Sustainability on Earth WebQuests as Problem-Solving Activities: Can Physical Sciences Teachers Rely on Them?

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Abstract

WebQuests are problem-solving activities that are supposed to be addressed by dealing with information that is available mainly on the internet. WebQuests integrate problem-solving challenges with ICT students' motivating power and they may be more useful learning tools than the usual free internet-based Problem-Based Learning settings. However, the educational value of WebQuests depends heavily on the type of task they include. This paper aims at analysing the problem-solving potential of 16 WebQuests, available from schools and universities sites, focusing on Sustainability on Earth. Results indicate that WebQuests differ with regard to the issues addressed in the analysis. Most of them tend to focus on science content and have very low cognitive and creativity demands. The results suggest that science teachers should not rely on the available WebQuests, but rather they should be able to analyse them critically in order to select those that better fit the problem-solving purpose of a WebQuest.

Keywords: WebQuests, Problem-Based Learning, sustainability on earth, science education, teacher education

Introduction

Pre-service teacher education programmes include Information and Communication Technology (ICT) courses. Some of these courses deal with WebQuest analysis and development. WebQuests are inquiry-based or problem-solving activities that face students with a task that is supposed to be answered by dealing with information that is available mainly on the internet (Dodge 1998). By following a set of predetermined steps (process), students will prepare the product specified in the task, both process and product being assessed by some criteria that are made explicit in advance (evaluation). As is known, students usually enjoy engaging in computer-based activities. Hence, WebQuests integrate problem-solving challenges with the motivating power of ICT for students (March 2005). However, there is some empirical evidence (Silva 2006) that WebQuests may be more useful learning tools than are the usual free internet-based Problem-Based Learning (PBL) settings.

Thus, WebQuests' educational value depends heavily on the type of task they include. Some tasks just ask students to collect data while others may require students to engage in problem-solving activities or in evaluation or synthesis activities (Dodge 2002). As WebQuests became well known, the diversity of levels of expertise of their authors may have increased. In addition, WebQuests developed by novices are often made available online. A consequence of this is that high quality problem-based WebQuests may coexist with low quality routine WebQuest-based activities. As WebQuests are freely available online, it is worth analysing them in order to find out whether or not teachers need to be both made aware of the diversity of their characteristics and educated in order to be able to select the most appropriate ones for PBL.

Objective

This paper aims at analysing WebQuests available from school and university websites and that focus on the Portuguese physical and natural sciences Sustainability on Earth curriculum sub-theme (hereafter referred to as 'theme'). This junior high school theme was selected, as it is a theme that encompasses cognitive, social and attitudinal components, and therefore is an appropriate theme to be tackled through a PBL approach.

Theoretical background

ICT in the Portuguese school curricula and in science teacher education

As far as the Portuguese basic school curriculum is concerned, it acknowledges ICT as a valuable educational resource. In addition, it advises that ICT should be used for the purpose of both "knowledge construction tasks" (DEB 2001, 22) and "appropriate use of diverse languages" (DEB 2001, 18). It also suggests that face-to-face or virtual interchange activities should be fostered through ICT (DEB 2011). Moreover, it recommends that teaching should be organized so that diverse information sources and ICT can be used "to develop problem-solving strategies" (DEB 2001, 23). From what has been stated earlier in this paper, WebQuests can help to fulfill this curriculum aim and therefore should be used in the science classroom.

Before the implementation of the Bologna process, pre-service teacher education in Portugal was done mainly through five-year undergraduate programmes on teaching a subject. These programmes combined courses on the subject (e.g., science) with courses on how to teach the subject, the basics of education and teaching practice. Every prospective teacher took at least one course on Educational Technology, or a course on ICT or equivalent (Gomes 2006; Costa and Carvalho 2006). Whatever the name, one of the issues dealt with in these ICT-

