

Junior High School Pupils' Perceptions of Air

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Abstract

The study examined Junior High School (JHS) pupils' ideas of the concept air. The study compared the ideas that pupils from endowed schools have about air with those of their counterparts from un-endowed schools. The study also sought to find out the misconceptions pupils have about air and the implications these have on teaching and learning of science at the basic level. The instrument used consisted of a test and an interview schedule developed from topics dealing with the concept of air. The test consisted of multiple-choice items and an essay. Four hundred and sixty-four (464) JHS pupils made up of 235 from endowed and 229 from un-endowed schools were randomly sampled for the study. A t-test (for independent samples) performed on the mean performances of the groups established a significant difference between pupils from endowed and un-endowed schools in favour of pupils from endowed schools. The interview revealed that JHS pupils express themselves better orally than in written form when examined. The interview also established the fact that pupils from endowed schools had better understanding of the nature of air than their counterparts. A number of recommendations were made. Teachers should identify pupils' pre-conceptions on topics to be taught and design appropriate strategies to effect conceptual change. Remedial interventions such as the Science, Technology and Mathematics Education (STME) clinics for JHS pupils should be intensified and expanded to improve the performance of these pupils in the sciences.

Introduction

Teachers will be astonished to learn that despite their best efforts, students do not grasp the fundamental ideas covered in class. Even some of the best students give right answers but are only using correctly memorised words. Stavy (1991) reported that students in his physics class had memorised equations and problem-solving skills, but performed poorly on test of conceptual misunderstanding. Children have preconceived notions or preconceptions, which they rely on to explain any phenomena. These mixed conceptions or conceptual misunderstandings do not match what is known to be scientifically correct. Ignoring them during teaching leads them to form misconceptions of concepts introduced to them formally (Stavy, 1991). Russel (1956) states that the soundness of child's concepts of things are the best measure of his probable success in school learning because meaning is fundamental to such success.

Children's Conception of air

Piaget (1929) reported that children could spontaneously speak of the movement of atmospheric air but what they do not know is whether it is air that set the leaves in motion or the air is set in motion by the leaves of a tree. What some children think about air is that it only has pressure when it is moving (Carolyn, 1996). Novick and Nussbaum (1978), in a study of junior high students found that many could not conceive of empty space in ordinary matter, including gases. In a cross-level study of junior secondary, senior secondary and university students within Cape Coast Municipality, Ampiah (2000) reported that students held the ideas that air is a continuous substance and that the flow of gases is similar to that of

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liquid. This difficulty with empty space persists even among a large group of university science majors, whose mental ideas about gases show gas particles being close to each other.

Sere (1986) reported on a study conducted on the conception of the gaseous state prior to teaching using children aged between 11 and 13 years. She found out that, everyday life gave rise to few problems about air gases. Apart from wind and draughts, air appears invisible, and leads to few perceptions. Prior to teaching, the children have a variety of experiences about gases. They feel wind and draughts. They also use various objects such as tyre-pumps and balls which utilize the physical properties of air. Sere (1986) used an open written question to find out the perceptions of children of the presence of air in open and closed containers and concluded that the children responded better for open containers than for closed ones. The percentage corresponding to closed containers was significantly low.

Interview results with children showed that what led to this error were: since the air came out so fast and powerfully from the tyre, none could remain inside at the end of the process. Some children hold the view that air can circulate in an open bottle, but not in a closed one. When there is a source of heat, they know that hot air rises, but never refer to cold air sinking. This is a sort of dissymmetry between their conceptions about air and cold air, which probably makes it difficult for them to conceptualise temperature. This lack of balance in thinking can be found and observed in the way pupils describe hot air and cold air. Some of them think that air is transformed into a gas when heated. Some claimed that this gas is carbon dioxide; which sets forth their mistake. Others think that cold air is air at room temperature. It was observed that majority of those interviewed did not know that it was impossible to squash completely a corked plastic bottle due to the presence of air in it. Guidoni (1985) states that from such experiences, and perceptions, children construct a first 'natural thinking' about the gaseous state and especially about air which is invisible and which cannot be felt at equilibrium.

The Calliper (2004) reported that when students were first told about Avogadro's law, it was quite difficult for them to perceive that equal volumes of gases at the same temperature and pressure contain the same number of molecules. They could not perceive also how invisible molecules have appreciable masses that could be measured.

