Reference # 46
Topic # 1

Science education for citizenship: Do textbook lab activities help teachers to put it into practice?

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One of the most outstanding aims of compulsory science education is to develop students' scientific literacy so that they can act as informed, active and responsible citizens. Thus, compulsory science education should lead students to acquire some awareness of the powers and limitations of science as well as to develop some reasoning competences that are relevant for daily lives. Lab activities are teaching resources that can be used in science classes to develop those competences. This paper content analyzes labs activities included in school science textbooks and discusses how they can promote or impair science learning for citizenship.

Education for citizenship at the compulsory education level

Nowadays, citizens living in democratic societies are often asked to take part in decision-making processes focusing on socio-scientific issues. By socio-scientific issues it is meant issues that both have to do with scientific matters and are relevant for societies and individuals living in them. Citizens' participation in decision-making processes may occur in several ways (Breslin & Dufour, 2006), and at diverse levels, ranging from the broad international political level to the local concrete problem-solving one. As far as the broad political level is concerned, European citizens' participation ranges from European to local levels and takes place when they vote for example for electing the European parliament members or for the national parliament delegates or even for the local authorities. In fact, when they vote for a given political party, citizens are influencing future decisions on scientific and technological matters related not only to dealing with things like environmental and energy issues but also to the funding of certain branches of scientific research instead of others. The local decision-making level happens when citizens engage into problem-solving processes whether they focus on issues with a global dimensions (e.g., in order to preserve the ozone layer) or on small scale local needs or demands (e.g., to improve the waste management systems of the locality they live in, to react to a project for settling a wind farm nearby or to save energy at home, or to acknowledge the growing of genetically modified organisms in their neighborhood).

According to Wellington (2002), educating citizens has to do with developing: individuals' sense of rights and responsibilities, meaning that citizens should be equipped with some basic information and develop critical reasoning abilities so that they can undertake responsible actions and show appropriate behaviors on their own; individuals' awareness of the fact that as actions relate to attitudes and values, and therefore all citizens should develop a sense of justice, tolerance, respect for others, etc., so that they perceive that their individual small scale actions may make a difference and affect the whole society and the planet; learning how to learn competences so that after leaving school citizens can continue learning on their own, maintain themselves updated, and get information on the new or relevant issues of the moment; a globalization framework, as citizens need to understand and fully acknowledge the idea that any local action taken by a single individual in a certain place has implications at the planet level, and will affect every individual in the whole society; sustainable development principled living strategy which requires an understanding of why the fulfillment of the needs of the moment must be appreciated within the global boundaries of the planet and the time scale of the future generations so that the future of the humankind is not put at risk.

Hence, as Breslin and Dufour (2006) put it, Citizenship Education should be “to enable young people and adults to understand and make sense of their own lives and of local, national and global, civic society” (p.xv). In addition, Wellington (2002) argues for the inclusion of a set of attitudes and values as well as of skills and abilities in education for future citizenship. The former includes: healthy skepticism; respect for others; critical judgment; careful and criteria based evaluation; informed opinion; critical reading, watching and listening; tolerance; open mind and relational thinking. The later encompasses abilities required to: making personal informed judgement; thinking critically; finding out and searching for information; questioning and evaluating the quality of information; thinking about consequences of own behavior. Therefore, as Roth & Désautels (2004) emphasize, education for citizenship cannot rely only on knowledge application to daily life. Rather it requires action in every day contexts and global analysis of daily life issues, so that students can develop attitudes and skills in the context they will use them later, within the scope of either their private or their professional lives.

Accepting that science education deserves a place in the compulsory school curriculum and that it has a role to play in education for citizenship, then a question may be raised: what sort of science education should be practiced at compulsory education level if it is to carry on for citizenship education? What would be its appropriate main goals?

Although science and science education have been capturing much attention since the beginning of the new millennium (Jenkins, 2000), and no argument has been built against the inclusion of science in the school curriculum, “science does not seem to feature a context for citizenship education” (Ratcliffe, 2006, p. 169). In fact, it still concentrates too much on teaching science (Jenkins, 2000) instead of concentrating on educating through science. Even though there are still five arguments for including science education in the school curriculum for all citizens (Millar, 2002). They are as follows: the economic argument that has to do with the fact that science and technology are inter-related and both affect economy; the utilitarian argument that bears in the idea that science is needed in our daily lives, whether as individuals or as members of a society; the democratic argument that focus on the individuals’ right and obligation to informed participation in public life; the social argument which relates to the fact that science should be related to the wider culture in order to maintain social cohesion; the cultural argument that has to do with the fact that science is the humankind major enterprise and therefore every young people should be able to understand and appreciate it.

