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A Comprehensive Survey On The Integration And Impact Of Innovative Pedagogy Techniques In Engineering Education

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ABSTRACT

The engineering syllabus in India, typically designed for a four-year undergraduate program, is indeed structured to provide students with a comprehensive education in engineering and related fields. Imbibing such a wide range of educational aspects within four years for differently-abled learners in a large classroom setting limits the educational innovations, more specifically use of a wide spectrum of pedagogy techniques. Teacher education is itself rarely learner-centred and hence importance is given to teaching skills, patterns of school organization and curricular content rather than pedagogy.

The acceptance of the innovative pedagogical techniques in engineering education, despite having numerous advantages,is doubtful and can only be confirmed by surveying the actual student and teacher experience in this regard.

Survey instrument with instructor led pedagogy techniques and pedagogy techniques promoting self paced learning was designed. Survey instrument consisting of 14 pedagogic techniques was circulated among 19 private affiliated engineering institutes across Maharashtra state of India. 1777 students and 221 teachers responded. The survey form was designed to record responses on 5 point likert scale (Never-Rarely- Sometimes-Often-Always).

Descriptive analysis, Bivariate analysis and Factor analysis were performed..

Research instruments were tasted and found reliable for both controlled groups i.e. students and teachers. By analyzing the survey responses it was found that the construct “Pedagogy” is independent of all demographic variables. Survey analysis also suggested the improvement in inclusiveness of a variety of pedagogy techniques in engineering education. According to both Student & Teacher survey; Classroom Games and Mathematical Puzzles were the least used pedagogy technique and Project is the most utilized pedagogic technique.

INTRODUCTION

The engineering syllabus in India, typically designed for a four-year undergraduate program, is indeed structured to provide students with a comprehensive education in engineering and related fields. It covers basic and engineering sciences, core & elective courses, humanities and projects. Apart from domain knowledge; engineering education demands a sense of continual learning, social sensitivity, corporate readiness and interpersonal skills. Imbibing such a wide range of educational aspects within four years for differently-abled learners in a large classroom setting limits the educational innovations.

Effective instructional techniques by virtue of impactful pedagogy selections helps teachers to deliver the contents within time constraint.

Effective teachers [1] use an array of teaching strategies because there is no single, universal approach that suits all situations. According to Britannica [2] Pedagogy is the study of teaching methods, including the aims of education and the ways in which such goals may be achieved. The field relies heavily on educational psychology, which encompasses scientific theories of learning, and to some extent on the philosophy of education, which considers the aims and value of education from a philosophical perspective.

Today’s pedagogical techniques have evolved over time, drawing from various teaching theories such as mental-discipline theory, Naturalistic theories, Apperception theories, Condition and behavioristic theories, cognitive theories, maturation and readiness theories, among others. But at the epicenter the selection of pedagogical technique depends on the effective delivery of the contents. Pedagogical techniques should be selected such that they will address the needs of cognition, psychomotor and affective domains of learning. Different authors have suggested different pedagogical techniques but all mainly fall in three categories [3] Teacher centric, Learner Centric and Teacher-Learner interactive methods. These categories likely serve as a framework for selecting appropriate teaching approaches.

Engineering education ideally being an outcome based education, needs to focus more on learner centered pedagogy techniques than the others. It is not possible [4] to meet student outcomes with the same instructional configuration.

Different learner centric pedagogy techniques which are feasible and suitable for engineering education are summarized in literature review sections.

LITERATURE REVIEW

Pedagogy techniques [5] shall facilitate learning experiences that meet the needs of special and general education of students in regular classroom settings and therefore result in opportunities for most students to succeed in their learning. Instruction delivery planning for learner centric classroom setting shall consider two basic principles i.e. the principle [6] of managed teaching (Every student will receive the chance to achieve the established learning objective in an independent, differing way), and the principle of continued progress in teaching (Every student should be in continual motion towards new learning requirements; in other words, no one should stand in the way of the student’s learning pace). Instructions [7] should be engaging the students and motivate them to learn. Atmosphere and conduct should reflect mutual respect between teachers and students. Learning challenges should build on learners’ aggregate existing knowledge and Dialogue (not only transmission) should be used in teaching and learning. Learning [8] environments should embrace personalization of the learning process according to the main characteristics of their learners.

