Hands-on Science
Science Education with and for Society
© 2014 HSci. ISBN 978-989-98032-5-1

An IBSE Approach for Teaching the Concept of Density in Preschool and Primary School

P Machado, MFM. Costa
Universidade do Minho, Portugal
machadopaulo@hotmail.com

Abstract. *This paper intends to suggest strategies for planning, development and implementation of simple activities, related to "density", in the classroom, in an Inquiry Based Science Education (IBSE) perspective, i.e. science education based on research/inquiry/experimentation. In this sense, we begin by contextualizing the curricular context on science teaching in pre-school and primary school, and presenting the theoretical context related to the teaching of science based in IBSE. The choice of the suggested activities was based on a set of criteria including their inclusion in preschool and primary school national curriculums, as well as the possibility that it can be addressed with varying degrees of depth, depending on the grade and level of cognitive development of students. The activities are proposed to explore the issue of density that is a subject commonly address in classroom from pre-school to primary school, and was developed to be applied in class with students of those school levels.*

Keywords. Density, physics, IBSE.

1. Introduction

Nowadays, education in science is assumed as an essential component in the education of citizens, as a perspective of individual and social development. There is a comprehensive knowledge of the problems and challenges facing the world, and it is essential that each individual acquire the basic skills that will enable the comprehension and decisions making in a responsible way.

What´s important to foster since the beginning, is the natural curiosity of students and their enthusiasm for science/technology. In particular, for young children, it´s important to explore their day-to-day experiences as a starting point, since it is there they can more easily recognize the contexts and this will possibly increase their motivation [1].

The selection of the theme and the proposed activities take into account the principles set out in the curriculums [2], which constitute the framework for the development of educational practices in the first stage of basic education.

Aware that the practices, at preschool level, should be globalizing, this does not contradict the possibility of children being initiated into procedures and ways of thinking typical of the construction of scientific knowledge [3].

The curriculum of the first level of basic education [4] includes sciences in the curriculum area of environmental studies and its guiding principles to the pedagogical action, recognizing the role of the environment as enhancer of learning and the knowledge that students already have.

There are no explicit references to IBSE strategies in the policy, however, promoting science education based in IBSE seems important from early education, starting at the preschool level.

2. Science Teaching in Preschool and Primary School

In preschool education, the area of knowledge of the world, root children's natural curiosity and their desire to know and understand why. This curiosity should be encouraged and expanded at preschool, through opportunities to engage children's with new situations, that are both opportunities for discovery and exploration of the world. This area appears as a science awareness, which may be more or less related with the nearby environment, including the extension of basic knowledge necessary for social life, and arising from experiences provided by the context of preschool education [5].

This awareness of the science interests of children must be extended and contextualized by the educator, who encourages the curiosity and the desire to learn. Whatever the issues addressed and their development, it seems essential the relation with the processes of learning, the ability to observe, the desire to experiment and the critical attitude.

The environmental studies at primary school level, should allow the development of themes covering various subject areas, in a cross curricular perspective, having the physical and social environment as a reference.

One of the general objectives of this area relates to the fact that students have the opportunity to *"use some simple processes of knowledge of the surrounding reality (observe, describe, formulate questions and problems, advance possible answers, test and verify), assuming an attitude of permanent research and experimentation"* [4].

It is intended that teachers recreate the program in order to meet the diverse starting points and rates of learning of the students, their interests and needs, and characteristics of the local environment. Thus, it will be through diverse learning situations involving direct contact with the surrounding environment and conducting small researches and experiences that the students will progressively integrate the meaning of the concepts [4].

3. Inquiry Based Science Education (IBSE) in Science Teaching

The rapid changes in our world brings new challenges to education and in particular to science education. Modern society requires schools to provide children with new tools, such as creativity, curiosity and lifelong learning. For this, it is necessary to motivate students to the studies of science, which requires changes in the way science is taught.

It seems necessary to review the teaching of science contents and apply appropriate and modern methods of teaching/learning. Such methods include student-centred approaches in sciences like IBSE, that integrates theory and practice, and the development of problem-solving skills and further the knowledge [6].

