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The Role of WebQuests in Science Education for Citizenship

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Summary

Science education for all aims at developing scientifically literate citizens. WebQuests are problem-solving activities that can promote the development of competences thought to be relevant for a responsible and well-informed citizenship. By solving WebQuests students may develop conceptual, epistemological and procedural knowledge as well as interpersonal skills and 'learn how to learn'. This article discusses the role of WebQuests in facilitating the lower secondary school students' understanding of science concepts, promoting their images of scientists and fostering their problem-solving abilities. Students' reactions to this kind of educational resource are also analysed.

Keywords

WebQuests; science education for citizenship; problem solving; science learning; images of scientists

Introduction

Over the last three decades or so, modern societies have been assisting to an ever-increasing entrance of Information and Communication Technologies (ICT) in the daily lives of their citizens. Internet-based ICT are the ones that most changed people's ways of communicating and living (D'Eça, 1998). This type of ICT enables access to information and knowledge and makes communication between geographically distant persons or institutions as easier and faster as communication between neighbours. ICT became so fascinating especially to young people that politicians and educators sooner felt that school should find ways of taking advantage from such fascinating power. However, this aim has been hardly fulfilled not only because school is conservative but also because ICT, namely when internet is at stake, is a sort of double sided coin (Cox, 2000; Fullick, 2004): it can provide access to lots of information but the amount of information together with the ill-organized way of putting documents in the web can also lead to information overload and cause disorientation in navigation. Therefore, taking profit from ICT information capabilities requires knowledge-selection and evaluation competences that most of the times school fails to develop in the students that attend it.

The exponential growth of science knowledge together with the idea of science for all require school to develop lifelong learning competences so that after leaving school citizens can continue not only updating their science knowledge background by themselves but also using new knowledge in their individual and professional lives (King, 2001; Roth & Désautels, 2004). To succeed in doing so, citizens would need to be acquainted with search, evaluation and use of information sources. They also need to be able to make sense of what they can read or hear and to communicate it to others. At the compulsory education level, science education has a part to play in preparing all students for lifelong learning, namely by teaching them how to make a positive use of Internet-based ICT for developing scientific literacy (Fullick, 2004). A way of using Internet for doing so may be through WebQuest activities.

WebQuests are problem-solving activities in which the information needed to solve the problems is all or in large part available in the web (Dodge, 1997b). WebQuests became motivating for diverse people (Dodge, 2006) and large amount and variety of WebQuests dealing, among others, with several topics including socio-scientific issues can be found in the web (e.g., www.webquest.org/index.php). As recent WebQuests research reviews (e.g., Cruz, 2006, Guimarães, 2005; Neves, 2006; Silva, 2006; Vieira, 2007) make it evident, over the last decade, a considerable amount of research has been carried out in order to evaluate students' opinions on WebQuests as teaching and learning resources. In general, those studies indicate that students enjoy working with WebQuests and would like to solve more WebQuests. However, they also suggest that research focusing on the efficacy of this teaching resource for promoting students' conceptual, procedural, and epistemological competences in science is quite rare, namely when natural and physical sciences are at stake.

Drawing heavily on three research studies (Neves, 2006; Silva, 2006; Vieira, 2007) carried out in low secondary school science courses, this paper discusses the role of WebQuests to facilitate the understanding of science concepts, to promote the images of the scientists and to foster problem-solving abilities. Students' opinions on this kind of educational resource will also be analysed.

ICT and science education for citizenship

Science education for citizenship

Every citizen plays a role in the development of the society to which he/she belongs to, However, citizens living in democratic societies have an additional role to play in the evolution of their own societies as they are asked to participate in government and parliament members' elections and therefore the decisions they take when they vote (in whatever election it is) will influence the future of the society.

Science was for long seen as a subject for specialists with no importance at all for the common citizen (Roth & Désautels, 2004). This way of conceptualizing the public relationship with science prevented most citizens from exerting an informed citizenship and may be at least in part responsible for the serious environmental problems that nowadays the Earth planet faces. The threat of the lack of potable water and the consequences (e.g., global warming) of the use of non-renewable and pollutant energy sources are two of the most relevant environmental problems that humanity has to face urgently (Manzanal, Barreiro & Jiménez, 1999; Pérez-Ruiz *et al.*, 2006). The increasing awareness of the tragic consequences for environment, health, economy, etc, of people's alienation from science led to educational policies that emphasize education for all and that acknowledge the key role of science education for promoting development, well-fare, equity and active and responsible citizenship (Roth & Désautels, 2004).

