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Influence of Age on Students' Alternative Conceptions of Scientific Phenomena

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Abstract
The study was designed to investigate the influence of age on students' alternative conceptions of scientific phenomena. The study employed an ex-post-facto design and was conducted in some sampled schools in Aguata education zone of Anambra State. The sample for this study comprised of five hundred and twenty two SS I students. The study was carried out in 8 secondary schools (4 boys and 4 girls). The schools were drawn through a stratified random sampling. In each school, intact class of SS I was used. Two research question and one hypothesis guided the study. An instrument known as Alternative Conception of Scientific Phenomena Test (ACSPT) was developed by the researcher and used for data collection. The research questions were answered using frequencies and percentages while the hypothesis was tested using cross tabulation with chi-square test of independence as the test statistic. It was revealed that age is not a significant factor in student's conception of motion. The reasons for the students' alternative conception of motion were centered on culture and practices prevailing in the environment. Based on the findings of the study, the researcher recommendation that alternative scientific conceptions based science instruction should be adopted in our school system; Ministry of Education and Professional Organizations like STAN should organize workshops, seminars and conferences for Physics teachers on the use of the scientific alternative conception based package and the use of conventional instructional approach should be de-emphasized in our school system since it encourages rote-learning. Physics teachers should employ the principles of the alternative conception of science to enhance knowledge acquisition among students.
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Introduction

Science as pointed out by Abimbola, (2013) in Kharis, (2016) is a body of knowledge, a way of investigating natural phenomena and a way of thinking in an attempt to understand nature. The knowledge of science and its implication is very important in our world today. Science has made a lot of tremendous achievements which has helped mankind in remarkable ways. Science, especially physics, is important to mankind, not only because it helps to satisfy our curiosity, but also helps to channel our curious mind to discovering and creating things. Physics in particular, not only solves man's problems and attain to daily needs but also proffer solutions to seemly difficult situations such as curing health issues Kaharis, 2016. Exlina (2000), observed a similar thought in his work where he was of the opinion that Science (Physics) is important to the public because it addresses issues that are the concern of the populace.

Physics is the study of matter, energy, and the interaction between them. Physics according to Kaharis (2016), has broken the barrier of limitations in many fields, brought explanations to myths and mysterious happenings, removed the covering of superstitions from physics student's minds and unveiled the conceptual approach to life.

The past decade of research in science education has dealt with many researchers into children's ideas (Sadler, 2007). Sadler further observed that most students have ideas or understandings that are quite different from their teachers or scientists. Even when much effort has been made to explain physics concepts to students, the students still hold to those alternative conceptions.

Alternative conceptions according to Driver and Bell (2009) are the information taken by learner from environment in which they construct personal interpretation and meaning based on prior knowledge and experience. They stress that alternative conceptions involve the study of intuitive motions or informal knowledge held by students on

scientific conceptions, which made learning meaningless. In view of this, Bruner (2010) said that meaningful learning depends on the learner's success in finding or creating connections between new information (Formal Knowledge) and pre-existing knowledge. According to Bruner, one way by which these connections are made is through the use of analogy. By analogy he means that in the learning process of scientific concepts a search for similarities between what is already known and the new or the alternative conception and the scientist's conception.

Alternative conceptions are therefore those ideas children hold about scientific concepts before coming to the classroom. Osborne & Freyberg (2000) in consonance with Duckworth (2010), pointed out that a lot of papers have been published revealing students' conceptions in different domains, for instance, Eckstein &Shemesh (1992) carried out an investigation on students' conception on "Projectile motion". They found out that a student held concept that ball falling from the edge of a table would fall straight down instead of exhibiting a motion path or trajectory path of a parabola. "These pre-conceptions will now form a base through which new information is processed and understood" (Anderson, 1990; 5) The alternative conception based technique if inculcated into curriculum, will enhance the students' active participation and better understanding in the actual teaching learning process of physics concepts such as "Motion".

