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Impact of Teaching Strategies: Demonstration and Lecture Strategies and Impact of Teacher Effect on Academic Achievement in Engineering Education

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ABSTRACT This study investigated the impact of Teaching Strategies and Teacher Effect on students' academic achievement in engineering education. Two different Teaching Strategies, one with demonstration strategy using working models and the other with lecture strategy were adopted. Experimental research design was used with the independent variables being Teaching Strategies and Teacher Effect and the dependent variable was Academic Achievement. Two-way ANOVA showed that the main effects of Teaching Strategies and Teacher Effect were significant. Demonstration strategy was found to be significantly better than lecture strategy. Teacher-B (more experienced) was found to be significantly better than Teacher-A with regard to students' academic achievement. Significant interaction effect was seen only with regard to lecture strategy with Teacher-B being better than Teacher-A. It was established from the findings that the demonstration strategy had produced significantly better academic achievement among engineering students independent of Teacher Effect. This study carries significant implications for improving the quality of engineering education.

INTRODUCTION

Many of our standard methods of teaching have been shown to be comparatively unproductive in the students' ability to master and then retain vital concepts. The traditional methods of teaching (lecture, recitation, and laboratory) do not tend to foster collaborative problem-solving, critical thinking and creative thinking (Wood and Gentile 2003; Costa 2014).

With regard to the prevailing scenario in engineering education, in general, students are taught memorization and routine application, and not reasoning methods, analysis, synthesis and evaluation (Somalingam and Shanthakumari 2013). Employers complain that today's college graduates are severely lacking in basic skills particularly communication, problem-solving, the ability to prioritize tasks and decision making (Selingo 2015). A high dropout rate is a current problem in the engineering schools. The institutions have to raise the student success ratio and have to reduce the numbers of dropouts (Paura and Arhipova 2009; Marcus 2012). It is reported that the Universities around the world are investing major efforts to: (a) identify the challenges faced by engineering education programs, and (b) make changes to achieve what is generally termed as "Excellence in Engineering Education" (Wood and Gentile 2003; Graham 2012). The poor performance of students in engineering education may be attributed to poor teaching strategies and skills (Vincent and Akpan 2014). These problems have led to desperate search for appropriate teaching strategies that would best be used to realize the aims of engineering teaching, thereby improving learning and skills acquisition.

Teaching strategies are decisions about organizing people, materials and ideas to provide learning (Nwachukwu 2005). Weston and Cranton (1986) viewed teaching strategies as both the teaching method and the materials used in the process of teaching. Some of these teaching strategies include inquiry, discussion, lecture and demonstration, among others (Vincent and Akpan 2014).

Lecture strategy contains a verbal presentation of ideas, facts, concepts and generalizations. The practice of this method is that of spoon-feeding the learners with facts or information. The students remain passive and obtain information from their teacher (Umoren 2001; Vincent and Akpan 2014).

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Demonstration strategy is a method of teaching concepts, principles of real things by combining explanation with handling or manipulation of real things, materials or equipment (Akinbobola and Ikitde 2011). "In the matter of physics, the first lessons should contain nothing but what is experimental and interesting to see. A pretty experiment is in itself often more valuable than twenty formulae extracted from our minds." A famous quote by Albert Einstein (Moszkowski 1970).

The novelty, spectacle and inherent drama of an in-class demonstration can provoke significant interest from students. Psychologists termed this kind of interest, situational interest which spontaneously creates interest among all students (Schraw et al. 2001). The demonstration strategy is effective for long-term memory retention and appropriate to college students' study skills (McCabe 2014). The act of demonstrating readily helps to kindle more natural interactions between the students and the teacher. Their active responses and completely spontaneous observations provide an excellent opportunity for the teacher to connect with them and with their unedited ideas.

In-class demonstrations, a standard constituent of science courses in schools and universities, are generally believed to help students understand science and to stimulate student interest (Crouch et al. 2004). Most students get a great deal more out of visual information than verbal information (spoken and written words and mathematical formulas) (Felder et al. 2000). Demonstrations provide a multi-sensory means to describe a concept, idea, or product that may otherwise be difficult to grasp by verbal description alone (Cabibihan 2013).

