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Effect of a Constructivist Instructional Strategy on Affective Outcomes by Integrated Science Students

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Abstract: Advocacy for the use of constructivist instructional strategy for teaching science at the primary and secondary school levels is very phenomenal in the literature on science education. This advocacy is strengthened by the assumption that it improves affective outcomes, among others, because it involves negotiation, among others, between the teacher and the students, during instruction. There is the need to seek empirical evidence to support, or not, this advocacy. This study therefore, sought to find out if the constructivist strategy will enhance affective outcomes among integrated science students. Two hundred (111 boys and 89 girls) junior secondary two (grade 8) students participated in this study. Affective Achievement Test with reasonable psychometric integrity, was administered before and after treatment, which utilized a non-equivalent control group design, to measure the treatment effect. The results [$F_{(1, 191)} = 69.378$, $p < 0.05$] support the use of the strategy for improving affective outcomes. The results also indicated that the students in conducive psychosocial environment had superior affective outcomes than their counterparts in non-conducive environment [$F_{(1, 191)} = 8.067$, $p < 0.05$]. No significant difference in affective achievement between high and low cognitive achievers was observed [$F_{(1, 191)} = 1.965$, $p > 0.05$]. Interaction effects among the variables were not significant. Implications of the findings are discussed and recommendations are made.

Keywords: Constructivist instructional strategy; psychosocial classroom environment; affective achievement; junior secondary school; integrated science; conceptual change pedagogy

1. INTRODUCTION

One of the contemporary instructional approaches in science is conceptual change pedagogy. This approach is based on constructivist epistemology which places much premium on science students' prior knowledge often referred to as alternative frameworks (Driver & Erickson, 1983), minitheories (Claxton, 1987), alternative conceptions (Abimbola, 1988). This epistemology suggests that students' alternative conceptions should be explored and used for adapting the instructional activities to the students' needs (Bybee, 2006; Fittell, 2010). Their needs can be appreciated within the context of cognitive dissonance which often exists between these alternative conceptions and the subject matter of study (Igwebuike, 1991; 2000). Specifically, and according to Driver and Bell (1986), and Driver and Oldham (1986), the precepts of constructivists epistemology are:

- Individuals are Purposive: Learning does not take place by the learner responding in a passive way to the environment, but by actively interacting with it. Learners set their own goals and are responsible for their own learning.
- What is in the Learner's head Matters: What a person learns depends not only on the learning environment, but on what the person brings to the learning situation.

* Knowledge is Constructed by Individuals through social interactions and experiences with physical environment; personal knowledge is constructed so as to “fit” with experiences in a coherent way.
* Meaningful learning involves the Construction of Links with Prior Knowledge: The construction of meaning by making links with prior knowledge occurs in situations provided by reading texts, listening to someone talking or observing or manipulating physical phenomena.
* The Construction of Meaning is an Active Process: Making links with prior knowledge is an active process in which the learner generates possible hypothetical links and checks those for “fit” in the situation.
* Learning Science involves Conceptual Change: It involves not only adding and extending one’s conceptual structure but it may involve radically reorganizing it.

By implication, meaningful learning in science takes place when the learner’s alternative conceptions are explored and used during instruction. Conducive learning environment should be created to enable the learner determine the intelligibility, plausibility and fruitfulness of his alternative conceptions vis a vis the scientific conceptions of study (Strike & Posner, 1985). Tenacious hold on the alternative conception by the learner is released or at least, reduced if he is assisted to see their inadequacies. Within this process, the alternative conception should not be treated with levity as is common in traditionalist science classrooms where it is referred to as misconceptions (Abimbola, 1987; Igwebuike, 2000; Fittell, 2010). In addition, the learner should be motivated and his feelings must be respected for conceptual change to take place (Pintrich, Marx & Boyle, 1993; Gregoire, 2003; Zhou, 2010; Igwebuike, 2013). For instance, Gregoire (2003) in his Cognitive-Affective Model of Conceptual Change (CAMCC), amplifies the role of affective constructs like anxiety and fear during conceptual change. He says that appraisals of stress and threat preceed the consideration of the characteristics of the subject matter of instruction. Depending on the results of the affective appraisal, there can be a strong inclination to dismiss the subject matter. This may account in part, for the tenacity of alternative conceptions by learners observed in some studies (Bell, 2005; Calkir, 2008; Igwebuike 2009, 2011) even when conceptual change pedagogy was used.