The study of alternative conceptions of scientific conceptions will help the discrepant events that high light the difference between student's conceptions to be explained to students during teaching and learning process so as to stimulate them to relinquish their intuitive ideas in favour of Scientists science (Congrove and Osborne, 2005). This study will help the learning of science education in Nigeria in particular because the science teachers can now think of better methods of making the students construct meaningfully. Recently efforts are being made to investigate into alternative conceptions of children in science education, Bruner (1996) earlier noted that concepts constitute basic elements one should understand in other to teach or learn science. From Physiological perspective, Okafor (2008:143) states "concepts originate as a result of sensation which is the cerebral cortex of the brain where the image of the object which generated the stimulus is formed".

In an empirical study conducted by Eckstein and Shemesh (1989) on students' age and alternative conception, they showed that the ideas of children are not static and the transformations of ideas increase with age. However, two different studies were carried on a quantitative comparison between Piagetian stages of development and stages of conceptual development byShayer&Wylam (1981). They investigated the percentages of children at the concrete (0-2 years), late concrete (2-4 years) and formal stages (4-8 Years) of Pigetian development using the mathematical model used by Eckstain and Schemesh to do the analysis. They calculated the half-lives, T1 for boys and T2 for girls. T1 for the transition from concrete to late concrete, and T2 from late concrete to formal. They found out that the half-live was found to be 2.5 years for boys and 7.8 years for girls. This situation coupled with poor formation of science concepts among students (Eze, 2014) and overall poor academic achievement of secondary students in science raise doubts in the efficacy of the existing instrumental approaches in science. In fact, the current approaches in science instruction in Nigeria have been criticized as hopeless and incapable of bridging the wide differences between the initial background of the learners and the new field of knowledge (Fafunwa, 1983).

The level of students' achievement and interest in science subject in general and physics in particular has not been as encouraging as expected for instance, the chief examiner's report of the West African Examination Council (WAEC, 2010) for both Senior School Certificate Examination (SSCE) May/June and November/December (GCE) 2010, respectively revealed that the weakness of students in science accrued from poor knowledge of basic scientific concepts and scientific terms, like in physics subject, the students' knowledge on motion as a concept is very poor.

The implication of this statement is that the conception of students' on motion as a basic scientific concept is very far from expected perhaps, the poor performance of students in physics subject with particular reference to motion as a concept could be arrested by exploring the influence of age in students alternative conception in motion.

Research Questions:

c) What are the alternative conceptions held by students about "motion"
d) To what extent does age influence the alternative conceptions of students in motion?

Hypothesis

HO_1: Senior Secondary School students' alternative conceptions of "motion" are significantly independent of age.

Methods

Stratified random sampling technique was used in drawing the sample for the study. In stratified random sampling, the population is divided into certain characteristics of males and females or urban and rural and a proportionate random sample is then drawn from each identified characteristics called stratum.

For the purpose of this, the schools were stratified into boys and girls. In the zone there are 8 boys and 9 girls schools. Out of 8 boys' school, 4 schools were randomly sampled and for girls, 4 schools were also sampled and for girls, 4 schools were also sampled randomly this gave a total of 8 schools for the study. The entire SS1 students in the sampled schools formed the sample size. The total of boys was 204 and girls were 318. The sum of boys and girls was 522.

The instrument for data collection was Alternative Conception of Scientific Phenomena Test (ACSPT) which was developed by the researcher. It contained ten items designed to elicit and identify secondary school students' alternative conceptions as contained in the senior secondary physics curriculum:

- Types of motion
- Relative motion
- Causes of motion
- Types of forces
- Reducing friction
- Simple idea of circular motion.

The instrument consists of two sections 'A' and 'B'. Section A, was concerned with the background information relating to the respondents such as name of the school and age. Section B consists of 10 items on motion. Each item was followed by three options. Each option reflects (a) Western Scientific (WS) (b) Supernatural View (SW) (c) popular view (PV). Western Scientific Views relate to methods of discovery and organization of knowledge gained through experience and empirical knowledge. Supernatural views are those responses relating to that which is above or beyond nature. Popular views are those held by majority of people which may in actual sense lack empirical or supernatural explanations. The instrument was designed to explore students' alternative conceptions of scientific phenomena with particular reference to "motion". 500 questionnaires were filled and returned. Data generated were analysed item by item using frequency, percentage and chi square. A value obtained for each item in the questionnaire using age as the classification variable. The score of each candidate in each dimension was determined by number of items in which reflected views along that dimension. A frequency and percentage sure for each view was determined. Summarily, the research questions were answer using frequencies and percentages while the hypotheses were tested using cross tabulation with chi-square test of independence as the test statistic.