If science education is to be consistent with the aforementioned arguments, to foster education for citizenship and to help school to develop students’ sense of responsibility as members of local and global societies, then it has to focus less on the teaching of science concepts and to pay more attention to teaching about science and to teaching how to do science (Longbottom & Buttler, 1999). On Roth and Désautels (2004) words, it should concentrate on scientific literacy so that it prepares students to act as informed, active and responsible citizens in their future lives.

Despite the fact that scientific literacy has not been a consensual concept (De Boer, 2000), it seems that there is some agreement on its multidimensionality, including dimensions that range from the conceptual and procedural to the affective and the epistemological ones. It is worth noticing that the epistemological dimension of scientific literacy is at the core of this concept, as the way other scientific literacy components are conceptualized depends on it. This is the main reason why compulsory science education should convey students an adequate image of science and scientists (Lin, Chiu & Chou, 2004; Sandoval, 2005) in order not only to lead some of them to engage in science and technology careers but also to create conditions for them to engage into public debates and political decisions on socially relevant science and technology issues and to benefit from science in their individual lives.

Teaching science for scientific literacy does not mean that students would need or would be able to learn all science concepts in science classes. Even if they were, it would not be of too much use to them as science progresses so fast that they would become outdated soon after leaving school. However, it does not mean that students do not need to know science concepts too. Rather, it means that science classes should lead students to acquire some foundational scientific ideas and to develop an awareness of the powers and limitations of science as well as some competences that are relevant for their daily lives (Longbottom & Buttler, 1999).

It is not easy to get a full consensus on the concepts and ideas that students should learn at school to develop scientific literacy. According to Millar (2002), the "criteria for choosing models to include in the school curriculum are their cultural significance and their role in underpinning an understanding, in broad terms, of issues which may enter public domain or that of personal action" (p. 122). As far as the development of an awareness of the powers and limitations of science is concerned, it requires an understanding of the nature of science and scientific knowledge so that citizens become equipped with competences relevant to evaluating the beneficial and the harmful uses of science knowledge, to identify the causes of the non-desirables consequences of men's uses of science, and to actively and consciously participate in debates and decision-making processes about scientific issues (Longbottom & Buttler, 1999). With regard to competences related to doing science, the major difficulty is that there is no major agreement on what science methods are (Millar, 2002). However, bearing in mind the democratic, social and cultural arguments, more important than seeking for a generally useful method of inquiry which pupils should be encouraged to use widely in their daily lives, it seems to be to have everybody knowing something about the way science knowledge has been, and continues to be, obtained. Besides, considering the competences that are relevant for citizens' daily lives, and to mention just a few, they range from critical reasoning to evidence-based argumentation, and even to locating and selecting information sources and to making sense of and using scientific information.

The 2001 Portuguese national compulsory education curriculum (grades 1 to 9) acknowledges the idea of science education for "educating through science". Consistently, it also acknowledges the development of students' scientific literacy as the main aim of science education up to grade 9. Therefore, it stresses the teaching of science along with the teaching about science and the teaching of how to do science. Besides, it acknowledges that some general competences (e.g., communication competences, reasoning competences) are to be developed by science teachers too. Although the secondary school curriculum (grades 10 to 12) emphasizes science teaching more than the previously mentioned one, it also recognizes scientific literacy as a goal of science education for students that choose to initiate a specialization in science after the age of 16. It seems therefore that the Portuguese curricula emphasize issues that are in the general education as well as in the science education agendas of the moment. However, a question on whether or not the philosophy that underlies the curriculum is acknowledged by teachers and guides their teaching practices and as well as those of the curriculum material (textbooks included) developers needs to be approached.

Science education for citizenship and the role of lab activities

The discussion held so far suggests that science education has a role to play in citizenship education and that it should be able to foster an active citizenship, inclusive democracy, life quality, economics and social change, socio-scientific problem solving, understanding and scientific literacy. As it was stresses above, in order to do so, it has to concentrate on conceptual knowledge, but also on procedural knowledge as well as on epistemological knowledge.