Opposite to the focus on science content that characterized science teaching for decades, science education for citizenship cannot just concentrate on the disciplines as such but it has to rather focus on the social, technological and environmental implications of science for the people, the economy and the environment (Jenkins, 1999; Roth & Désautels, 2004). Besides, given that when voting for electing their governors, citizens are indirectly taking decisions about science research policies, then they need to become aware of the nature of the scientific enterprise and the way it relates to politics, so that they can elect the politicians that they feel can better foster a development of science consistent with the sustainable development of the planet. Hence, the Portuguese National Curriculum (DEB, 2001) acknowledges the idea of 'educating through science'. To achieve this goal, science education should include the following three dimensions (Hodson, 1990): learning science (e.g., concepts, laws, theories), learning how to do science (e.g., methods and tools used by the scientists) and learning about science (e.g., nature of science, characteristics of science knowledge, image of scientists).

Philosophers of science no longer accept the idea of science as a body of true and objective knowledge. They rather see science as a problem-solving multidisciplinary activity done by professionals that engage in networks spread all over the world and that produce knowledge that can just be taken as the best available at the moment (McComas, 1998). However, there is some empirical evidence that students and teachers hold conceptions about science and the scientists that are not consistent with it (Manassero, *et al.* 2001; Fung, 2002). A possible explanation for this mismatch is that the new way of conceptualizing science may make some people feel insecure about science knowledge and therefore it is avoided in the science classroom. However, despite the novelty of this conception of science, it is acknowledged by the Portuguese National Curriculum for compulsory education (DEB, 2001) and should therefore be worked out in science classes in order to help students to acquire a good level of scientific literacy.

Problem-based learning (Lambros, 2002) would be a proper way to do so because it could enable students to simultaneously develop competences within the scope of the three dimensions of science education referred to above as well as learning how to learn, communicational, and interpersonal relationship competences that are relevant for every citizen. In fact, as in Problem-Based Learning contexts students learn without being formally taught by a teacher, they not only learn science and get some insight on how scientists work but they also develop learning how to learn competences, including those related to problem solving strategies. In addition, if problem solving takes place in the

Internet, then they can develop informational literacy (Oliveira, 2002) and learn how to select and use the information that is available to them (Mandel, 2003; Rogers, 2004). It is worth mentioning that the National Curriculum (DEB, 2001) also acknowledges the development of these competences in science classes both in cross curriculum areas and in disciplinary subjects.

ICT in science education for citizenship

The most outstanding and widespread ways of using ICT have to do with Internet-based ICT. Over the past decade or so Internet-based ICT entered almost every domain of our daily life and have been increasingly changing our ways of living and communicating with people. Suddenly, letters and post-cards gave place to e-mail messages, post-sent paper invoices were replaced by electronic downloadable invoices, visits to the bank or to certain shops are no longer required, the telephone is being replaced by the skype, etc.

As Bartolomé (1999) has stated, no matter whether we like it or not, Internet will be with us for many years and we do better to face it with a positive feeling and be prepared for its ever surprising novelty. However, to take profit from the Internet potential, citizens need to develop "informational literacy" (Oliveira, 2002) that enables them not only to technically use the Internet but also to evaluate and use the information they access to. Internet makes easily, fast and cheaply available lots of information. However, that information may come from a very large variety of sources ranging from those that deserve full credit to others that despite having been rejected for publication elsewhere were made available by their authors in their personal web pages, escaping to any peer refereeing system (Mandel, 2003).

Interactivity gives Internet an added value, not only because it facilitates information organization and access but also because it is the main cause for its motivational power that makes students feel willing to learn (Fullick, 2004; Bartolomé, 1999). Despite the resistance of some schools and/or teachers, computers, followed by the Internet, have been progressively entering the schools and the classrooms as well. Governors realized that the school has to prepare students to appropriately deal with ICT when they become active citizens. Also, by using more and more Internet to communicate with schools and teachers, governors have been fostering the use of the Internet in schools. Whatever teachers' age and professional experience, they can no longer refuse using Internet. In fact, not only novice teachers are forced to use it in their very firsts step of their professional lives that is to apply for a job in a school but also in-service and experienced teachers have to use it if they want to keep a place in a given school. This kind of bureaucratic measures can help teachers to overcame their fear from the Internet and facilitate the entrance of the computer in the classroom.