Results

Research question 1:

What are the alternative conceptions of students on motion.

Data as regards the conception of students on motion are presented in Table 1

Table 1:

Students' Alternative Conception on Motion

Item	Questions describing issues/phenomena	WS*		SN**		P***		Null****		Total	
		No	%	No	%	No	%	No	%	No	%
1	Motion of aeroplane from Enugu to Lagos	285	57.0	39	7.8	134	30.8	22	4.4	500	100
2	Cause of motion of an object	420	84.0	28	5.6	29	5.8	23	4.6	500	100
3	Exhibition of a projectile motion from a bullet	335	67.0	28	5.0	108	21.6	29	5.8	500	100
4	Earth revolving round the sum	323	64.6	25	5.0	95	19.0	57	11.4	500	100
5	Opposition of motion between two surfaces	89	17.8	112	22.4	5	1.0	294	588	500	100

6	Explanation to climbing of a staircase being tiresome	2.22	44.4	54	10.8	82	16.4	142	28.4	500	100
7	Student on projectile motion	122	24.4	26	5.2	280	56.0	72	14.4	500	100
8	Reason for heavier object reaching the ground before light one	174	34.86	36	7.2	233	46.6	57	11.4	500	100
9	Type of motion exhibited by the planets moving round the sum	102	204	15	3.0	314	62.8	69	13.8	500	100
10	Type of motion experienced by a stone fastened to a threat and moved in a circle	269	53.8	53	10.8	83	16.6	95	19.0	500	100
	Percentage average		47.0		8.0		28.0		17.0		

******N=Nil**

The results from table 1 indicate that generally 47% of students had western scientific view while 8% had supernatural view, 28% had popular view and 17% of the students had nil view.

Observing the table further shows that students indicate that items 2, 3, 4, 10 have Western Scientific views with percentage frequency scores of 84.0, 67.0, 64.6 and 53.8 respectively while items with supernatural view had very low percentage frequency scores ranging from 22.4% for item 4 to 50% for item 7. On the popular view, items 9, 7 and 8 had their highest frequency counts with 62.8%, 5.6% and 46.6% frequency scores respectively.

However some students did not indicate any view in some of the items. For instance, item 5 had the highest nil view with 58.8% frequency count followed by item 6 with frequency score of 28.4% and item 1 had lowest nil view with only 4% frequency count.

Research Question 2

To what extent does age influence the alternative conception of students on motion?

Table 2:

Age related difference on students' perception of motion

Item	Question describing Phenomena	9 – 12 years				12^{+} – 15 years				15^{+} – and above			
		WS	SN	P	NIL	WS	SN	P	NIL	WS	SN	P	NIL
1	Motion of aeroplane from Enugu to Lagos	5 (62.5)	1 (12.5)	2 (25.0)	0 (0.0)	98 (75.4)	6 (4.6)	22 (16.9)	4 (3.1)	182 (50.3)	32 (8.8)	130 (55.9)	18 (5.0)
2	Cause of Motion of an object	8 (10.0)	0 (0.0)	0 (0.0)	0 (0.0)	111 (85.4)	6 (4.6)	5 (3.8)	8 (6.2)	301 83.1	22 (6.1)	210 (58.0)	54 (4.1)
3	Exhibition of a projectile motion from a	7 (8.5)	0 (0.0)	1 (12.5)	0 (0.0)	79 (60.8)	8 (6.2)	26 (20.0)	17 (13.1)	249 (50.3)	20 (8.8)	81 (35.9)	12 (5.0)