The teaching by IBSE refers to the activities of students in which they develop knowledge and the understanding of scientific ideas, as well as, how scientists study the world. It is a multifaceted activity that involves making observations; posing questions; consult books and other sources of information to find out what's already known; planning investigations; review of knowledge based in experimental evidences; use of various tools

© 2014 HSci. ISBN 978-989-98032-5-1

to collect, analyse and interpret data; proposing answers, explanations and predictions, and communicate results [7].
It seems logical that the IBSE perspective is specific and dependent on the age of the students to be applied to the teaching of science. However, the use of this teaching perspective involves a large set of activities that constitute the commonly referred hands-on science.
These activities include conducting researches, sharing ideas with colleagues, model definition and development of representations for the observed phenomena [6].
This type of science education involves active learning, and takes advantage of the natural curiosity of children, thereby increasing their understanding of the world by solving problems. However, for students develop the appropriate skills in science, they should have the opportunity to participate in a wide range of activities proposed by the teacher.
This perspective of science education (IBSE) breaks with the traditional teacher-centred didactic, and students, according to this perspective are encouraged to develop the ability to solve problems independently.

4. Proposed Activities for the Classroom

This paper aims to suggest strategies for planning, development and implementation of simple activities in the classroom, based on Inquiry Based Science Education.
Strategies for the development of students' knowledge on these subjects will be presented in an investigative perspective, focused on raising questions, formulation of hypotheses, and the analysis and communication of the findings upon the observations recorded.
The activities will explore the content of density, which is a frequent issue in classrooms from preschool to primary school, and could be applied to students at these levels.
The choice of the suggested activities was based on a set of criteria: inclusion in the national policies [4], [5]; the possibility that can be addressed with varying degrees of depth, depending on the grade and level of cognitive development of students; its frequent observation in family and non-academic contexts; and, to allow the development of creativity and satisfaction of children's natural curiosity.

4.1. Activity 1 – Experiments on Buoyancy

This activity aims to develop the students' understanding of the concepts of mass, volume and buoyancy [8], [9].
It is important that students learn to make predictions and test whether the given objects (coin, pencil, ruler, play dough, rubber, and tree leaf) sink or float in a large water container, and learn to classify the objects, as objects that sink or float, which will depend on two factors: density and buoyancy.
At preschool level, students cannot fully understand these concepts. The most important is that students observe if these objects sink or float. Therefore should be consistent in the way that an object behaves in the water which will allow students to form their own opinions and ideas about the properties of objects and how it will help them sort the objects.

© 2014 HSci. ISBN 978-989-98032-5-1

Guiding questions

- *Which means sink and float?*
- *Can you predict what objects will float? And sink?*
- *The predictions made were different or equal to that was observed?*
- *Describe the characteristics of the objects that sink. Do they have some identical property between them?*
- *Describe the characteristics of the objects that float. Is there some identical property between them? If there are no common characteristics, what do you think has happened?*
- *Is there any surprising result?*

Implementation

The students probably already made some remarks, in a pool or bathtub. Typically, students think that the mass of an object is decisive for determining whether or not a body floats.
Discuss with students the case of boats (huge mass) floating and otherwise very light objects (small mass) sinking. The teacher should clarify the concept of heavy (mass), once in the experience of the students, the boats that use to play are made from plastic/rubber.
Children can develop their activities, games, demonstrations, predictions, results and discussion. If considered necessary, or suggested by any children, measurements of objects mass could be made.
Students should share their interpretations of results and conclusions. All students should have the chance to communicate their main conclusions.

Discuss with students how they can relate the results of this activity to other day-to-day experiences and how they can learn more about this topic.

4.2. Activity 2 – Same Size and Shape

The purpose of this activity is to test the buoyancy of objects made from different materials, with the same shape and size, and develop the ability to understand the different properties of each material that constitutes the objects [8].
In this activity, students should understand that the objects (golf ball, Ping-Pong ball, play dough ball) have two attributes in common: the size and shape.
However the composition of objects is different shows that the material in which an object is made, affects the behaviour that the object will have on the water, or whether it will float or sink.
Students should also be able to understand that the size and shape do not always affect the behaviour of the objects in the water.