Within a context or rationale created by these expositions it becomes imperative, among other things, to assess students’ level of affectivity during instruction premised on conceptual change. This is further supported by West and Pines (1983) who argue that while it is important to create situations which will challenge students’ alternative conceptions to bring about conceptual change, their feelings and dispositions are an important aspect of the process. They say that the learner should feel good, or proud, or satisfied after conceptual change and should not feel bad, demeaned or dissatisfied. Studies by Chang (2000), Chang and Bell (2002), indicated that the use of conceptual change pedagogy improved students’ interests, satisfaction, enjoyment, willingness to attend, listen to the lesson and participate in discussions; and increased learning commitment out of class. Igwebuike and Oriaifo (2012) provide evidence to support the use of conceptual change pedagogy for boosting affective outcomes among students in non-conducive psychosocial classroom environments.

Some studies have investigated the effectiveness of constructivist instructional strategy for improving cognitive achievement by science students and have found it is very efficacious (Zietsman & Hewson 1986; Asim, 1999; Bajah & Asim, 2000; Ndioho, 2007; Igwebuike & Oriaifo, 2012; Igwebuike, 2012). The studies by Igwebuike and Oriaifo (2012) and Igwebuike (2012) attempted to assess the efficacy of this strategy on affective outcome but these studies were single variable studies. They suggested, following Walberg’s (1970) exposition that each of the predictor variables of learning outcomes may be necessary but insufficient by itself for classroom learning to occur. There is the need to determine the efficacy of this teaching approach for improving affective achievement of students in various types of learning environment and with different types of characteristics. There is much to be learned from investigating affective achievement by science students taught using constructivist instructional strategy. For instance, a conceptual change agent or teacher may to some extent, know the nature of affective appraisal by the students. Such knowledge is uncommon especially among science educators in non-Western cultures.

Specifically, the problem addressed in this study is, "Is there any significant difference in the affective achievement between integrated science students (grade 8) taught using a constructivist instructional strategy and their counterparts taught using transmissive/expository strategy? Answers were sought to the research questions/through testing the following hypotheses:

1. There is no significant difference in the post-test affective mean scores between integrated science students (grade 8) taught using a constructivist instructional strategy and their counterparts taught using transmissive/expository strategy.
2. There is no significant difference in the post-test affective mean scores between integrated science students (grade 8) that are high achievers and their counterparts that are low achievers.
3. There is no significant difference in the post-test affective mean scores between integrated science students (grade 8) in conducive psychosocial learning environment and their counterparts in non-conducive environment.
4. There is no significant interaction effect of method, achievement level and nature of psychosocial learning environment.

2. METHOD

2.1 Sample

A sample of 200 (111 boys, 89 girls) junior secondary school (grade 8) students of four randomly selected secondary schools in Warri Municipality, Nigeria took part in this study. Two of these schools were classified as non-conducive learning environment while the remaining two were regarded as conducive environment. The classification was based on the responses by the participants on Individualized Classroom Environment Questionnaire which is described under 'Instrumentation". An intact class was randomly selected from each of the four schools and each of the classes had localized treatment to avoid contamination which could confound the study by invalidating the results. It was also necessary to use intact classes to avoid disrupting the instructional plans of the classes. Each of the two conducive classes was randomly assigned to a treatment, either constructivist instructional strategy or traditional (transmissive) strategy. The age range of the participants was from 12 years 7 months to 16 years 5 months with a standard deviation measure of 0.75.