Demonstration strategy has emerged to become an instructional approach that is gaining rising interest within the engineering education community (Hadim and Esche 2002). Research has found that diverse students benefit vastly when they have the opportunity to participate in activities, interact with materials and manipulate objects and equipment (Carrier 2005; Prpic and Hadgraft 2009). An earlier work that made use of demonstrations in engineering education reported an increase in student attendance from thirty percent to eighty percent (Kresta 1998).

Ogwo and Oranu (2006) affirm that demonstration strategy is the most widely used Teaching Strategy for acquisition of practical skills as it includes the verbal and practical illustration of a given procedure. The authors have further added that the strategy is highly effective because it contains active participation of the student.

Cabibihan (2013) used working models for in-class demonstrations and reported that a multi-background, multidisciplinary, and multinational student audience had responded favorably to the in-class demonstrations. It was also reported that the students' academic achievement could be attributed to the immediate appreciation of concepts from the practical examples that the students experienced from the demonstrations. Jaksa (2009) has utilized a number of demonstration models in his teaching in geotechnical engineering. In conclusion, the author reiterates the effectiveness of demonstration models as a tool to improve learning and to engage students. Adekoya and Olatoye (2011) and Daluba (2013) have studied the effect of demonstration strategy using working models in an aspect of Agricultural Science and reported that this Teaching Strategy brought about the most significant positive impact on the students' academic achievement.

Maizuwo (2011) investigated the effectiveness of demonstration Teaching Strategy on students' misconceptions of concepts in organic chemistry and academic achievement of chemistry students. He has reported that there is a significant difference in academic achievement of students when exposed to Demonstration Teaching Strategy which implies that Demonstration Teaching Strategy is an effective Teaching Strategy. He has added in his findings that there is no significant difference in the performances of male and female students when exposed to Demonstration Teaching Strategy in the teaching of concepts of organic chemistry. Ikitde and Edet (2013) have reported that there is no influence of gender on students' academic achievement when taught Biology using demonstration strategy. Thus, demonstration Teaching Strategy is gender friendly.

Reports in the literature show that the teachers' influence significantly contribute to students' academic achievement, a ûnding that has sharpened policy makers' focus on teacher effectiveness (Hanushek and Rivkin 2006; Adams et al. 2009; Kini and Podolsky 2016). Along with the Teaching Strategy, Teacher Effect is widely believed to be important for education, although substantial but inconsistent data show that teachers' credentials matter for students' achievement. Rockoff (2004) and Dial (2008) found that the differences among teachers were statistically significant and large. In addition, the authors have also reported that the teaching experience has statistically significant positive effects on students' academic achievement. Ronald (2009) has studied the Teacher Effect on student achievement in 156 elementary schools. It was found by the author, that the effectiveness of teachers was significantly related to student achievement in reading and maths. Kini and Podolsky (2016) found that the teachers with more experience influence their students not only in academic achievement, also in their class attendance.

It is evident from the above discussion that demonstration based Teaching Strategy has the significant impact on students' achievement. Demonstrations provide the multisensory approach to teaching through practical hands-on learning using working models. It is also evident that this Teaching Strategy can be successfully implemented at the university level with moderate initial investments in time and money and a commitment to effective teaching. The outcome of Demonstration based Teaching Strategy with significant success in engineering education is widely reported by the researches cited. It is also evident that a large body of education literature reveals positive impact of Teacher Effect on student achievement. However, most studies are limited to elementary schools, used less precise methods and do not use proper regression techniques (Seebruck 2015; Kini and Podolsky 2016). Also, there is certainly a dearth of information available in literature on the combined and interactive effect of Teaching Strategy and Teacher Effect on students' achievement. Hence, this study became necessary to determine the effects of Teaching Strategy and Teacher Effect on students' academic performance in engineering education.