related courses was that of WebQuests. Thus, in these courses, prospective teachers learned about the concept, the development requirements and the educational use of WebQuests. They also learned how to analyse WebQuests critically. This means that science teachers who completed their undergraduate programmes over the last ten years or so may be able to deal with WebQuests, from both the user and the developer perspectives. The same applies to the teachers formed through the newly created masters in teaching (under the Bologna philosophy). Nevertheless, teachers who completed their first degree in the last century may not be aware of the educational value of this teaching tool, may feel uncomfortable in selecting and using it and may not possess the required technical skills to develop new WebQuests, unless they have been recently enrolled in masters programmes or in-service teacher education short courses focusing on ICT. A visit to the in-service teacher education courses certification entity website (http://www.ccpfc.uminho.pt) confirms that there are many short courses for in-service teachers focusing on ICT. These courses can be attended by science teachers even though they are not specially targeted at them. Also, an analysis of courses of studies of Portuguese masters programmes targeted at in-service science teachers indicates that most of them include at least a compulsory or an optional ICT-related course. This is the case for the Master of Arts – Educational Supervision on Science Teaching, at the University of Minho, which includes an optional course on Hypermedia and the Information Society. The information provided so far indicates that science teachers may have learned about WebQuests during their undergraduate programmes, may have become familiar with this educational tool when they attended in-service masters programmes or in-service short courses or may have no formal education on the issue. Even without formal instruction on the topic, the latter group of teachers, probably the largest one, may come across and feel like using WebQuests to fulfil the National Curriculum requirements with regard to the educational use of ICT.

WebQuests and Problem-Based Learning

As mentioned above, WebQuests are problem-solving activities devised to be addressed by the students through information searches mainly using online information sources. According to Dodge (1997), a WebQuest includes six sections, as follows:

- Introduction: this should motivate the student/solver to engage with the task;
- Task: this describes student expected achievements, therefore it is a very important part of the WebQuest;
- Process: this describes the methodology that should be used to fulfil the objective underlying the task;
- Resources: this section provides the student with selected online resources that can be used to complete the task; usually, they include websites relevant for the task that

are appropriate to the characteristics of the solver. Instead of being accessed directly by the URL, they should be named after their main content (using a sort of keyword) so that the user can easily identify their relevance for each part of the process;
- Evaluation: this provides the student with information on how to evaluate his/her own work;
- Conclusion: without providing an answer to the task, this should motivate the student to carry out further work related to the topic.

A few years later, Carvalho (2002) added two other elements to Dodge's list:

- Home page: this informs the visitor about the site he/she is accessing (e.g., type of activity, author, target school level, date of construction, etc.) and should include information on credits and author's contact, target population, date of development, etc.;
- Help page: this explains how the site works (offering, for example, information for performing some technically based activities) and advances strategies for how the WebQuest can be used.

Dodge (2002) formulated a taxonomy of WebQuests that includes 12 types of tasks that can be briefly defined as follows:

- Re-telling: write a report, a summary, a text;
- Compilation: organize information selected from several sources;
- Mystery: create a fictional puzzle by synthesizing information;
- Journalistic: Write a deep, broad, fair, creative, accurate report;
- Design: build in authentic constraints, for example, a product being needed;
- Creative Product: produce something with creativity and self-expression;
- Consensus Building: integrate opinions and facts for a specific audience;
- Persuasion: convince someone of your opinion;
- Self-Knowledge: answer complex questions about oneself;
- Analytical: find and explain similarities/differences, cause/effects;
- Judgment: evaluate (behaviour, opinions, etc.) based on criteria;
- Scientific: approach a question through scientific methodology.

It should be noticed that there is no order in this list of tasks and that a WebQuest may combine two or more types of tasks. However, bearing in mind the types of WebQuests defined and the time needed to solve the task (Dodge 1997), a given type of task may fit one type of WebQuest better than another. Thus, short WebQuests, that is WebQuests that can be solved in a one to three class hours, usually comprise low cognitive requirement tasks, focusing on understanding new information or integrating new information with previous

knowledge. Long WebQuests, that is WebQuests that may take one week to one month to be solved, fit better to medium or high cognitive requirement tasks, concentrating on re-examination of previous knowledge, increase in the accuracy of previous knowledge, transformation of one's knowledge and points of view, and examination of things from a different perspective.

PBL is a student-centred teaching approach in which students learn by solving problems (Lambros 2002). In PBL settings, learning occurs in multiple dimensions, including content knowledge, procedural knowledge, attitudinal knowledge, interpersonal relationship skills, learning how to learn skills, etc. As it acknowledges active learning, PBL leads to great changes in teachers' and students' usual roles. Thus, teachers do not teach in the usual sense; they create conditions for students to learn by solving problems. Hence, they are guides or tutors that play the key role of keeping students on the job (Lambros 2002). Students, in their turn, have to look for solutions for the problems and to share those solutions with their own teacher and classmates. They are not sitting there waiting for the teacher to tell them new ideas; rather, they have to look for the new ideas and tell them to the teacher and colleagues. This also applies to WebQuest-based educational environments. As Mentxaka (2004) argues, WebQuests facilitate teachers' job in the classroom, as they themselves guide students' work.