There is a wide variety of teaching resources and types of activities that can be used in science classes to teach science as well as to teach how to do science and about science. Successful teaching requires a selection of those that best foster science learning and give students an insight of how science knowledge is produced and how scientists behave, cooperate, communicate and so on.

There is a widespread belief that one of the teaching resources that can best suit the goal of developing this variety of competences is the science-teaching laboratory. This belief is grounded in the idea that science is a practical activity and it has led to looking at the laboratory as an outstanding resource for teaching science as well as for teaching how to do science and about science. However, Millar (1998) counter-argues that if it is true that science is a practical activity it is also true that science is a theoretical activity. In fact, it is often argued that in the lab students might work like scientists and that they not only acquire science knowledge but also gain an insight on how scientists work and develop competences that are relevant for every citizens living in modern society. However, there are some difficulties associated with the use of the lab to learn science. The major cause of those difficulties may lay in the fact that lab activities show what happens but do not show why it happens the way it does (Woolnough & Allsop, 1985). Another difficulty that is related to the previous one, is due to the complex inter-relationship between theory and evidence (Leach, 1999). In fact, theory is required to design an experiment and to select empirical evidence, which in turn lead to theory through a conclusion drawing process. In addition, science teaching requires students to draw conclusions consistent with the explanations that scientists accept at the moment irrespective of being counter-intuitive or not. As we discussed elsewhere (Leite, Mendoza & Borsese, 2007), explaining in science is different from explaining in science teaching. On one hand, explaining in science means making sense of the world and it may require scientists to invent entities and to settle new explanations and theories (Ogborn *et al.*, 1997). On the other hand, when explaining in science classes, teachers and students are conditioned by the explanations accepted by the scientific community. Teachers are supposed to teach and students are expected to learn the explanations previously built by the scientists. This learning process requires students to look at the world "by the eyes of the scientists" and to use the same real or invented entities scientists do, with the same characteristics and behaviors. As Leach (1999) points out, the learning of formal knowledge can be portrayed as a process of enculturation that includes a process of internalization through which individuals appropriate knowledge from the social plane to individual use. Hence, lab can do only a small part of this.

As far as the use of the lab for teaching about science is concerned, it should be noticed that the role of the lab in science education depends on how science and science knowledge production is conceptualized. Modern conceptions of science tend to conceptualize science, as a human enterprise that uses several procedures to create knowledge that is not only temptative, fallible and uncertain, but also that is accepted through a social scrutiny process as far as it is useful to consistently explain the natural world (McComas, 1998). Instead of uncovering truths that are there in real world waiting to be discovered, scientific research tries to build up explanations for natural phenomena and to make sense of data collected from experiments, bearing on logical relationships between theories and evidences. Then, opposite to what empiricists would think, creativity, critical thinking, insight, and tacit knowledge have also a role to play in such knowledge building process (Leach, 1999; Longbottom & Butler; 1999; McComas, 1998). A consequence of this is that students cannot reproduce in the time of a class the pathways that were once followed by the scientists to rediscover a given idea, unless they are told what to do.

Teaching about science means teaching about the nature of science knowledge, including the way it is developed, accepted and rejected. According to Longbottom & Butler (1999), it should acknowledge three aims. First of all, it should enable children to perceive that scientists are successful in developing an understanding of the world even though they do not have a fail-safe method that leads to truthful science. Secondly, it should enable children to perceive that accepted scientific knowledge is the best available at the moment. Finally, it should lead students to adopt the critical and creative attributes of the scientists, including seeking and evaluating evidence and taking part in reasoned debates.

