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Using flipped classroom approach to assist pupils understand the concept of density

Francis Quansah[1], Sylvester Donkoh[2], Michael Appiah Osei[3]
[1, 2] Tutor, Department of Science, Foso College of Education, Assin Foso, Ghana
[3] Student, Department of Science, Foso College of Education, Assin Foso, Ghana

Abstract
This study adopted Flipped Classroom Approach in assisting basic seven pupils to understand the concept of density. The type of research design used was the action research design. Purposive sampling technique was used to select 20 pupils. Pre-test and post-test items on density were developed and administered to pupils. Performances of pupils in the two tests were analysed with statistical tools. When scores of the two tests were computed and compared, it was found that the mean score and standard deviation for the pre-test was far below the mean score and standard deviation for the post-test. Post-tests results of pupils showed that pupils' performance improved due to the application of the Flipped Classroom Approach (FCA). The results confirmed that the use of flipped classroom to assist the pupils in understanding the concept of density was very effective. From the study, proximity of school to pupils' home has an influence on the effectiveness of the application of the FCA. FCA suites pupils who do not have to travel long distance on foot to school better than those who travel long distances on foot to school. It was recommended for stakeholders to consider using the flipped classroom approach as one of the innovative teaching strategy especially for pupils in need of learning help.

Keywords: flipped classroom, backward classroom, scientific education, understanding density, teaching strategies

Introduction

Globally, new instructional opportunities continue to evolve and challenges educationists to provide inventive and scientific education that meets the needs of the society (Brown, Lauder, & Ashton, 2010) [5]. Educational authorities are constantly engaged in partnership to share opinions on the kind of educational system that is sustainable and can be recommended for addressing these challenges (Fullan & Langworthy, 2013) [8]. Over the years, government of Ghana has initiated a number of reforms in Ghanaian educational systems, geared toward addressing key performance issues in the educational sector, especially in areas of excellent and proficient science education delivery.

In Ghana, integrated science is considered a core subject at the basic school level and a prerequisite for pupils with the BECE (Basic Education Certificate Examination) to enter the Senior High School. Science education for pupils is considered a priority for national development. For this reason, science clinics are organized annually for science teachers and pupils with the view of reducing challenges associated with the learning of science. Integrated science involves the teaching and learning of the natural science in a holistic manner i.e. (Physics, Chemistry, Biology and Agriculture science), such that none of the fields stand on its' own (Crossan, Lane & White, 1999) [6].

Johnstone (1991) [12] has remarked that many pupils in the third world nations find it difficult to study integrated science as a subject due to the perception that science is difficult. According to Johnstone (1991) [12], one of the major reasons why some pupils perceive this notion against integrated science is about how teachers present the science lessons in class. Masingu (2017) [14] further explained in his work that science was once easy to learn and teach. This means that, pupils in the learning environment can no longer be perceived and treated as "empty containers" just waiting to be filled up with parcels of knowledge. Instead, if the teaching of science is turned into learner-centered and teacher-guided, it will help offset the minds of pupils who remark science as abstract and difficult to learn.

Educationists have revealed that pupils at the basic school level experience many issues with reference to the learning of integrated science. According to Angell *et al.* (2004) [2], density is one of the topics under physics that basic school pupils perceive to be difficult to understand. Ayres (2017) [4] added that experiencing difficulties in learning science topics negatively affect students' motivation and achievement. In effect, teachers are equally faced with the challenges of the digital world, characterized by the rapidly growing knowledge explosion to present lessons content in a smarter, faster and better way (Prensky, 2010) [17].

One of the innovative instructional strategies that discover the potential values in pupils to explore resources around them and enhance their understanding of density is the Flipped Classroom Approach or backward classroom. Riendeau (2012) [16] observed that Flipped Classroom Approach (FCA) allows the learners the opportunity to access learning instruction at their own pace and apply what they have learned through different activities provided in a face-to-face interaction. By shifting from a teacher-centered to this "pupil-centered-teacher-guided" learning style, it is undeniable that flipped classroom style can make an enormous impact on today's generation of learners to navigate various devices

better than adults (Jacobs & Castek 2018) [11].