In the original PBL contexts (Berkel, et al. 2010), students solved problems by looking for information in environments other than the internet. However, over the last five years or so, a few books (Savin-Baden and Wilkie 2006; Savin-Baden 2007) dealing with PBL online came out. Despite the fact that WebQuests were not at first associated with PBL, they may nevertheless include PBL activities (Leite, et al. 2007) depending on the type of task they include. Of course, some types of tasks (e.g., compilation tasks) make low demands, from both a cognitive and a procedural point of view, and they would not be therefore the best examples of WebQuests for problem based learning online. However, WebQuests with judgment or scientific tasks would be good examples of WebQuests as online problem solving activities.

Methodology

Sixteen WebQuests focusing on the sub-theme Sustainable Development and Resources Sustainable Management that could be accessed on Portuguese school and university sites were analysed with regard to: the science content dealt with in the task; the type of task; the cognitive level of the questions associated with the task; and the type of product demanded. The WebQuests were content analysed by two of the authors separately. Afterwards, the results of the two analyses were compared and a discussion was held among the three authors before consensus was reached. The categories of analysis regarding types of task

and cognitive level of the task were taken from the literature, namely from Dahlgren and Öberg (2001) and Dodge (2002), respectively. These categories are given in tables 2 and 4. Categories for other relevant issues were developed for the purpose of this study.

Results

Most of the WebQuests include just one task. However, one WebQuest includes two sub-tasks and another one includes four sub-tasks. This means that for 16 WebQuests there are 20 sub-tasks. If one does not differentiate between tasks and sub-tasks, one can notice that most (12, that is 60%) of the tasks are presented as orders, as shown in table 1; they describe an action that students are supposed to carry out. The remaining eight tasks were presented as interrogations; they ask a question that students are supposed to answer.

Table 1. Format of tasks or sub-tasks (16WQs; 20 tasks)*

Format	*f*	*%*
Order	12	60
Interrogation	8	40

*1WQ has 2 sub-tasks; 1WQ has 4 sub-tasks

As shown in table 2, the majority of the order-like tasks are meaning-oriented. An example of this type of task is as follows: “Each small group should do research work on one of the following renewable energy sources: sun, water, biomass, wind, geothermal energy”.
In the case of the interrogation-like tasks, tasks are spread over several categories, with a quarter of them classified at the encyclopedic level, which is the lowest level, from a cognitive point of view. An example of a task classified in this category is as follows: “What are the possible uses of water?”
Solution-oriented tasks appear in both formats, although with low absolute frequencies. This is not good, as this type of task is the most interesting from a PBL point of view. “What could you and your colleagues do in order to save water in school?” is an example of this type of task.

Table 2. Cognitive level of tasks or sub-tasks (16WQs; 20 tasks)

Cognitive Level	*Order-like task (n=12)*		*Interrogation-like task (n=8)*	
	f	%	f	%
Encyclopaedic	0	00.0	2	25.0
Meaning-oriented	7	58.3	3	37.5
Relational	0	00.0	0	00.0
Value-oriented	0	00.0	0	00.0
Solution-oriented questions	5	41.7	3	37.5

Although March (2005) argues that WebQuests can facilitate students' relationship of school acquired knowledge with daily life, 40% of the tasks analysed focus on school science only (table 3). The following example is representative of this type of task:

> *"You and your team are asked to select one of the sub-themes below, look for information on it, and organize this information into a PowerPoint to present it to the other teams and to your teachers in the final class.*
> *Sub-themes: What is the greenhouse effect and what originates it?; Clean technologies, […]"*

Table 3. Context of tasks or sub-tasks (16WQs; 20 tasks)

Context	*f*	*%*
School Science	8	40.0
Science & Technology Research	0	00.0
Daily life	12	60.0

However, the remaining 12 tasks focus on daily life and therefore can facilitate the interrelationship between school science and students' daily life: "What could you and your colleagues do in order to save water in school?; What could you do to save water at home?". Although the set of WebQuests analysed includes a diversity of types of tasks (table 4), most of the tasks are Compilation tasks (table 4) with low cognitive requirements and can hardly be classified as problem-solving tasks. An example of a compilation task is as follows: "What are the possible ways you can use water?".
Examples of more creative and cognitively demanding tasks are the tasks that ask students to "Prepare a campaign for the use of clean energy to be put in action in your school in the world environment day" (Design task) or to do a role playing exercise:

