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Measuring Students' Attitude Towards Chemistry: The Strengthening Mathematics and Science Education's Approach

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Abstract

Students' academic success is dependent on several affective factors. Critical among these factors is students' attitude. Hence, the need to view attitude as an outcome rather than influence, becomes imperative. The Activity, Student-centered, Experiment, Improvisation-Plan, Do, See, Improve (ASEI-PDSI) approach is a pedagogical model for strengthening mathematics and science education in Nigeria and thought to promote positive attitudinal change towards learning. Hence, this study investigated the effects of ASEI-PDSI approach on Senior School students' attitude towards Chemistry. The study was a quasi-experimental one, the sample comprised 139 SSI students from two randomly selected co-educational schools in Ilorin, Nigeria. The ASEI-Instructional Package (ASEI-IP) was the stimulus instrument while the Attitude Towards Chemistry Scale (ATCS) was the test instrument. The reliability of ATCS was found to be 0.68. The data gathered were analysed using Analysis of Covariance and t-test statistics. The finding revealed that ASEI-PDSI approach did not bring about any significant change in attitude towards chemistry. The study concluded that ASEI-PDSI approach might not promote students' attitude towards chemistry all the time.

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INTRODUCTION

Students' academic success has been the focus of researches in science education. As such, effects of several innovative strategies such as inquiry model, discovery learning, advance organizers, activity-based learning, and so on, were examined on academic achievement in science subjects. Perhaps, this is because inappropriate teaching methodologies was considered as a dominant factor adduced to students' under-achievement in sciences (Ngeme, 2016; Odhiambo, 2016; Strengthening Mathematics and Science Education [SMASE], 2010). However, academic success may be directly or indirectly linked to many other affective factors which among others include attitude, self-efficacy, motivation, and anxiety (Wan & Mat, 2013). Attitudes, like achievement, are crucial outcomes of science education (Cheung, 2009), as such, every teacher is charged with the responsibility of promoting students' positive attitude towards learning (Cheung, 2009). The concept of attitude has been widely debated over the years and one of the conclusions drawn was that attitude represents a multidimensional construct that is cognitive, affective, and behavioural (Montes et al., 2018). Hence, attitude is a conceptual belief which may be positive or negative and indicates like or dislike towards an item. Essentially, attitude are considered not to be resistant to reform, that is, students' attitude will change through direct and indirect learning, observations, experiences, and learning environment (Heng & Karpudewan, 2014).

Having established that students' positive attitude towards chemistry is congruent to their achievement (Al-Mutawah & Fateel, 2018; Montes et al., 2018), teachers and stakeholders in education are compelled to understand and revamp students' attitude in order to support their achievement in chemistry. This is because, even though, several instructional strategies were introduced to enhance achievement in chemistry, students' performance in external examinations is still worrisome. This claim is evident in the haphazard trend in performance of students in chemistry in the West African Senior School Certificate Examinations (WASSCE) of 2009-2019, where less than two-third of the total enrolments in the years under review made it to credit pass. Perhaps, this could be the consequences of negligence of their attitude towards the subject. Attitude towards learning plays a central role in achievement in science. Positive attitude are considered to be the basis for optimism which in turns enhances achievement through persistence and resilience (Mokoro et al., 2014). On the hand, negative attitude could breed anxiety and consequently, worsen students' achievement in sciences. Hence, the factors influencing students' attitude towards chemistry should not be disregarded. Factors, such as teachers' characteristics, parental influence, grade level, gender, motivation, depression, anxiety, instructional methods, interest, classroom environment, perceived difficulty, relevance of curriculum and so on were considered to influence students' attitude towards chemistry. However, instructional methods, gender and grade level were prominent among these factors (Musengimana et al., 2021). Hence, the need to investigate the effects of innovative instructional strategy such as ASEI-PDSI approach on attitude towards chemistry becomes imperative.

The ASEI is an acronym for Activity, Student-Centered, Experiment and Improvisation, an inherent strategy that promotes student-centered pedagogy among teachers while PDSI stands for Plan, Do, See, and improve that encourages culture of teachers' continuous improvement (Mwelese & Atwoto, 2014). The ASEI-PDSI approach is pedagogical model for Strengthening Mathematics and Science Education (SMASE) in Nigeria. The SMASE Nigeria Project was launched in 2006 through in-service training for teachers with emphasis on the need to revitalize teachers' performance in lesson delivery, and promote positive attitude towards teaching and learning of science and mathematics through the ASEI and PDSI. The ASEI-PDSI approach ensures that students learn by their own efforts. Essentially, during learning process, the teacher guides and channels the students towards making their own efforts for learning. Perhaps, positive development may be observed in students' attitude.