In the present research work, a demonstration based Teaching Strategy using working models was developed to teach an undergraduate course in automobile engineering within a mechanical engineering degree. Automobile engineering is a branch of mechanical engineering that concerns the design, development and manufacture of cars, trucks, motorcycles and other motor vehicles. Automobile engineers also design and test many subsystems or components that comprise a motorized vehicle. Automobile engineering covers a vast industry. It offers considerable employment opportunities in the following fields: global automobile industries, transportation companies, defense sector and self-employment such as automobile garage or maintenance workshops. However, there is a dearth of studies based on Teaching Strategy and Teacher Effect in teaching a course on automobile engineering within the mechanical engineering degree. The present work aims to fill this gap.

Research Problem

The problem of this research is to study the impact of Teaching Strategy (Demonstration based Teaching Strategy using working models and Lecture based Teaching Strategy) and Teacher Effect on students' academic achievement in Automobile Engineering course in Mechanical Engineering degree. This study also aims to investigate the presence of interaction effect of Teaching Strategies and Teacher Effect on students' academic achievement.

Research Objectives

In order to study the research problem outlined above, the study was conducted in two phases.

Phase 1

- To develop working models to facilitate demonstration based Teaching Strategy in an engineering curriculum.

Phase 2

- To assess the impact of Teaching Strategies on students' academic achievement: demonstration based Teaching Strategy using working models and the Lecture based Teaching Strategy.
- To assess the impact of Teacher Effect on students' academic achievement: in both demonstration based Teaching Strategy using working models and lecture based Teaching Strategy.
- Strategies and Teacher Effect on students' academic achievement.

Hypotheses

Review of related literature generally indicates that the Teaching Strategy and Teacher Effect have an impact on students' academic achievement. However, there is a dearth of studies concerning students' academic achievement in the specific course of Automobile Engineering in Mechanical Engineering degree. Also, there is a dearth of research data on the combined and interactive effect of Teaching Strategy and Teacher Effect on students' achievement. Hence null hypotheses have been formulated in the present study.

The following hypotheses have been formulated in the present study.

H1. There will be no significant main effect of Teaching Strategy (Demonstration based and Lecture based) on students' academic achievement.

H2. There will be no significant main effect of Teacher Effect (Teacher-A and Teacher-B) on students' academic achievement.

H3. There will be no significant interaction effect of Teaching Strategy and Teacher Effect on the students' academic achievement.

METHODOLOGY

The present research has been divided into two phases.

Phase 1- Development of working models to facilitate demonstration based Teaching Strategy in Automobile Engineering course.

Phase 2- (a) Implementation of intervention program which consisted of class sessions conducted using two different Teaching Strategies. Before implementing the intervention program, students' GPA of the previous end-of-semester University examination was taken into account to establish homogeneity of the students in the sample. One Teaching Strategy used demonstration based teaching using working models and the other Teaching Strategy used lecture based traditional teaching. Two different teachers (Teacher-A and Teacher-B) taught using both the Teaching Strategies.

Phase 2- (b) Analysis of data based on students' grade scores in the end-of-semester University examination in Automobile Engineering course.

Research Design and Variables

To analyze the impact of Teaching Strategy and Teacher Effect on students' academic achievement, experimental method was used in the present study. The independent variables were the Teaching Strategies (Demonstration based and Lecture based) and Teacher Effect (Teacher-A and Teacher-B). The dependent variable is the students' academic achievement (Grade Score) in the end-of-semester University examination.

Selection of Target Group of Students and Sample Characteristics

The sample comprised of 144 undergraduate mechanical engineering students from a private engineering college in Chennai, the capital city of Tamil Nadu State, India. The students in semester V were divided into four sections by the college management based on the alphabetical order of their first names. The pre-intervention academic achievement of the students of all the four sections from semester V was found to be homogenous on their academic achievement, based on their GPA of the previous end-of-semester University examination results. Hence, all the four sections of students (36 in each section) formed the sample. This methodology of establishing homogeneity of students using GPA is important as bias in outcomes are minimized (Katsikas and Pangiotidis 2010). The college draws students from middle and upper middle economic strata. Six female students participated in each of the four sections. The age range of the students was from 20 to 22 years.