As far as ICT in the classroom is concerned, the Portuguese Curriculum for compulsory education (DEB, 2001) acknowledges ICT, including Internet, and argues for the development of students' informatics competences, ih cross curriculum areas as well as in every school subject. Hence, science teachers must engage in this cross-curriculum enterprise and also use ICT, including internet-based tools, to enrich the science curriculum and to promote students' learning in a variety of ways (D'Eça, 1998; Pickersgill, 2003; Fullick, 2004).

As it was mentioned above, learning science is only one of the aims of science education. Therefore, using the Internet as a science education resource requires that it is used with a variety of purposes, being the acquisition and/or development of information on science concepts just one of them (Rogers, 2004). If compulsory science education is acknowledged as having as it main goal the development of students' scientific literacy (as it happens nowadays in Portugal), then it has to focus not only on science concepts but also in science processes, on the epistemological dimension of science and on the relation and use of all of them to daily life (Roth & Désautels, 2004). In addition, science education should be taught in such a way as to prepare students for further independent learning, so that as soon as they leave school they have enough tools to maintain their knowledge-base updated and to develop it especially if their personal, professional or citizen lives require so. This means that students need to develop lifelong learning competences in science which further means that they need to learn how to learn and how to take profit from all the facilities that an ever and ever more accessible resource – the Internet - offers to them.

WebQuests in science education for citizenship

A brief characterisation of WebQuests

Bernie Dodge, in cooperation with Tom March, developed WebQuests in the early 90s within the scope of the course EDETC 596 (interdisciplinary Teaching with Technology) at the University of S, Diego, California. Although WebQuests are problem-solving activities, they model students' learning as they draw heavily on guided Internet search by including a list of pre-selected resources available in the Internet (Dodge, 1995) and offering guidelines on how to solve the problem task.

As far as the structure of a WebQuest is concerned, it should include at least six parts (Dodge, 1997): Introduction, Task, Process, Resources, Evaluation, and Conclusion. Carvalho (2002) recommends the inclusion of two other parts: Home page, and Help page. The Homepage informs the visitor about the site he/she is accessing (giving data about type of activity, author, target school level, date of construction, etc) while the Help page explains how the site works (offering, for example, information for performing some technically based activities) and suggests a sequential use of the document.

The educational value of a Webquest depends heavily on what the students learn by solving it. Hence, the Task is a central part of a WebQuest activity, as it is the one that establishes what they are supposed to learn. In addition, it should challenge and motivate students (Dodge, 2002), and promote the relationship between the school content to be learned and their own daily lives (March, 2005), so that they can feel rewarded by their engagement in the task (Carvalho, 2004). According to Dodge (2002), there are 12 types of tasks ranging from the simplest retelling tasks to the most complex ones that require the solver to build up a product (creative products development) or to judge something (judgement) or to do a meta analysis of the development of science (meta scientific). The Process is the part of a WebQuest that guides students in the resolution of the task, telling them how they should organize themselves, in order to carry out the task and prepare and share with others the final product (Dodge, 1999; Carvalho, 2004). It cannot be too directive in order to avoid preventing students from developing learning how to learn competences but it should be strict enough so that students don't loose time doing irrelevant things that may also make them feel frustrated. The Resources (texts, experts, databases, etc) to be used should be available in the web through a link, preferably named by a keyword that informs about their contents (Carvalho, 2002). Dodge (1997a) argues for the inclusion of the resources in the process page, as he believes that this can prevent students from feeling tempted to start navigating in the web, without instructions, before reaching the resources page. The Evaluation page should inform the students about the qualitative and the quantitative dimensions that will be used to assess their performance when solving the WebQuest. As Bellofato *et al*. (2001) emphasised, those dimensions depend on the nature of the task and should therefore be consistent with it. They are relevant not only for final assessment purposes but also for guiding students in their job of solving the WebQuest. The Introduction should motivate students for the task while the Conclusion should motivate them for going deeper into the issue dealt with in the WebQuest or in other related issues. However, neither the introduction nor the conclusion can give insights on the answer expected for the task (Dodge, 1997a).

