characteristics of solid based on the number of surfaces, edges and corners
- **Estimated Time for activity: 35 minutes**
- **Planned Sub-activities:**

Stages	Sub-activity	Estimated Time (minutes)
1	Construction of two dimensional unfolded drawing with base, top face and all lateral surfaces with appropriate measurement	15
2	Cutting of unfolded portion of surfaces	8
3	Folding the surfaces correctly	6
4	Joining surfaces appropriately to complete the model (Fit and finish)	6

Assessment Rubric for paper model with weightages

Descriptors	4	3	2	1	Weights
Level of Completion	Completed all four stages of the task	Completed three stages of the task, completion of folding in stage 4	Completed three stages of the task	Completed two stages of the task. Partial completion of stage 3	50%
Level of finishing	Well-developed model comprising the required faces and edges. Properly labelled faces.	Well-developed model with minor constructional error in folding and joining.	Developed model with constructional error in folding and joining.	Developed model with significant error in folding and joining.	30%
Time Management	Completed the task within the planned execution time of 35 minutes	Completed the task with in the execution time in the range 35-40 minutes	Completed the task with in the execution time in the range 40-45 minutes	Not completed in the class. Completed the task after the class hours.	20%

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THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI - 625015
DEPARTMENT OF MECHANICAL ENGINEERING
Self Assessment – Paper Modeling (06.10.16) – I sem B.E. (CSE)

Name of Student. Roll No.:

- Parameters Score
  Level of Completion
  Level of finishing
  Time Management

Signature

14ME170 Engineering Graphics I sem CSE II - Academic Year 2016-17

Fig. 2 Assessment rubric and self-assessment form

14ME170 – Engineering Graphics – I sem – CSE II - Academic Year 2016-17

Definition of a Pyramid:

A pyramid is a polyhedron with one face (known as the "base") a polygon and all the other faces triangles meeting at a common polygon vertex (known as the "apex"). A right pyramid is a pyramid for which the line joining the centroid of the base and the apex is perpendicular to the base. A regular pyramid is a right pyramid whose base is a regular polygon. An n-gonal regular pyramid (denoted Yn) having equilateral triangles as sides is possible only for n=3, 4, 5. These correspond to the tetrahedron, square pyramid, and pentagonal pyramid, respectively.

1. Construction of two dimensional unfolded drawing with base, top face and all lateral surfaces with appropriate measurement

   Dimension of hexagonal pyramid for paper modeling:Side= 50 mm; Height = 120 mm;

2. Cut the required unfolded portion of surfaces
3. Fold required surfaces at appropriate places as shown in figure
4. Join surfaces appropriately to complete the model (Fit and finish)

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Fig. 3 Instruction Sheet for students on Paper modelling

- Orientation to Faculty members: The faculty members that are assisting during the activity are informed about the activity and its implementation. The hand-out of the activity, directions and assessment forms are given to them prior to the activity as a preparatory work before the start of the class. Faculty assessment format and students' feedback formats are prepared and are as shown in fig. 4 and fig. 5 respectively. An informal interaction is arranged to sensitise the learning preferences to students. In addition, the schedule for the oral feedback of the activity is estimated as 10 minutes
- A coloured card board paper model is prepared earlier and showcased as a concrete example just before the start of the task to build confidence amongst students during the in-class activity and the estimated time is 2 minutes.

14ME170 – Engineering Graphics – I sem – CSE II Academic Year 2016-17

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DEPARTMENT OF MECHANICAL ENGINEERING
Assessment of Paper Modeling (06.10.16)

S.No	Roll No.	Name of Student	Level of Completion	Level of finishing	Time Management	Remarks
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
11.						
12.						
13.						
14.						
15.						

Fig. 4 Faculty Assessment Form

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI - 625015
DEPARTMENT OF MECHANICAL ENGINEERING
Assessment of Paper Modeling (06.10.16)

Name of Student: Roll No.:

Please furnish your response with '✓' mark at the appropriate box.