Characteristics of the Teachers

Two teachers (Teacher-A and Teacher-B) have carried out the intervention in this study. Teacher-A has 10 years of only teaching experience in the field of engineering. Teacher-B has 30 years of industrial and teaching experience in the field of engineering. Teacher-B is the first author of this research.

Development of Working Models for In-Class Demonstrations

In-class demonstrations using working models promote practical learning. Practical classes/ laboratories and workshops play a major role in engineering education. The benefits of practical

Fig. 1. Working model of petrol automobile
Source: Authors

Fig. 2. Working model of diesel automobile
Source: Authors

learning are usually much broader and might include the following (Fry et al. 2009). Gaining practical skills; Gaining experience in the use of particular techniques or pieces of equipment; Produce a design; Plan an experiment; Make links between theory and practice; Gather, manipulate and interpret data; Make observations; Form and test hypotheses; Use judgement; Develop problem-solving skills; Communicate data and concepts; Develop personal skills; and Develop safe working practices.

Laboratories are expensive in terms of equipment, infrastructure and maintenance and hence may not always be available to all students. Development of working models offers a possible alternative solution so that the benefits gained by the students through practical/ laboratory sessions are not compromised. In this present research work, an attempt was made in developing automobile working models for teaching automobile engineering course in a mechanical engineering curriculum.

These working models were developed with the aim of facilitating an effective in-class demonstrations in teaching the different topics covered in the syllabus of undergraduate automobile engineering course within the mechanical engineering degree. In most of the cases, the working models were developed using actual components of automobiles. Based on the course syllabus topics, 22 working models were developed. The working models included cut-sectioned components which were cut-sectioned using wire-cut electro-discharge machining process for producing smooth cut surfaces. Care has been taken to see that most of the cut-sectioned models remain functional (working) even after cut-sectioning the components.

Figures 1 and 2 represent two of the twenty-two working models developed. These working models were developed with the aim of facilitating an effective demonstration based Teaching Strategy in teaching an undergraduate automobile engineering course within the mechanical engineering degree. These vehicle models were developed using real-life automobiles. Two automobiles, one with a gasoline engine and front wheel drive (Fig. 1) and the other with a Diesel engine and rear wheel drive (Fig. 2) were selected. To keep the budget low, used automobiles in good running condition were procured from the local automobile dealer after a thorough inspection of all the sub-systems for proper functioning.

The body of real-life automobiles were cut at different places which include the top and side cover portions, doors, etc. to provide easy functional visibility to students. The following systems were thereby clearly visible to the students in these two working models - the fuel circuit, engine air induction system, ignition circuit, cooling system, lubrication system, exhaust system, engine cranking circuit, battery charging circuit, brake system, front and rear suspension systems, vehicle transmission system, drive system, steering system, driver controls, etc. Since the automobiles were of monocoque structure, the remaining portion of the body structure, after cutting, was strengthened using adequate steel reinforcements. This was necessary so that the balance portion of the body, after cutting, remain robust to carry the load of the engine and other drive assemblies and to remain stable while running of the automobile. A low-budget ramp was built so that these two automobile working models can be driven over the ramp for easy functional visibility of under-carriage sub-assemblies and components pertaining to brakes, suspension, front and rear drives, vehicle body structure, etc.

Intervention Methodology

Demonstration based Teaching Strategy using the 22 working models described earlier was carried out both by Teachers A and B for students of Sections 1 and 2 respectively. Lecture based Teaching Strategy was used by Teachers A and B for students of Sections 3 and 4 respectively as shown in Table 1.