Bearing in mind the time required to solve a WebQuest, activities of this type can be classified as short WebQuests and long WebQuest (Dodge, 1997b). The former type of WebQuests leads students to understand new information and to integrate it with previous knowledge and it can be solved during one to three class periods. The resolution of the later type of WebQuest can last for one week to one month and it leads to re-examine previous knowledge to increase its accuracy, to transform one's own knowledge and point of view and to look at things from a different perspective.

WebQuests have technical, aesthetical and scientific quality requirements (Bellofato *et al.*, 2001; Carvalho *et al.*, 2004; Dodge, 1998; Jonhson & Zufall, 2004). Therefore, before being used in a classroom or made available on-line, WebQuests should be content, technically and aesthetically analysed by experts and its usability should also be assessed with subjects similar to the future users. This is very important because teachers may want to use WebQuests in their classes and they may not be aware of some of the quality criteria that a good WebQuest needs to fit.

Educational value of WebQuests

Using WebQuests is a way forward of bringing the Internet into education. They enable to take profit from students' time and to promote high levels of reasoning (Dodge, 1995). However, using them as using any other educational resource will not overcome all the problems of education. Besides, their educational value depends not only on their characteristics but also on the way they are used and the aim they are used for.

According to March (2005), WebQuests have educational value from a student's point of view due to their motivational power, their capacity to promote reasoning abilities and to offer cooperative learning opportunities. In fact, it is fully accepted that students enjoy navigating in the Internet, but for Internet navigation to become worthwhile they have to learn how to use, relate and integrate information coming from different sources. WebQuest can help them developing such information-use related competences and, at the same time, foster the development of interpersonal and communication competences, specially if the WebQuest is solved in small groups.

Mentxaka (2004) adds advantages from a teacher's and a curriculum point of view. In the former case the author argues that WebQuests facilitate teachers' job in the classroom, as they themselves guide students' work and facilitate the introduction of the Internet in the classroom. In fact, when using

WebQuests, teachers do not teach in the sense of transmitting (in a more or less teacher-centred way) knowledge to the students; they just take the role of students' learning facilitators. In the later case, WebQuests foster the development of cooperative and problem solving abilities. In addition, if students solve WebQuests working in small groups, then they will have the opportunity of cooperating within the group and competing with other groups. As Carvalho (2002), points out, this would prepare students to work cooperatively, as well as to collaborate and to compete in their future working lives.

To solve the problem associated with the task, students need to search the information in the Resources, to make sense of it, to select the information felt as relevant for the task and to integrate information selected from diverse sources. This enables them to develop lifelong learning competences relevant for citizens living in modern societies. However, as the information sources are listed in the WebQuest, students will not have opportunities to develop competences related to looking for information sources in the web. Due to the amount and the diversity of material available in the Internet, these competences have to be developed by means of other teaching strategies and resources.

Besides, as the task is defined by the WebQuest author(s), and therefore given to the students in a quite final form, they will not develop competences related to problem identification and (re)formulation. This competency is also relevant for an active citizenship and can be better develop through other varieties of problem-based learning (Lambros, 2002). However, they can contribute to developing problem-solving related competences (Chang & Barufaldi, 1999; Gandra, 2001), ranging from problem analysis and strategies planning to problem-solving process evaluation.

WebQuests and science learning

Two pieces of research aiming at comparing the effect of short and long WebQuests concentrated on 5th (Neves, 2006) and 8th (Vieira, 2007) graders' science learning. The science contents selected for these pieces of research were "The importance of water for living organisms", a 5th grade Natural Sciences theme, and "Energy sources", a 8th grade Physical Sciences theme. These are science topics that have a social component and a strong relationship with everyday life. Hence, they were thought to be relevant for any citizen and adequate to develop citizenship competences and to be taught through problem-solving.

In each piece of research a *quasi*-experimental pre- post-test design (Gall, Gall & Borg, 2003) was adopted and two classes were enrolled. Besides, in each grade level a long WebQuest was used in one of the classes and two (5th grade) or three (8th grade) short WebQuests were used in the other to teach the selected science topic. Whatever the grade level and the type of WebQuest used, by solving one or more WebQuests in small groups, all the students of a grade level would learn the same concepts and ideas, over similar periods of time. Evidence of science leaning was collected through science tests that both focused on the contents dealt with in the WebQuests and were applied twice (before and after the resolution of the WebQuests) to each class.