Immersive interactive learning [9] and augmented reality; gamification of learning and instructions; reverse instruction / flipped classroom; robots in the classrooms; and adaptive personalized learning can be used in engineering education. Gamification i.e. the use of game elements in non-game settings [10] is now more and more used in education to increase learner motivation, engagement, and performance. The Simulation game environment [11] attracts more student attention and makes tacit knowledge like perception, collective knowledge, conceptualization, analytical thinking, and experience more explicit. Decision Making Games [12] help to arrive at a decision in a dynamic scenario. Flipped classroom [13] plays a key role in a modern engineering education by freeing time for student focused activities and inspiring students to become free self-students.

Project-based learning [14] is driven by the end product. PBL is student centered, Teaching through skills, Process centered, Group based, Experiential and communication intensive, lifelong learning and it involves critical thinking. The component of project based learning [15] should be increased in extent, complexity and autonomy in later years of program.

Challenge based learning (CBL) [16] enhances students' motivation and learning effectiveness. It improves learning and problem solving ability. It provides a high degree of satisfaction among learners.

Computer Simulations [17] provide better knowledge to the subjects. simulations promote “connectivism” which underscores the importance of learning to think as opposed to learning knowledge. Simulation fosters the development of creativity and cognitive effectiveness in forming new concepts and technical solutions, introducing innovations into existing solutions and original thinking and also provides a positive effect on the acquisition of technical knowledge.

Crossword puzzles [18] promote interaction through learning activities in a large classroom environment. Technique helps to understand student performance and comprehension in class, and give instant response without interfering with the teaching process.

Interdisciplinary seminars, guest lectures, field trips, lab assistantship etc [19,20] helps in increasing student interest in education.

Various methods as cited above were proposed and implemented. Even though these methods focus on students' active learning; they are often resisted by academicians [21]. Importance is given to teaching skills [22], patterns of school organization and curricular content rather than pedagogy. Teacher education is itself rarely learner-centred, and so does not provide suitable models upon which teachers can base their practice. This shapes the extent of their commitment to effective pedagogy in general. And hence despite offering rich promises, innovations in pedagogy are very difficult to implement. Attempts should be made to build interactive pedagogy techniques on conventional pedagogical practices [7,23,24]. The extent of overlapping of conventional and innovative pedagogy techniques will determine the learning experience of the students. Higher the overlapping better will be the learning experience.

Positioning of the pedagogical innovations in engineering education needs to be identified. The effective way in doing this is to take a survey on the practice of different pedagogical techniques in engineering institutes from the most important stakeholders i.e. students and teachers.

THE AIM OF THE STUDY

The acceptance of the innovative pedagogical techniques in engineering education, despite having numerous advantages,is doubtful and can only be confirmed by surveying the actual student and teacher experience in this regard.

The aim of the study involves surveying the existence of various pedagogical techniques in engineering institutes' context by designing a reliable survey instrument and conducting a survey among students and teachers.

FRAMEWORK OF SURVEY INSTRUMENT

While designing the survey instrument instructor led pedagogy techniques and pedagogy techniques promoting self paced learning were considered. Students including alumni and Faculty members were asked to rate exposure to the pedagogy techniques in their institutes. Following pedagogy techniques were used for survey purpose:

Video Lectures, Classroom games, Computer Simulations, Computer generated environment like scenes and objects (Virtual Reality), Mathematical Algorithm, Writing Journals, Peer Feedback, Interactive white boards, Field Trips, Mathematical Puzzles, Scientific experiments, worksheets, independent studies, and projects.

