Enhancing Transfer of Knowledge in Physics through Effective Teaching Strategies

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Abstract
The study assessed the enhancement of transfer of knowledge in physics through the use of effective teaching strategies in Nigerian senior secondary schools. Non-randomized pretest-posttest control group design was adopted for the study. A total of 278 physics students took part in the study. Transfer of Knowledge Test in Physics (TKTP) with the internal consistency of 0.76 using Kuder Richardson formula 21 was the instrument used in collecting data. Analysis of Covariance (ANCOVA) and t-test were used to analyze the data. The results showed that guided discovery was the most effective in facilitating students' transfer of knowledge in physics. This was followed by demonstration while expository was found to be the least effective. Also, there exists no significant difference in the transfer of knowledge of male and female physics students taught with guided discovery, demonstration and expository teaching strategies. It is recommended that guided discovery and other student-centred teaching strategies should be adopted for teaching various concepts in physics so as to engage the students in various activities for meaningful acquisition and transfer of scientific knowledge processes and ethics. Also, physics teacher must emphasize on variety of procedures for promoting insight, meaningfulness, organization of experience, discovery of interrelatedness among ideas and techniques, and the application of knowledge acquired in one situation to a variety of situations.
Keywords: Physics, Knowledge, Teaching strategies, Learning.

Introduction

Processes of learning and transfer of learning are central to understanding how people develop importance competences. Learning is important because no one is born with the ability to function competently as an adult in society (Byrnes, 1996). According to Akinbobola (2006), transfer of knowledge is the ability to extend what has been learned in one context to new contexts. Educators hope that students will transfer knowledge from one problem to another within a course, from one year in school to another, between school and home, and from school to work place (Pintrich & Schunk, 1996).

The key characteristics of learning and transfer that have important implications for education according to Anderson, Reder and Simon (1996) include:

* Initial learning is necessary for transfer, and a considerable amount is known about the kinds of learning experiences that support transfer.
* Knowledge that is overly contextualized can reduce transfer; abstract representations of knowledge can help promote transfer.
* Transfer is best viewed as an active, dynamic process rather than a passive end-product of a particular set of learning experiences.
* All new learning involves transfer based on previous learning, and this fact has important implications for the design of instruction that helps students learn.

The first factor that influences successful transfer is the degree of mastery of the original concept. Without an adequate level of initial learning, transfer cannot be expected (Mayer, 1988; Cognition & Technology Group at Vanderbilt, 1996). Transfer is enhanced by helping students see potential transfer implications of what they are learning (Anderson-Inman, Knox-Quinn & Horney, 1996).

Transfer is also enhanced by instruction that helps students represents problems at higher levels of abstraction. According to Singley and Anderson (1989), students who were trained on specific task components without being provided with the principles underlying the problems could do the specific tasks well, but they could not apply their learning to new problems. By contrast, the students who received abstract training showed transfer to new problems. Singley and Anderson also argue that transfer between tasks is a function of the degree to which the tasks share cognitive elements. Transfer can be improved by helping students become more aware of themselves as learners who actively monitor their learning strategies and resources and assess their readiness for particular tests and performances (Schoenfeld, 1991).

The ultimate goal of teaching or educational experiences both in and out of school is to enable the individual to meet new situations of various degrees of relatedness and similarities more effective. If the learning at school does not transfer to other areas of life, an excessive amount of a person's life would have been spent in efforts that yield no apparent return. Besides, our reactions to later situations in life are influenced by our previous experiences (Oladele, 2004).

Transfer of knowledge is the effort of prior learning on present learning or the effect of prior learning on the subsequent performance of different tasks. All application of knowledge in the understanding and solution of new problems and the use of old habits in dealing with new situations are cases of transfer of knowledge (Akinbobola, 2006). Transfer effects in human learning may be described under three main categories:

* Positive transfer occurs if the learning of a new task is facilitated by an old experience.
* Negative transfer occurs if previous experience retards or inhibits or interferes in performance of a task in a new situation.
* Zero transfer occurs if previous experience in one activity seems in no way affect the performance of a task in a new situation. That is, there is no noticeable effect of performance on one task over the performance of another task.

