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Effect of Cognitive Apprenticeship Instructional Method on Auto-Mechanics Students

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Abstract

This study focused on the effect of cognitive apprenticeship instructional method on the achievement of auto-mechanics students in Rivers State, Nigeria. A quasi-experimental pre-test design with an experimental and non-equivalent control group was adopted. The population of the study comprised all the 212 second-year auto-mechanics students of the four technical colleges in Rivers State, no sampling was carried out as the entire population of the students was used. Three instruments were used for data collection. These were cognitive apprenticeship instructional lesson plans, which served as the treatment, traditional lesson plans, and an auto-mechanics achievement test. Five research questions and five hypotheses were formulated, mean and standard deviation was used to analyse the data for answering the research questions while analysis of covariance (ANCOVA) was used to test the hypothesis at 0.05 level of significance. The study found that the students taught with cognitive apprenticeship instructional method tended to have higher mean post-test scores in the auto-mechanics achievement test than those taught with the conventional lecture method. Based on this, it was recommended that auto-mechanics teachers should always adopt cognitive apprenticeship instructional components, namely: modelling, scaffolding, coaching, articulation and exploration. This will enable them to cater for the diverse learning styles of the students.

Keywords: *Achievement, post-test scores, conventional lecture method, modelling, scaffolding, coaching, articulation, exploration, Rivers State, Nigeria.*

Introduction

Auto-mechanics involves the application of specific knowledge in the design, selection of materials, construction, operation and maintenance of automobiles. Auto-mechanics technology is one of the trades offered in technical colleges (Federal Republic of Nigeria 2004). The programme for auto-mechanics technology in technical colleges is designed to produce competent craftsmen in auto-mechanics trades. According to the National Board for Technical Education (NBTE 2009), auto-mechanics craftsmen are expected to test, diagnose, service and completely repair any fault relating to the conventional automobile assembly main units and systems by following the manufacturers' specifications. However, it is generally known that (Collins *et al*. (1991): "Although schools have been relatively successful in organizing and conveying large bodies of conceptual and factual knowledge,... too little attention is paid to the reasoning and strategies that teachers employ when teaching the learners how to solve complex or real life tasks."

The lecture method being predominantly used in teaching automobile technology is based on the behavioural learning theories which, according to Boyle *et al*. 2003, emphasize knowledge transmission from the teacher to passive students and encourage rote memorization of facts. The consequence of this is that the students are unable to retain their learning and to apply it to new situations. The shortcomings of the present teaching method partly accounted for the poor performance of students in automobile technology certificate examinations in recent years as reported by NABTEB (2002). The increasing effect of globalization and the rapid rate of technological changes in the workplace have been acknowledged in the recommendation by UNESCO and ILO (2002) which states that all vocational and technical education (VTE) systems in the 21st century should be geared towards lifelong learning. This requires that schools should, in addition to academic skill, inculcate workplace skills such as creativity, problem solving, collaborative skills and higher order thinking skills in order to increase the student's flexibility and job mobility which will make them adaptable to the present and envisaged changes (Hallak and Poisson 2000). This is a challenge which necessitates a shift from the instructional approaches based on the behavioural learning theories to those rooted in constructivism learning theories, one of which is the cognitive apprenticeship instructional method.

Cognitive apprenticeship, according to Collins *et al*. (1987), is an instructional innovation which was introduced to address the problem of inert knowledge. This approach is based on the underlying principle of apprenticeship learning and focuses on the use of such strategies as modelling of behaviour and coaching students to mimic and exert skills until they are competent in their performance.

Cognitive apprenticeship components include modelling, scaffolding, coaching, articulation and exploration (Collins *et al*. 1987). Cognitive apprenticeship is a method of teaching aimed primarily at teaching the processes that experts use to handle complex tasks. The focus of this learning through guided experience is on cognitive and meta-cognitive skills rather than on the physical skills and processes of traditional apprenticeship. Applying apprenticeship methods to largely cognitive skills requires the externalization of a process that is usually carried out internally. When the students observe the processes by which an expert listener or reader thinks and practices those skills, it can help the learners learn on their own more skilfully (Collins *et al*. 1987). Therefore, the purpose of this study was to identify the effect of the cognitive apprenticeship instructional method on the performance of auto-mechanics students in technical colleges. Specifically, the study sought to:

1. Identify whether there were significant differences in the pre-test and post-test between students taught with the modelling instructional approach and those taught with the lecture method in learning the brake system of the automobile.
2. Ascertain whether there were significant differences in the pre-test and post-test between students taught with the scaffolding instructional approach and those taught with the lecture method in learning the engine lubricating system of the automobile.
3. Find out if there were significant differences in the pre-test and post-test between students taught with the coaching instructional approach and those taught with the lecture method in learning the fuel system of the automobile.
4. Identify if there were significant differences in the pre-test and pos-test between those taught with the articulation instructional approach and those taught with the lecture method in learning the cooling system of the automobile.
5. Ascertain whether there were significant differences in the pre-test and post-test between the students taught with the exploration instructional approach and those taught with the lecture method in learning the drive train of the automobile.