METHODOLOGY

Data Collection

A self descriptive survey form consisting of 14 pedagogic techniques was circulated among 19 private affiliated engineering institutes across Maharashtra state of India. The survey form was designed to record responses on 5 point likert scale (Never- Rarely-Sometimes-Often-Always). 1777 students and 221 teachers responded. Students from second year onwards were selected for the survey.

Data Analysis

Descriptive Statistics, demographics and related cross tabulation, Tests of scale reliability, and correlation between the pedagogy and demographic parameters were established with the help of IBM-SPSS software. Correlation between variable Pedagogy and family income was calculated using Spearman's Correlation coefficients. Correlation between variable Pedagogy and age group was also calculated using Spearman's Correlation coefficients.Correlations between variable Pedagogy and other demographic variables were calculated using biserial Coefficient. Based on the test of scale reliability, Principal Component Analysis (PCA)was carried out with Oblimin rotation because it was assumed that the factors would be correlated. Visual scree test and traditional method of producing eigenvalues by PCA were used to determine the appropriate number of factors to retain. Theoretical convergence was also considered. Further for statistical identification, a factor comprising at least three measured items were considered [25]. Student and Faculty responses for individual pedagogy techniques were compared by comparing means and standard deviations. Given the number of respondents to the questionnaire, pattern coefficients ≥ .51 were considered salient [25]. Complex loading of salient pattern coefficient was rejected to obtain a simple structure. Factors with minimum three salient pattern coefficient, internal consistency reliability ≥ .70 and that were theoretically meaningful were considered adequate.

RESULTS

Demographic characteristics

The student group comprised 1234(69%) male and 543 (31%) female students & alumni. Out of 1234 Male students, 925 (75 %) were belonging to 18-21 age groups, 275 (22%) from 22-25 age groups and others from 26 and above age group. In case of girls, 440 (81%) were between 18-21 age group, 94 (17%) were from 22-25 age group, and others from 26 and above age group. 595 (48%) Male and 456 (84%) female students represented the Circuit branches and the remaining were from Non-Circuit branches. Out of 1777 students 955 (54%) were from the Open category and

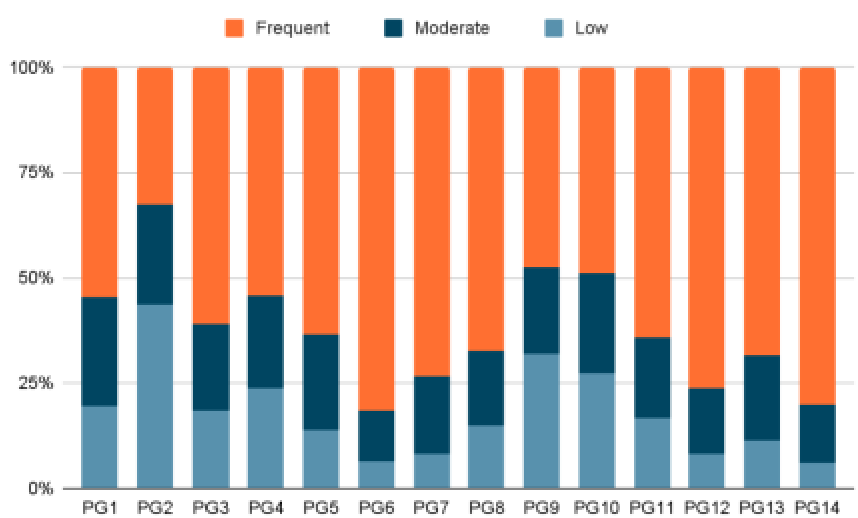
822(46%) were from the Reserved category. 540 (44%) male students and 222 (41%) female students were belonging to the income bracket of Nil to 1 Lac.