Undoubtedly, gender as an important factor interacting with attitude towards science cannot be overlooked, especially with increasing emphasis on how to boost man power for technological development as well as increasing the population of females in the field of science and technology. The issue of gender differences in researches in science education is inconclusive. For instance, the studies of Heng and Karpudewan (2014), Ratamun and Osman (2018) reported significant gender difference in students' attitude towards chemistry while Wahyudiati et al. (2020); Montes et al. (2018); Cheung (2009); Majere et al. (2012), reported no significant gender difference in students' attitude towards chemistry. It is therefore, a focus in this study to contribute to literature by exploring the influence of gender on

students' attitude towards chemistry

Attitude is one of the popular hypothetical construct used to explain phenomena of ones' interest, the way people think, how they feel and how things are being carried out (Heng & Karpudewan, 2014). Hence, attitude could be a good predictor of students' choice of subject especially, in the context of science education where students favour certain science subjects. Essentially, while attitude have powerful effect on behavior, this same influence can also create attitudinal change. That is, attitude are not set in stone and can be reformed. In view of this, this study is guided by the theory of planned behaviour (TPB). The TPB was proposed by Ajzen (1985) and posits that intentions are determinant of behavior which in turns depends on person's attitude, his subjective norms and the perceived behavioural control.

The combination of the three factors of attitude towards behavior, subjective norms, and the perceived behavioural control influence a person's intention and ultimately, his final behaviour. This concept was proposed to improve on the predictive power of the theory of reasoned action (TRA) proposed by Fishbein and Ajzen in 1975. Hence, the TPB was developed to strengthen the assumptions of TRA. Fundamentally, TRA sought to find out individual's voluntary behaviour by examining the basic and substantive motivation to perform an action (Doswell et al., 2011). The perceived behavioural control was added to the TRA to become TPB and takes into account if a person truly believes that he has control over the behaviour he wants to carry out. Hence, the TPB suggests that interaction between beliefs and practice can be explained better with the concept of behavioural intentions. That is, all behaviours over which people have the ability to exert self-control were the focus of the TPB. Hence, behavioural intent is the key component of the TPB model (LaMorte, 2019) and the chance to understand a person's attitude is greater. Fishbein and Ajzen (1975) viewed behavioural intention as a behaviour that is predicted by intention to perform such behaviour. That is, attitude, which is the degree to which a person has a favourable or unfavourable evaluation of behaviour; the subjective norms which is the perceived social pressure to participate or not in a behaviour; and the perceived behavioural control that refers to individual's perception of their ability to carry out a given behaviour, influence intention and provide evidence of causes of behaviour and thus, serve as a mean to change or influence desired behaviour (Miller et al., 2019).

In classroom context, The TPB uses students' attitude and opinion, in combination with their perceived behavioural control and the societies' subjective norms to influence learning which in turns leads to enhanced achievement. For instance, if a student who is not doing well with his studies, has negative attitude, he feels he has total control of his action, and quits. The people in the society disapprove this action, then it is likely to have negative impact on his intention for the action. Therefore, an individual attitude, perceived behaioural control and subjective norm can have positive or negative impact on intentions and the actions of behaviour. Thus, the TPB provides a framework to shape behaviour to a preferred one. As such, the ASEI-PDSI explored the perceived behavioural control of discovery and knowledge construction; the subjective norm of authentic presentation and collaboration among students to provide pressure to do well in chemistry; and perhaps, promoting positive attitudinal change towards chemistry.

While studies related to ASEI-PDSI and attitude are substantial (Khakoni, 2013; Mwelese & Atwoto, 2014; Ngila, 2016; Odhiambo, 2016; Ndirangu, 2017; Protus et al., 2020; Tukur et al., 2020), most of these studies focused on investigating teachers' attitude as implementers of ASEI-PDSI rather than promoting students' positive attitudinal change. This perhaps, could be because teachers' factors are considered to be crucial, and a driving force behind successful classroom practices. The studies of Ndirangu (2017); Tukur et al. (2020) reported teachers' positive attitude towards implementing ASEI-PDSI in the classroom. However, contrary to this, was the finding of Odhiambo (2016) that reported teachers' negative attitude towards ASEI-PDSI.