	bullet												
4	Earth revolving round the sun	6 (75.5)	1 (12.5)	0 (0.0)	1 (12.1)	80 (61.5)	6 (4.6)	24 (18.5)	20 (15.4)	237 (65.5)	18 (5.0)	71 (19.6)	36 (9.6)
5	Opposition of motion between two surfaces	2 (25.0)	3 (37.5)	0 (0.0)	3 (37.5)	34 (26.2)	23 (17.7)	1 (0.8)	72 (55.4)	53 (14.6)	86 (23.8)	4 (1.1)	219 (60.9)
6	Explanation to climbing of a staircase being tiresome	6 (75.0)	1 (12.5)	1 (12.5)	0 (0.0)	60 (43.1)	13 (3.8)	18 (42.6)	39 (28.5)	156 (43.1)	40 (3.3)	63 (22.7)	103 (30.9)
7	Statement on projectile motion	1 (12.5)	1 (12.5)	4 (50.0)	2 (25.0)	41 (31.5)	7 (5.4)	66 (50.8)	16 (12.3)	80 (22.1)	18 (5.0)	210 58.0	54 (14.9)
8	Reason for Heavier Object reaching	5 (62.5)	1 (12.5)	2 (25.0)	0 (0.0)	48 (36.9)	8 (6.2)	57 (43.8)	17 13.1	121 33.4	27 (7.5)	174 (48.1)	40 (11.0)

	the ground before light one												
9	Types of motion exhibited by the planets moving round the sun	1 (12.5)	0 (0.0)	6 (75.0)	1 (12.5)	24 (18.5)	2 (1.5)	79 (60.8)	25 (19.2)	77 (21.3)	13 (3.6)	229 (63.3)	43 (19.1)
10	Types of motion experienced by a stone festered to a thread and moved in a circle	3 (35.5)	1 (12.5)	3 (37.5)	1 (12.5)	73 (56.21)	13 (10.0)	19 (14.6)	25 (19.2)	193 (53.3)	39 (10.8)	61 (16.9)	69 (19.1)

No of students for 9 – 12 years = 8

No of students for 12^{+} – 15 years = 130

No of students for 15^{+} and above = 362

WS = Western Scientific

P = Popular

N = No Answer

Values in bracket are percentages.

The result from table 2 shows that generally majority of highest percentage of students in different age groups are of western scientific view in most of the items. However some lesser percentage of students in different age groups had supernatural, popular and nil views of the concepts. Students in the age bracket 9 – 12 years that have western scientific view range from 75% for items 4 and 6 to 12.5% for items 7 and 9. Moreover students in the age bracket of 9 – 12 years that have supernatural view range from 37.5% to 0% for item 5 to items 2, 3, and 9 respectively. Also students for popular view within same age bracket of 9 – 12 years from 75% to 0% for items 9 to items 2, 4, and 5 respectively. Also for nil view within same range age bracket of 9 – 12 years range from 37.5% to 0% for item 5 to items 1, 2, 3, 6 and 8 respectively.

Furthermore students in the age bracket of 12^{+} – 15 years that have western scientific range from 85.4% to 18.5% for item 2 to item 9. While students in the same age group of 12^{+} – 15 years that have supernatural view range from 17.7% to 1.5% for item 5 to item 9 respectively. Moreover students within the age bracket of 2^{+} – 15 years that have popular view range from 60.8% to 0.8% for item 9 to item 5 respectively. Also students within this same age bracket that have nil view range from 55.4% to 3.1% for item 5 and item 1 respectively.

In addition students in the age bracket of 15^{+} and above that have western scientific view range from 83.1% to 21.3% for item 4 to item 12. Moreover students within the age bracket of 15 and above have supernatural view range from 23.8% to 3.3% for item 5 to item 6 respectively. While students within this same age bracket that have popular view range from 63.3% to 1.1% for item 9 to item 5 and also students in the age bracket of 15^{+} and above that have nil view range from 60.9% to 4.1% for item 5 to item 2 respectively.

***H*ypothesis**

HO: Senior Secondary School Students' alternative conceptions of motion are significantly ($P < 0.05$) independent of age.