Guiding questions

- *What are the different or identical characteristics of the different objects?*
- *Why some objects float in water and others do not? What characteristics have these objects? Describe the objects that float and those that sink.*
- *How objects behave according to the predictions made? The predictions were different or equal to the observations you made?*

© 2014 HSci. ISBN 978-989-98032-5-1

Implementation

Typically students think that the mass of an object is decisive for determining whether or not a body floats.
Questioning students about the volume of the different balls used in the activity and ask them to compare their masses.
Guiding students so they can infer that the weight of the balls are different, but the volumes are (approximately) the same.
Introduce to the students the concept of density in a simple way, as a physical property of matter that is related both to the mass and the volume of a body. The more dense body (ball), has the highest weight for the same volume.
Guide students in order to conclude which of the objects (balls) will have lower and higher density. Help students understand that the objects "have the same volume" and should have different masses (in order to have different densities).
Students should develop a simple research to infer the density of golf, Ping-Pong and play dough balls.
After making their observations, guide students in order to develop a hypothesis on which of the balls has a higher (and lower) density and if it will float or sink.
Children can develop their activities, predictions, observations, discussion of results and possible measurements of the masses of the objects if it proves necessary.
Students should share their findings, interpretations of the results and conclusions.
Students should describe how identical objects are quite different and how it affects its buoyancy. Discuss some of the characteristics that influence the buoyancy of the bodies (mass and composition) and the ones do not (e.g. colour).

4.3. Activity 3 – Same Shapes Different Sizes

This activity aims to investigate whether objects made of the same material with same shape but different sizes, float or sink.
In this activity, students should compare whether each set (pair of cubes) of the same material and shape (wood, Styrofoam, acrylic, aluminium) but different sizes (large and small cubes) float or sink and understand that the objects in question have a common attribute - the shape, and a different attribute – size [10].
Children should also understand the importance of the material as a factor affecting buoyancy, while at the same time, consider size as a possible additional factor.
During the activity, students should also be able to understand that the shape (cube) and size does not affect the behaviour in water, i.e., all objects of the same material, whatever the size, always have the same behaviour, because the material has the same density that does not vary with size.
The teacher should be aware that, generally, the objects less dense than water float and that objects denser than water sink.

Guiding questions

- *All cubes are made from the same material?*
- *What is similar and different between the cubes?*
- *Does the size of the cubes affects its buoyancy?*

© 2014 HSci. ISBN 978-989-98032-5-1

- *Why do you consider some cubes floated?*
- *How objects behave according to the predictions made? The predictions were different or equal to the observations you made?*

Implementation

Is provided a pair of cubes of each materials available, to each group, for example, a pair of wooden cubes (one large and one small) and a pair of Styrofoam (one large and one small).
Question and discuss what are the differences and similarities between the cubes. It may be considered the mass, volume, shape or colour of the cubes.
Students should group the cubes in pairs, according to a chosen criteria. Maybe examples of these criteria, the size (large and small), material (wood or Styrofoam), colour (white or brown), or other criteria chosen by the students. Help students understand that all large cubes have the same size and all the little cubes.
Students should develop a simple research to infer the buoyancy of each cube. After making their observations, guide students in order to develop a hypothesis about which cubes float or sink. Students should share their findings, observations and conclusions. All students should have the chance to communicate their main conclusions.
In large group, at the end, compare the results, and conclude that the activities of the students showed that the type of material that constitutes the cubes is the determining factor for the object to float or to sink. Students should describe the common, different features of the objects used discussing some characteristics that influence the buoyancy of the bodies (the material), and did not influence (size and colour).
Recall the notion of density as a physical property of matter that is related to the mass and volume of a body, and does not depend on the shape or size of objects.

4.4. Activity 4 – The egg

This activity pretends to develop the understanding that an object floats or sinks in a certain liquid depends on the density of the object but also the density of the liquid [11], [12].
This activity aims to demonstrate that the density of water changes when substances are dissolved in it, and that this could affect the buoyancy of an object, in this case one egg. If an object is denser than the liquid, it will sink. If an object is less dense, it will float.
In this activity, the egg sinks in the water because it is denser than water. However, the egg floats in seawater, because the seawater has a higher density than the egg.
This concept can be advanced to the level of preschool level, but it is important that students realize that the change in composition of the water can have an effect on the buoyancy of an object.