Contrastingly, the studies of Khakoni (2013); Mwelese & Atwoto (2014); Ngila (2016); Protus, et al. (2020) focused on how ASEI-PDSI could be used to promote positive attitudinal change among students and these studies reported improved students' attitude on exposure to ASEI-PDSI. The studies of Khakoni (2013); Mwelese & Atwoto (2014); Protus, et al. (2020) explored the effects of ASEI-PDSI on attitude towards mathematics while the study of Ngila (2016) measured the effects of ASEI-PDSI on attitude towards chemistry. Although, Ngila's (2016) study was similar to the present study as they both examined the effects of ASEI-PDSI on students' attitude towards chemistry, these studies however, differ from each other because this present study was guided by theory of planned behavior rather than social constructivism used by Ngila (2016).

Also, this study was conducted in Nigeria and influence of gender on attitude towards chemistry was also examined in this study. Thus, the overall aim of this research was to examine the effects of ASEI-PDSI instructional approach on attitude towards chemistry. To guide the present study, the following research questions were raised to address the main purpose of the research: What is the effect of ASEI-PDSI approach on students' attitude towards chemistry?; What is the difference in attitude of students exposed to ASEI-PDSI instructional strategy based on gender?

METHODS

The study adopted pretest, posttest, non-equivalent control groups of 2 x 2 quasi-experimental research design. The first 2 represents the experimental and the control groups; the next 2 represents the students' gender, also at two levels of male and female. Also, in this study, intact classes of the students were involved so as to avoid distortion of the regular school program and to control for selection bias. The experimental and control groups were exposed to pre-test and the corresponding post-test.

Figure 1. The Design Layout

Population, Sample and Sampling Techniques

The population for this study was all Senior Secondary School students in Ilorin, Nigeria; while the target population was all first year Senior School students (SSI) offering chemistry in Ilorin. The choice of SSI as the target population was considered appropriate because it is at this level that chemistry is being introduced as a subject, intrinsically, it becomes crucial for the students to develop positive attitude towards chemistry at this earlier stage. There are seventy-eight (78) public Senior Schools in Ilorin, Nigeria. Out of these 78 schools, seven (7) schools are not co-educational, thus, they were exempted from the study. Two schools with qualified chemistry teachers which have been presenting candidates for Senior School Certificate Examinations (SSCE) for at least ten years, and not situated close to one another were selected from the remaining 71 schools in Ilorin using simple random sampling technique. The sampled schools were randomized into experimental and control groups and their intact classes were involved in this study with a total sample size of 139 students (61 males and 78 females).

Instrumentation

Two instruments were used in gathering data in this study:

1. The ASEI Instructional Package (ASEI-IP);
2. Attitude Towards Chemistry Scale, (ATCS); and

The ASEI Instructional Package (ASEI-IP) was a stimulus instrument that is made up of ASEI activity sheet, the ASEI lesson plan, ASEI interaction plan, and ASEI chalkboard plan for the experimental group. The ASEI activity sheet provided the students with step-by-step procedures to employ during instruction, the ASEI lesson plan showed the intended lesson objectives and procedures in achieving the stated objectives that take into cognizance students' topic of interest and their misconceptions; students' prior knowledge; suitable language to be used for the local materials and how to reach the pedagogical goals through relevant class activities. The ASEI interaction plan contained the types of questions to be asked by the teacher, the expected responses from the students and the questioning techniques at each stage of the lesson. The ASEI chalkboard plan showed the logical flow of the lesson, corresponding to each step of the lesson plan. The Attitude Towards Chemistry Scale, (ATCS) was a questionnaire designed to measure students' attitude towards chemistry. The ATCS consisted twenty (10 positive & 10 negative) statements reflecting the subscales of liking chemistry for theory; liking chemistry for practical; evaluative beliefs about school chemistry; and the behavioural tendencies to learn chemistry. These statements consisted responses on a 4-point Likert scale of strongly agree (SA); agree (A); disagree (D); and strongly disagree (SD). The ratings ranged from Strongly Agree (4) to Strongly Disagree (1) for the positive statements and the reverse ratings, Strongly Agree (1) to Strongly Disagree (4) were used for the negative statements. The scores from the ATCS ranged from the lowest, 20 (25%) to the highest, 80 (100%). In this study, students with scores below (50) 62.5% were adjudged to have negative attitude. The items in attitude towards chemistry lesson scale, ATCLS (Cheung, 2009) were adapted and modified to develop the ATCS used in this study. The modifications made were to reduce the response modes from 7-point Likert to 4-point Likert and some items were changed into negative statements. This was necessitated in order to reduce the effects of acquiescence and other response biases.

The instruments were given to two experts in Department of Science Education, University of Ilorin, Nigeria; two experienced Senior School chemistry teachers; a senior lecturer in the Department of Chemistry, University of Ilorin for both face and content validity. This ensured that these instruments were appropriate and the items measured what they were designed to measure. Also, in order to ascertain the internal consistency, the ATCS was trial tested. A test-retest reliability method was employed involving 20 non-participating SSI students in Ilorin with an interval of two weeks between the first and the second test. The resulting data were analyzed using Cronbach's alpha and a reliability coefficient of 0.68 was obtained. Hence, the ATCS was adjudged to be reliable.