It is worth mentioning that WebQuests are included in the master dissertations that are available from the RepositoriUM of the University of Minho (http://www.sdum.uminho.pt) and that they include different types of tasks that were classified according to Dodge's (2002) taskonomy. The WebQuests for the 5th grade include a creative product task. The long WebQuest targeted to 8th graders includes judgement, design and consensus-building tasks; the first and the second short WebQuests include compilation and journalistic tasks, respectively; the third one includes a consensus-building task (like the long WebQuest).

The final products are different from study to study too. The 5th grade long WebQuest as well as each one of the short WebQuests ask students to prepare a poster on water-preservation related issues, that should be organized from the information available in the WebQuests and afterwards discussed with the whole class. The 8th grade long WebQuest and the third short WebQuest asked each small working groups to prepare a proposal to be submitted to the electric energy supply company, arguing for the most viable energy source to be selected for a new electric power station. It also asked them to make a presentation to the whole class and to discuss with other groups which energy source should be chosen. The first short 8th grade WebQuests asked students, to organize an informative leaflet about the non-renewable energy sources dealt with in the WebQuest. The second one asked students to make an oral presentation about one of the renewable energy sources about which they had been searching for information.

Table 1 synthesises the results of the 5th grade study, by comparing the evolution of the two classes on the test (when applied as pre- and post-test) on "The importance of water for living organisms". The analysis of data given in this table shows that both research groups (SWQ – using short WebQuests, and LWQ – using long WebQuests) underwent positive conceptual evolutions due to the study of the theme through WebQuests. However, SWQ group outperformed the LWQ group in a larger number of topics (nine) than the LWQ (six) did. These results suggest that the two short WebQuests were more efficient than the long WebQuest was.

Table 2 gives a summary of the results obtained with the 8th grade groups. The results of this research study seem to indicate that the long WebQuest was more efficient than the short WebQuests as the conceptual evolution of students in the LWQ group was larger than that of the SWQ group. In fact, although there was a positive conceptual evolution in both groups, the LWQ groups outperformed the SWQ group in a larger number of topics (five) than the SWQ did (two). Surprisingly, the topics in which the LWQ group performed lower than the SWQ one are those that require higher levels of reasoning, namely comparison of vantages and disadvantages of diverse sources of energy.

This pre/post test comparison of 5th and 8th grade research results shows that, irrespective of the grade level and the science topic, all the research groups showed a positive evolution in their conceptual background due to the work carried out with the WebQuests. In addition, it may support the hypothesis that short WebQuests were more efficient with the younger students while long WebQuests were more efficient with the older students.

Table 1 – Comparative analysis of the evolution of the 5th grade classes on the science test

(N=48)

1.1.1 Topics	LWQ (n=24)	SWQ (n=24)
Movement/distribution of water in nature		
Origin of rain water	+	+
Possibility of rain water coming from sea and being not salty	++	+
Quantity of potable water available in the planet	+	++
Uses of water		
Concept of "potable water"	++	+
Human activities needing potable water	++	+
Concept of "polluted water"	++	+
Concept of "water inadequate for consumption"	+	++
Ways of preserving water		
Necessity of saving water	+	++
Measures to saving water in daily life	+	++
Ways of preventing water pollution	+	++
Agents responsible for water pollution		
Causes of water pollution	++	+
Possible consequences of water pollution	+	++
Importance of water treatment		
Possible water treatments	++	+
Relationship between water quality and health	+	++
Indicators of water quality	+	++
Obtaining potable water from polluted water	+	++

Note: **+** means students' positive evolution; **++** means students' bigger positive evolution

Table 2 – Comparative analysis of the evolution of the 8th grade classes on the science test

(N=52)

Topics	LWQ (n=26)	SWQ (n=26)
Non renewable energies: meaning, examples, pollutant character	++	+
Fossil combustibles: concept definition	++	+
Fossil combustibles: vantages and disadvantages	+	++
Nuclear power station: energy source and environmental impact	++	+
Renewable energies: meaning, examples, pollutant character	++	+
Non renewable energies *vs* Renewable energies	+	++
Electric power stations: energy sources	++	+

Note: **+** means students' positive evolution; **++** means students' bigger positive evolution

However, due to both the difference between the content topics used in the two studies and the reduced dimension of the samples, it can be argued that more research is needed in order to confirm or reject this hypothesis. Besides, a question can be raised about the efficacy of WebQuests when compared to other types of teaching and learning methodologies. To answer it, it would be necessary to compare the results of groups using WebQuests with those obtained by groups using other types of resources and teaching methodologies.