The result of the test of hypothesis one is presented in table 3

Table 3:

X^2 of Age Difference in students' conception of motion

Item	Question describing the phenomena	Age Category	WS	SN	P	NIL	Df	X^2	Remark
1	When an aeroplane lies from Enugu to Lagos. It undergoes?	9 – 12 12^+ – 15 15^+ and above	5 (4.6) 98 (74.1) 182 (206.3)	1 (0.6) 6 (10.1) 32 (28.2)	2 (2.5) 22 (40.0) 130 (111.5)	0 (0.4) 4 (5.7) 18 (1.9)	6	25.47	S
2	The bullet from a gun fired upwards exhibits a projectile motion because….?	√ √ √	7 (5.4) 79 (87.1) 249 (242.50)	0 (0.4) 8 (7.3) 20 (20.3)	1 (1.7) 26 (28.1) 81 (28.2)	0 (0.5) 17 (7.5) 12 (31.0)	6	18.7	S
3	Which of the following statement on projectile motion is correct?.....	√ √ √	1 (2.0) 41 (31.7) 80 (88.3)	1 (0.4) 7 (6.8) 18 (18.8)	4 (4.5) 66 (72.8) 210 (202.7)	2 (1.2) 16 (18.7) 54 (52.1)	√	6.86	NS
4	Motion of an object	√	7 (6.0)	1 (1.4)	0 (0.4)	0 (0.2)	6	4.58	NS

	is caused by?.....	√	104 (94.5)	16 (22.1)	6 (7.3)	4 (3.1)			
		√	264 (271.5)	68 (61.5)	22 (20.3)	8 (8.7)			
5	What type of force keeps the earth	√	6 (5.2)	1 (0.4)	0 (1.5)	1 (0.9)			
	revolving round the	√	80 (84.0)	6 (6.5)	24 (24.7)	20 (14.8)	√	5.41	NS
	sun? ……	√	237 (233.9)	18 (18.1)	71 (68.8)	36 (41.3)			
6	What type of force	√	7 (6.0)	1 (1.4)	0 (0.4)	0 (0.2)			
	helps a man to walk …….?	√	104 (97.5)	16 (22.1)	6 (7.3)	4 (3.1)	6	4.58	NS
		√	264 (271.5)	68 (61.5)	22 (20.3)	8 (8.7)			
7	Man to walk	√	264 (271.5)	68 (61.5)	22 (20.3)	8 (8.7)			
	without falling	√	104 (97.5)	16 (22.1)	6 (7.3)	4 (3.1)	√	4.58	NS
		√	7 (6.0)	1 (1.4)	0 (0.4)	0 (0.2)			
8	A child playing with	√	7 (5.5)	0 (0.5)	1 (1.3)	0 (0.7)			
	a piece of metal	√	88 (88.7)	10 (8.8)	20 (21.6)	12 (10.9)	√	2.20	NS
	found that the piece	√	246 (246.9)	24 (24.6)	62 (60.1)	30 (30.4)			
	of metal is attracting a razor blade. This indicates that ……?								
9	When a man slaps	√	7 (5.5)	1 (0.7)	0 (0.9)	0 (0.9)			

	another man, both feel the pain, what type of force is responsible for this ……?	√ √	94 (89.4) 243 (249.1)	7 (11.2) 35 (31.1)	11 (14.6) 45 (40.5)	18 (14.8) 39 (41.3)	√	5.12	NS
10	Two objects were released from the same height, the heavier one reached the ground before the light one. This is because.....?	√ √ √	5 (2.8) 48 (45.2) 121 (126.0)	1 (0.6) 8 (9.4) 27 (26.1)	2 (3.7)	0 (0.9) 17 (14.8) 40 (41.3)	√	3.24	NS

NOTE:

Values in bracket are expected frequencies

X^2 tabular ($P \leq 0.05$) = 12.59

From table 63, X^2 calculated are less than X^2 tabular at 0.05 level of probability in all the questions raised except questions 1 and 2.

As a result, this null hypothesis that students' alternative conceptions of motion are significantly independent of age is accepted for questions 3 to 10 and rejected for questions 1 and 2.