A letter of introduction was presented to the principals of the sampled schools. This was to seek their permissions and consents to involve their schools, teachers and allow their students to take part in the study. The researcher interacted with the chemistry teachers, enlightened and acquainted them with the nature of the study and thus, formally sought their consents through the informed consent forms, to serve as research assistants for this study. Also, the researcher met with the students and apprised them of the significance and benefits of the study to their academic pursuits. Similarly, the researcher affirmed and disclosed to the students that: the data obtained from the study is strictly for research purpose; their identity would be treated with utmost confidentiality; the study would not be forced on them; and they may withdraw their participation at any stage of the study. Hence, the consents of the students and that of their parents were sought through filling of the informed consent forms.

The researcher revisited the sampled schools to retrieve the informed consent forms and ascertained the participation status of the subjects of the study. The research assistants for the experimental group received a special training on how to use ASEI-IP and were provided with training manual for reference purpose. The experimental group was taught with ASEI-IP while the control group was taught without using ASEI-IP. The ATCS was administered as pre-treatment attitude test to both groups to measure their attitude prior to the treatment. Six periods of forty minutes lesson were used in each of the schools for the actual treatments. The control group was taught using the conventional method of teaching. However, the students in the experimental group worked cooperatively in a group of seven, where each member of a group had specific task assigned and interacted with the materials provided, and the ASEI-activity sheet served as guide to reaching the lesson objectives. The researcher and the research assistants only facilitated the learning process in this group by identifying topics of students' interest and their misconceptions; fitting the learning materials to the students' prior knowledge; providing suitable language to be used for the local materials and reaching the pedagogical goals. Thereafter, the ATCS was administered as post-treatment attitude test after the treatment.

RESULTS AND DISCUSSION

As shown in Table 1, there are 139 valid subjects with total of 61 male and 78 female participants in both groups. The experimental group exposed to ASEI-PDSI instructional strategy comprised 77 (42 males, 35 females) subjects while control group that was not exposed to ASEI-PDSI instructional strategy comprised 62 (19 males, 43 females) subjects. The distribution of the subjects based on score levels shows that the sample comprised 45, 42, and 52 low, medium and high scorers respectively in both groups.

Research Question 1: what is the effect of ASEI-PDSI approach on students' attitude towards chemistry?

This study explored the effects of using ASEI-PDSI approach to promote positive attitude of senior school students in chemistry. Hence, the main effect

Table 1. Demographic Data of the Subjects

Group		Gender		Score Levels			Total
		Male	Female	Low	Medium	High	
Experimental	*F*	42	35	29	23	25	77
	%	68.9	44.9	64.4	54.8	48..1	100.0
Control	*F*	19	43	16	19	27	62
	%	31.1	55.1	35.6	45.2	51.9	100.0
Total	*F*	61	78	45	42	52	139
	%	43.9	56.1	32.3	30.3	37.4	100.0

Table 2. Mean and Standard Deviation of Attitude Test by Groups

Groups	N	Tests	Mean	Std. Deviation	Remark
Control	62	pre-treatment attitude test	52.39	6.73	Average
		post-treatment attitude test	54.52	6.50	Average
Experimental	77	pre-treatment attitude test	52.23	6.17	Average
		post-treatment attitude test	59.10	7.92	Average

of ASEI-PDSI and influence of gender on attitude towards chemistry were examined. Table 2 shows the arithmetic mean of students' posttest scores in the control and experimental groups as =54.52 and 59.10 respectively. Hence, a difference of 4.58 in favour of experimental group was observed. Hence, there was difference in the attitude of students exposed to ASEI-PDSI approach and those that were not.

Consequently, a one-way between-groups analysis of covariance was conducted to find out if the difference was statistically significant using the pre-attitude test as covariate. However, preliminary checks were conducted to ensure that there was no violation of assumptions of normality, linearity, homogeneity of variances and reliable measurement of the covariate. Hence, Table 3 presents the result of Levene's test of equality of variance.