The faculty group comprised 151 (68%) male and 70 (32%) female teachers. Out of 151 male teachers, 65(43%) were belonging to the 41 and above age group. In the case of female teachers, 19 (29%) were belonging to the 41 and above age group. 75 (50%) Male and 48 (68%) female teachers represented the Circuit branches and the remaining were from Non-Circuit branches. Out of 221 teachers 149(67%) were from the Open category and 72(33%) were from the Reserved category. 112 (74%) male students and 52(74%) female teachers were belonging to the income bracket of 5 lacs & above.

Survey Results

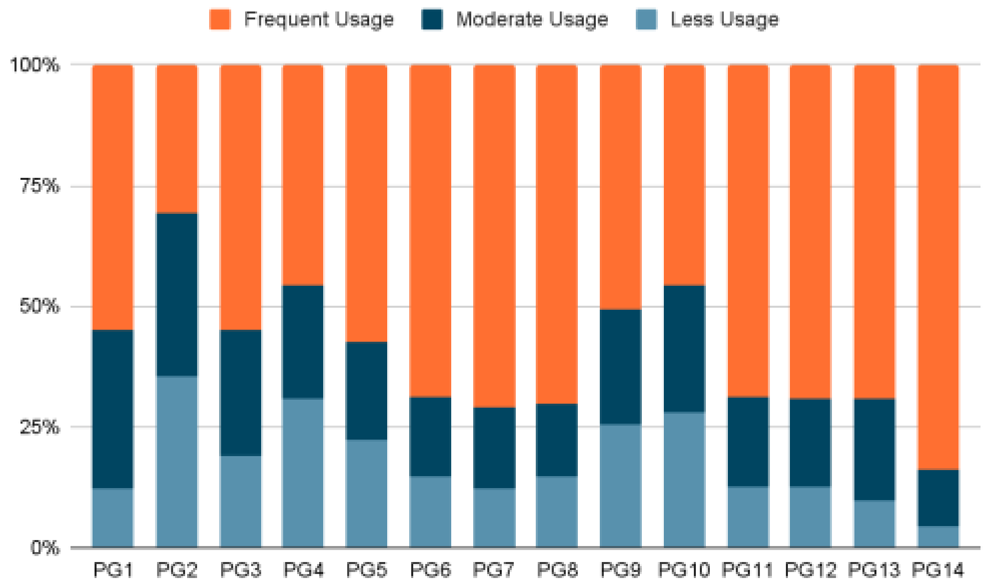
Survey results for pedagogy techniques under consideration are graphically represented below through Graph No. 1 & Graph No. 2

Graph No. 1: Use of Pedagogy Techniques: Student Survey responses



PG1: Video Lectures, PG2: Classroom Games PG3: Computer Simulations PG4: Virtual Reality PG5: Mathematical Algorithm PG6: Writing Journals PG7: Peer Feedback PG8: Interactive White board PG9: Field Trips PG10: Mathematical Puzzles PG11: Scientific Experiments PG12: Worksheets PG13: Independent Studies PG14: Projects

Graph No. 2: Use of Pedagogy Techniques: Teacher Survey responses



PG1: Video Lectures, PG2: Classroom Games PG3: Computer Simulations PG4: Virtual Reality PG5: Mathematical Algorithm PG6: Writing Journals PG7: Peer Feedback PG8: Interactive White board PG9: Field Trips PG10: Mathematical Puzzles PG11: Scientific Experiments PG12: Worksheets PG13: Independent Studies PG14: Projects

Descriptive Statistics & Scale Reliability

Based on the survey results of individual items; mean of means for construct "Pedagogy" was calculated for students' as well as teachers' data and the same is tabulated through Table No. 1. Scale item reliability estimates (Cronbach's Alpha) were found above 0.8.

Table No. 1: Descriptive statistics & Scale reliability for Construct "Pedagogy"

Sr. No.	Study Group	Mean	Standard Deviation & Skewness	Skewness	Cronbach's Alpha
01	Student	3.6857	0.83534	(-)ve L	0.92

02	Teacher	3.6215	0.77124	(-)ve L	0.894

(-)ve L: Negative low skewness (L-Low, M- Modearwate, H- High)
Low skewness: -.5 to +.5, Moderate skewness: -1 to -.5 or +.5 to +1,
High skewness: Below -1 or above +1

Table No. 2 depicts means and standard deviations for all individual items considered in the construct.