2.2 Instrumentation

Three instruments were used in this study. They are: 1) Affective Achievement Questionnaire (AAQ); 2) Individualized Classroom Environment Questionnaire (ICEQ) (the Actual); and 3) Interview-about-Instances (IAI). The first, AAQ, provides a measure of the dependent variable, the second, ICEQ was used for demarcating the classes as conducive and non-conducive learning environments while the third, IAI, was used for probing the students' alternative conceptions. AAQ which was designed and factorially validated by Afemikhe (1985) was used for measuring affective achievement by the students resulting from the use or not of constructivist instructional strategy. It has 4 sub-scales of self-concept, confidence, attitude and motivation with 12, 3, 8 and 3 items respectively. Using Cronbach alpha procedure, the reliability coefficient of the AAQ was determined to be 0.65, 0.59, 0.46 and 0.45 respectively.

ICEQ, as mentioned earlier, was used for categorizing the classes as conducive and non-conducive learning environments. This instrument was developed by Fraser and Fisher (1983) and it has both the short and long forms. Each of the forms has the following scales; Personalization, Participation, Independence, Investigation and Differentiation with each scale of the short having 5 items. The simplicity and parsimony of the short form facilitated its selection for this study. The students that constituted the sample were very young and would be fatigued while responding to the long form of the instrument. These scales have reliability co-efficient of 0.78, 0.67, 0.83, 0.75 and 0.78 and discriminant validity measures of 0.28, 0.27, 0.07, 0.21 and 0.10 respectively (Fraser & Fisher, 1983). A cross-validation of ICEQ using a Nigerian sample yielded test-retest reliability coefficients of 0.71 for Personalization, 0.69 for Participation, 0.76 for Independence, 0.78 for Investigation and 0.67 for Differentiation (Igwebuike and Ilegar, 1992). For the purpose of this and other related studies, a composite reliability coefficient of 0.74 was obtained using

Cronbach alpha procedure and a sample of 63 grade 8 students which was different from the one used for this study. A description of ICEQ is provided in Table 1.

Table 1: Description of ICEQ

Scale Name	Scale Description	Sample Item
Personalization	Extent to which opportunities are provided for individual student to interact with the teacher and concern for the personal welfare of and social growth of the individual	The teacher considers students' feelings (+)
Participation	Extent to which students are allowed to make decisions and have control over their own learning and behaviour.	The teacher lectures without student asking or answering questions. (-)
Independence	Extent to which students are allowed to make decisions and have control over their own learning and behaviour.	Students choose their partners for group work. (+)
Investigation	Emphasis on the skills and processes of inquiry and their use in problem solving and investigation.	Students find out the answers to questions and problems from the teacher rather than from investigation. (-)
Differentiation	Emphasis on selective treatment of students based on ability, learning style, interests, and rate of working	Different students use different books, equipment and materials. (+)

The third instrument used for this study is Interview-about-Instances (IAI) which was developed by Osborne and Gilbert (1980a, 1980b). The purpose of this instrument was for probing students' alternative conceptions on energy. Instances of sub-concepts of energy – Energy as an Invention, Forms of Energy, Systems Undergoing Change and Conservation of Energy, were presented on different cards by means of line-drawings. Guides given by Learning in Science Project of the University of Waikato, New Zealand were followed carefully. The interviews yielded a catalogue of 17 students' alternative conceptions which were used for designing and implementing the instruction. A panel of 3 experts in integrated science teaching ascertained the content coverage of the IAI cards.

2.3 Design and Procedure

The design adopted for the study is the non-equivalent control group design utilizing a 2 x 2 x 2 factorial design in which the classes selected, as mentioned earlier, were randomly assigned to experimental and control conditions. Experimental group comprised of subjects taught using constructivist instructional strategy while the control group was made up of subjects who were taught using expository method. This was done in subtlety to the intention of examining any possible treatment effect due to exposure to constructivist instructional strategy. The two treatment conditions shared a common curriculum content which is energy.