WebQuests and the image of scientists

An important but often forgotten or even rejected dimension of science education is learning about science (Hodson. 1990). Motivated by the need to find ways of strengthening it, a research study (Silva, 2006) aiming at analysing the effect of WebQuests in promoting adequate images of the scientist was carried out.

A *quasi*-experimental pre- post-test research design (Gall, Gall & Borg, 2003) was adopted and two 9th grade classes were enrolled in the study. One of the classes used a WebQuest (included in the master dissertation that is available in the RepositoriUM of the University of Minho: http://www.sdum.uminho.pt) and the other class carried out a task similar to the one included in the WebQuest but it was not given any instructions about procedures to be followed or sources to search information in. However, the later class could look for information in diverse places, including the internet. Bearing in mind Dodge's (2002) taskonomy, the WebQuest task can be classified as a creative product type task, as students had to prepare and perform a role-play on a discovery carried out by one of the three scientist belonging to the scientists set they had chosen to study when solving the WebQuest. Whatever the class, students were asked to solve the task by doing small group work and to concentrate on the same heterogeneous groups of three scientists. Evidence of learning about scientists was collected through a test (adapted from the VOSTS (Aikenhead, Ryan & Fleming, 1989) and the draw a scientist test (Mead & Metraux, 1957)) dealing with some characteristics of the scientists' personal lives and work. The test was applied twice (before and after the resolution of the task) to each class.

Table 3 shows an overall pre/post test comparison of the results obtained in the two classes, one using the WebQuest (WQ) and the other solving the same task, given to them in a 'paper and pencil' support (PS).

Table 3 – Comparative analysis of the evolution of the 9th grade classes on the test about scientist

(N=46)

1.1.2 Topics	WQ (n=23)	PS (n=23)
Influence of social context on scientists' work	+	-
Influence of cultural and religious contexts on scientists' work	+	-
Scientists' personal characteristics	=	=
Scientists' gender	=	=
Scientists' motivation	=	=
Scientists' work	-	+
Electric power stations: energy sources	+	-
Scientists' appearance	+	-

Note: **-** means students' regression; = means no change in students' results; **+** means students' positive evolution

Although no systematic pattern of differences was found, the group that solved the WebQuest showed bigger evolution than the other group in four topics and a regression in only one of the topics. In the remaining three topics, both groups showed similar evolutions. These results suggest that the WebQuest was more efficient in promoting students' ideas about scientists and their work than the methodology used in the other class. The superiority of the WebQuest may be due to the orientation given by the WebQuest as students using the WebQuest stated that they felt more orientated in the task than their PS counterparts who stated to have often felt themselves lost in the job. Anyway, the occurrence of a regression in a topic indicates that the use of WebQuests to foster students' learning about science should deserve more attention from both a research and a teaching methodology point of view. In addition, the occurrence of regression in several topics in the PS group may indicate that learning about science is not easy or motivating or both for the students and, consequently, a challenge may remain for science teachers and science teacher educators.

WebQuests and problem solving activities

The study carried out by Vieira (2007) concentrated also on the contribution of long and short WebQuests to the development of students' problem solving abilities. To fulfil this objective, a test on problem solving was applied twice (before and after solving the WebQuests) to both groups of 8th grade students. It included two problems, being one (electric power station problem) related to the science content and task dealt with in the WebQuests and the other (landfill problem) related to a different content and task. The idea underlying the use of two problems with different characteristics was to find out about whether or not solving WebQuests promotes the development of problem-solving competences and to get some insight on the dependency of such development on the problem-solver's familiarity with the content the problem focuses on.

Table 4 gives a summary of the results obtained for the diverse dimensions of problem-solving taken for the analysis of the data collected in this part of the study. First of all, it should be noticed that while in the electric power station problem both groups showed progress in all the dimensions used for the purpose of the analysis of the problem solving abilities, the same did not happen in the landfill problem. However, in the overall, the group that used the long WebQuest increased its performance more than the group that used three short WebQuests. In addition, no regression occurred in the LWQ but regressions occurred in SWQ into two of the dimensions taken into account.