Leach (2002) argues that learning about science requires developing students' understanding of how scientists undertake empirical investigations to address a question or problem as well as to develop the ability to use standard laboratory instruments and procedures in undertaking investigations. To develop such competences students should be enrolled into scientific inquiry processes, starting from identifying a problem to planning a problem-solving strategy and reaching a sensible solution for the problem (Ntombela, 1999) that should be evaluated for its empirical support and theoretical consistency. The fulfillment of this aim requires that activities with high degree of openness are performed so that students can draw upon their own particular ontological and epistemological representations and test them against empirical evidence and other concurrent explanations. In addition, it requires dealing with the complex interrelationship between theory and evidence (Leach, 1999) as well as with the provisional nature of science knowledge. The implementation of activities with such characteristics may be impaired by teachers' beliefs in that doing investigations is performing receipt-based laboratory activities (Ntombela, 1999). In addition, learning epistemological knowledge should not be expected to be a short time process. In fact, there is some empirical evidence that students' epistemological conceptions remain unchanged despite their participation in a yearlong project-based, hands-on science courses (Moss, Abrams & Robb, 2001). This result is relevant because students' ideas of how science knowledge became reliable may influence their performance in the lab. According to Leach (2002), there are three major representations that influence students' expectations *towards* and behavior *in* the lab. Firstly, they see measurement and data collection as copying reality. This belief leads them to approach the process of drawing a conclusion as one of stating what happened in terms of data collected. Secondly, they adopt a radical relativist approach that leads them to conceptualize the drawing conclusions process as inherently problematic because they think that every individual can draw the conclusion he/she wants from the same set of data refusing the possibility of evaluating conclusions drawn against data collected. Thirdly, they believe that what scientists believe in and what they do in the lab and the data they collect are all interrelated. This belief prevents them from judging the confidence they can put in individual data values. It s worth emphasizing that these beliefs can hardly be dismissed by telling students that they are wrong or by any sort of structured activity performed in lab class. This is due at least in part to the tacit nature of scientific methodology. Dismissing them would require students to have the chance to spend some time in a science research lab, working with the scientists, in order to get a feeling of how they plan, conduct, and reorient an experiment and how they use insight and creativity in their jobs.

If science education lab activities are to succeed in helping students to learn about science, then they should require students to engage in an inquiry process similar to the one carried out by scientists in their research settings. However, research has shown that most of the lab activities carried out in schools are receipt-based close activities (Leite & Dourado, 2007; Ramalho, 2007) that can be carried out mechanically and are hardly able to develop students' reasoning abilities and learning how to learn competences.

In addition, although the Portuguese compulsory education school curricula acknowledges the nature of science as an important component of a science literate person, this seems to be one of the areas that teacher education programs have not taken seriously, as there are some undergraduate teacher education programs that do not include a compulsory course on the nature of science. On the other hand, research has shown that teachers are highly dependent on textbooks, namely in what concerns the lab activities carried out in their science classes (Leite & Dourado, 2007; Ramalho, 2007). Besides, research focusing on Portuguese science textbooks, shows that they are hardly consistent with science education research results in many areas namely in the area of how to use the laboratory for teaching science. In fact, there is some evidence that textbooks do not accompany the modifications of the educational policies on this issue that have been introduced by curriculum reforms (Moreira, 2003), and that they keep on suggesting close lab activities (Figeiroa, 2001; Leite, 1999; Moreira, 2002, Sequeira, 2004) that show several types of internal inconsistencies (Leite, 2006), do not deal appropriately with the inter-relationships between data, evidence and conclusions (Leite & Figueiroa, 2004) and that concentrate on low level scientific explanation (Figeiroa, 2007).

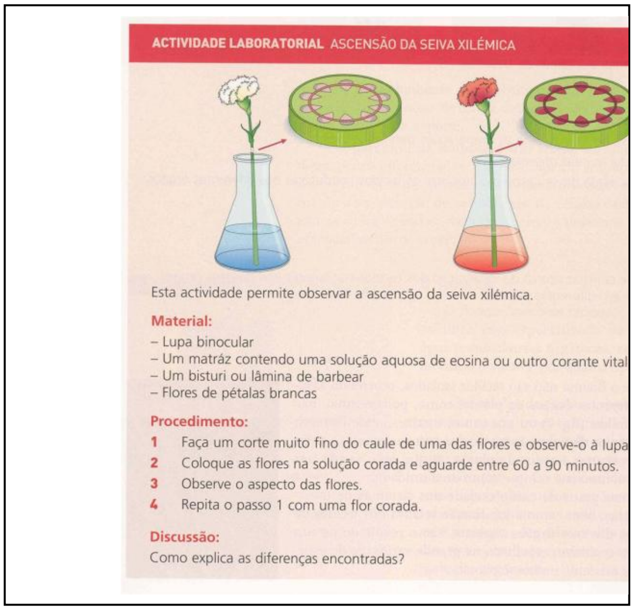
Therefore, the question is whether or not teachers can rely on textbooks lab activities if they want their students to learn about science and to develop adequate images of science and scientists so that they can behave consistently in their daily lives.