Table No. 2: Means & SD of individual items in the survey

Sr. No.	Code	Pedagogy Technique	Student Data		Teacher Data	
			Mean	Standard Deviation & Skewness	Mean	Standard Deviation & Skewness
01	PG1	Video Lectures	3.48	1.22 (-)ve M	3.6	1.038 (-)ve L
02	PG2	Classroom games	2.77	1.395 (+)ve L	2.9	1.149 (-)ve L
03	PG3	Computer Simulations	3.63	1.23 (-)ve M	3.53	1.281 (-)ve M
04	PG4	Computer generated environment like scenes and objects (Virtual Reality)	3.42	1.295 (-)ve L	3.22	1.355 (-)ve L
05	PG5	Mathematical Algorithm	3.75	1.12 (-)ve M	3.45	1.284 (-)ve M
06	PG6	Writing Journals	4.29	0.992 (-)ve H	3.85	1.176 (-)ve M
07	PG7	Peer Feedback	4.02	1.056 (-)ve H	3.95	1.173 (-)ve H
08	PG8	Interactive white boards	3.82	1.222 (-)ve M	3.91	1.294 (-)ve H
09	PG9	Field Trips	3.19	1.406 (-)ve L	3.33	1.256 (-)ve L

10	PG10	Mathematical Puzzles	3.27	1.327 (-)ve L	3.17	1.253 (-)ve L
11	PG11	Scientific experiments	3.71	1.212 (-)ve M	3.84	1.152 (-)ve M
12	PG12	Worksheets	4.09	1.039 (-)ve H	3.8	1.171 (-)ve H
13	PG13	Independent studies	3.89	1.125 (-)ve M	3.83	1.069 (-)ve M
14	PG14	Projects	4.26	0.983 (-)ve H	4.33	0.916 (-)ve H

With a highest mean value for student data (M= 4.26 SD .983) & for Teacher data (M= 4.33, SD .916); Projects is a widely practiced pedagogical method in engineering.

Bivariate Analysis

Construct "Pedagogy" and all demographic variables showed low correlation for student as well as Teacher data as tabulated in Table no. 3 & Table no. 4 respectively.

Table No. 3. Correlation between construct "Pedagogy"and Demographic variables
(Student survey)

Construct		**Gender***	**Age group****	**Family Income****	**Category***	**Branch***
Pedagogy	Correlation coefficient	0.043	0.099	0.043	.048	.089
	p value	0.068	<0.001	0.068	.042	<.001

* Biserial Correlation factor r_p values: Upto 0.3- weak Correlation, 0.3 to 0.5- Moderate Correlation, 0.5 onwards- strong correlation at p = <0.001

** Spearman Correlation factor r_s values: Upto 0.4- weak Correlation, 0.4 to 0.6- Moderate Correlation, 0.6 onwards- strong correlation at p = <0.001

Table No. 4. Correlation between construct “Pedagogy”and Demographic variables
(Teacher survey)

Variable		Gender*	Age group**	Family Income**	Category *	Education*	Branch*
Pedagogy	Correlation coefficient	.035	-0.063	0.037	.017	.083	-.135
	p value	.603	.354	0.585	.806	.222	.045

* Biserial Correlation factor r_p values: Upto 0.3- weak Correlation, 0.3 to 0.5- Moderate Correlation, 0.5 onwards- strong correlation at p = <0.001

** Spearman Correlation factor r_s values: Upto 0.4- weak Correlation, 0.4 to 0.6- Moderate Correlation, 0.6 onwards- strong correlation at p = <0.001

Factor Analysis for the construct

As the scale reliability for the construct in both i.e. student and Teacher survey lies above 0.8, Bartlett’s test of sphericity (BTS) was used to ensure that the correlation matrix was not random and the KMO statistic was required to be above a minimum of .6 [25]. Determinant values above 0.0001 are required to obtain a factor analytic solution. After confirming that the correlation matrix for respective latent variables were factorable; they were submitted to Factor Analysis.