According to Afolabi and Akinbobola (2009), constructivism is a theory that suggests that learner construct knowledge out of their experiences which is associated with pedagogical strategies (such as guided discovery) that promote learning by doing or active learning. Constructivist teaching such as guided discovery according to Akinbobola and Afolabi (2009) focus on problem solving, independent learning, critical thinking and creativity. Since the activities are interactive, democratic and learner-centered, the teacher role is to serve as facilitator of learning in which learners are encouraged to construct their own understanding of each of the scientific concept, responsible and autonomous in order to practice and apply the scientific knowledge gained to new situation by making use of the process skills of science.

Demonstration is an activity strategy where the teacher does some work and the learners endeavour to do it the way he has done it. It is employed when the teacher wants the learners to do a piece of work the way he has done it and learn a little by listening a little, more by watching but then as a rule, learn most by actually doing the piece of work. That is, it is a strategy of teaching concepts, principles or real things by combining oral explanation with the handling or manipulation of real things.

The principal function of expository teaching strategy is the presentation of ideas and information meaningfully and effectively such that clear, stable and unambiguous meaning emerge and are retained over a long period of time as an organized body of knowledge. The teacher's role is very important in the learning process and involves the selection, the organization and the translation of subject matter content in a developmentally appropriate manner. According to Akinbobola and Afolabi (2009), this pedagogy emphasizes that contents of material be presented in a logical order, moving from generic to specific concepts, so that learners can form cognitive structures and encode new information.

Statement of the Problem

Physics being a fundamental science course has found numerous applications in all other sciences and hence its principle constitute the bedrock of development in the science and technology of nations. Achieving proficiency in physics is, therefore, a national concern. However, developing countries including Nigeria suffer from persistent power failure, insufficient food, inadequate medical care and portable water supply as well as unconducive living and working environment that indicate the low level of scientific and technological development. The major aim of physics teaching is to promote the understanding of the concepts being taught with a view to applying knowledge of such understanding to real life situations. Hence, will effective teaching strategies enhance the transfer of knowledge of students in what they have learned in one content to new contexts in physics?

Purpose of the Study

The study is designed to achieve the following objectives:

1. To examine the effects of teaching strategies on students' transfer of knowledge in physics.
2. To investigate the effects of gender on students' transfer of knowledge in physics.

Hypotheses

The following hypotheses were tested at .05 level of significance.

1 There is no significant effect of teaching strategies (guided discovery, demonstration and expository) on students' transfer of knowledge in physics

2 There is no significant effect of gender (male and female) on students' transfer of knowledge in physics taught with (i) guided discovery (ii) demonstration and (iii) expository teaching strategies.

Method

Non-randomized pretest-posttest control group design was adopted for the study. All the 852 senior secondary two (SS2) physics students in the 12 co-educational secondary schools in Ife central Local Government Area of Osun State, Nigeria constituted the population of the study. Criterion sampling technique was used to select six (6) schools from the population. The criteria are:

(i) School that are currently presenting candidates for the Senior Secondary School Certificate

Examination (SSSCE).

(ii) Schools that have between 35 and 40 students (average standard class size in Nigeria) offering physics in senior secondary two (SS2).

(iii) Schools that have at least one professional graduate physics teacher with minimum of three years of teaching experience.

(iv) Schools in which the concept of heat energy transfer has not been taught already.

The six schools used for the study were randomly assigned to treatment and control groups. One intact class was randomly selected in each school. In all, a total of 278 students took part in the study; this was made of 141 male students and 137 female students.