Table 1: Details of intervention methodology

Student population	*N**	*Teaching strategy*	*Teacher effect*
Section 1	36	Demonstration based	Teacher A
Section 2	36	Demonstration based	Teacher B
Section 3	36	Lecture based	Teacher A
Section 4	36	Lecture based	Teacher B

N*= Sample Size

Conduct of Class Sessions

In the intervention classes using demonstration based Teaching Strategy, each topic of automobile engineering course was started with a practical demonstration using the automobile working model. For example, the class on gasoline engine ignition system started with a practical demonstration of the working model of gasoline engine ignition system which commenced with the visual identification (visual input) and location of components such as battery, ignition switch, high tension coil, ignition distributor, spark plugs and ignition cables in the automobile working model. Then the form, fit and function of each component of the ignition system in the automobile working model was explained by the teacher (auditory input) followed by dis-assembly, assembly and functional testing of certain components by using proper maintenance tools with the participation of students in teams of 6 each (kinesthetic input).During the testing part of the practical session, students used proper test equipment wherever necessary and tested the automobile working models for a proper functioning of the parts and sub-systems which were dis-assembled and re-assembled.

The demonstration session was followed by a power-point presentation to learn the construction details, materials used for manufacture, applications, part and assembly drawings, etc. Demonstration sessions also consisted of question and answer discussions on points observed/ learned from the practical learning, and presentations by students. Thus the various modalities such as visual, auditory and kinesthetic were efficiently combined to promote a conducive learning environment. The total duration of automobile engineering course in a semester was 60 hours spread over 15 weeks. By using the demonstration based Teaching Strategy, both the teachers were able to cover the complete syllabus within the allotted time of the semester. Whereas in the class sessions of lecture based Teaching Strategy, the teachers followed the traditional chalk and talk lecturing with power point presentations.

Data Collection

In this study, the quantitative research methodology was used. Grade Scores from the end-of-semester University examination in Automobile Engineering course were obtained for students in the sample after the intervention program. Overall Grade Point Average (GPA) was obtained for the same students from their previous end-of-semester University examination results for establishing the homogeneity in academic achievement for all the four sections of students (Section 1 to Section 4). Homogeneity with regard to academic achievement of students was established at the outset of the study using one-way ANOVA before initiating the intervention program. This was based on the students' GPA.

Statistics Used

The following statistics were employed to analyze the data collected to compare two Teaching Strategies (Demonstration based and Lecture based) and Teacher Effect (Teacher-A and Teacher-B). One-Way ANOVA was used to establish homogeneity among the four sections of students (Sections 1 – 4) with regard to academic achievement before commencing the intervention program. This was based on students' GPA. 2x2 Factorial ANOVA was conducted to compare the main effects of Teaching Strategies and Teacher Effect and to study the interaction effect on students' academic achievement. SPSS software version 22 was used for analysis.

RESULTS

Table 2 shows that the sample size is identical for the four student groups based on their GPA of the previous end-of-semester University examination results. The range of mean difference is 0.345. The dispersion of the scores is fairly low as the standard deviations range from 0.952 to 1.672. The standard error is also low thereby enhancing the representativeness of the sample to the population.

Table 2: Descriptive statistics based on GPA for four sections of students before intervention

Sections	*N*	*Mean*	*Std. deviation*	*Std. error*
1	36	6.671	1.673	.279
2	36	6.835	1.294	.216
3	36	7.016	.952	.159
4	36	6.972	1.233	.205
Total	144	6.874	1.306	.109

Homogeneity test using One-Way ANOVA was carried out on four sections of students before intervention based on students' GPA from the previous semester University examination results. One-Way analysis of variance (Table 3) shows no significant difference in the GPA of four sections of students before the intervention, $F(3, 140) = .506$, $p>0.05$. Hence the selected sections of students were found to be homogeneous with regard to academic achievement, before the intervention program.

Table 3: One-way ANOVA based on GPA for four sections of students before intervention

Source	*Sum of squares*	*df*	*Mean square*	*F*	*Sig.*
Between sections	2.618	3	.873	.506*	.679
Within sections	241.440	140	1.725		
Total	244.059	143			

* Not Significant (p> 0.05)

Table 4 shows the means, standard deviation and sample size for the four different groups that is, Teacher-A and Teacher-B for demonstration based strategy; Teacher-A and Teacher-B for Lecture based strategy. The sample sizes are identical for all the four groups. The dispersion of scores around their respective means is observed to be low.