Textbooks lab activities and learning about science

Students develop ideas about science and science knowledge from lab activities carried out in school science classes. In addition, the lab activities performed may foster the development of some competences rather than others depending on the way they are structured and the involvement they require from students. Students' cognitive involvement with lab activities is of major relevance if learning from lab activities is to be transferred to every day contexts and to promote citizenship education.

Going through the science textbooks several obstacles to educating for citizenship can be found. The most frequent one has to do with the fact that almost all lab activities included in science textbooks are based on receipt like worksheets. As these types of worksheets (see examples bellow along with the discussion of other obstacles) give students information about procedures to follow, including data to collect and data analysis procedures to adopt, they can hardly help students to develop competences related with doing science.

Another obstacle is related to the fact that some worksheets convey students the idea that doing science is just to "watch and see". Worksheet A (given in figure 1) enables students to see that colorful water goes up into the carnation.



ACTIVIDADE LABORATORIAL ASCENSÃO DA SEIVA XILÉMICA

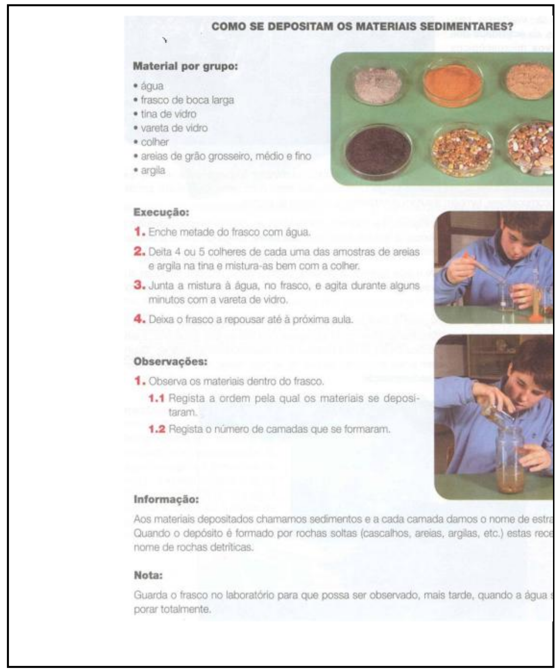
Esta actividade permite observar a ascensão da seiva xilémica.

Material:
– Lupa binocular
– Um matráz contendo uma solução aquosa de eosina ou outro corante vital
– Um bisturi ou lâmina de barbear
– Flores de pétalas brancas

Procedimento:
1 Faça um corte muito fino do caule de uma das flores e observe-o à lupa
2 Coloque as flores na solução corada e aguarde entre 60 a 90 minutos.
3 Observe o aspecto das flores.
4 Repita o passo 1 com uma flor corada.

Discussão:
Como explica as diferenças encontradas?

A



COMO SE DEPOSITAM OS MATERIAIS SEDIMENTARES?

Material por grupo:
• água
• frasco de boca larga
• tina de vidro
• vareta de vidro
• colher
• areias de grão grosseiro, médio e fino
• argila

Execução:
1. Enche metade do frasco com água.
2. Deita 4 ou 5 colheres de cada uma das amostras de areias e argila na tina e mistura-as bem com a colher.
3. Junta a mistura à água, no frasco, e agita durante alguns minutos com a vareta de vidro.
4. Deixa o frasco a repousar até à próxima aula.

Observações:
1. Observa os materiais dentro do frasco.
1.1 Regista a ordem pela qual os materiais se depositaram.
1.2 Regista o número de camadas que se formaram.

Informação:
Aos materiais depositados chamamos sedimentos e a cada camada damos o nome de estra
Quando o depósito é formado por rochas soltas (cascalhos, areias, argilas, etc.) estas rece
nome de rochas detríticas.

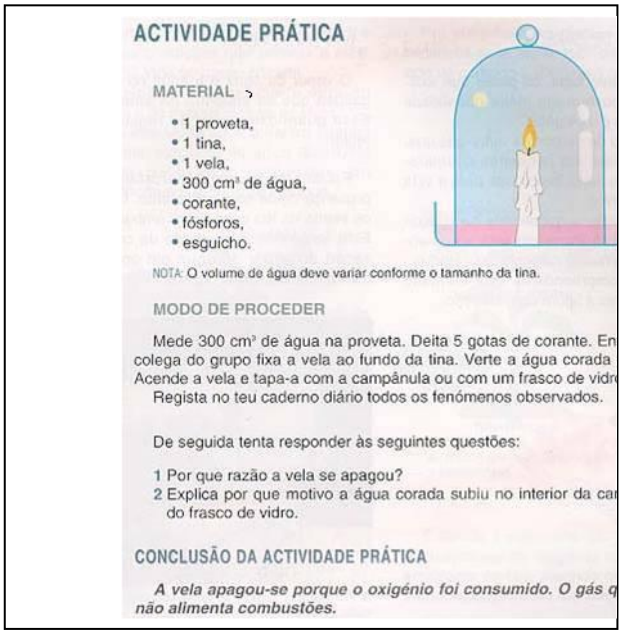
Nota:
Guarda o frasco no laboratório para que possa ser observado, mais tarde, quando a água s
porar totalmente.