> *"You should take the role of a member of the team working for the environment in your city. In a city council meeting, you should discuss the importance of collective practices for the solution of environmental problems as well as for global resources management".*

Table 4.Type of task or sub-task (16WQs; 20 tasks)

Type of task	*f*	*%*
Compilation Tasks	13	65.0
Mystery Tasks	1	05.0
Design Tasks	1	05.0
Creative Product Tasks	2	10.0
Persuasion Tasks	1	05.0
Role Playing	2	10.0

As far as the final product is concerned, the WebQuests analysed ask students to prepare and/or present a variety of products, ranging from answering questions, writing a text for an oral presentation or participating in a discussion to designing a leaflet, creating a blog or organizing a persuasion campaign (table 5). One of the WebQuests has one task and asks for two products, one of them being a poster and the other not being made explicit. Another WebQuest that includes four tasks asks for two products: a text to be presented orally and an awareness campaign.
An example of a product with the format of a debate was asked as follows:

> *"A debate moderated by your teacher will be scheduled soon. During the 30 minutes of the debate you will present your suggestions to your classmates. The classroom should be organized in such a way as to create an environment that promotes discussion."*

An example of a product with the format of a role playing exercise was demanded as follows:

> *"We suggest that you organize a role playing exercise so that you can discuss the importance of an international organism like UNO for global environmental problems solution".*

One of the WebQuests asks students to choose the format of the WebQuest's products among four possible types:

> *"Using teamwork, organize a campaign with cards, posters, figures or drawings, so that you can make the school community aware of the need for water."*

Despite the fact that this research was not concentrating on the internal consistency of WebQuests, the analysis carried out has shown that many WebQuests have low internal consistencies that may put their educational value at risk.

Table 5.Types of final product (16WQs; 19 products)

Type of Product			*f*	*%*
Written piece of work	Leaflet, poster	With oral presentation	2	10.5
		Without oral presentation	2	10.5
	Text	With oral presentation	2	10.5
		Without oral presentation	1	5.30
	PPT presentation	With oral presentation	2	10.5
		Without oral presentation	0	0.00
Persuasion Campaigns			1	5.30
Multimedia production (video, site, blog, etc.)		With oral presentation	1	5.30
		Without oral presentation	2	10.5
Discussion			3	15.8
Answering to questions			2	10.5
Not made explicit			1	5.30

In fact, some WebQuests skip the resources section (which would be helpful to guide students in their information search), others include low level tasks but ask for higher level products, others show inconsistencies between product asked (e.g., organization of a campaign) and the focus of the assessment (e.g., research and materials construction), or they mix elements of the WebQuest, with the product (PowerPoint to be presented to the class) being mentioned only in the process section (instead of being mentioned in the task).

Conclusions and implications

Results indicate that the WebQuests analysed differ with regard to the issues addressed in the analysis. However, most of them tend to focus on science content and have very low cognitive demands. A smaller number of them deal with looking for a solution and very few pay attention to affective issues, namely to persuasion.

Hence, despite the small size of the sample, the results suggest that WebQuests may be inconsistent with the requirements of a problem solving activity. In addition, in some cases, their internal inconsistencies may put WebQuests' educational value at risk. Hence, science teachers should not rely on the WebQuests that are made available on institutional websites, but rather they should be able to analyse them critically in order to select those that better fit the problem-solving requirements.

Thus, within a teacher education development framework, in-service teacher education courses should help teachers to improve their expertise in evaluating, selecting and adapting WebQuests, as well as in developing good ones, not only from a technical point of view but

also from a scientific and a pedagogical one. This is worthwhile because research (Leite, et al. 2007) has shown that whatever the science topic and school level, students not only enjoy using WebQuests but also learn more from them in terms of both science content learning and development of problem-solving competences.

On the other hand, WebQuests should not be made available online before being technically, scientifically and educationally validated. Thus, schools and universities should find ways of supporting their staff members who want to publish this sort of online teaching tool in order to help authors to improve them so that they can meet the required high quality standards. School and university intranets can be used as intermediate stages from WebQuests' development to their worldwide publication.

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