2x2 factorial ANOVA was used to analyse the effect of Teaching Strategy and Teacher Effect on students' academic achievement based on students' Grade Score (10 point scale) in the end-of-semester University examination in Automobile Engineering course. From the ANOVA summary table (Table 5) it is seen that the main effects of Teaching Strategy and Teacher Effect were highly significant that is, $F(1, 140) = 143.317$, $p < 0.001$ for Teaching Strategy and $F(1, 140) = 6.958$, $p < 0.01$ for Teacher Effect. The interaction effect of Teaching Strategy and Teacher Effect was also found to be highly significant, $F(1, 140) = 13.838$, $p < 0.001$. Hence the null hypotheses formulated have been thereby rejected.

Since the main effect of Teaching Strategy was found to be significant, it can be observed from Table 6 that Demonstration based Teach-

Table 4: Descriptive statistics for analyzing the effect of teaching strategy, teacher effect and their interaction on students' academic achievement

Teaching strategy	*Teacher effect*	*Mean*	*Std. deviation*	*N*
Demonstration Based	Teacher A	8.89	.667	36
	Teacher B	8.67	.717	36
	Total	8.78	.697	72
Lecture Based	Teacher A	5.67	1.586	36
	Teacher B	6.97	1.612	36
	Total	6.32	1.718	72
Total	Teacher A	7.28	2.023	72
	Teacher B	7.82	1.504	72
	Total	7.55	1.797	144

Table 5: 2x2 factorial ANOVA of effect of teaching strategy and teacher effect on students' academic achievement

Source .	*Type II Sum of squared*	*df*	*Mean square*	*F*	*Sig*	*Partial Eta*
Corrected model	249.132[a]	3	83.044	54.704	.000	.540
Intercept	8205.340	1	8205.340	5405.165	.000	.975
Teaching strategy	217.562	1	217.562	143.317	.000*	.506
Teacher effect	10.562	1	10.562	6.958	.009*	.047
Teaching strategy x Teacher effect	21.007	1	21.007	13.838	.000*	.090
Error	212.528	140	1.518			
Total	8667.000	144				
Corrected total	461.660	143				

[a] R Squared = .540 (Adjusted R Squared = .530)
*Significant (p< 0.05)

ing Strategy using working models (Mean= 8.778) was significantly better than the Lecture based Teaching Strategy (Mean=6.319) with regard to students' academic achievement in Automobile Engineering course.

Since the main effect of Teacher Effect was found to be significant, it can be observed from Table 7 that Teacher-B (Mean=7.819) was significantly better than Teacher-A (Mean=7.278) with regard to students' academic achievement in Automobile Engineering course.

These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

From Table 8, it can be seen that the interaction effect (Teaching Strategy x Teacher Effect)

Table 6: Pair-wise comparison of the teaching strategies (Demonstration vs Lecture) on students' academic achievement.

	Source of variation	*Mean*	*Mean difference*	*Std. error*	*Sig.*[b]
Teaching Strategy	Demonstration Based	8.778	2.459*	.205	.000
	Lecture Based	6.319			

Based on estimated marginal means*. The mean difference is significant at the .05 level.b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Table 7: Pair-wise comparison of the teacher effect (Teacher A vs Teacher B) on students' academic achievement

	Source of variation	*Mean*	*Mean difference*	*Std. error*	*Sig.*[b]
Teacher Effect	Teacher A	7.278	-.541*	.205	.009
	Teacher B	7.819			

Based on estimated marginal means*The mean difference is significant at the .05 level.[b]Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Table 8: Analysis of variance of the interaction effect (Teaching Strategy x Teacher Effect) on students' academic achievement

	Source of variation	*Sum of squares*	*Degree of freedom (df)*	*Mean square*	*F*	*Sig.*
Demonstration Based	Contrast (Teacher A vs Teacher B)	.889	1	.889	.586	.445#
	Error	212.528	140	1.518		
Lecture Based	Contrast (Teacher A vs Teacher B)	30.681	1	30.681	20.210	.000*
	Error	212.528	140	1.518		

