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Using guided inquiry-based approach to teach refraction: An experience with College Students

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ABSTRACT

The teaching and learning of Integrated Science at the Colleges of Education in Nigeria urgently needs to provide student- teachers with instructional competencies such as knowledge of the subject matter content, skills of inquiry and pedagogy. The author reports his classroom teaching experience where he used a problem-solving approach that involves methods of inquiry and activities to teach refraction. Through this effort, he observed that using science process skills such as observing, formulating hypotheses, testing hypotheses and explaining, teachers of science could make their science lessons more enriching and student-centered. Some of the implications of this approach to teaching and learning of science include; emphasizing detailed observation in practical lessons by textbook authors, adequate teacher preparation before practical lessons and teachers' openness in dealing with students' questions, especially when the teacher does not have a quick answer to such questions.

Key Words: Science, Inquiry-based Science teaching, Understanding, Refraction.

INTRODUCTION

The teaching and learning of integrated science at the Nigeria Certificate in Education (NCE) level is relatively new. The Nigerian Certificate in Education Programme has its origin from the Ashby Report in 1960 and it recommended that grade 1 teacher colleges should be established for the purpose of producing teachers for the primary and junior secondary schools (Adesina, 1988; FRN, 2014). It is in line with this that the Federal Government of Nigeria in coalition with UNESCO established the Advanced Teachers Training Colleges in 1978, which has today metamorphosed to the Colleges of Education.

These Colleges are higher institutions charged with the training of teachers for the NCE programme, which the Nigerian government has set to be the minimum teaching qualification. There are a total of a total of 82 colleges of education consisting of 22 federal, 14 privates and 46 state-owned institutions and they are all under the supervision of the National Commission for Colleges of Education, (NCCE). The teaching of science in the College of Education, therefore, stems from the need to train NCE. science teachers who will teach at the primary and junior secondary schools, although many of the graduates now teach at the senior secondary schools due to the dearth of university graduate teachers who are expected to teach at the senior secondary school level.

The teacher training integrated science programme in Nigeria seeks to achieve the following objectives:

i) Enabling students to acquire and demonstrate the intellectual competence and professional skills necessary for the teaching of integrated science in the Junior Secondary Schools, as an inquiry-based subject, in conformity with the national curriculum;

ii) Developing in students the ability and the spirit of inquiry into living and non-living things in the environment;

iii) Developing the ability and motivation for students to work and think in an independent manner and

iv) Enabling students to carry out scientific investigations, emphasizing co-operation and

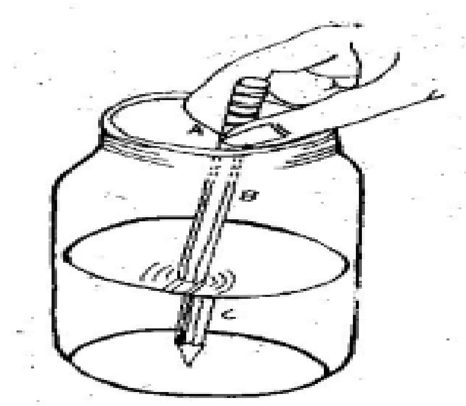

Figure 1a. Pencil dipped in water in a glass jar.

v) development of appropriate science processes and skills etc., (FRN, 2013).

To achieve the above aims, the guided discovery, inquiry and activity-based methods were recommended by the National Commission for Colleges of Education Minimum Standards Syllabus as ways of integrating theory and practical work and enabling students acquire science process skills which include: the skills of observation, measuring, classifying, handling of apparatus, formulation and testing of hypothesis, experimenting of data etc. The inquiry-based method of teaching science has evolved from the use of exercises and experiments that include;

i. Identification of a problem
ii. Formulation of hypotheses
iii. Testing of hypotheses
iv. Drawing of conclusion based on the specific observations made and
v. Predicting and generalization from the findings obtained.

Integrated science teachers at the NCE level are required to use the activity-based approach at all points in the course because practical work is not separated from theory and besides, the integrated science teacher trainers are to teach in a way that student teacher should observe things closely, watching, listening and trying out ideas to observe details of the investigation. This method of teaching should be such that the students will adopt same methods in later years as full-fledged teachers, and also, help the teachers develop process skills which serve as ways to sharpen their inquiry and problem-solving abilities.

My experience while teaching refraction in Integrated Science (ISC 125): Man and Energy II

Just recently refraction was taught by the author to a group of integrated science students offering ISC.125, which is a two-credit-hour Nigerian Certificate in Education (NCE.) course. All through the period of the course, methods of discussion in small groups, activity-based investigation and circus experiments for different topics were utilized. While teaching refraction, the author tried to explain the concept to the understanding of the students by carrying out a number of investigations that illustrates refraction phenomena.