The FCA according to Davies, Dean & Ball (2013) [7], is not just using 'new' pedagogical technique; rather it is a technology-enabled teaching practice which support teachers to exploit individual face-to-face period with pupils (Sams & Bergmann, 2013) [18]. It therefore allows for extra free time for pupils to collaborate with peers, engage more deeply with content, employ skills, and get feedback on their progress. Besides, Hamdan, McKnight, McKnight & Arfstrom (2013) [10], added that teachers are capable of using the extra free time to coach pupils, inspire and assist them gain control over their own learning in challenging topics such as density.

FCA has been reported to be effective in improving learners' performance. Ghana and Palestine participated in TIMSS for the first time in year 2003. By the year 2011 Palestine performance in TIMSS was ahead of Ghana as a result of implementation of the FCA in their schools (Atwa, Din & Hussin, 2018) [3]. In another study, Troy Faulkner with his team of instructors implemented the FCA to resolve students' achievements problem in mathematics learning. It came out that students' scores were better in FCA than that of the traditional approach to teaching (Fulton, 2012) [9]. Again, the flipped learning network and the classroom window conducted an online survey for 450 teachers in 2012. They also observed that; majority of the students' standardized test scores increased, their attitudes towards learning had improved for eight out of ten teachers and the job fulfilment also improved for about 90% of the teachers investigated (Nilsson, 2008) [15].

Even though flipped classroom has been widely utilized in recent times, it is largely not used in some countries including Ghana. This study aimed at using the FCA to assist pupils understand the concept of density. We also sought to explore other possibilities that FCA would enable the pupils to access learning instruction at their own tempo and apply whatever they have learned successfully.

Methods

The design used in the study was the action research design. The action research design was employed because the problem was a classroom issue that needed immediate attention. The design helped the researchers worked in collaboration with the pupils and teachers in the school. The population for the study was the Junior High School One pupils. The total number of pupils was 42. It consisted of 23 boys and 19 girls. Out of the 42 pupils, 16 of them resided in three villages while the remaining 26 pupils were residents from the town in which the school was located. Purposive sampling procedure was employed to get a sample size of twenty (20) pupils for the study after identifying pupils' challenges understanding the concept of density through a pre-intervention test.

The sample comprised of ten pupils from the villages and ten from the town. Pre-test – post-test items were designed and administered to pupils. This helped in the introduction of FCA intervention and subsequent determination of the outcome of the FCA on pupils' understanding of concept of density. The test items consisted of eight questions divided into two parts. In part "A", pupils were asked to answer three multiple choice questions. Part 'B' consisted of five questions which demanded that pupils solve by calculation. The entire study was carried out within seven weeks; the researchers met with pupils three times in a week and each meeting session lasted for one hour.

Before the flipped classroom activity

This was the first session of the FCA and it lasted for a week. A pre-test (Density Understanding Test (DUT)) was designed and administered to pupils. Pupils answered the pre-test items within 45 minutes after which answer scripts were collected and marked the same day. This was done with the intention of identifying the challenges pupils faced in understanding the concept of density and common mistakes pupils commit when solving problems on density and establish whether or not pupils have challenges with understanding density.

During flipped density lesson

During the FCA application, Researchers introduced the concept of density and provided background information of the concept of density through a short briefing. The researchers employed their personal computers, laptops, tablets and smartphones; prepared slide show presentations, and used pre-prepared simulations and video shows as learning aids for pupils. Pupils were taken through the meanings of some technical words, materials to use and procedures to follow in peer groupings. Again, the researchers checked for pupils' understanding of the concept of density by collecting pupils' responses and reactions about the video and slide show they had watched, so as to help pupils develop procedural confidence.