ICEQ was administered to the subjects for the purpose of classifying the classes into conducive and non-conducive learning environment. This was achieved by comparing the group means of the scores on the perceptions of their actual classroom environment and not the preferred. The two classes that had the higher group means than the second set of two classes was classified as conducive environment. The unit of analysis selected for this purpose was the individual member of each class. An analysis of the group means of conducive and non-conducive classes was carried out to justify this dichotomy statistically. The result of this exercise strengthened our use of classroom environment as an independent variable in this study.

AAQ was administered to the subjects as pre-test. This was followed by eight weeks of instructional treatments which involved a total of twelve lessons of about 40 minutes per lesson. The treatments were administered by one of the researchers to control for some teacher variables which could affect the results but were not the focus of the study. Such variables include; commitment to the use of the teaching strategy, skills-gap, perceptions of, and beliefs about classroom practices, and knowledge of the subject matter of study.

A sample of 15 students was randomly selected from the experimental group for the interview using the IAI which has been described earlier. A total of 17 alternative conceptions was arrived at during the interview exercise. Constructivist instructional strategy used for teaching the students in the experimental group involved the presentation of the relevant alternative conceptions for each lesson, from the list of the 17 catalogued alternative conceptions. After this, the relevant scientific conceptions were presented and the subjects were assisted by the teacher/researcher to assess the usefulness and plausibility of their own conceptions vis-à-vis the scientific conceptions. Following an observation by Lawson and Thompson (1988) that students at the concrete operational level find it difficult to evaluate competing theories, guides were provided to the subjects in the experimental group during the assessment process. The subjects belong to this category. The guides, for instance, included providing some clues for analyzing the implication of both their conceptions and scientific conceptions during negotiations.

Subjects in the control group were not given this interview. They were taught using the teacher-dominated, expository method. After eight weeks of instruction, the two groups were given the post-test on affective achievement. This was done in the same manner as the pre-test.

3. RESULTS

A t-test was carried out to determine if the difference between the perceptions of subjects in the conducive and non-conducive learning environment achieved significance. The result indicated that the difference is significant [$t_{(198)} = 3.06$, $p < 0.05$]. (See table 2). The result justified the labels – conducive and non-conducive learning environments.

Table 2

Means, Standard Deviations and t-test Comparison of Subjects in Conducive and non-conducive Learning Environments

Group	N	$\overline{X}$	SD	t-value
Conducive	100	74.40	6.94	3.06*
Non-conducive	100	69.10	5.18	

** Significant at 0.05 level of significance*

Statistically significant difference was found between the experimental and control group means in the pre-test on affective measures [$t_{(198)} = 9.97$, $p< 0.05$]. This means that there was an initial difference between the two groups. There was a strong reason to use Analysis of Covariance (ANCOVA) for testing the hypotheses.

Table 3: T-test on experimental and control group means on pre-test

Group	N	$\overline{X}$	SD	t-value
Experimental	100	47.70	8.55	9.97*
Control	100	52.10	8.32	

Note * $p < 0.05$

Table 4: 3 – way analysis of covariance of post-test achievement scores

Source of Variation	SS	df	MS	F	P
Covariates	10589.629	1	10589.629		0.000
Main effects	1168.083	3	389.361	25.787	0.000
Method	1047.556	1	1047.556	69.378	0.000*
Environment	121.809	1	121.809	8.067	0.005*
Achievement	29.674	1	29.674	1.965	0.163
2 – Way Interactions					
Method x Environment	0.001	1	0.001	0.000	0.994
Method x Achievement	4.868	1	4.868	0.322	0.571
Environ. x Achievement	0.988	1	0.988	0.065	0.798
3 – Way Interactions					
Method x Environment X Achievement	2.982	1	2.982	0.197	0.657
Explained	11766.521	8	1470.815	94.410	0.000
Residual	2883.959	191	15.099		
Total	**14650.480**	**199**	**73.621**		