These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.
* Significant ($p < 0.05$), # Not Significant ($p > 0.05$)

Table 9: Pair-wise comparison of the interaction effect (Teaching Strategy x Teacher Effect) on students' academic achievement

	Source of variation	*Mean*	*Mean difference*	*Std. error*	*Sig.*[b]
Demonstration Based	Teacher A	8.889	.222	.290	.445
	Teacher B	8.667			
Lecture Based	Teacher A	5.667	-1.305*	.290	.000
	Teacher B	6.972			

Based on estimated marginal means
*The mean difference is significant at the .05 level.
[b]Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

was highly significant for Lecture based Teaching Strategy, $F(1, 140) = 20.210$, $p < 0.001$. However, there was no significant interaction effect for Demonstration based Teaching Strategy, $F(1, 140) = .586$, $p > 0.05$.

The interaction effect is significant for Lecture based Teaching Strategy. It can be seen from Table 9 that Teacher-B (M=6.972) was significantly better than Teacher-A (M=5.667) under the condition of Lecture based Teaching Strategy. That is, the academic achievement of students taught by Teacher-B using Lecture based Teaching Strategy was significantly higher than the academic achievement of students taught by Teacher-A using Lecture based Teaching Strategy. However, there was no significant interaction effect for demonstration based Teaching Strategy. Both Teacher-A and Teacher-B were found to be equally effective when this strategy was used. This finding is further highlighted in the Mean Plot of Interaction Effect (Fig. 3).

DISCUSSION

The results of this study have shown that the main effect of Teaching Strategy on students' academic achievement was highly significant ($p < .001$). Further analysis revealed that the demonstration based Teaching Strategy using working models brought about the most significant positive impact on the students' academic achievement compared to the lecture based Teaching Strategy. (Adekoya and Olatoye 2011; Maizuwo 2011; Daluba 2013; Ikitde and Edet 2013). In demonstration based Teaching Strategy, various modalities such as visual, auditory and kinesthetic were efficiently combined to promote a better understanding of concepts taught. This would have also helped in sustaining the interest and attention of the students thereby enhancing their concentration. The outcome of this is seen in significantly better academic achievement when the demonstration based Teaching Strategy was used.

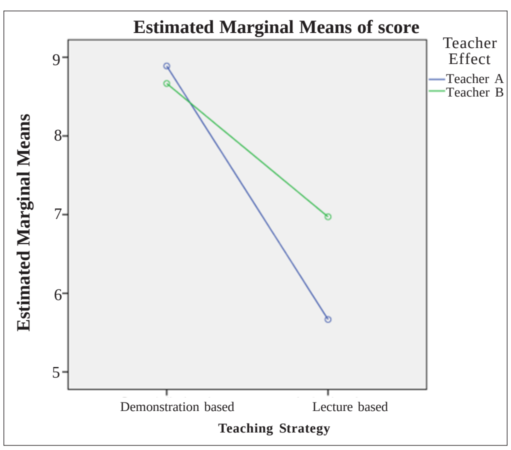

Fig. 3. Mean plot of interaction effect of teaching strategy and teacher effect

It was also found from the present results that the main effect of Teacher Effect on students' academic achievement was significant ($p < .01$). Teacher-B having 30 years of industrial and teaching experience was found to have a better overall effect on students' academic achievement compared to Teacher-A having 10 years of teaching experience. This finding confirms the findings of Rockoff (2004), Dial (2008) and Kini and Podolsky (2016) that the teaching experience of the teacher has statistically significant positive effects on students' academic achievement. A combination of both industrial and teaching experience would enable the teacher to be lucid in his explanations as he would be able to connect effectively with practical applications of concepts, tools and equipment in engineering education.