This was done because Amber and James (2012) remarked that though light is everywhere and in the daily life experience of students, yet despite its ubiquity, most light phenomena remain intangible and confusing to many science students. Also, Chen et al. (2004); Galili and Hassan (2001); Fyttas et al. (2013) identified poor application of geometry to refraction principles, misunderstanding of the daily experiences regarding light refraction and the graphic symbolism of light refraction which requires an explanation for students to understand.

The two investigations that were carried out to illustrate refraction are;

i. A piece of stick partly submerged in water is apparently bent or broken at the media boundary and,
ii. A coin at the bottom a beaker of water apparently appears elevated than its real position.

Investigation I

To observe the first phenomenon, a pencil or ruler was put inside a beaker partly filled with water (Figure 1a). When this was done, it was observed that the pencil appeared bent at the surface of separation of the water and air as shown Figure 1a. The students asked the author to explain why this happened.

Theoretical Explanation

To answer my students' question, it was explained that refraction can be referred to as the change in the direction of light waves at the interface where the light waves pass from one medium into another, say from air to water or vice versa. When light waves move from air

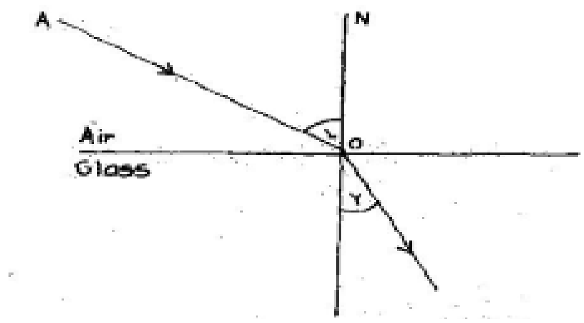

Figure 1b. Refraction of light. **Source**: Keith, 1978.

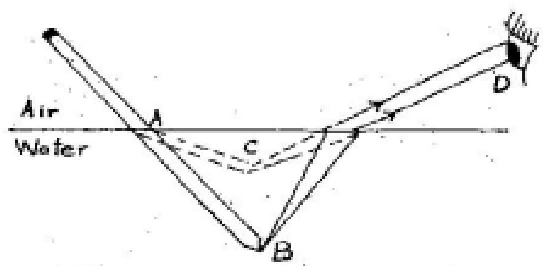

Figure 1c. A pencil in water appears bent in water. **Source**: Keith, 1978.

to water as it's shown in Figure 1b, since water is optically denser than air, the light ray is bent towards the normal as it moves from air to water.

(Where i is the angle of incidence and r is the angle of refraction). Similarly, a ray traveling from the denser (water) to a less dense(air) medium bends away from the normal as it moves past the surface of separation of the two media.

With Figure 1c, it was explained why the pencil appeared broken at water-air interface. The ray of light from the end of a pencil B passes from water to air and thereby shifting away from the normal. This ray on reaching the eye appear to be coming from a point C above the end B, so that the immersed part of the pencil AB from the above explanation appear to be along AC when viewed from D.The above explanation was given to the students and it was quite satisfactory to them as to why the pencil appeared bent at the surface of separation of air and water and at this point, a student drew my attention to the fact that the immersed part of pencil appeared bigger than the part outside the water (Figure 1a) and asked for the reason why it was so. When the author looked and confirmed the observation, he realized that he didn't have an immediate answer to give for the reason why it was so.

Formulating and testing hypotheses

To solve the problem facing the class, the author guided the students to formulate some intelligent guesses for the reason why the pencil inside the water was bigger than the part outside the water (Figure1a). The student put forth a number of intelligent guesses which the author helped to narrow down to these few hypotheses:

i. A pencil put in a glass bottle is magnified

ii. A pencil put in water contained in a glass bottle is magnified

iii. A pencil put in water in a curved container is magnified

With this done, the class went on to test the validity of these hypotheses one after another

Hypothesis 1: A pencil in a glass bottle will be magnified

To test this hypothesis, we put the pencil into an empty glass bottle and the class observed that the size of the pencil remained the same and therefore, hypothesis one was rejected. The class went on to try the second hypothesis.

Hypothesis 2: A pencil in water in a glass bottle will be magnified

The pencil was put in a rectangle shaped glass containing water as shown in figure Id. A look at the flat surface of the glass shows no sign of magnification of the pencil. The class concluded that it is not necessarily the presence of water and glass but some other factors that are responsible for the magnification of the pencil. The

Figure Id. Pencil in a rectangular glass bottle with water.