Table 4 – Comparative analysis of the evolution of the 8th grade classes on the problem-solving test

(N=52)

Problem-Solving Dimensions	Problem Situation			
	Electric Power station		Landfill	
	LWQ (n=26)	**SWQ** (n=26)	**LWQ** (n=26)	**SWQ** (n=26)
Identification/understanding of the problem situation	++	+	++	=
Prediction/identification of relevant factors	++	+	=	-
Planning/definition of multiple tasks	++	+	++	+
Prediction/identification of information sources	++	+	++	+
Planning of problem-solving strategies	++	+	++	+
Acknowledgement of teamwork and opinions discussion	++	+	++	+
Conclusion/ending of reasoning	++	+	++	+
Presentation of critical/evaluative judgements	+	+	=	-

Note: **-** means students' regression; = means no change in students' results; **+** means students' positive evolution; ++means bigger positive evolution

These results may indicate that the problem solvers' familiarity with the content of the problem interferes with their performance but the results obtained with the landfill problem (which is unfamiliar to the students) suggest that working with long WebQuests promotes the development of some problem solving abilities. However, due to the reduced dimension of the sample and the low number of instances used to evaluate this possible effect of PBL on students' problem solving abilities should deserve more attention from researchers in ICT as well as in science education.

Students' opinions on using WebQuests to learn science

Students were asked to express their opinions on learning through WebQuests by answering to opinion questionnaires. A selection of results from two of the studies will be given in order to illustrate how students appreciate WebQuest as a teaching and learning resource.

Table 5, based on Vieira's (2007) study, shows that the aspect that a larger number of 8th grade students stated that they enjoyed most was searching in the Internet. Although this number is bigger for the SWQ group, the number of students that would like to have the opportunity of carrying out Internet search is equal in the two groups. Teamwork won the second place as an aspect that LWQ students enjoyed most. However, about one third of the students in each research group would like to continue working in small groups.

Table 5: Comparative analysis of positive aspects found by the 8th graders on WebQuest based classes (f)

(N=52)

Aspects …	Categories of answer									
	Internet search		Teamwork		Discussions		Presentations		Everything	
	LWQ	SWQ	LWQ	SWQ	LWQ	SWQ	LWQ	SWQ	LWQ	SWQ
They enjoyed most	15	21	9	1	0	2	2	0	0	2
To be maintained	8	8	8	10	0	2	4	0	6	6

Note: n LWQ = n SWQ = 26

Table 6, also based on the results of Vieira's (2007) study, shows that 11 students in each group hated the conditions in which they had to work. The main reason for that has to do with the fact that they often could not use the computers-room and had to loose time looking for permission to use a computer elsewhere in order to be able to carry out their job. However, about one third of the students in each group stated that they did not hate anything. On the other hand, one third of the students of the LWQ and a bit less in the SWQ stated that they would like teamwork to continue. The moderate enthusiasm of the students with regard to teamwork has to do with the fact that some students were not used to work ih small groups and that the members of some groups did not fit very well together.

Table 6: Comparative analysis of negative aspects found by the 8th graders on WebQuest based classes (f)

(N=52)

Aspects that they…	Categories of answer							
	Work conditions		Teamwork		Nothing		Don't know	
	LWQ	SWQ	LWQ	SWQ	LWQ	SWQ	LWQ	SWQ
Hated	11	11	5	2	8	8	2	5
Did not want to repeat	7	6	8	7	10	11	2	2

Note: n LWQ = n SWQ = 26

The results obtained with Silva's (2006) study show that contrary to what is often expected students may prefer doing other things rather than carrying out searches in the Internet. In fact, the results given in table 7 show that the majority of 9th grade students stated that the activity they enjoyed most was to search about scientists' lives and work. Although this result may moderate educators' enthusiasm with WebQuests (as they are internet-search based activities) it may nevertheless be interesting from a science education point of view, as it suggests that students may be willing to engage in learning about science.

Table 7 – Aspect that 9th graders enjoyed most and least on WebQuests based classes (f)

(N=23)

Aspects that they…	Categories of answer				
	Internet search	Search about scientist	Role-play	Everything	Nothing
Enjoyed most	1	16	3	2	---
Enjoyed least	1	---	5	---	17

As far as what students enjoyed least is concerned, the majority of the students were unable to identify a thing that they did not really enjoy. Role-play was identified as the least enjoyed activity by a larger (but still low) number of students. This reaction may be due to the fact that students were not used to this type of activity, it took them time and effort to prepare and they did not feel comfortable performing it in front of their classmates. Hence, it can be stated that although students enjoy solving WebQuest activities, some factors may interfere positively and others negatively with such enjoyment and science teachers should be aware of them.