The researchers made instrument, Transfer of Knowledge Test in Physics (TKTP) consisted of 50 multiple-choice items on the concept of sound energy and light energy. Each item had four options with only one correct answer. The test was used to determine the ability of the students to extend what had been learned in heat energy to their studies in the concepts of sound energy and light energy. The instrument, TKTP was face and content validated by four physics teachers. The validators were required to look at the appropriateness of the items in the instrument in providing correct responses to the test items. All their corrections and comments were incorporated into the final form of the instrument. The TKTP was trial tested to establish its reliability with 50 subjects in schools within the population but were not used for the main study. The data obtained was subjected to Kuder-Richardson formula – 21. The result indicated that TKTP has a reliability coefficient of 0.76. The average difficulty and discrimination indices of TKTP items were 60.62 and 0.52 respectively.

The physics teachers in each school served as research assistants to teach each group. The research assistants were trained for one week on how to use the teaching strategy attached to their group and they were also given detailed instruction with well-articulated lesson packages on the concept of heat energy transfer. In order to account for possible pre-existing differences in overall ability between the experimental and control groups, pretest was administered to the two groups (experimental and control groups) and the results were used as covariate measures.

After the pretest, the treatment was given for six (6) weeks by the research assistants. This is done by the teaching of the heat energy transfer with a well prepared lesson packages. The lesson packages were prepared by the researchers in order to standardize the concept that was taught. The experimental group 1 was taught with guided discovery approach. Using this approach, the students must perform certain mental processing tasks such as observing, classifying, measuring, predicting and inferring. As such, a lot of inquiry prevails in the classroom with the teacher acting as a motivator, getting from point-to-point to guide the learning of students and helping them overcome difficulties. The teacher performs the role of a resource person who guides the learners sources of information. The experimental group 2 was taught with demonstration. Using this approach, apparatus is introduced to the student in such a way that he is able to understand its uses and limitations; the student is encouraged to adopt by imitation of the correct methods of use of the apparatus and the student is shown experiments which because of the danger, cost or complexity involves, he could not perform in the laboratory. The group 3 (control group) was taught with expository. Using this approach in teaching a concept, the teacher should proceed from the most generic concepts to the most specific ones. It is a teacher-centered, student's peripheral teaching approach in which the teacher delivers a pre-planned lesson to the students with or without the use of instructional materials and by doing most of the talking where students learn by rote memory, concepts and principles.

Results

Table 1: Summary of mean and standard deviation of pretest and transfer of knowledge scores of experimental and control groups by levels of teaching strategies and gender

Gender	**Teaching Strategies**	**N**	**Pretest Scores**		**Transfer of Knowledge Scores**		**Means Gain Scores**
			$\bar{X}$	**S.D.**	$\bar{X}$	**S.D.**	
Male	Guided Discovery	47	29.23	7.51	64.51	8.16	35.28
	Demonstration	49	28.74	7.92	58.08	6.28	29.34
	Expository	45	28.18	7.54	50.18	5.44	22.00
Total		**141**	**28.72**	**7.62**	**57.70**	**8.86**	**28.98**
Female	Guided Discovery	47	29.87	7.53	64.47	8.19	34.60
	Demonstration	44	29.82	7.32	57.18	6.60	27.36
	Expository	46	28.17	6.86	50.35	5.42	22.18
Total		**137**	**29.29**	**7.24**	**57.39**	**8.96**	**28.10**

As shown in Table 1, it was observed that the area mean scores of male and female students taught with guided discovery were greater than the mean gain scores of students taught with demonstration which in turn were greater than the mean gain score of students taught with expository. The mean gain score of male students (28.98) was slightly greater then the mean gain score of female students (28.10).

Hypothesis Testing
Hypothesis One
There is no significant effect of teaching strategies (guided discovery, demonstration and expository) on students' transfer of knowledge in physics.
The analysis is as shown in Table 2.

Table 2: One way Analysis of Covariance (ANCOVA) of transfer of knowledge scores of students taught with guided discovery, demonstration and expository teaching strategies

Source of Variation	Sun of Squares	DF	Mean Square	F-cal	F-critical	Decision at P<.05
Pretest	5722.12	1	5722.12	199.38	3.89	*
Main effect	8328.96	2	4164.48	145.10	3.04	
Explained	14051.08	3	4683.69	163.20	2.65	
Residual	7863.81	274	28.70			
Total	21914.89	277	79.12			

* = Significant at P<.05 alpha level.