B

Fig. 1: Science textbook lab worksheet showing what happens but giving insight on why it does

What the activity shows (what happens) is something that some students might already know from their daily lives. However, the worksheet is not too useful for students to go behind commonsense and to answer the final question: How do you explain the differences found between the two carnations? Moreover, and opposite to what is stated, students are not expected to give their own explanations but rather expected to explaining the way scientist do. The trouble is that they cannot see the explanation "there". Worksheet B also shows what happens when students put grains of different sizes into water, something that children are also familiar with. If it is true that it does not ask students to guess an explanation for what they will observe (like worksheet A does), it is also true that performing the activity will be of little educational value if an explanation for the results obtained is not worked out. The performance of these activities may result in time wasting if explanations are not worked out. Moreover, it will convey students an idea that science is just a sort of "watch and uncover a hidden explanation" and will not lead them to develop reasoning abilities.

Some of the worksheets are not consistent in terms of the relationship between the lab procedure and the conclusion to be draw from it. Examples of such worksheets are given in picture 2. Both worksheets deal with a candle burning. While worksheet A does not make it explicit the objective of the activity nor does it present a problem to be solved, worksheet B starts by asking what are the properties of the constituents of air.



ACTIVIDADE PRÁTICA

MATERIAL

- 1 proveta,
- 1 tina,
- 1 vela,
- 300 cm³ de água,
- corante,
- fósforos,
- esguicho.

NOTA: O volume de água deve variar conforme o tamanho da tina.

MODO DE PROCEDER

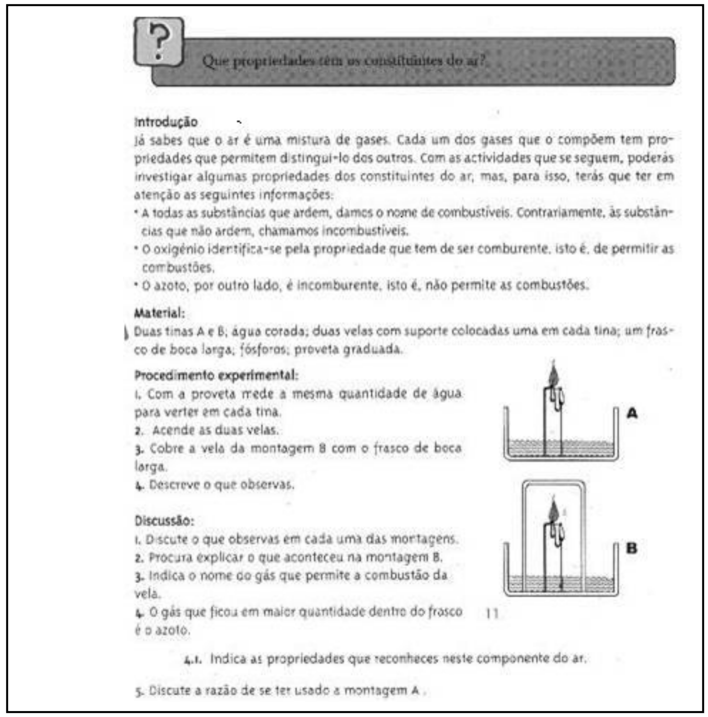
Mede 300 cm³ de água na proveta. Deita 5 gotas de corante. En colega do grupo fixa a vela ao fundo da tina. Verte a água corada Acende a vela e tapa-a com a campânula ou com um frasco de vidr Regista no teu caderno diário todos os fenómenos observados.

De seguida tenta responder às seguintes questões:

1 Por que razão a vela se apagou?
2 Explica por que motivo a água corada subiu no interior da ca do frasco de vidro.

CONCLUSÃO DA ACTIVIDADE PRÁTICA

A vela apagou-se porque o oxigénio foi consumido. O gás q não alimenta combustões.