Note * $p < 0.05$

Table 5: MCA table of the 3 – Way ANCOVA on post-test of affective achievement

Grand Mean = 55.24 **Variable + Category**	**N**	**Unadjusted Deviation**	ETA	**Adjusted for Independent + covariance deviations**	**For Indep- covariance**	**BETA**
Method						
1. Experimental	100	2.62		2.29		
2. Control	100	-2.62		-2.29		
Environment			0.31			0.27
1. Conducive	100	1.48		0.79		
2. Non-conducive	100	-1.48		-0.79		
Achievement			0.17			0.09
1. High Achievement	100	5.45		0.57		
2. Low Achievement	100	-5.45		-0.57		
			0.64			0.07
Multiple R. Squared						0.622
Multiple R.						0.751

The results of the 2 x 2 x 2 ANCOVA and the corresponding Multiple Classification Analysis are presented in tables 4 and 5. There is a significant difference in affective achievement between the subjects exposed to the constructivist instructional strategy and their counterparts exposed to the expository (transmissive) strategy [$F_{(1, 191)} = 69.378$, $p < 0.05$] in favour of those exposed to the constructivist instructional strategy. They had an adjusted group mean of 57.53 while their counterparts exposed to the expository strategy had an adjusted group mean of 52.93. By implication, hypothesis 3(i) which deals with the effect of method of instruction on affective achievement was rejected.

The tables have data that indicate that learning environment had a significant main effect on affective achievement [$F_{(1, 191)} = 8.067$, $p < 0.05$]. Hypothesis 3(ii) which deals with the effect of nature of learning environment on affective achievement was rejected. The subjects in the conducive environment with an adjusted group mean of 56.03 had superior affective achievement than their counterparts in non-conducive environment with an adjusted mean of 54.45. The hypothesis of no difference was therefore rejected.

The tables indicate that there was no significant main effect of achievement level on affective achievement [$F_{(1, 191)} = 1.965$, $p > 0.05$]. The hypothesis of no difference in affective achievement between high and low achievers was therefore not rejected. There was also no significant interaction effect.

4. **DISCUSSION**

The overarching question raised in this study is on whether constructivist instructional strategy would improve affective outcomes by integrated science students learning energy concepts. The results of the study (see Tables 4 and 5) indicate that the strategy improved affective achievement significantly [$F_{(1, 191)} = 69.378$, $p < 0.05$]. This result agrees with the findings of similar studies (Chang, 2000; Chang and Bell, 2002; Ndioho, 2007; Igwebuike & Oriaifo, 2012; Igwebuike, 2012). In particular, Chang (2000), and Chang and Bell (2002) found that the strategy improved students' perceptions of interest, satisfaction, enjoyment and achievement, willingness to attend, listen to the lesson and participate in discussions; and increased learning commitment out of class. Similarly, Igwebuike and Oriaifo (2012) found that using the strategy improved students' composite perceptions of self-concept, confidence, attitude and motivation.

The result obtained in this study was not surprising. An explanation can be speculatively provided by considering the nature of the constructivist instructional strategy. An aspect of the nature of the strategy is that it values the students' alternative conception whether it is 'right' or 'wrong'. This provides a stark contrast with the traditional transmissive strategy which brands students' conceptions that are in conflict with the scientific tradition misconceptions. The students may feel dehumanized when their conceptions are treated this way. This may lead to students' tenacious hold on their alternative conceptions (see Igwebuike 2011).

West and Pines (1983) argue tenaciously that while it is important to provide a learning environment in which the students' alternative conceptions can be challenged to bring about conceptual change, the students' feelings and dispositions must be taken adequate care of. They argue that the learner should feel good, or proud, or satisfied but should not feel bad, demeaned (or dehumanized) or dissatisfied. They are supported by Pintrich, Marx and Boyle (1993), Gregoire (2003), and Zhou (2010). Gregoire (2003) amplifies the role of affective constructs like anxiety and fear during conceptual change which is a major phase in the constructivist instructional strategy. He also says that appraisals of stress and threats proceed the consideration of the characteristics of the subject matter being studied. These appraisals have a very strong link with, and infact constitute the first stage in the development of the level of affectivity by the learner.