As shown in Table 2, the teaching strategies main effect was significant at P<.05. The calculated F-value of 145.10 is greater than the critical F-value of 3.04, therefore the null hypothesis stating a non significant effect of teaching strategies on students' transfer of knowledge in physics was rejected. This implies that the three types of teaching strategies (guided discovery, demonstration and expository) differ significantly in their enhancement of the transfer of knowledge of physics students. Consequent upon the observed difference in the teaching strategies main effect, Multiple Classifications Analysis (MCA) was considered to determine the contribution of the different types of teaching strategies to the variation on students' transfer of knowledge in the concept of heat energy transfer in physics as presented in Table 3.

Table 3: Multiple Classifications Analysis (MCA) of the transfer of knowledge scores of students taught with guided discovery, demonstration and expository teaching strategies

Grand Mean=57.55	**N**	**Unadjusted**			**Adjusted for Independent Variable and Covariates**		
Variable + Category		Dev'n	Mean Scores	Eta	Dev'n	Mean Scores	Beta
TEACHING STRATEGIES				0.65			0.62
Guided Discovery	94	6.94	64.49		6.64	64.19	
Demonstration	93	0.11	57.66		-0.03	57.52	
Expository	91	-7.28	50.27		-6.83	50.72	
Multiple R=0.80							
Multiple R. Squared = 0.64							

* = Significant at p<.05 alpha level.

As shown in Table 3, the teaching strategies (guided discovery, demonstration and expository) have an index of relationship of 0.38 (Beta value of 0.62^2), with transfer of knowledge of students in physics. The table also shows a multiple regression index of 0.80 with a multiple regression squared index (R^2) of 0.64. This implies that 64% of the total variance in the transfer of knowledge of students in physics is attributable to the effect of teaching strategies. In order to find the direction of significance, the transfer of knowledge mean scores were subjected to Scheffe pairwise comparison post hoc analysis as shown in the Table 4.

Table 4: Results of Scheffe's transfer of knowledge test for scores for multiple comparisons of teaching strategies.

Dependent Variable : TRANSFER OF KNOWLEDGE SCORES

(i) Teaching Strategies	(j) Teaching Strategies	Mean Difference (I-J)	Std Error	sig	95% confidence Lower Bound	Interval Upper Bound
GDY	DEM	6.83*	0.988	.000	4.40	9.27
	EXP	14.23*	0.994	.000	11.78	16.67
DEM	GDY	-6.83*	0.988	.000	4.94	-4.40
	EXP	7.39*	0.996	.000	5.94	9.84
EXP	GDY	-14.23*	0.994	.000	-16.67	-11.78
	DEM	-7.39*	0.996	.000	-9.84	-4.94

* The mean difference is significant at the .05 level.
Where: GDY = Guided Discovery
DEM = Demonstration
EXP = Expository

As shown in Table 4, the mean difference between GDY and DEM was 6.83, between GDY and EXP was 14.23, and between DEM and EXP was 7.39. This implies that guided discovery ($\bar{x}$=64.19) is the most effective in facilitating students' transfer of knowledge in physics. This is followed by demonstration ($\bar{x}$=57.52) while expository ($\bar{x}$=50.72) is seen to be the least effective.

Hypothesis two

There is no significant effect of gender (male and female) on students' transfer of knowledge in physics taught with (i) guided discovery (ii) demonstration and (iii) expository teaching strategies.

H_o2: (i) There is no significant effect of gender (male and female) on students' transfer of knowledge in physics taught with guided discovery.

The analysis is as shown in Table 5.

Table 5: t-test comparison of transfer of knowledge mean scores of male and female students taught with guided discovery

Gender	N	$\bar{X}$	S.D.	DF	t-cal.	t-critical	Decision at P<.05
Male	47	64.51	8.16	92	0.02	1.98	NS
Female	47	64.47	8.19				

NS = Not significant at P<.05 alpha level.