Que propriedades têm os constituintes do ar?

Introdução

Já sabes que o ar é uma mistura de gases. Cada um dos gases que o compõem tem propriedades que permitem distingui-lo dos outros. Com as actividades que se seguem, poderás investigar algumas propriedades dos constituintes do ar, mas, para isso, terás que ter em atenção as seguintes informações:

- A todas as substâncias que ardem, damos o nome de combustíveis. Contrariamente, às substâncias que não ardem, chamamos incombustíveis.
- O oxigénio identifica-se pela propriedade que tem de ser comburente, isto é, de permitir as combustões.
- O azoto, por outro lado, é incomburente, isto é, não permite as combustões.

Material:

Duas tinas A e B; água corada; duas velas com suporte colocadas uma em cada tina; um frasco de boca larga; fósforos; proveta graduada.

Procedimento experimental:

1. Com a proveta mede a mesma quantidade de água para verter em cada tina.
2. Acende as duas velas.
3. Cobre a vela da montagem B com o frasco de boca larga.
4. Descreve o que observas.

Discussão:

1. Discute o que observas em cada uma das montagens.
2. Procura explicar o que aconteceu na montagem B.
3. Indica o nome do gás que permite a combustão da vela.
4. O gás que ficou em maior quantidade dentro do frasco é o azoto.
   4.1. Indica as propriedades que reconheces neste componente do ar.
5. Discute a razão de se ter usado a montagem A.

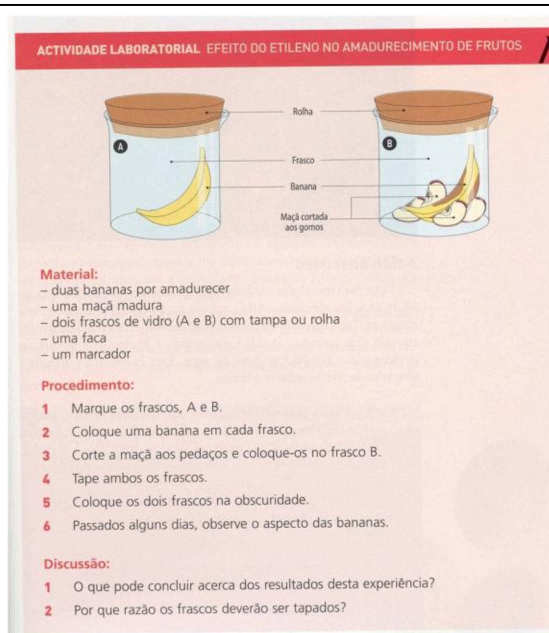
A B

Fig 2: Science textbook lab worksheets dealing with constituents of air

Based on an analysis of the conclusion of activity A, it can be inferred that it aims at showing that there is oxygen in the air and that intervenes in the burning of the candle. In fact, the conclusion assures that "the flame of the candle vanished because the oxygen was consumed". As far as worksheet B is concerned, it starts by synthesizing the properties of the constituents of air mentioning among others that Oxygen takes part in burning phenomena. At the discussion section it asks students to explain what happened in setting B. Both worksheets deal with the same knowledge and do it in similar wrong ways as none of them asks students to measure the concentration of oxygen inside the bell-shaped glass (A) or the lab beaker (B), during the burning process. It seems that there is an intention of explaining the entrance of water into the bell-shaped glass or the beaker, based on the idea of oxygen consumption. However, there are quite big problems with this. One is that the main cause of entrance of water is not oxygen consumption but rather changes in the inner pressure due to changes in temperature caused by the flame. The other is that oxygen is not the only gas involved into the candle burning. If it is true that oxygen from the air is "consumed", it is also true that CO_2, CO, H_2O, etc are "produced". Hence, the final level of water would hardly be explained based only on oxygen "consumption" only. Finally, it is not expectable that the concentrations of oxygen inside the bell shaped glass or the baker decrease to zero. Usually, it reduces from about 21% to around 12 to 14%. Hence, instead of collecting data that would provide evidence that there is oxygen in the air and that oxygen is consumed when a candle burns, these worksheets rely on students' knowledge (A) or on knowledge given to them (B) and distort the procedure and the interpretation of results to lead students to guess and "see what they cannot see", although they could easily "see it" if they were asked to use an oxygen meter. This leads to making the point that students will not develop competences related to the building of empirical based argumentation if they are exposed to activities like these.