S.No.	Description	Strongly Agree	Agree	Satisfied	Disagree	Strongly Disagree
1.	I am confident in developing a solid using paper modelling					
2.	Paper modelling gives me better understanding of solids about its faces, edges and corners					
3.	I can construct two dimensional unfolded drawing with base and all lateral surfaces with appropriate measurement					
4.	I can cut the unfolded portion of surfaces					
5.	I can correctly fold required surfaces to form a solid					
6.	I can complete the model by joining surfaces appropriately					
7.	Pre-class instructions from weblink is sufficient to perform this task					
8.	Faculty showcased finished model before the activity					
9.	Instructions in the class are clearly stated before start of the task					
10.	I have given enough time to think before start of the activity					
11.	Hand-out for in-class activity is given					
12.	I had given with sufficient time to complete the task within the estimated time					
13.	I have learnt better by doing this kind of activities such as paper modelling					
14.	I had concrete learning experience on paper modelling of solids					

- Most clear point from this activity :
- Most unclear point on this activity :
- Suggestions for improvement :

Signature

Fig. 5 Students Feedback form for paper modelling

Assessment Plan:

An assessment plan is also prepared and the target on the success of the task is set as Average score of rubrics is greater than 3. The nature of the activity is individual and in-class activity. Besides, a self-assessment is also implemented to engage them in self-assessment, by using a given scoring sheet attached with a hand-out. The students are then instructed to submit their self-assessment score after the completion of the model. To measure the success of this activity, a feedback form as shown in figure 4, is structured to receive the students' responses in Likert scale 0-4 (Strongly disagree to Strongly agree). The expected overall achievement target is set as "greater than 3" i.e. at an average, every student strongly agrees on the use of this activity.

C. Activity 2: TAPPS and Note Check

Another challenge is to engage the students in problem solving independently. It is found that students do not take notes and mention the important points. This results in lack of understanding of concepts and spending more time in practical (drawing) sessions. To reduce /overcome these learning obstacles the two activities known as Think Aloud Pair Problem Solving (TAPPS) and Note Check are chosen and recommended. Based on paper modelling experience, the topic "*Section of Solids and their Development of Surfaces*" is selected for subsequent active learning. At the end of the session, the expected outcome of would be that the students will be able:

- To solve the problem on section of a hexagonal pyramid and its development of surfaces using the projection.
- To write down the step by step procedure for determining the projection of the sectioned hexagonal pyramid and its development collaboratively.

Nature of the activity: Paired; In-Class Activity

Think-aloud Pair Problem Solving (TAPPS):

The students are engaged to solve the problems in the area of 'Sections of Solids' and enabled to develop the surfaces for cut-solid. Besides, they need to identify the differences in handling prisms and pyramids. As the problem solving on this topic consumes approximately 20 minutes, the problem is divided into sub-problems named as 'stages'. There are 3 stages in solving a problem on pyramid in the given worksheet.

Note Check:

The students are expected to note down the important instructions and the procedures for problem solving and this subsequently improves their performance in the subsequent practical/drawing sessions. It would be difficult for a faculty to check the class notes individually in a large class room environment. Hence, it is planned to implement "Note Check" activity to ensure proper note taking process. This activity will enable them to engage in interaction and get them an opportunity for a collaborative learning.

The estimated time for both activities was predicted as 18 minutes. The following steps were taken to implement the activities successfully.

- Distributing a problem sheet on section of variety of solids and their development of surfaces ahead of the session
- Identification of sub-problems (Stages) for the identified problem on hexagonal pyramid. Since the problem solving is time consuming, the problem is sub divided into three stages
- Preparation of questions for each stages of TAPPS
- Identification of roles of questioner and explainer (Problem Solver) in TAPPS
- Preparation of estimated time for each stage of the activity
- Planning for team change-over - Pair of Students for each stage
- Preparation of feedback questionnaire

Stage 1: Placing a sectional plane

Row n+1	Student 3-Q	Student 4-E
Row n	Student 1-Q	Student 2-E

Stage 2: Determining true shape on the sectional plane

Row n+1	Student 3-E	Student 4-Q
Row n	Student 1-E	Student 2-Q

Stage 3: Developing the surface for the cut solid

Row n+1	Student 3-Q	Student 2-E
Row n	Student 1-Q	Student 4-E

Q- Questioner; E – Explainer (Problem Solver)