The analysis in Table 5 shows that the calculated t-value of 0.02 is less than the critical t-value of 1.98 at p<.05. Therefore, the null hypothesis stating a non-significant effect of gender (male and female) on students' transfer of knowledge in physics taught with guided discovery was retained. This implies that gender does not significantly influence students' transfer of knowledge in physics when they are taught with guided discovery.

H_o2 (ii) There is no significant effect of gender (male and female) on students' transfer of knowledge in physics taught with demonstration.

The analysis is as shown in Table 6.

Table 6: t-test comparison of transfer of knowledge mean scores of male and female students taught with demonstration

Gender	N	$\bar{X}$	S.D.	DF	t-cal.	t-critical	Decision at P<.05
Male	49	58.08	6.28	91	0.68	1.98	NS
Female	44	57.18	6.60				

NS = Not significant at P<.05 alpha level.

The analysis in Table 6 shows that the calculated t-value of 0.68 is less than the critical t-value of 1.98 at p<.05. Therefore, the null hypothesis stating a non significant effect of gender (male and female) on students' transfer of knowledge in physics taught with demonstration was retained. This implies that gender does not significantly influence students' transfer of knowledge in physics when the students are taught with demonstration.

H_o2 (iii) There is no significant effect of gender (male and female) on students' transfer of knowledge in physics taught with expository.

The analysis is as shown in Table 7.

Table 7: t-test comparison of transfer of knowledge mean scores of male and female students taught with expository

Gender	N	$\bar{X}$	S.D.	DF	t-cal.	t-critical	Decision
Male	45	50.18	5.44	89	0.15	1.98	NS
Female	45	50.35	5.42				

NS = Not significant at P<.05 alpha level.

The analysis in Table 7 shows that the calculated t-value of 0.15 is less than the critical t-value of 1.98 at P<.05. Therefore, the null hypothesis stating a non significant effect of gender (male and female) on students' transfer of knowledge in physics taught with expository was retained. This implies that gender does not significantly influence students' transfer of knowledge in physics when the students are taught with expository.

Discussion of Results

The results of investigation as shown in Table 2 indicated that a significant difference was found to exists in the transfer of knowledge of students in physics taught with guided discovery, demonstration and expository. Multiple Classification Analysis (MCA) as shown in Table 3 indicated that 64% of the total variance in the transfer of knowledge of students in physics is attributable to the influence of the teaching strategies. The result of Scheffe pairwise comparison post hoc analysis as shown in Table 4 indicated that guided discovery was the most effective in facilitating students' transfer of knowledge in physics. This was followed by demonstration while expository was seen to have the least effective in facilitating students' transfer of knowledge in physics. The results might be due to the fact that a method of instruction which would allow the learner to become 'active' in the learning situation may possible have effects with regards to transfer. A learner is active in discovery learning, and provides for individual differences as well as makes the process of learning to be self-sequenced, goal directed, with the goal perceived and the pace self-determined. Discovery learning is intrinsically motivating and thus promotes the comprehension of inquiry. Also, guided discovery is a form of constructivist learning in which students are exposed to more realities of life and tend to work as scientist and acquire knowledge by themselves which the teacher only correct their misconceptions.

The result is in agreement with the findings of Hakes (1998), Akinbobola (2006), and Akinbobola and Afolabi (2009) that in the learning process involving manipulating, reacting, doing and experiencing such as demonstration and guided discovery, students achieved and retained the concepts taught better than those taught with expository strategy. The results also tally with the findings of Kersh (1998), Adesoji (2007), Adesoji and Ifamuyiwa (2007) Afolabi (2009), and Afolabi and Akinbobola (2009) that problem-based learning technique removes teacher as a dictator and sole owner of knowledge which render students passive. Students are actively involved in problem based learning technique which is not so in conventional learning method. This study is in line with the findings of Ikitde (2008), Adesoji and Ibraheem (2009), Akinbobola (2009) and Akinbobola and Afolabi (2010) that expository strategy does not promote learning in that under this strategy, many intellectual and manipulative skills are not learnt and also it kills the spirit of inquiry and investigation because it is a teacher-centered strategy where students learn by rote memory, concepts and principles.