Research Questions

The following research questions were formulated to guide this study:

1. What are the mean score and standard deviation of the experimental and control groups of students taught with the modelling instructional approach and those taught with the lecture method in learning the brake system of the automobile?
2. What are the mean score and standard deviation of experimental and control groups of students taught with the scaffolding instructional approach and those taught with

the lecture method in learning the engine lubricating system of the automobile?

3. What are the mean score and standard deviation of experimental and control groups of students taught with the coaching instructional approach and those taught with the lecture method in learning the fuel system of the automobile?
4. What are the mean score and standard deviation of experimental and control groups of students taught with the articulation instructional approach and those taught with the lecture method in learning the cooling system of the automobile?
5. What are the mean score and standard deviation of experimental and control groups of students taught with the exploration instructional approach and those taught with the lecture method in learning the drive train of the automobile?

Hypotheses

The following null hypotheses, which were tested at 0.5 level of significance, will guide this study.

HO_1: There is no significant difference between the mean scores of students taught with the modelling instructional approach and those taught with the lecture method in learning the brake system of the automobile.

HO_2: There is no significant difference between the mean scores of students taught with the scaffolding instructional approach and those taught with the lecture method in learning the engine lubricating system of the automobile.

HO_3: There is no significant difference between the mean scores of students taught with the coaching instructional approach and those taught with the lecture method in learning the fuel system of the automobile.

HO_4: There is no significant difference between the mean scores of students taught with the articulation instructional approach and those taught with the lecture method in learning the cooling system of the automobile.

HO_5: There is no significant difference between the mean scores of students taught with the exploration instructional approach and those taught with the lecture method in learning the drive train of automobile.

Methodology

The study adopted the quasi-experimental design. Specifically, the pre-test and post-test designs with experimental and non-equivalent control groups were used. This is because intact classes (non-randomized groups) were used for the study. The area of this study covered the six technical colleges in Niger State offering auto-mechanics. The population for the study comprised all the 212 second-year auto-mechanics students in said six technical colleges in Niger State. The instruments used for data collection were the cognitive apprenticeship lesson plans and the traditional lesson plans. The cognitive apprenticeship instructional lesson plans constituted the treatment that was given to the experimental group while the traditional lesson plans were used to teach the control group. There were 20 achievement test items, 10 items were used for the pre-test, while the remaining 10 items were used for the post-test.

Three experts from the Department of Industrial and Technology Education, Federal University of Technology, Minna, and two experts from the Department of Technical Education, College of Education, Minna, carried out the face validation of the instruments: cognitive apprenticeship lesson plans, the traditional lesson plans and the auto-mechanics achievement test (AMAT). The test-retest reliability technique was used to determine the reliability of the auto-mechanics achievement test.

Results

Research Question 1

What is the mean score and standard deviation of experimental and control groups of students taught with the modelling instructional approach and those taught with the lecture method in learning the brake system of the automobile?

The data in Table 1 indicate that the experimental group had a mean of 25.80 and a standard deviation of 8.6 in the pre-test and mean score of 38.60 and standard deviation of 6.42 in the post-test making the pre-test - post-test gain in the experimental group to be 12.8. The control group had a mean score of 25.3 and a standard deviation of 6.58 in the pre-test and a mean of 30.50 and standard deviation of 7.56 in the post-test, resulting in a gain of 5.2. This implies that the experimental group performed better than the control group in learning the brake system of the automobile.

Research Question 2

What are the mean score and standard deviation of experimental and control groups of students taught with the scaffolding instrumental approach and those taught with the lecture method in learning the engine lubricating system of the automobile?

The data in Table 2 show that the experimental group had a mean score of 13.31 with a standard deviation of 7.44 in the pre-test and a mean score of 17.70 with a standard deviation of 3.54 in the post-test, resulting in a gain of 4.39. On the other hand, the control group had a mean score of 13.92 and a standard deviation of 6.26 in the pre-test and a mean score of 16.06 with a standard deviation of 6.58 in the post-test, resulting in a gain of 2.14. This means that the experimental group performed better than the control group in learning the engine lubricating system of the automobile.