Statement of the problem

Majority of Ghanaian pupils at the basic level have been performing poorly at the Basic Education Certificate Examination (BECE) in science over the past few years. It was reported by the chief examiner of General Science that the continuous failure of pupils in science at the BECE was due to misconceptions that these pupils have in science (WAEC, 1990; 1991). It is also regrettable to note that 12 junior secondary schools in the Asunafo District of Brong-Ahafo region scored zero percent in the 2001 BECE, and another four schools in the same district scored zero percent in the 2002 BECE. This poor performance was attributed to misconceptions that these pupils have in the subject taught and learned, among other factors (Daily Graphic, 2002).

Research studies found that even after having been taught the particulate theory and properties of gases (e. g. weight, volume), the majority of high school students still believed that air has no weight (Stavy, Eben and Yaakobi, 1987; Sere, 1989). Before formal instruction, pupils hold a variety of intuitive conceptions that are in conflict with the correct scientific conceptions (Lin, Cheng & Lawrenz, 2000). Air is one of the foundational topics treated in junior secondary school to lay a foundation for the study of matter.

With air, some common misconceptions could be found among junior secondary school pupils in Ghana (WAEC, 1991). The study of air forms the basis upon which higher concepts are built. Any misconceptions and wrong notions would tend to cloud pupils' understanding of other important scientific concepts and could mar their performance at the BECE and future academic progress.

Purpose of the study

The purpose of the study was to investigate Junior High School (JHS) pupils' preconceptions and misconceptions of air, so that teachers may design instructions to address misunderstandings. It was also the purpose of the study to determine the differences (if any) between endowed and un-endowed Junior High School pupils' preconceptions and misconceptions about air stemming from the differences in their learning environments. The study sought to investigate whether or not there were significant differences between ideas that pupils from endowed Junior High Schools have about air and those of students from un-endowed schools.

The study was undertaken for the following reasons. Some misconceptions that would be prevalent among students about air would be identified and listed. Such a list would be useful to science teachers, curriculum developers and science text book writers. Teachers who teach science at the JHS level will benefit, since they will be aware of the misconceptions and how to address them. Teaching strategies can be developed to help remove such notions. This will enhance teaching and learning of science in schools. Furthermore, it was hoped that if suggested remedies are accepted and used to remove misconceptions among students it would make the teaching and learning of science enjoyable, thereby making science more attractive to students. It is expected that this would help increase the enrolment of elective science majors in senior high schools and in the universities. These institutions would in turn produce more scientists to feed our industries in Ghana.

Method

Population and sample

The study covered all JHS 2 and 3 pupils in the East Mamprusi District in the northern region of Ghana. The district capital is Gambaga. Natives of the district are predominantly subsistent farmers; a few of them are government employees; yet others work in the Baptist Mission Hospital at Nalerigu as nurses and cleaners. There were 45 public Junior High Schools in the district at the time of the study was conducted. JHS one pupils were not included in the study because air as a topic is taught in the second year.

A sample random sample of 12 out of 45 schools (comprising 6 endowed and another 6 un-endowed) was used for the study. Two circuit supervisors of senior ranks in the GES helped in the classifications of the schools into endowed and un-endowed based on their environmental conditions for teaching and learning. The endowed schools had in addition to what prevails in most schools, enough seating desks for every pupil, qualified teachers, prescribed text books and syllabuses for teachers' and pupils' use. They also had well-stocked libraries. A table of random numbers was used with a list of pupils in each school to select the sample for the study. Forty pupils in each school (comprising 20 from JHS 1 and another 20 from JHS 2) took part in the study. A total of 464 pupils (made up of 235 pupils from endowed and another 229 pupils from un-endowed junior high schools in the district) were randomly sampled for the study. Again the simple random sampling method was used to select 96 pupils among the 464 participants to take part in an interview. The interviewees comprised 48 endowed and another 48 un-endowed junior high school pupils.