The results of the findings as shown in Table 5,6 and 7 indicated an insignificant effect existing between the transfer of knowledge of male and female physics students taught with guided discovery, demonstration and expository teaching strategies. The result is also in agreement with the findings of Leinhardt, Seewald and Engelra (1997), Akinbobola (2006), Adesoji and Babatunde (2008), Onwioduokit, Akinbobola & Udoh (2008), Afolabi and Akinbobola (2009) and Akinbobola and Afolabi (2009) that found an insignificant difference exists between the achievement and retention of male and female physics students taught with different instructional strategies. This might not be unconnected with the scientific awareness and literacy in the society which has gone a long way in changing some societal expectations as well as the attitudes of the women folks. The outstanding achievement of some prominent female scientists, medical officers and engineers may have also served as great motivators for the female students in the study of physics in particular and the sciences in general. This might be so because any good teaching strategy adopted in the teaching of physics does not discriminate between the sexes. This result implies that both the male and female students have equal capability of responding to any type of teaching strategies used in teaching physics and can adequately achieve equal level of performance in physics.

Conclusion and Implications

Guided discovery is the most effective in facilitating students' transfer of knowledge in physics. This is followed by demonstration while expository is found to be the least effective. Also, there exists no significant difference in the transfer of knowledge of male and female physics students taught with guided discovery, demonstration and expository teaching strategies. Hence, any good instructional strategy equalizes interactions between male and female physics students.

The findings of this study have implications for improvement of science and technology in Nigeria.

Memorizing facts and information is not important skill in today's world of science and technological development. Guided discovery provides students the opportunity to construct the understanding necessary to produce deeper learning. Such understanding greatly increases the chances that students will be able to transfer the knowledge acquired and apply the concept in new situations. This increases the probability that it will be remembered. Guided discovery strategy serves as a stimulus for planning, learning, thinking, reflecting, investigating, predicting, reporting and questioning that will enable the students to be more creative, resourceful, innovative, interactive and constructing new ideas which are vital ingredients of process skills of science that could lead to the development and acquisition of technology in the country.

Strategies of Promoting Transfer

* **Using Varieties of Examples:** It is only by applying a principle to different kinds of situation that will make students to see the common features or characteristics.
* **Degree of Mastery:** Over – learning of the new situation will help to solve the problem of interference which the old learning has on the new situation.
* **Generalization**: This is the 'heart' of transfer. It enables a learner to apply general concept or principles to other situations. Transfer occurs only to the extent that an individual generalizes.
* **Similarity:** This occurs when learner has made a response to a similar stimulus. Similarity differs from common elements in that one does not need to examine very critically before one sees the similarity, whereas, one examines common elements very critically before seeing them.
* **Common Components**: Training in one area tends to transfer to another area when there are common components. These common components are also known as identical elements.

Recommendations

In the light of entire results and the implications of this study, the researchers share the view that as part of the efforts to improve students' transfer of knowledge in various concepts of physics, the following points should be noted for implementation.

1. Physics teachers must emphasize on a variety of procedures for promoting insight, meaningfulness, organization of experience, discovery of interrelatedness among ideas and techniques, and the application of knowledge acquired in one situation to a variety of situations.
2. Physics teachers should promote the development of efficient learning habits and tools. For instance, self-discovery tends to promote greater transfer than role learning and memorization.
3. Physics teachers should provide practice in transfer. Students should be given practices in finding relationships on their own.
4. Physics teacher should relate learning experiences to the new situations to which transfer is expected.
5. Students should be encouraged to become transfer conscious by emphasizing various concepts that are applicable to out-of-school life. Also, high degree of mastery of content should be encouraged.
6. The curriculum should be planned in such a way as to have transfer value in terms of the learner's goal and purposes.
7. Guided discovery and other student-centered teaching strategies should be adopted for teaching various concepts in physics so as to engage the students in various activities for meaningful acquisition of scientific knowledge, processes and ethics.

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