Summary of the Findings

1. Out of 500 subjects who answered the questionnaire, 47% of the subjects had the western scientific view, 8% had the supernatural view (SN), 28% had popular view while 17% of the subject had no view. This shows that most of students had western scientific view.
2. 75% of the students within the age range of 9 – 12 years had western scientific view in 2 concepts, 12.5% of the students had western scientific view in 2 concepts in the age range of 9 – 12 years, 37.5% of the students had supernatural view in one concept and 37.5% of students within this range did not answer any question. Also 75% of the students had popular view in one concept.
3. Among those in the range of 12^{+} – 15 years 85.4% of the students had western scientific in one concept, those with supernatural view is 17.7% in one concept and those with popular view is 60.8% in one concept. Also among those within the range of 15^{+} and above, those with scientific view (83.1%) is highest in one concept, those with supernatural (23.8%) is highest in one concept and those with popular view (63.3%) is highest in one concept.

Discussion

The data collected with respect to Alternative Conception of Scientific Phenomena Test (ACSPT) were analyzed quantitatively in terms of western scientific view, supernatural view and popular view. Table 1 reveals that about 84.0% of respondents had western scientific view over cause of motion, 5.6% of students were of the opinion that motion is caused by energy from Supreme Being while 5.8% of students have the view that pressure on the environment causes motion. This group of respondents had alternative conception about the cause of motion which was not western scientific view but popular. About 85.0% of the respondents were of the view that the spiritual force guiding the man helps him to walk without falling. This is regarded as the supernatural view. Also about 62.8% of students had the belief that planet moving round the sun exhibits rotational motion.

Table 1 also reveals that more than 65% of the respondents had western scientific view of relative velocity with respect to objects. They also have reason for projectile, the type of force that keeps the earth revolving round magnetic property of attracting objects. In the above circumstances, some of the respondents however had supernatural view of projectile motion.

On the reason why a heavier object reached the ground before the lighter one, about 34.7% of the respondents were able to indicate the effect of air resistance on the light object while up to half of the respondents still held to their popular view and supernatural view probably either rag a result of wrong conception as regards parents; their views were either that the end of air was angry with the higher objects or that the heavier one had more speed than the lighter one.

Fafunwa (1983) observed that the non interpretation of African culture into the leaving process tend to distort the cognitive process in terms of anticipated outcome in western science. This is because indigenous concepts are culturally based and supernaturally re-enforced. Nelson (1974) in his analysis of concept is of the view that an African child acquires his concepts from the African environment. The findings of the study showed that most of the respondents that ticked western scientific views could not explain or reason scientifically but rather they reasoned culturally or supernaturally indicating rote-learning.

In the case of influence of age on alternative conception of students on motion. The findings revealed that students of 15 years and below had high percentage of western scientific view in most items than students of 15 years and above which is at variance with the study of Eckstein and Shemesh (1992) that the transformations of ideas increase with age.

However, for the hypothesis, summary of table 3 indicates that the X^2 calculated for eight concepts out of ten concepts was less than the X^2 tabular of 12.59 at 0.05 level of significance. The null hypothesis for each of the alternative conceptions was accepted. This shows that age is not a significant factor in the senior secondary school student's alternative conceptions of motion on those concepts. On the other, the X^2 calculated for concepts 1 and 2 was greater than the X^2 tabular of 12.59. The decision rule is also to reject the null hypothesis whenever the calculated value is more than the critical value. The null hypothesis was rejected for the two concepts which implies that there was significant difference between students' age and alternative conceptions for those concepts.

Conclusion

Based on the findings of the study on the influence of age on students' alternative conceptions of scientific phenomena with particular reference to motion, the following conclusions were made.

1. Most senior secondary students hold western scientific view of motion.
2. Age may or may not be an important factor influencing school student to hold alternative conceptions about motion.
3. The tendency for senior secondary school students to hold alternative conceptions about motion and its inherent characteristics is determined by the interaction of personality, reasoning pattern and environment. Also their reasons for inherent characteristic of motion were central on their spiritual real.

Recommendations

1. Alternative scientific conceptions based science instruction should be adopted in our school system.
2. Ministry of Education and Professional Organizations like STAN should organize workshops, seminars and conferences for Physics teachers on the use of the scientific alternative conception based package.
3. The use of conventional instructional approach should be de - emphasized in our school system since it encourages rote-learning. Physics teachers should employ the principles of the alternative conception of science to enhance knowledge acquisition among students.

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