The interaction effect of Teaching Strategy and Teacher Effect was also found to be highly significant ($p < .001$) on students' academic achievement. Further analysis on this particular aspect of interaction had revealed that Teacher-B (with 30 years of industrial and teaching experience) was significantly better than Teacher-A (with 10 years of teaching experience) under the condition of lecture based Teaching Strategy. That is, the academic achievement of students taught by Teacher-B using lecture based Teaching Strategy was significantly higher than the academic achievement of students taught by Teacher-A using the same strategy. This was again substantiated by the findings of Rockoff (2004), Dial (2008) and Kini and Podolsky (2016). As the lecture based Teaching Strategy is based solely on the teacher effectiveness, it is seen that the teacher who has had more intensive and extensive experience is more effective in teaching the students. That is, his experience pays rich dividends in terms of improved academic performance of students.

However, there was no significant interaction effect for demonstration based Teaching

Strategy using working models. Both Teacher-A and Teacher-B were found to be equally effective when this strategy was used. This finding shows that the demonstration based Teaching Strategy using working models is independent of teacher effect. Since the demonstration based Teaching Strategy promotes practical hands-on exposure to students and makes them active learners, the Teacher Effect is minimized. The novelty, spectacle and inherent drama of an in-class demonstration can provoke significant interest from students. Psychologists termed this kind of interest, situational interest which spontaneously creates interest among all students (Schraw et al. 2001). Demonstrations provide a multi-sensory means to describe an idea, product, or concept that may otherwise be difficult to grasp by verbal description alone (Cabibihan 2013). Hence demonstration based Teaching Strategy using working models has produced significantly better academic achievement among engineering students independent of Teacher Effect.

Homogeneity with regard to academic achievement among the four sections of students was established at the outset of the study before initiating the intervention program. This was based on students' GPA. This methodology of establishing homogeneity of students using GPA helps in minimizing biases in the outcomes of this study. Keeping in mind the size of the sample which was sufficiently large for an intervention based study combined with the fact that the assumption of homogeneity has been met with, one can say that the generalizability of the results obtained has thereby increased.

CONCLUSION

In this study, 22 working models were developed successfully for facilitating demonstration based Teaching Strategy in engineering education. This study has also significantly highlighted the efficacy of demonstration based Teaching Strategy in enhancing students' academic achievement. The significance of providing the multisensory approach to teaching through in-class demonstrations using working models is highlighted in this study. As compared to traditional lecture based teaching, the present demonstration based Teaching Strategy resulted in highly significant gains in students' academic achievement. The Teacher Effect had a significant impact on the students' academic achievement. Teacher-B having 30 years of industrial and teaching experience was found to have a better overall effect on students' academic achievement compared to Teacher-A having 10 years of teaching experience. The interaction effect (Teaching Strategy x Teacher Effect) was highly significant for lecture based Teaching Strategy. However, there was no significant interaction effect for demonstration based Teaching Strategy. It was established from the findings that the demonstration based Teaching Strategy using working models had produced significantly better academic achievement among engineering students as compared to traditional lecture based teaching. The demonstration based Teaching Strategy was also found to be independent of Teacher Effect. This study carries significant implications for improving the quality of engineering education.

RECOMMENDATIONS

The successful development of automobile working models proved that at the University level, with moderate initial investments in time and money, such an approach can be used fruitfully for the successful implementation of demonstration based Teaching Strategy. This would aid in multisensory learning coupled with effective teaching and can bring in significant improvements in the teaching-learning process. The hands-on learning experience with the working models through demonstration based Teaching Strategy along with the gain in academic achievement would facilitate the transition of the students from the academic World to the career World.

Teaching engineers wide-ranging set of skills that are also required by the industries would enhance their employability skills significantly. The present demonstration based Teaching Strategy, even though was designed for teaching automobile engineering course in mechanical engineering degree, would apply to other branches of engineering as well. The results will also be highly applicable to employee training and continuing education at the industrial level as the same principles of learning apply to these groups as well. The present demonstration based Teaching Strategy would also help in fostering team spirit and cooperative learning among engineering students. This is because, teachers as well as students in the class, will learn about hands-on dynamics, teamwork, planning and leadership skills, organizational and professional ethics.

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