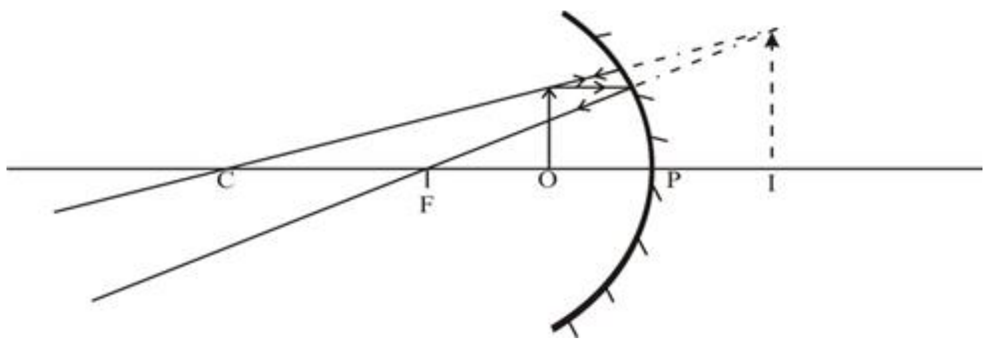

Figure If. Magnified Image formed by a concave surface when the object is between the principal focus and the mirror. **Source**: Okeke and Anyakaoha, (2011).

class, therefore, tried an empty transparent nylon bag and no magnification of the pencil was observed. Lastly, when water was poured into the nylon bag, the class observed that the pencil was magnified.

Hypothesis 3: A pencil put in water in a curved glass bottle is magnified

From our observation with water in a nylon bag, we also used a round glass bottle containing water as shown in the Figure Ie. Before water was poured in, there was no change in the size of pencil outside the water a, and inside the water, c; but when water was poured in, we observed that pencil inside the water, c became magnified. It was concluded that the curved nature of the water acts as a magnifying glass for the pencil, just like a concave mirror. The square shaped bottle, therefore, does not have the ability to magnify the size of the pencil.

Further Observation

The class further observed that the pencil c, inside the water got bigger when moved away from the centre of the beaker to any of the sides of the round shaped bottle. The students equally asked for the explanation for the variation in the size of the pencil when moved away from the centre of the bottle to any of the sides close to us. This observation was an explanation that arises from the fact that the water in the round bottle acts as a concave mirror or magnifying glass and would magnify the image when an object moves closer to the converging surface. To illustrate this, we used a concave mirror to verify the magnification obtained when an object is placed between the principal focus and the mirror and the class was surprised to see a magnified erect and virtual image of an object formed on a screen (Figure If).

Educational Implications for the Teaching and Learning of Science

After the lesson, the author took time to look up for these observations in many physics books and was shocked to discover no mention of other phenomena apart from the bending of the rays of light, caused by the change in the speed of light as it moves from one medium to other. The magnification of the image of an object being observed by the class was not mentioned in all the textbooks sampled: none of the authors tried to deviate from the general pattern. There is therefore the need for textbook authors to emphasize the 'other side' observations which would serve as a guide to teachers and students in their investigations. It is for this reason Osborne and Freeman (1989) emphasized the need to highlight salient features from complex patterns generated in wave experiments.

The science teacher on his own part is expected to try out the investigations before lessons and this will enable him observe all occurrences before coming to teach. With this kind of preparation, teachers of science will be equipped to answer students' questions and point out what students should observe in an investigation and what constitutes a distraction. Without this guidance, students may be busy doing /observing the wrong things which will eventually defeat the purpose of the investigation. Teachers in the teacher training institutions need to be well versed in the use of inquiry-based methods and should often use this method so that their students can understand inquiry and its use in science teaching.

Also, the teacher should during lesson activities be ready to answer students' questions in a way to encourage them to be more inquisitive and curious. A teacher who is not at hand with an answer should not rebuke students for asking too many questions as that will kill the spirit of inquiry which science seeks to develop. He should be sincere enough to confess his ignorance and set out to carry out more investigations with the students. Again, the presence of the teacher during laboratory investigation is very important, as the laboratory attendant may not give enough guidance and give answers to students' questions as can be done by the teacher, who is the subject specialist.

Lastly, teachers should know that investigations of this kind though time-consuming is not a waste of time but an opportunity to develop science process skills like hypothesizing, testing hypotheses, explaining observation, interpreting data and experimenting, which are not usually developed by most teachers in their day to day lessons but could only be achieved through this type of inquiry-based teaching. This, therefore, implies that sufficient time should be allotted for teaching science subjects in the classrooms and hence enable teachers to shift from the age-long traditional science teaching methods that are both didactic and lecture based which science teachers claim are saving time and helpful in the coverage of overloaded syllabuses.

CONCLUSION

The use of guided inquiry and activities in the teaching of science to pre-service teachers is both necessary in helping students become active learners in the classroom, thereby making science interesting and providing opportunities for to the use of science process skills needed for rich learning experience. This approach no doubt could compel both students and teachers to jettison traditional instructional practices that are teacher centred for more learner-friendly approaches as has been exemplified in this teaching report. Both students and the researcher benefited in broadening their horizon of understanding of light through the investigation.

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