Further discussions on the concept took extra 15 minutes at the beginning of each meeting session before continuing with the normal class. The procedural framework for this flipped classroom activities is found in Figure 1. Pupils were again introduced to the displacement method at this session, so they could measure the volumes of irregular objects (v) and submitted their result for the following day's discussions. Pupils were further introduced to the skills of determining the masses of various sizes of objects as "m". Finally the researchers took pupils through the S.I. Unit conversion on density from $kgdm^{-3}$ to gcm^{-3} and vice versa.

In the second session, pupils determined the volumes of regular objects using the mathematically formula for volume as V= L x B x H (where; V is volume, L is length, B is breadth and H is height). Pupils were allowed to do assignments collaboratively, by designing suitable materials for determining the volumes of both regular and irregular objects. Pupils in their groupings prepared improvised beakers, measuring cylinders, and other relevant materials. They generated ideas in their group and led in step – by – step presentation of procedures outlined for determining density. Pupils performed more exercises and homework in groups and submitted their reports for discussion. This session took about four (4) weeks and each week had pupils and researchers engaged in activities.

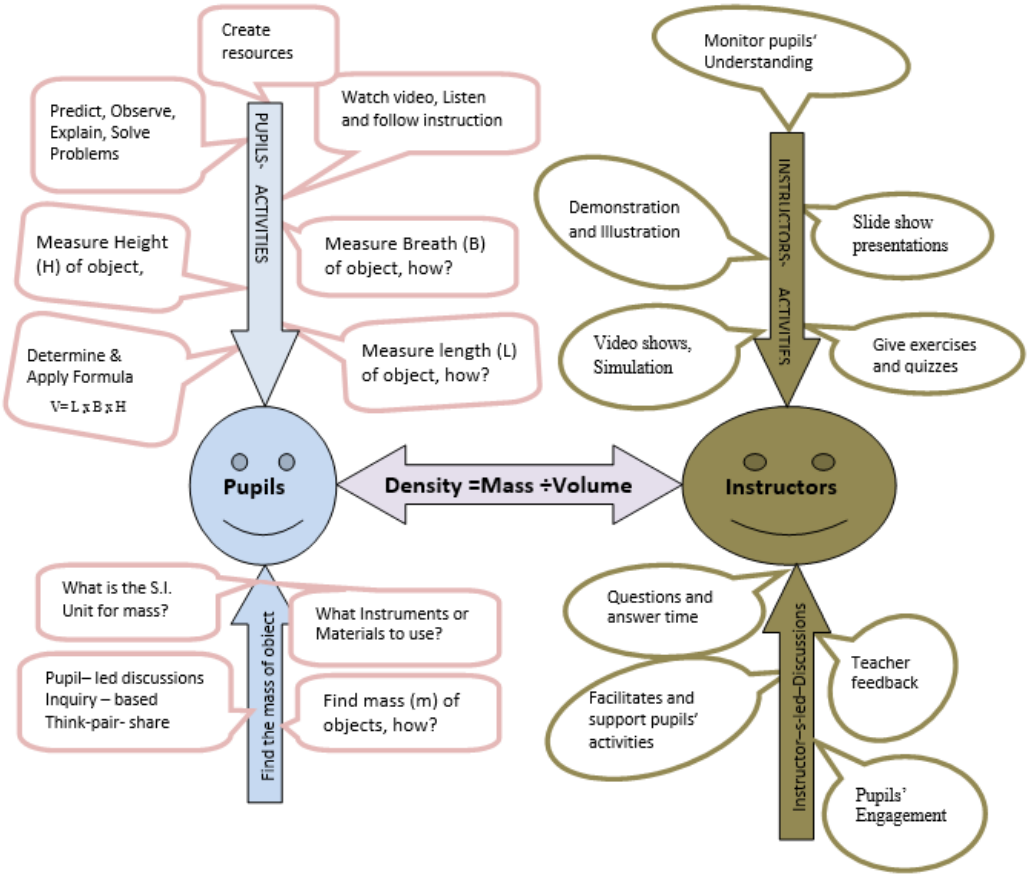

Fig 1: Flipping Classroom Model

After Flipped Density Lesson

At the end of the last week of the intervention period, another test (post-test) was conducted to check the effectiveness of the intervention. The same test items used before the intervention stage was used in the post–test to find out if pupils' understanding of the concept of density has improved. The average mean scores of pupils' performances at the pre-test and post-test were computed and compared using simple statistically tool shown in Tables 1 and 2 respectively.