Research Question 3

What are the mean score and standard deviation of experimental and control groups of students taught with the coaching instructional approach and those taught with the lecture method in learning the fuel system of the automobile?

The data in Table 3 reveal that the experimental group had a mean score of 12.77 and a standard deviation of 5.18 in the pre-test and a mean score of 14.00 with a standard deviation of 4.98 in the post-test, making a post-test difference of 1.23. On the other hand, the control group had a mean score of 11.53 and a standard deviation of 4.02 in the post-test, making a post-test - pre-test gain of 0.56. This shows that the performance of the experimental group is better than that of the control group in learning the fuel system of the automobile.

Table 1. Mean and standard deviation of pre-test and post-test scores of experimental and control groups in the AMAT taught with the modelling instructional approach and those taught with the lecture method in learning the brake system of the automobile.

Groups	N	Instructional Technique	Pre-test		Post-test	
			x	*SD*	*x*	*SD*
Experi-mental	40	Modelling instructional approach	25.8	8.6	38.6	6.42
Control	40	Lecture method	25.3	6.58	30.5	7.56

Table 2. Mean and standard deviation of pre-test and post-test scores of experimental and control groups in the AMAT taught with the scaffolding instrumental approach and those taught with the lecture method in learning the engine lubricating system of the automobile.

Groups	*N*	Instructional Techniques	Pre-test		Post-test	
			x	*SD*	*x*	SD
Experi-mental	40	Scaffol-ding	13.31	7.44	17.70	3.54
Control	40	Lecture	13.92	6.26	16.06	6.58

Table 3. Mean and standard deviation of pre-test and post-test scores of experimental and control groups in the AMAT taught with the coaching approach and those taught with the lecture method in learning the fuel system of the automobile.

Groups	*N*	Instructional Techniques	Pre-test		Post-test	
			x	*SD*	*x*	*SD*
Experi-mental	40	Coaching	12.77	5.18	14.00	4.98
Control	40	Lecture	10.97	7.84	11.53	4.02

Research Question 4

What are the mean score and standard deviation of experimental and control groups of students taught with the articulation instructional approach and those taught with the lecture method in learning the cooling system of the automobile?

Table 4. Mean score and standard deviation of experimental and control groups in the AMAT of those taught with the articulation instructional approach and those taught with the lecture method in learning the cooling system of the automobile.

Groups	*N*	Instructional Techniques	Pre-test		Post-test	
			x	*SD*	*x*	*SD*
Experi-mental	40	Articula-tion	16.13	10.21	20.56	8.62
Control	40	Lecture	16.44	10.92	19.30	9.44

As shown in Table 4, the experimental group had a mean score of 16.13 and a standard deviation of 10.21 in the pre-test and a mean score of 20.56 with a standard deviation of 8.62 in the post-test, resulting in a gain of 4.43. The data in the same Table 4 also shows that the control group had a mean score of 19.30 with a standard deviation of 9.44 in the post-test, making a post-test - pre-test gain of 2.86. This means that the performance of the experimental group is better than that of the control group in learning the cooling system of the automobile.

Research Question 5

What are the mean score and standard deviation of experimental and control groups of students taught with the exploration instructional approach and those taught with the lecture method in learning the drive train of the automobile?

Table 5. Mean score and standard deviation of experimental and control groups in the AMAT of those taught with the exploration instructional approach and those taught with the lecture method in learning the drive train of the automobile.

Groups	*N*	Instructional Techniques	Pre-test		Post-test	
			x	*SD*	*x*	*SD*
Experi-mental	40	Explora-tion	17.22	8.06	22.06	6.12
Control	40	Lecture	17.24	8.22	19.28	6.78

The data presented in Table 5 indicate that the experimental group had a mean of 17.22 and a standard deviation of 8.06 in the pre-test and a mean score of 24.06 and standard deviation of 6.12 in the post-test, resulting in a gain of 6.84. The control group had a mean score of 17.24 and a standard deviation of 8.22 in the pre-test and mean of 19.28 and a standard deviation of 6.78 in the post-test with a pre-test - post-test difference of 12.04. This implies that the experimental group performs better than the control group in learning the drive train of the automobile.

Hypothesis 1

There is no significant difference between the mean scores of students taught with the modelling instructional method and those taught with the lecture method in learning the brake system of the automobile.