Another problem with lab worksheets comes from the inappropriate control and manipulation of variables. To answer to the lab worksheet shown in figure 3 students need to guess that apple can spread out ethylene and that this gas has an accelerating effect over the matureness of the banana. Despite the fact that the title of the activity mentions "the effect of ethylene on fruits matureness", no ethylene is used in the activity. Besides, the idea that apples has or can produce ethylene does not belong to common sense knowledge. Therefore, although students might be familiar with the effect of mature apples on kiwis or other fruits, they probably are not aware of the ethylene content *of* and release *from* mature apples and therefore they will not be able to guess what ethylene has to do with apples and bananas. On the other hand, it is well-known that students tend to make generalizations from single cases and uncontrolled experiments. The lack of an appropriate control (involving banana and ethylene) may not only impair students from reaching a conclusion but also prevent them from developing adequate images of the science practice.

Finally, it should be mentioned that some worksheets suggested by textbooks describe lab procedures that are inconsistent with the objective or the "research problem" they present. Fig 4 shows an example of such worksheets. The problem is "what happens to the food that arrives at the different parts of the plants. What is suggested is to test rice, carrots and potatoes for the presence of starch, using iodine. Of course, there is a mismatch between the goals prescribed for the activity and what the activity can be useful for. Again, what is under question is the value of such activity for learning about science, and for citizenship education.



ACTIVIDADE LABORATORIAL EFEITO DO ETILENO NO AMADURECIMENTO DE FRUTOS

Material:
– duas bananas por amadurecer
– uma maçã madura
– dois frascos de vidro (A e B) com tampa ou rolha
– uma faca
– um marcador

Procedimento:
1 Marque os frascos, A e B.
2 Coloque uma banana em cada frasco.
3 Corte a maçã aos pedaços e coloque-os no frasco B.
4 Tape ambos os frascos.
5 Coloque os dois frascos na obscuridade.
6 Passados alguns dias, observe o aspecto das bananas.

Discussão:
1 O que pode concluir acerca dos resultados desta experiência?
2 Por que razão os frascos deverão ser tapados?

Fig 3: Science textbook lab worksheet on the effect of ethylene on fruits

? O que acontece ao alimento que chega às diferentes partes da planta?

DESCOBRE

Enquanto que uma parte do alimento produzido é utilizado pela planta para o seu crescimento e para a produção de energia, a restante é armazenada como reserva nos diferentes órgãos. Para observares este facto realiza a seguinte actividade e discute os resultados.

MATERIAL
• Cenoura
• Batata
• Arroz
• Água iodada
• Conta-gotas
• 3 vidros de relógio

MODO DE PROCEDER
1. Coloca em cada um dos três vidros de relógio uma pequena porção de cenoura, arroz e batata, respectivamente.
2. Deita sobre cada uma das plantas duas gotas de água iodada.

Fig. 5.7

3. Observa o que sucede e regista os resultados no caderno diário.

DISCUSSÃO DOS RESULTADOS
1. Refere o que aconteceu a cada planta quando deitaste as duas gotas de água iodada.
2. Sabendo que a água iodada cora o amido de azul, o que podes concluir quanto à existência de amido na cenoura, no arroz e na batata?

Fig 4. Science worksheet showing that there is starch in some materials

Concluding remarks

This paper discusses the role of science education in education for citizenship. It was argued that science education in general and science lab activities in particular can give a meaningful contribution to education for citizenship. To succeed in doing so, lab activities should require students to develop competences related to data gathering, empirically based argumention, conclusion drawing, critical judgement, among others. However, content analysis of lab activities indicates that lab activities often lack internal consistency and empirical support for the conclusions drawn. Therefore, it suggests that citizenship relevant competences are hardly developed if teachers put lab activities into practice like textbooks suggest them. If it were doing so, their performance would become a waste of time and a way of impairing learning about science instead of promoting science education for citizenship. Hence, if science teachers want to use the lab to educate for citizenship (as the curricula wants them to do), then they need to be critical about science textbooks lab activities and to be able to modify them, by increasing their internal consistency and their degree of openness, in order to have the chance of leading students to develop an adequate image of science and science practice to develop competences that are needed by citizens living in modern democratic societies.

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