Conclusions and implications

Results of Vieira's (2007) and Neves' (2006) studies indicate that WebQuests were efficient in terms of promoting the development of students' conceptual learning. Although it was expected, this result is not of much value because, whatever the teaching approach adopted, it can always be expected that some learning takes place due to a teaching intervention. Thus, the most interesting information coming from these studies lays in the fact that their results are not consistent with regard to the relative efficacy of long and short WebQuests. It could be expected that Long WebQuests would lead to a larger conceptual development, as they provide students with better opportunities to integrate knowledge. However, it did not seem to have been the case in the 5th grade study. A possible explanation for this discrepancy may be related to the differences between the students taking part in both studies. It may happen that younger students did not succeed as much as older students in doing such integration. This hypothesis may also be supported by the fact that 8th graders using a long WebQuest did not succeed two much in topics requiring high levels of knowledge integration. However, as the samples were small and the content topics were different, it seems necessary to develop further research in order to find out whether this difference is due to research design conditions or to the students' cognitive development or even to other unanticipated factors.

The results of Silva (2006) study indicate that Webquest are better than more traditional resources for promoting students' images of the scientists. This is an interesting conclusion, as the performance due to the use of a WebQuest is compared to the performance due to a different teaching approach and therefore this result can give some insight on the efficacy of WebQuest. In addition, the study concentrated on a topic belonging to the dimension learning about science that is as much as possible avoided by students and teachers. Bearing in mind that teachers can use with their students WebQuests available in the web, the fact that the WebQuest seems to have led to better performance may suggests not only that even teachers that do not feel too much compelled and well documented to teach about science can use this type of teaching resource to do so but also that students may succeed in developing some ideas related to the nature of science and scientists. However, going deeper into the results obtained it seems that the effect of the WebQuest was not independent of the topic under question. A possible explanation for this may be that some of the topics were more appealing to the students than others. However, it may also be the case that the resources made available for the students did not cover the diverse topics with similar depth, breath or motivational power. Hence, it seems necessary to carry out follow up studies in order to better understand these results. Parallel to these studies, research focusing on other aspects of the learning about science dimension should be carried out in order to further compare the efficacy of WebQuests for learning about science purposes.

Vieira's (2007) results concerning problem solving showed that the long WebQuest led to further development of students' problem solving abilities, as it was expected based on the fact that not only long WebQuests foster conceptual knowledge integration more than short WebQuests do but also because the former deal with more challenging and broader tasks and therefore may require students to invest more knowledge and effort to solving the problem. The fact that students' performance on the problem focusing on content and task that was familiar to the students was better than the other may reinforce the idea that problem-solving is not content independent. However, these results together with the fact some positive evolution occurred in students' performance regarding the landfill problem may suggests that solving problems develops problem solving abilities which are partially independent from the content. Nevertheless, the reduced number of problem situations used to evaluate this item prevents us from going further into this speculations and recommends further research including data collection from several, familiar and non-familiar, problem situations and tasks.

Whatever the type of WebQuest, and the content dealt with in the WebQuest, students stated that they enjoyed solving the WebQuests. This result could be expected based on research studies carried out with different aims and in different school subjects but it adds to our knowledge about resources for science education and indicates that teachers can relay on it to increase students motivation to learn science.

Although it is necessary that students enjoy the teaching resources and approaches, enjoyment is not enough to guarantee successful learning. However, taken together, the results of the three studies analysed above, indicate that WebQuests may not only motivate students to learn but also improve their learning and develop their problem solving skills. It can therefore be argued that WebQuests have a role to play in science education for citizenship. Then, the point is whether science teachers are willing or not to use them in their science classrooms. The shortage of WebQuests and resources written in the mother tongue can be expected to be one of the barriers to the entrance of WebQuest in the science classroom. School environment and computer-rooms rules may also cause resistance to the use of this teaching resource. Bearing in mind the requirements of a student-centred learning environment, another additional challenging factor for using WebQuests or any other problem-based leaning methodologies is the change that they require in terms of teacher's and students' roles (Rogers, 2004). Therefore, teacher education concentrating not only on the technical dimension but also on the conceptions about teaching and learning is required so that teachers can successfully cope with the multitude of changes in their own roles and in their students' roles.

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