Considering the time-honoured revelation of association between affective components and cognitive achievement (Bryne, 1984; Iran-Nahed, 1987; Aghadiuno, 1992) one can say that the result obtained in this study is heart-warming. This is because, it is expected that learners with better perceptions of interests, satisfaction etc will achieve better than their counterparts that do not have good perceptions of these affects.

This observation however, is not supported by Igwebuike's (2012) study. More studies are needed to improve our knowledge of this phenomenon.

The results in Tables 2 and 3 also indicated that there was significant main effect of psychosocial classroom environment on affective achievement [$F_{(1, 191)} = 8.07$, $p < 0.05$]. This means that the students in conducive learning environment had better affective achievement than their counterparts in non-conducive environment. This finding agrees with the results of other studies (Goh & Fraser, 2000; Quek, Fraser & Wong, 2001; Margianti, Fraser & Aldridge, 2011; Dorman, 2002; Dorman, McRobbie & Foster, 2002; den Brok, Brekelmans & Wubbels, 2004, den Brok & Fisher, 2004; Akinbile, 2010) which indicate positive association between perception of psychosocial classroom environment and affective achievements. For instance, Akinbile (2010) using Individualized Classroom Environment Questionnaire found that biology-students with positive perception of their classroom environment had more positive attitude towards science.

The result obtained in this study, with respect to psychosocial classroom environment can be explained by the nature of the scales of ICEQ. For instance, Perosnalization, one of the scales is concerned with finding out the extent to which the teacher provides opportunities for individual student to interact with him and the extent to which he is concerned about the personal welfare of the students in his class. Differentiation, another scale emphasizes selective treatment of the individual student based on his ability, learning style, interest and rate of working. Definitely students who perceive their learning environment positively and are taught using a constructivist instructional strategy which shares almost the same characteristics with psychosocial classroom environment, will have better affective achievement.

A major goal of teaching science is the development of affective components. To that extent the results of this study are heart-warming. It suggests the potency of the constructivist instructional strategy and practices in integrated science class that will improve students' perception of their psychosocial environment, and by implication affective achievement by the students at this level. Integrated science teachers and educators should be excited about this especially in the light of some time - honoured corroboration of studies by Byrne (1984), Iran-Nahed (1987), Aghadiuno (1992), and Ukwungwu and Nworgu (1999) that there is a strong association between affective components and cognitive achievement.

An intriguing revelation from this study is that achievement level did not significantly affect affective achievement [$F(1, 191) = 1.965$, $p > 0.05$). It was expected that integrated science students with higher cognitive achievement level would have superior affective achievement. This expectation was premised on the established positive association between cognitive and affective achievements (Byrne, 1984; Iran-Nahed, 1987; Aghadiuno, 1992; Ukwungwu & Nworgu 1999). It is patently difficult to give a plausible explanation to this result. But if an explanation can be hazarded it may be that it was likely that there were vacillations by the higher cognitive achievers with respect to affective achievement. These probably created an opportunity for the low achievers to catch up with the high achievers.

An implication of the result of this study which indicates that integrated science students (grade 8) taught using a constructivist instructional strategy had better affective achievement than their counterparts taught using a transmissive/expository strategy is that integrated science teachers and educators should be sensitized about the efficacy of the strategy. It should be acknowledged however, that this is a mere suggestion since it is not based on firm conclusion. The design used in the study lacks complete or strict control of extraneous variables and this may jeopardize generalizability of the findings. Further studies are therefore needed to validate or otherwise, the findings of this study. Nonetheless, the fruitfulness of the direction of enquiry carried out here cannot be controverted especially in a non-Western culture where school science is based on Western scientific tradition.

5. CONCLUSIONS

This study provides evidence to support claims about the potency of constructivist instructional strategy for producing superior affective outcome among integrated science students (grade 8). It has also shown that such students in conducive psychosocial classroom had superior affective outcome than their counterparts in non-conducive classrooms. Cognitive achievement did not affect affective outcomes.

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