Table 3. Levene's Test of Equality of Error Variances[a]

F	*df1*	*df2*	Sig.
2.411	1	137	.123

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
a. Design: Intercept + group + pretest

The result of ANCOVA in Table 4 reveals no statistically significant difference at $p > .05$ alpha level in the post-attitude scores for the experimental and control ($F_{(1, 136)} = 2.25$, $p = .14$, partial eta squared = .02). The outcome of this study revealed no significant difference in the attitude of students exposed to ASEI-PDSI approach and those not exposed. This implies that the ASEI-PDSI approach did not bring about any significant change in attitude towards chemistry, even though, the mean score for the experimental group was higher than that of the control. In this study, the benchmark for positive attitude was set to be 50 (62.5%), the two groups already met this benchmark before the treatment. That is, their attitude was already positive. Perhaps, this could mean that chemistry as a subject doesn't appear to be a disliked subject by students. This finding agrees statistically with the findings of Barchok et al. (2013) Sengul and Katranci (2014); Bamidele, Adetunji, Awodele and Irinoye (2013). It however, disagrees with Protus et al. (2020); Mwelese and Atwoto (2014) Tukur et al. (2020). Although, this study reported that ASEI-PDSI approach could not be used to promote positive attitude towards chemistry, it cannot be ruled out that ASEI-PDSI had no effect if other measure of attitude were employed or if other topics in chemistry were explored. Also, intrinsically, better mode of instruction like the ASEI-PDSI approach are envisaged to promote positive attitude in students, the outcome of this study indicated that this may not happen all the time. The differences observed could be as a result of influence of other students' variables unknown to the researcher.

Research Question 2: what is the difference in attitude of students exposed to ASEI-PDSI approach based on gender?

Table 5 shows the arithmetic mean of = 60.24 and 58.37 in the post-attitude test for male and female students in the experimental group respectively after the intervention. A mean difference of 1.87 was noted, which could be negligible. Hence, there was no difference in the attitude towards chemistry of male and female students exposed to ASEI-PDSI approach.

Consequently, in Table 6, an independent sample t-test was conducted to compare the achievement of male and female students in the treatment group reveals no statistically significant difference in scores for males (= 60.24, SD = 7.40) and females (= 58.37, SD = 7.98, $t_{(75)} = 1.06$, $p = .29$, two-tailed). Therefore, finding on the influence of gender on attitude of students exposed to ASEI-PDSI instructional strategy revealed no significant difference in the attitude of male and female students exposed to the treatment. This implies that being a male or female does not influence their attitude towards chemistry when taught using ASEI-PDSI approach. The reason could be adduced to the fact that both the males and females appreciated their active roles in the learning process, and as such, contributed to better understanding and the enhanced attitude. The finding supports the earlier findings of Tukur et al. (2020); Sofiani et al. (2017); Ebuoh (2011) which reported no significant difference in male and female attitude towards chemistry. It however, contradicts the findings of Kenar et al.

Table 4. Analysis of Covariance for Difference between Group Means in Attitude Test

Source	Type III Sum of Squares	*Df*	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	2302.03[a]	2	1151.02	28.09	.00	.29
Intercept	1272.55	1	1272.55	31.05	.00	.19
Pre-attitude test	1486.30	1	1486.30	36.27	.00	.21
Group	92.28	1	92.28	2.25	.14	.02
Error	5573.49	136	40.99			
Total	462913.00	139				
Corrected Total	7875.53	138				

R Squared = .29 (Adjusted R Squared = .28

Table 5. Mean and Standard Deviation of Male and Female Students in Post-attitude Test

Gender	N	Mean	Std. Deviation	Std. Error Mean
Male	42	60.24	7.40	1.14
Female	35	58.37	7.99	1.35

Table 6. The t-test Analysis for Difference between Male and Female Students' Mean Scores in Post-Attitude Test

	Levene's test for Equality of Variance		*t*-test for Equality of Mean						
								95% Confidence Interval of the Difference	
	F	Sig.	*t*	*df*	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	.34	.56	1.06	75	.29	1.87	1.76	-1.63	5.37

(2015); Oluwatelure (2015); Heng and Karpudewan (2014) that reported significant difference in the attitude of male and female students in chemistry. The differences could because of their belief that male students are being highly engaged in attention seeking activities.

CONCLUSION

Evidence abounds that students' attitude towards science is congruent to achievement. That is, attitude, like achievement is also an important outcome of science learning. Hence, this study examined whether ASEI-PDSI approach might be used to promote positive attitudinal change towards chemistry. Based on the results and earlier discussion of findings, the following conclusions were made:

The students' attitude towards chemistry remain neutral when taught using ASEI-PDSI approach. This implies that ASEI-PDSI approach did not bring about any significant change in attitude towards chemistry. Similarly, the ASEI-PDSI approach succeeded in minimizing the gender stereotype among the students, as there was no significant difference in the attitude of male and female students exposed to ASEI-PDSI approach. Thus, ASEI-PDSI approach is gender friendly.

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