TABLE 2 IMPLEMENTATION PLAN FOR TAPPS AND NOTE CHECK

Activity	Specific questions	Details of implementation	Time Allotted (Seconds)	Maximum Time allowed
Think Aloud Pair Problem Solving (TAPPS) - in stages	Stage 1: Placing a sectional plane • Where do you place the sectional plane? Front view or top view? Justify • How many cut points are available for the cutting plane? Label the cutting points.	• Team: Pair of students • Left will be the questioner and person sitting right will be explainer.	90 90	150 150
	Stage 2: Determining true shape on the sectional plane • Identify the sectioned portion and what is nature of the shape on sectional plane? • How does the shape differ from the sectioned part in prism? • Is this a true shape? Justify. • Write the steps involved in the determining a true shape	• Same Pair of students • Role is exchanged i.e. left is the explainer and right is the questioner.	60 30 30 90	90 60 60 150
	Stage 3: Developing the surface for the cut solid • Differentiate the development of uncut and cut solids • How does the development of pyramid differ from the development of prism? • Write down the steps involved in the development of cut solids	Exchanged Pair of students	30 30 60	60 60 90
Note Check	• Review the steps involved in the determining true shape • Review the steps involved in the development of cut solids • Identify the missing points and highlight them in the notes using pencil. • Observe the procedure and fill up the gaps, if any. • Discuss the procedure and consolidate the same	Exchanged Pair of students Exchange of class notes	45 45 45 45	60 60 60 60
Total Estimated Time (Seconds)			690	1080

4. Results and Discussion

A. Results of Activity 1 – Paper Modelling

In order to measure the success of the activity, overall success rate was aimed at achieving average score of students' feedback should be greater than 3 in all the parameters. An enthusiastic involvement of every one of the students in this task was observed which was not seen before in the drawing practice sessions. Students and faculty members are appreciated this activity which is completely different from monotonous drawing practice session. It is felt that the activity is under control during its implementation due to the clarity of instructions even for the sub-activity level with timelines. The feedback of the students on paper modelling experience has been summarised in figure 6.

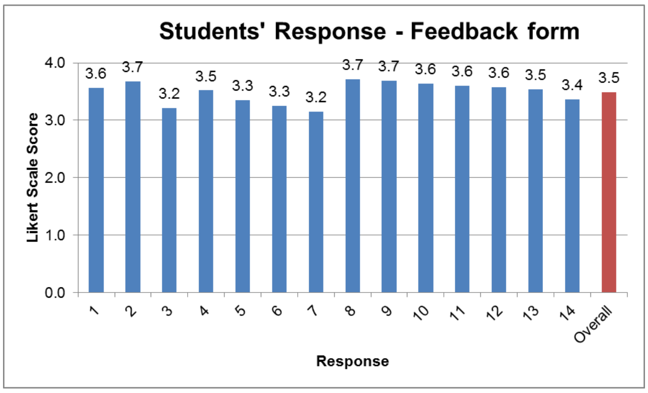

Fig. 6 Students' Response on Paper Modelling

	Description
1.	I am confident in developing a solid using paper modelling
2.	Paper modelling gives me a better understanding of solids about its faces, edges and corners
3.	I can construct two dimensional unfolded drawing with base and all lateral surfaces with appropriate measurements.
4.	I can cut the unfolded portion of surfaces.
5.	I can correctly fold the required surfaces to form a solid.
6.	I can complete the model by joining surfaces appropriately.
7.	Pre-class instructions from weblink are sufficient to perform this task.
8.	Faculty showcased the finished model before the activity.
9.	Instructions in the class are clearly stated before the start of the task.
10.	I have been given enough time to think before the start of the activity.
11.	Hand-out for in-class activity is given.
12.	I am given with sufficient time to complete the task within the estimated time.
13.	I have learnt better by doing this kind of activities such as paper modelling
14.	I get a concrete learning experience on paper modelling of solids

The activity is successful from the Students' feedback and the overall average score of feedback on this paper modelling is 3.5 which is more than set value of greater than 3. Besides, the following Students' statements of experience in this activity are observed from their feedback form. The following students' statements also reflect the success of the activity.