Results

The test Scores

The DUT items were administered at the pre-intervention stage and post-intervention in order to measure pupils' understanding before and after the intervention. Table 1 shows the pre-test results of pupils:

Table 1: Pupils Pre – Test Results

Marks/ Scores	Number of Pupils	Percentage (%)
1	1	5
2	6	30
3	4	20
4	0	0
5	3	15
6	0	0
7	5	25
8	1	5
9	0	0
10	0	0
11	0	0
12	0	0
13	0	0
14	0	0
15	0	0
16	0	0
Totals	= 20	100

From Table 1, the total mark awarded was 16. The highest score obtained by pupils at the pre-test was eight and only one pupil (5%) got that score. Five pupils (25%) managed to score seven marks. Out of the total marks of sixteen, no single pupil could score nine marks and above. Three pupils representing 15% scored five marks. The lowest mark scored among the 20 pupils was one, and one person had this mark. As many as six pupils representing (30%) scored two marks only. The mean average score for the pre-test as was 4.15 and the standard deviation was 2.24.

Table 2: Frequency Distribution of the Post-Test Scores

Marks/ Scores	Number of Pupils	Percentage (%)
1	0	5.0
2	0	30.0
3	0	20.0
4	0	0.0
5	0	15.0
6	0	0.0
7	0	25.0
8	2	5.0
9	4	0.0
10	6	0.0
11	0	0.0
12	0	0.0
13	4	0.0
14	0	0.0
15	3	0.0
16	1	0.0
Totals	= 20	100

Table 2 represent the scores of the second test conducted after the flipped classroom lesson which again has the total marks awarded as 16. Out of the 20 pupils, one pupil (5%) at this stage was able to get the highest mark of 16 from the total marks of 16. Three pupils (15%) also scored 15 marks and six other more pupils representing (30%) obtained 10 marks. The lowest mark obtained this time was eight marks and two pupils (10%) had that score. For the remaining eight pupils; four pupils each representing (20%) each scored 13 marks and nine marks respectively. The mean score for the post-test was 11.25 and standard deviation was 2.53.

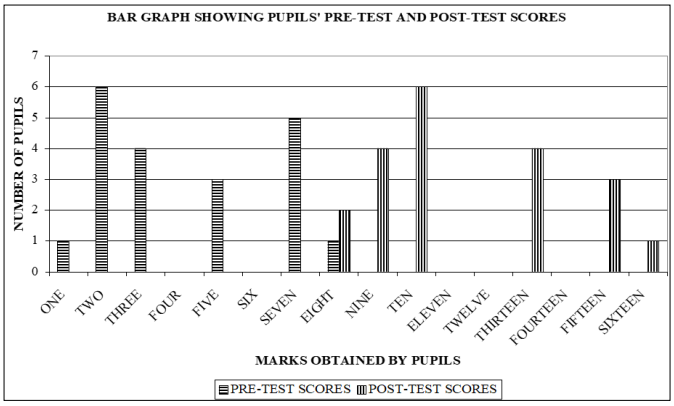

Fig 2: Bar Graph showing pupils' pre-test and post-test Results

The bar graph from figure 2 above clearly shows that the performance of pupils after the FCA was better than that before using the flipped classroom activities. It is important to note that some of the pupils' performance in the post-test was still low. The researchers therefore decided to determine what might have accounted for the low performance. It came up that these were pupils from the villages and so a comparative study of pupils' from the villages verses those from town was also done. The figure 3 gives the summary of findings.