Guiding questions

- *What happened to the egg when it was introduced in the glass with water?*
- *What happened to the egg when it was introduced in the glass with salt water?*

© 2014 HSci. ISBN 978-989-98032-5-1

- *Why do you think the egg behaved differently in water and in salt water?*
- *Can identify other liquid capable of making eggs float or sink?*
- *What is the relation between the density of water and density of the egg? And between the density of salt water and the egg?*

Implementation

Remind students what they have learned up to this point about density.
Place the egg inside of the glass with water and check if it sinks. Question and discuss with students why egg sink and relate this observation with the previous knowledge they already have about density.
Guide students in order to reflect on the density of the body, but also on the density of the liquid. Discuss with students the egg size and if the amount of water will have influence. Also, discuss the need to control some variables, such as the volume of water and the amount of salt.
Help students understand that salt water is denser than water and realize that we can dissolve salt in water in order to increase the density of water.
Students should develop a simple investigation dissolving in water spoons of salt, watching what happens, until the egg floats.
Students perform their procedures until find the number of spoons of salt needed to dissolve until the egg floats, i.e. until the salt water being denser than the egg.
Students should share their findings, interpretations of results and conclusions. All students should have the chance to communicate their main conclusions, namely the number of spoons of salt used until the egg float.
At the end, compare the results and conclude that the liquid density is another factor that affects the buoyancy of an object.
Students should understand that when salt is added, water gradually became denser.
Students may also discuss suggestions and problems experienced during the activity execution.

4.5. Activity 5 – Different Liquids

This activity aims to analyse, the different densities of liquids, and then compare the density of different objects used with the density of liquids [8], [13].
Initially it is intended that students compare the density of different liquids used (olive oil, honey, water). Later, when they put different objects (marble, metal clip, pieces of cork), it is noted that they occupy different positions in the liquid mixture.
The teacher should note that the concept of miscibility is underlying in this activity, and is the property of two or more liquids mix with each other more or less easily, forming one or more phases. Separated phases when two substances are insoluble when mixed (the best-known example of this is the oil-water mixture). On the other hand, water and alcohol are soluble in any proportions, while other combinations of substances are partially soluble (e.g. salt in water).

Guiding questions

- *If the amount of liquid used was different, there will be changes in the observed layers?*

© 2014 HSci. ISBN 978-989-98032-5-1

- *Why honey is in the lower layer and oil at the surface?*
- *Who will be denser, oil or water?*
- *Why the cork floats while the marbles and the clip sink?*
- *How objects behave according to the predictions made? The predictions made were different or equal to that observed?*

Implementation

Remind students what they learned to the point about density, specifically in previous activities. Present this activity with the aim of investigate different liquids and how objects float or sink in these liquids. Introduce students to the materials available. Begin discussing with students the fact of two liquids mix or not, using simple examples such as water and oil, or oil leaks in the oceans. Discuss with students about if the amount of liquid used, particularly if small/large quantities of oil float or sink in small/large quantities of water.
May be appropriate to students start with simple activities to verify the formation of layers with olive oil and water. Students conclude that regardless of the used amounts of oil and water, always observe two layers, oil on top of water, so the oil is less dense than water.
Lead students to understand that when there is a density difference between the two substances, which do not mix, the less dense substance floats in the other.
Initially present all liquids to the students (honey, oil, water) and introduce them to the problem, by first predict how many layers will observe and how they will be organized, once the liquids do not mix. Discuss with the students, based on how many layers are observed and what is their position in the glass.
At this stage, it may be useful to help students putting the liquid in the glass. The order in which the liquids are poured into the glass is irrelevant, since the liquids are immiscible.
Students should develop a simple research in order to conclude about the density of the liquids involved in the activity. Help students understand that there are three layers of which, honey at the bottom, then water and oil on top. Lead students to conclude that honey is denser, then water and finally the oil.
Show the objects, for instance, clip, marble and piece of cork. Question and discuss with the students what will happen to each of the objects when placed in the glass containing the three liquids. At this stage it is important to listen to students' ideas and what they think about whether certain object floats or sinks. It is possible that students (especially preschool) do not predict that some objects will float in a liquid and be sunk in another (the intermediate layer). Discuss this with students helping them to realize that objects have different densities, such as the liquids used, and they may be denser than a liquid and less dense than the other.
Students of these ages understand in the abstract, the concept of miscibility, as something that does not mix.
Students should share their findings, results and conclusions.