"It is interesting to do some practical work like this and I understand this concept clearly with this paper modelling"
"Developing models and learning makes imagination/ thinking effective"
"It gives better understanding of solids about its faces, edges and corners"
"Helped to visualize a 3D object"
"I feel confident on developing a solid"
"It helps a lot with projections when we literally visualize the model"
"It is a better approach to make models for efficient understanding"
"Concepts can clearly be understood visually and theoretically"
"Making models can improve concentration"
"I can confidently do any solids without much guidance"
"It is easy to solve problems from the models made"

However, five of the students have expressed their response under unclear point category. The following students' responses reveal that there is a need of attention for outside class room activities.

"Pre-class instructions for weblink are not sufficient to perform this task"
"I have not been given enough time to think before the start of the activity"
"Difficulty in folding a triangle in a correct shape and gluing the sides"
"How to manage time is quite unclear"

Sparing additional time for activities such as oral instructions, distribution of hand-outs, distribution and collection of feedback form and students' interaction is not considered in the overall time estimation for the activity. Flipped mode video is not watched by all the students and no formative assessment is conducted on it.

B. Results of Activity 2 : TAPPS & Note Check

The overall success rate was estimated that the achieving average score of students' feedback should be greater than 3 in all the parameters. Students are engaged throughout the sessions and demonstrate an active participation in activities. Students also enjoy during the changeover at the end of each stage. The more number of questions are received from almost every student during the activity. Besides, an effective interaction was remarkably observed during and after the class hours. Students understand the concepts better when the problem is formally divided into various stages and they write down the steps clearly. The first two stages of the TAPPS are successful, based on the scores of the responses 1 and 2. Paired note check has facilitated them to bring out a detailed procedure for the given problem. Most of the students agree that sufficient time is provided for the completion of the task at each stage. The overall experience on the implementation of activities has given a great level of satisfaction by doing differently in the class. It is visibly evident that the degree of students' attention during these activities has gone up always. This activity is not an obstacle to hinder the coverage of the syllabus. In contrast, this alternative new teaching and learning approach seems to be a boon which enables the student community to feel pleasure rather than pressure. Though they have well participated in TAPPS, the feedback score on the role of activity in bringing out the procedure is marginally lesser than 3. TAPPS activity has given confidence on stage 3 due to higher time than the expected. The summary of the students'' response on TAPPS and Note Check activities are presented in figure 7.

C. Faculty and Student interactions

In order to maintain a constant interaction with students, 'WhatsApp' messenger is used as a discussion forum for this course. This forum is customized for improving the student-faculty and student-student course level interactions. Faculty and student volunteers have taken the role as the administrators. Since this course is a common course for all branches of engineering, it was attempted to engage them in some kind of discussion on topics after the class hours as well as before the class room sessions to establish the relevancy of the course on their domain. This platform helps the author in engaging them in learning beyond the classroom hours on a flipped mode. Some of the important discussions the author had with the students and their responses are precisely presented below.

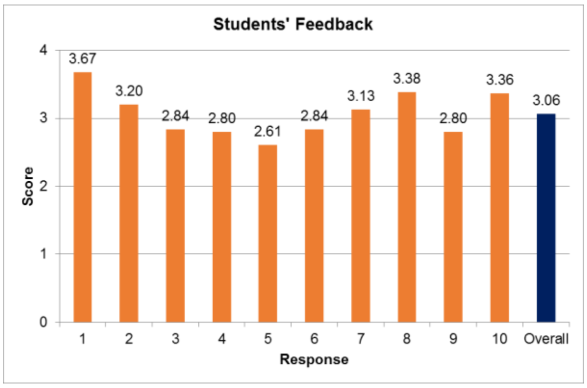

Fig. 7 Students' Response on TAPPS and Note-Check

	Description
1	I am confident in choosing simple position of solid
2	I clearly understand the placement of cutting planes
3	I am able to identify the cutting points on the solids
4	I can draw the development of surfaces of uncut and cut solids
5	I can explain the procedure in solving problems in section of prisms and pyramids
6	TAPPS activity has helped me to understand the procedure involved in section of solids and development of surfaces
7	Paired note check has improved my class notes
8	I am given with sufficient time to complete the task
9	I can extend this procedure in solving problems on other solids
10	I have acquired a better learning experience through activity-based class room sessions in this course