Instrumentation

The instrument used for collecting data consisted of a test and an interview schedule on air. The test consisted of two sections A and B. Section A had 10 multiple-choice items and section B had an essay item. The items tested ideas such as air occupies space, has pressure, expands when heated etc. The test and interview were meant to complement each other. The interview guide consisted of the items culled from Section B of the test. The purpose was to compare students' verbal responses in the interview with their written texts. The researcher administered the instrument. The study made use of a previously validated instrument

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constructed by Abraham, Williamson & Westbrook (1994). Furthermore, three experienced researchers in the Department of Science Education, University of Education, Winneba, examined the modified instrument and found it good for use in the Ghanaian setting. The researchers also reviewed the interview scheduled and their suggestions were used to modify it.

The internal consistency of the achievement test was determined through the application of the Kuder-Richardson 21 (KR – 21) formula and Cronbach alpha coefficient. Using Kuder-Richardson 21 (KR – 21) formula, a reliability coefficient of 0.84 was established for the multiple-choice set of items (Section A) of the test. The alpha reliability (Cronbach, 1951) of the item under Section B was obtained to be 0.78. Diederich (1973) contended that if a teacher's test requires a full class period to complete (approximately 50 minutes), its internal consistency reliability should be 0.65 and more. The two reliability coefficients of 0.84 and 0.78 for the instrument are above this acceptable value of 0.65 and hence could be used. These two internal consistency coefficients were evaluated by employing the SPSS computer programme.

Results

The results show that pupils from endowed schools performed much better than their colleagues from the un-endowed schools.

Table 1: Type of school and percentage of pupils' who got the various items correct in Section A of the test on air

Item No.	1	2	3	4	5	6	7	8	9	10
Endowed	73.00	30.00	34.00	59.00	61.00	64.00	37.00	46.00	30.00	25.00
Un-endowed	65.00	33.00	28.00	45.00	34.00	72.00	31.00	38.00	31.00	18.00

In order to evaluate the difference in the performance levels between the two groups of pupils on the concept of air, scores of pupils under section A were added to that of section B and the mean scores found. The t-test for two independent samples was performed on the mean performances of the groups and the results presented in Table 2. The mean score ($M = 2.83$) for pupils of endowed schools is greater than that of their counterparts ($M=2.38$) of the un-endowed schools as shown in Table 2. The mean difference of 0.45 seems to suggest that pupils of endowed schools have a better understanding of the concept of air than pupils of un-endowed schools. In order to find out whether the mean difference was significant a t-test was performed on the difference of the means.

Table 2: Type of school and pupils' performance on items on air

Type of school	n	M	S ²	SD	df	t	p-value
Endowed	235	2.83	2.31	1.52			
Un-endowed	229	2.38	2.22	1.49	462	2.69	p<.05

Theoretical $t_{\leq 1.96}$, $p < .05$

Since the calculated value of $t_{0.25} = 2.69$ is greater than the theoretical value at $p < .05$ the null hypothesis was rejected. The analysis of data produced significant results to show that pupils

from endowed schools performed better than their colleagues. Therefore they had a better understanding on the concept air than their counterparts from un-endowed schools.

Results of pupils interviewed:

The key questions used during the interview sessions were the following:

- (i) Is there air in the deflated balloon that is attached to the flask as shown in figure 1?
- (ii) What happens to the air in the flask when heat is applied to the flask?
- (iii) What makes the balloon to rise as seen in figure 2?

Pupils were probed further based on their responses given to a question. This was to help illicit appropriate ideas from them. Below is a recorded case of one interview.

Interviewer: Is there some air in the deflated balloon that is attached to the flask as shown in figure 1?
 Pupil: 'No sir, there is no air in the deflated balloon.'
 Interviewer: What makes you think that there is no air in that deflated balloon?
 Pupil: 'The deflated balloon is so small, so no air can enter'
 Interviewer: What happens on the air in the flask when heat is applied to the flask?
 Pupil : 'It becomes hot and try to go out'
 Interviewer: What makes the balloon to rise as seen in the figure 2?
 Pupil: 'In the second one balloon is bigger, so air can enter into it'.

This student had a specific misconception about air in vessels. The pupil had the notion that since the balloon was small in size there was no air in it. Both the written exercise and the interview affirm to the fact that some students think air is not present in deflated objects such as balloons, lorry and bicycle tyres. Sere (1986), earlier interviewed children on air and also reported similar unscientific ideas. What might have led to this error was that since the air came out fast and powerfully from the tyres and balloons, none could remain at the end of the process. The results to the questions 'Is there air in the deflated balloon in figure 1' and 'What made the balloon to rise as seen in figure 2' are indicated in Tables 3 & 4 respectively.