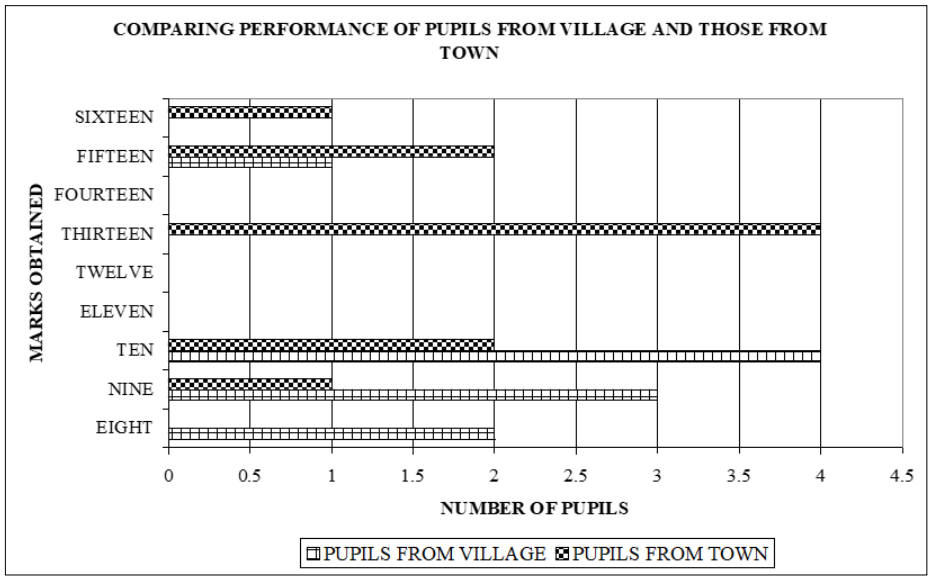

Fig 3: Scores Obtained by Pupils from Villages and Town after the Post-Test

From figure 3, none of the pupils from the town had eight marks but two of the pupils from the villages had eight marks out of the 16 marks awarded. One pupil from the town had nine whiles three pupils from the village had nine. Again, two pupils from the town scored ten marks as against four pupils from the villages that scored the same four marks. Whereas no single pupil from the villages scored 13 marks, four of the pupils from the town had the 13 marks. Two more pupils from

the town scored 15 marks as against only one pupil from the village who had the same marks. The only person who had the highest mark of sixteen came from the town where the school is located.

Mistakes Pupils Commit When Solving Questions on Density

Based on the responses pupils gave in the pre-test and the presentation the pupils made, a number of mistakes and misconceptions were recorded. The researchers discovered at the pre-intervention stage that pupils were committing mistakes in the conversion of units of density. This peculiar mistake occurred in the intervention process too. This was realized when the pupils were writing answers to questions on density in gram per cubic centimeter (g/cm^3) instead of kilogram per cubic meters (kg/m^3) which is the SI unit for density. The researchers instructed them to change their answers into the SI unit of density and they were getting the answers wrong. This made the researchers realize that the pupils were lacking the concepts of converting units. The pupils were not well abreast with the conversion from one unit to another unit. It was clearly shown when a pupil in converting 40g into kilogram wrote 4kg as the answer instead of 0.04kg. Another group of pupils in presenting their assignment couldn't convert their final answers from grams per cubic centimeter (g/cm^3) to kilograms per cubic meters (kg/cm^3).