5. Final Considerations

We opted to develop activities under the density thematic, because it is included in preschool and primary school curriculum,

© 2014 HSci. ISBN 978-989-98032-5-1

and also because they are activities that can be used at different levels of depth. In this sense, the proposed activities for the teaching of physics, are based on IBSE and are properly framed in the curriculum.

The set of proposed activities conform an integrated approach to a progression in students' learning enabling the consolidation of knowledge and skills that allow effective progress with understanding progressively more elaborate concepts.

However, in relation this work, seems to be essential its implementation as a way to test them in the context of the classroom, in order to verify that they meet the proposed goals.

This perspective of science education breaks the traditional teacher-centred didactic, and students according to this perspective, are encouraged to develop the ability to solve problems more independently. This type of science education involves active learning, and takes advantage of the natural curiosity of children, thereby increasing their understanding of the world by solving problems. However, for students develop appropriate skills in science they should have the opportunity to participate in a wide range of activities proposed by the teacher.

6. References

[1] Cachapuz A, Praia J, Jorge M. Da educação em ciências às orientações para o ensino das ciências: um repensar epistemológico. Ciência & Educação 2004; 10 (3): 363-381.

[2] ME. Despacho nº 5220/97, 04/08/1997. Lisboa: Imprensa Nacional.

[3] Martins I, Veiga, M, Teixeira F, Tenreiro-Vieira C, Vieira R, Rodrigues A, Couceiro F. Educação em Ciências e Ensino Experimental - Formação de Professores (2ª edição). Lisboa: Ministério da Educação; 2007.

[4] ME. Organização Curricular e Programas: Ensino Básico - 1º Ciclo – Estudo do Meio (4ª edição revista). Lisboa: Ministério da Educação; 2004.

[5] ME. Orientações Curriculares para a Educação Pré-Escolar, Setembro 2007. Lisboa: Editorial do Ministério da Educação; 1997.

[6] Trna J, Trnova E, Sibor J. Implementation of inquiry-based science education in science teacher training, Journal of Educational and Instructional Studies in the World 2012. 2(4): 199-209.

[7] Watters J, Diezmann C. Reforming Education: The pursuit of learning through authentic inquiry in mathematics, science and technology. Em epiSTEME 2004 Dec 13-17, Dona Paula, Goa, India; 2004.

[8] Tytler R, Hubber P. Ideas for Teaching Science: Years P-8. Deakin Print Services. Deakin University, Geelong, Victoria 3217, Australia; 2005.

[9] Gibson G, Kenyon T. Making Things Float and Sink: With Easy-to-Make Scientific Projects. Millbrook Press Incorporated. Brookfield, Conn.: Copper Beeck Books; 1995.

[10] Longhini M, Tenório M, Grillo G. Flutuação dos corpos: elementos para a discussão sobre sua aprendizagem em alunos dos anos iniciais do Ensino Fundamental. Revista Brasileira de Ensino de Física 2011. 33 (3).

[11] Rose L, Sophr H. The Nature of Matter (Grades 5-8). On the mark press: S&S

© 2014 HSci. ISBN 978-989-98032-5-1

Learning materials. United States of America, Covington, KY; 2009.
[12] www.deltasee.org/CTC/ActivityFloatingEggs.pdf [visited 28-Aug-2012].
[13] Schoeder C. Atividades experimentais de física para crianças de 07 a 10 anos. Textos de Apoio ao Professor de Física N°I6. Mestrado Profissionalizante em Ensino de Física. Instituto de Física – UFRGS; 2005.