Table 3 : Percentage of pupils' who held varying ideas about air in a deflated balloon

	Pupils' of endowed schools	Pupils' of non-endowed schools
There is air	31.25	25.00
There is no air	65.63	75.00
No idea	3.21	0.00
Total	100.00	100.00

NB: All numbers are in percentages (%).

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Table 4 : Pupils' ideas of what made the balloon to rise when the flask was heated

Source	Pupils' of endowed schools	Pupils' of un-endowed schools
Heated air from flask	55.16	37.50
Air from the mouth	18.80	20.00
Heat from flask	3.50	9.90
Heated balloon expands	9.00	12.90
Vapour from flask	10.42	15.60
Gas	3.12	4.10
Total	100.00	100.00

NB: All numbers are in percentages.

Quite a good number of pupils, 18.80% from the endowed and 20% from the un-endowed schools held the idea that air blown from a person's mouth filled the balloon. This of course was not so strange to hear from pupils of the age group 13 to 18 years, for they daily play with balloons (filling them with air blown from their mouth) and kites. Others too (15.60% and 10.42% of pupils of endowed and un-endowed schools, respectively) thought that it was risen vapour from the heated flask that entered into the balloon through the delivery pipe and caused it to rise. It is likely that such a misconception has risen from pupils' every day observation of water vapour rising from boiling water.

Discussion

There was significant difference ($t_{0.25} = 2.69$, $p < .05$) between pupils from endowed and un-endowed schools in the ideas they had about air. The pupils from endowed schools performed better than their colleagues in the test on air. It is the usual expectation of students who are advantaged in one way or the other in terms of academic environment that facilitates learning to perform better than their colleagues of the same grade who are disadvantaged in some way. Results from interview with pupils was compared with their written work and found to be consistent. The results of the interview also attest to the fact the pupils from endowed schools in the district have far better understanding of air than their colleagues from un-endowed schools.

The results in Table 3 show that majority of pupils have the misconception that air is not found in deflated objects like flat lorry tyres and balloons. Some pupils had the notion that there was no air in the deflated balloon because there was no heat (at the beginning) to cause air to enter it or just that flat objects contain no air in them due to their small size. This is shown by 65.63% for pupils from endowed schools and a much higher percentage of 75% for pupils from un-endowed schools who said there was no air in the deflated balloon. Those who said there was air in the deflated balloon was made up of 31.25% of the pupils from endowed schools and as low as 25% of those from un-endowed schools. These findings during the interview were consistent with the results reported by Sere (1986) that children of about 14 years think that there was no air in flat objects like empty balloons and lorry tyres. This showed, how for children, the idea that there is air in empty containers is unstable in their minds.

To the question 'what made the balloon to rise as seen in figure 2?' varying ideas were expressed by pupils such as air from the flask enters, air from the mouth entered, heat from the flask, heated balloon expands, vapour, gas and or smoke entered the balloon. The

percentage of students who held varying ideas about the issue is reported in table 4. As shown in table 4, more than half (55.16%) of pupils from endowed and 37.50% pupils of un-endowed schools held the idea that heated air from the flask expanded and flowed through the delivery tube into the attached balloon. This was the accepted scientific explanation to the set up.

Conclusion

From the analysis of the study, there was a significant difference between pupils from endowed schools and their counterparts from un-endowed schools in the ideas that they had about air. The general performance of the pupils on the test items on air was below the expectations of the researcher. One misconception that ran through the two categories of pupils was that ‘there can be no air in deflated objects like balloons and flat tyres because all the air escapes when such objects burst or collapse’. The results of the oral interview with pupils revealed that there were pupils who had a fair knowledge of air but could not express such ideas well in written communication to convey to the researcher their understanding of air. This situation was the same for both groups of pupils.

In view of the general poor performance of all the pupils, and especially those from the un-endowed schools, there is the dire need to research into the conditions that affect students understanding of science concepts in deprived areas in Ghana. There is also the need to use oral interview as an assessment method to augment written examination in the final examinations at the JHS level in all subject areas.

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