Though the term 'spatial intelligence' has been used in class to emphasize the need of this course, that students are expected to spend more time on reflecting it. Therefore, the author initiated an interaction in continuation with previous class by sharing a web link on Spatial Intelligence to reinforce this concept.
"*https://en.wikipedia.org/wiki/Spatial_intelligence_(psychology) (Links to an external site.): Send me one statement that you liked in this link*".
The author received significant responses from his students where everyone exposes the expected important statements. Some of Students' responses through 'WhatsApp' are:

'A blind person can recognise shapes in a non-visual way'

'Spatial intelligence provides an ability to imagine transformations and orientation of the objects'

'It's a kind of human computational ability to solve spatial problems, visualize an object in a different space and note even minute details in it.'

'An intelligence provides the ability to solve problems or create products that are valued in a particular culture'

Before the start of a topic on 'Development of Surfaces' which has a major application in packaging industry, an interaction has been initiated with a question *"Name any one man-made object that is available in market without packaging"*

Some of the interesting Students' responses are:

- *Pots, Books, Bricks, Plywood, Balloons, Currency*

Intervening questions: *How are all these materials transferred from one place to another...is there any object without packaging before reaching to market or your home????*
Students Response:

- *But everything is mostly packed before they deliver it to the market. Then they are unpacked. So, it's quite confusing sir. Bags, Pots, Books and everything are packed for transportation.*

An intermediate peer interaction has also been started on one student's response on this discussion. Some of them are:

- *Vegetables : 'They r not man made'*
- *Pollution or dust? - 'Pollution is not an object'; 'That is available in market?'*

The author has experienced a great feel of satisfaction in addressing their need as early as possible through this discussion forum. The students have shown keen interest in participating in this interaction forum. Their interactions show their social consciousness and responsibilities. They have also reflected that they have a different thought process towards packaging and its importance in day-to-day life. The worksheets are also shared through this forum which has been used as partial mobile-based learning management system. The author has got a rich experience in using the technology and its benefit in stretching students' learning experience. The students' response has surprised the author and driven him to do more in future. However, students have got a better learning experience in paper modelling than in the TAPPS. On informal interaction, they have expressed that paper modelling is so different and they have got satisfied on hands-on experience which clearly reflects the nature of millennial learners.

5. Conclusions

Learning is supposed to be an outcome in terms of knowledge, skill, and attitude. The attitude drives the interest in learning new things and subsequently acquiring related knowledge and skill. Inculcating the learning attitude among the students is the challenging task for teachers, on which the faculty ought to explore, examine, and experiment much towards better teaching and learning process. Besides, the teacher's responsibility is to turn the teacher-centric teaching environment into a student-centric learning atmosphere. In order to address the millennial learners, the responsibility of the course handling faculty is to create a learning environment with a trade-off between comfortable and challenging tasks. A variety of activities has to be designed to address the different learning style preferences. Moreover, sequence of activities should be planned to enable the students to get engaged in consistent learning. Besides, a constant interaction between the faculty and students is required inside and outside the classroom i.e. physical and virtual classroom environment for maintaining a sustainable learning environment. The challenges and strategies are summarised in this paper.

Active students' participation through sequence of activities promotes their critical thinking and problem solving approaches. Paper Modelling has been implemented with other supporting learning activities such as flipped classroom and TPS to improve the spatial visualization abilities for the students. TAPPS and Note Check activities are employed to address the problem solving abilities. All the activities are planned and executed with timelines. Moreover, the assessment of students' learning is performed through self-assessment, informal interactions, and feedback questionnaire. It has also been observed that teaching efficiency also improves in spite of the limited resource availability and there is an opportunity for developing innovative approaches. No resource can hinder in doing simple learning activities for better students' learning. However, technology-enabled activities help maintaining curiosity, accessible learning resources and information, which in, turn help in tracking the level of learning. There are teacher-student interactions in the classrooms and off-the class rooms rough a discussion forum by using WhatsApp for to keep the teaching-learning process continuously live and effective. Designing, planning, implementing, assessing, and reflecting on appropriate learning activities will create an effective learning environment with satisfaction to students and faculty as well. More such technology-enabled activities need to be devised to enhance the millennial learners' participation.

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