For student data, scree plot and eigenvalues suggested that the Two factors should be retained. For teachers data a single factor solution was found. Details are tabulated through table no. 5 & table no. 6.

Table No. 5. Factor analysis report for Student Survey Data

KMO Measure of Sampling Adequacy: 0.94 BTS Approx. Chi-Square: 13211.95 (p= <.001)				
Dimension	**Item**	**Loading**	**Variance**	**Scale reliability α**
Dimension 1	**PG1** Video Lecture	0.767	49.28	0.901

	PG2 Classroom Games	0.938		
	PG3 Computer Simulations	0.694		
	PG4 Computer generated environment like scenes and objects (Virtual reality)	0.748		
	PG5 Mathematical Algorithms	0.516		
	PG9 Field Trips	0.843		
	PG10 Mathematical Puzzles	0.777		
Dimension 2	**PG6** Writing Journals	0.878	10.84	0.814
	PG7 Peer Feedback	0.592		
	PG12 Worksheets	0.781		
	PG13 Independent Studies	0.527		
	PG14 Projects	0.696		
	PG8 Interactive White Board	Loading 0.484: Low Salient coefficient hence not considered in any factor		
	PG11 Scientific Experiments	Complex Salient Loading on the factor, hence not included in any dimensions		

Table No. 6. Factor analysis report for Faculty Survey Data

KMO Measure of Sampling Adequacy: 0.883 BTS Approx. Chi-Square: 1245.402 (p= <.001)				
Dimension	**Item**	**Loading**	**Variance**	**Scale reliability α**
Dimension 1	**PG1** Video Lecture	0.62	42.53	0.893

	PG2 Classroom Games	0.717		
	PG3 Computer Simulations	0.712		
	PG4 Computer generated environment like scenes and objects (Virtual reality)	0.752		
	PG5 Mathematical Algorithms	0.702		
	PG7 Peer Feedback	0.614		
	PG8 Interactive White Board	0.616		
	PG9 Field Trips	0.566		
	PG10 Mathematical Puzzles	0.745		
	PG11 Scientific Experiments	0.611		
	PG12 Worksheets	0.68		
	PG13 Independent Studies	0.678		
	PG14 Projects	0.561		
	PG6 Writing Journals	Complex Salient Loading on the factor, hence excluded		

DISCUSSION & CONCLUSION

Research instruments designed to understand the acceptance of the innovative pedagogical techniques in engineering education were tasted and found reliable for both controlled groups i.e. students and teachers.

The construct "Pedagogy" is independent of all demographic variables under consideration.

Low negative skewness and the difference between mean and highest scale values for the construct indicates the requirement of overall improvement in inclusiveness of innovative pedagogy techniques in engineering education.

According to a student survey, Classroom Games, Field Trips and Mathematical Puzzles are the three least experienced pedagogy techniques during engineering as compared to other techniques. According to the teacher survey, Classroom Games, Mathematical puzzles and use of Virtual reality are the three least practiced pedagogy techniques during course duration. Writing Journals, Projects and Worksheets are most often experienced by the students during the education. According to the teachers; Projects, Peer Feedback and Interactive whiteboards are the most utilized pedagogic techniques.

Factor analysis suggests that the students grouped the pedagogic techniques in two distinct subgroups one underTeacher assisted pedagogical techniques and other under the Self driven pedagogical techniques. Such factors were missing in factor analysis of teachers' data.

SCOPE FOR FUTURE STUDIES

Only one parameter (Pedagogy) in adaptive educational strategies was considered for the survey. Existence of adaptive educational processes in other conventional parameters of education such as Teaching- Learning, Curriculum, Exposure etc. need to be studied

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