Also, the researchers observed that the pupils were writing same answers as densities of objects which have the same masses but different volumes. This was seen mostly on determining the densities of irregular objects. The pupils, once seeing objects with same masses jump into conclusion that their densities are equal without going through the process of finding their volumes. This mistake was as a result of pupils not properly understanding the volume of irregular objects. The researchers did enough to assist the pupils to understand the determination of volume of irregular objects using the displacement method. The approach helped the pupils to realize that the densities of objects with the same masses but different volumes are not the same and vice versa

Discussions

The findings of the study showed that the FCA was effective and affected pupils understanding of concept of density positively. Instructors' interaction with pupils improved because pupils became more active in lessons and learning process also became more interesting. Integrating the digital learning materials (computers, laptops, tablets and smartphones) in the FCA made the lesson very exciting and colourful to pupils as pupils had opportunity to control their learning with enthusiasm. Pupils mapped out how the concept, ideas or theories of density are thematically related in a visual manner. Pupils were able to do conversion from one unit to another and subsequently applied it in calculations involving density.

Challenges that pupils faced in solving problems in density were identified to include; their inability to do conversion of units in the S.I. system, some misconceptions pupils had on the concept of density and lack of basic learning materials due to their background location. In the first place, the pupils had difficulties in converting gram per centimeters cube into kilogram per centimeter cube. This was because in their earlier lessons with their teachers, pupils remained passive and did not contribute towards solving problems since the method used by the teachers were teacher-centered. In this respect, we can therefore agree with Kim, Khera and Getman (2014) [13] that pupils' involvement in classroom tasks, challenges them to have control over their learning difficulties and seek for antidote appropriately. The researchers through the use of the flipped classroom model helped the respondents to gain much understanding in converting one unit to another in the metric system.

Secondly, pupils were found to commit errors due to misconceptions relating to mass and volume with respect to size, shape and material. Initially, pupils' substituted weight for density by explaining density as the thickness of a material. Pupils perceived that smaller objects had lesser densities than larger objects and large objects sink whereas smaller objects floats. Pupils thought that volume is additive and so is density; so if you have twice as much material, you have twice as much volume and twice as much density. These misconceptions were traced to pupils' misunderstanding of the concept of displacement. Until the flipped classroom, pupils had neither been exposed to video shows and simulations nor engaged in peer lesson in relation to the concept of density. However after the introduction of the variety of learning aids, lesson became real, meaningful and misconceptions cleared. In addition, the notion that pupils had about density as a challenging topic was minimized.

The implication here is that, concepts in science would be perceived to be difficult to understand by pupils, if pupils are not made to control the learning process themselves and subsequently pupils would not be able to understand a host of real world phenomena. This affirms the observations made by Kim, Khera, and Getman (2014) [13] that pupils understand what they are taught better by using approaches such as the flipped classroom. Pupils manipulated the teaching and learning materials themselves and were able to come out with their own conclusions. The study further revealed that pupils who came from the villages performed relatively low as compared to their counterpart from the town.

Lastly, time constraint was another obstacle observed. In the midst of the intensive competing subjects to be taught within the space provided on the time table, the researchers organised the flipped outside the normal classes' hours. This brought additional burden on pupils especially those from the villages. This is because these pupils from villages walked for about three kilometers to and from school each day. The situation coupled with inadequate source of light for pupils from the villages to learn in the evenings was a contributing factor to their low performance. In some few cases where they had hurricane lantern, it could be only one lamp which was supposed to be used by the entire family. Pupils would have no option than to wait till the lamp is free before they can use it to learn. Sometimes, they even sleep without attending to their homework. In spite of these limitations, the FCA was effective and successful since the performance of the pupils after the post-test showed improvements in performance.

Conclusion

The outcome of this study evidently showed that pupils gained higher levels of interest and confidence in solving problems on density and became more actively engaged in the performance of activities to build ideas. This affirms the previous studies done by earlier researchers including Riendeau (2012) [16] and Agommuoh and Ifeanacho (2013) [1]. Again during the FCA lessons, pupils had the opportunity to learn at their own pace, and enjoyed lessons in a more interactive manner. The FCA was effective in improving pupils' understanding of density. From the study, proximity of schools to pupils' home has an influence on the effectiveness of the application of the FCA. FCA suites pupils who do not have to travel long distance on foot to school better than those who travel long distances on foot to school. For those who travel long distances have limited time to work on their assignments.

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