Table 6. Analysis of covariance of the scores of experimental and control groups in the AMAT in learning the brake system of the automobile.

Sources of variation	*df*	Sum of squares	Mean sq.	*F-cal*	*F-critical*
Between groups	1	2,544.09	2,544.09	46.37	3.92
Within groups	78	4,279.32	54.86		
Total	79	6,823.29			

In Table 6, *F-cal* > *F-critical*; for the null hypothesis that there is no significant difference between the mean scores of the students taught with the modelling instructional approach and those taught with the lecture method in learning the brake system of the automobile, the achievement test is rejected at 0.05 level of significance. This implies that there is a significant difference between the mean scores of experimental and control groups in the brake system achievement test in favour of the experimental group.

Hypothesis 2

There is no significant difference between the mean scores of student taught with the scaffolding instructional approach and those taught with the lecture method in learning of the engine lubricating system of the automobile.

Table 7. Analysis of covariance of the scores of experimental and control groups in the AMAT in learning the engine lubricating system of the automobile.

Sources of variation	*df*	Sum of squares	Mean sq.	*F-cal*	*F-critical*
Between groups	1	838.80	838.30	25.40	3.92
Within groups	78	2,575.32	33.02		
Total	79	3,414.12			

Table 7 shows that for the null hypothesis that there is no significant difference between the mean scores of students taught with the scaffolding instructional approach and those taught with the conventional lecture method in learning the engine lubricating system, the performance test is rejected at 0.05 level of significance. This is because *F-calculated* is greater than the *F-critical* (*F-cal* > *F-critical*). This implies that a significant difference exists between the mean scores of experimental and control groups in the lubricating system achievement test in favour of the experimental group.

Hypothesis 3

There is no significant difference between the mean scores of students taught with the coaching instructional approach and those taught with the lecture method in learning the fuel system of the automobile.

In Table 8, for the null hypothesis that there is no significant difference between the mean scores of students taught with the coaching instructional approach and those taught with the conventional lecture method in learning the fuel system of the automobile, the achievement test is rejected at 0.05 level of significance since *F-cal* > *F-critical*. This implies that there is a significant difference between the mean scores of experimental and control groups in the fuel system achievement test in favour of the experimental group.

Table 8. Analysis of covariance of the scores of experimental and control groups in the AMAT in learning the fuel system of the automobile.

Sources of variation	*df*	Sum of squares	Mean sq.	*F-cal*	*F-critical*
Between groups	1	1,648.83	1,648.83	31.39	3.92
Within groups	78	4,096.30	52.51		
Total	79	5,745.13			

Hypothesis 4

There is no significant difference between the mean scores of the students taught with the articulation instructional approach and those taught with the lecture method in learning the cooling system of the automobile.

Table 9. Analysis of covariance of the scores of experimental and control groups in the AMAT of the cooling system of the automobile.

Sources of variation	*df*	Sum of squares	Mean sq.	*F-cal*	*F-critical*
Between groups	1	1,919	1,919	36.78	3.92
Within groups	78	4,069	52.17		
Total	79	5,988			

In Table 9, for the null hypothesis that there is no significant difference between the mean scores of students taught with the articulation instructional approach and those taught with the conventional lecture method in learning the cooling system of the motor vehicle, the achievement test is rejected at 0.05 level of significance since *F-cal* > *F-critical*. This means that the difference between the mean score of experimental group and control groups is significant in the cooling system achievement test.

Hypothesis 5

There is no significant difference between the mean scores of students taught with the exploration instructional approach and those taught with the lecture method in learning the drive train of the automobile.

Table 10. Analysis of covariance of experimental and control groups in the AMAT of the drive train of the automobile.

Sources of variation	*df*	Sum of squares	Mean sq.	*F-cal*	*F-critical*
Between groups	1	648.38	648.58	124.2	3.92
Within groups	78	406.90	5.22		
Total	79	1,055.28			

In Table 10, since *F-cal* > *F-critical*, for the null hypothesis that here is no significant difference between the mean scores of the students taught with the exploration instructional approach and those taught with the conventional lecture method, the achievement test is rejected at 0.05 level of significance. This implies that there is a significant difference between the mean scores of experimental and control groups in the drive train achievement test in favour of the experimental group.

Findings

On the basis of the data collected and analysed for this study, the following findings were made with respect to the research questions and hypotheses:

- Students taught with the cognitive apprenticeship instructional method scored higher in the post-test than those taught with the conventional lecture method. This means that the components of the cognitive apprenticeship instructional method such as modelling, scaffolding, coaching, articulation and exploration lead to higher academic achievement in auto-mechanics than the lecture method.
- There was a significant difference in the mean scores of students taught with the cognitive apprenticeship components (modelling, scaffolding, coaching, articulation and exploration) than those taught with the conventional lecture method in learning the brake system, engine lubricating system, fuel system, cooling system and drive train of a motor vehicle.

Discussion of Findings

The analysis of the results of the auto-mechanics tests summarized in Tables 1, 2, 3, 4 and 5 shows that the experimental group had higher mean scores in the post-test than the control group. These findings indicate that the cognitive apprenticeship instructional method has a positive effect on the student performance in auto-mechanics. This implies that the key components found in the cognitive apprenticeship instructional method (modelling, scaffolding, coaching, articulation and exploration) when used collectively are more effective than the conventional lecture method in enhancing the academic achievement of the students in auto-mechanics. The analysis of covariance of the post-test scores presented in Tables 6, 7, 8, 9 and 10 confirms that the difference between the mean scores of experimental and control groups in the post-test was significant. This significant difference is attributed to the treatment. This is an indication that the cognitive apprenticeship instructional method has positive effects on the academic achievement of the students. This also means that the cognitive apprenticeship instructional method is more effective that the conventional lecture method when it comes to developing students in handling complex tasks on the brake system, the lubricating system and the fuel system during vehicle maintenance.

The finding is in line with the works of Johnson and Fischbach (1992) and Elliott (1996) who in their separate studies found that the adoption of the cognitive apprenticeship instructional method and its components as an instructional framework greatly improves the academic achievement of the students and provides them with a comprehensive education that incorporates academic and technical knowledge and skills as a preparation for the future. The finding could be explained by the fact that the provision of an engaged or active learning environment where students can participate actively in the learning process with the opportunity to interact freely with the teachers, converse with peers, present and defend ideas, and question other conceptual frameworks increases their self-confidence and self-reliance. This consequently improves their learning skills and performance. Integrating modelling and other cognitive apprenticeship instructional components into the classroom will greatly enhance students' learning and prepare them to be successful participants in the workplace (Boyle *et al*. 2003; Collins *et al*. 1987; Collins *et al*. 1991). Brunner (2001) in his views affirms that an exploration is one strategy that can lead students to be involved in logical argument, deductive an inductive reasoning, and high order thinking and hence enhance diversity in understanding and mastery of whatever skill they need to learn.

In the same vein, Panitz (2001) and Davis (2009) affirmed that students learn best when they are actively involved in the learning process regardless of the subject matter. Tables 1 and 5 presented the analysis of the results of the achievement tests on the brake system and the drive train of the motor vehicle, respectively. The performance tests of the experimental group shown in the two tables had higher mean scores in the post-test and the analysis of covariance of the performance tests in Tables 6 and 10 confirmed that the difference in the mean scores of students taught with instructional strategy based on modelling and exploration and those taught with the conventional lecture method is significant. This implies that cognitive apprenticeship instructional components (modelling and exploration) for reinforced learning and exploration learning techniques have positive effects on student achievement tests in auto-mechanics. It means that reinforced learning and exploration learning when used together are more effective than the conventional lecture method in developing students' thinking skills in handling complex tasks in the workplace.

Conclusion

On the basis of the findings of this study, the following conclusions are drawn. The approach adopted by a teacher greatly affects the students' learning of the subject. This is reflected in their cognitive performance. Students learn and master skills better when they are allowed to participate actively in the class by interacting freely with the teacher and their peers, work in groups, and perform practical projects. The adoption of the cognitive apprenticeship instructional method generally enhances students' performance during auto-mechanics technology certificate examinations.

Recommendations

The following recommendations were made on the basis of the findings of the study:

- Teacher training institutions and colleges with courses that include auto-mechanics should provide the students with instructions using the cognitive apprenticeship instructional method, since it enhances the academic achievement of the students.

- Auto-mechanics teachers should always adopt cognitive apprenticeship instructional components, namely: modelling, scaffolding, coaching, articulation and exploration. This will enable them to cater for diverse learning styles of students in the classrooms and hence improve their acquisition and development of practical skills.

- Teachers should initiate activities that require students to process and apply new information as these activities help the students to strengthen their cognitive structure.

- Curriculum developers should have cognitive apprenticeship instructional method built into the curriculum of auto-mechanics technology programs.

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