Contents lists available at ScienceDirect

Education for Chemical Engineers

journal homepage: www.elsevier.com/locate/ece

Real and virtual bioreactor laboratory sessions by STSE–CLIL WebQuest

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ARTICLE INFO

Article history:
Received 17 April 2015
Received in revised form 9 June 2015
Accepted 11 June 2015
Available online 26 June 2015

Keywords:
WebQuest
STSE
CLIL
Bioreactor
Laboratory
Virtual simulation

ABSTRACT

An innovative teaching methodology, which incorporates all the advantages offered separately by WebQuest (an inquiry-oriented lesson format in which most or all the information that learners work with comes from the web), CLIL (Content Language Integrated Learning) and STSE (Science, Technology, Society and Environment) was developed to integrate real bioreactor experiments to produce ecological bioethanol with virtual bioreactor computer simulation. Thus, by means of this type of WebQuest, it is possible to connect STSE real laboratory sessions in a Spanish university with CLIL sessions in English in a virtual foreign laboratory through the Internet introducing students to the international scientific world.

This teaching approach can be very helpful solving the common problem of limited time to conduct enough applied practical contents, it empowers independent work of students and it is technologically adapted to the times we live.

The effectiveness of the implemented system was obtained by evaluation through direct experimentation, assessment (with a rubric for the laboratory session reports and a written test) and survey (through a questionnaire) with 40 undergraduate students. All these results show that students are more motivated and learn more following this kind of laboratory sessions.

1. Introduction

Student science interest could be improved by making changes to relatively easy-to-manipulate aspects of learning environments (Swarat et al., 2012). Thus, virtual laboratories in biochemical engineering are used more and more replacing real laboratory because most students consider this practice very useful and teachers can assess significant improvement in students' performance in the lab, and also a more thorough discussion of the results in the reports (Domingues et al., 2010). In addition, it has been proven that integration of real experiments with virtual computer simulation improves the learning process. It is not a question of whether to use real or virtual laboratory experiments in teaching science because both of them used in a complementary manner can contribute to more effective active learning (Kocijancic and O'Sullivan, 2004; Jong et al., 2013).

1.1. *WebQuest*

The WebQuest methodology, developed in 1995 by Bernie Dodge at San Diego State University, is an inquiry-oriented lesson format in which most or all the information that learners work with comes from the web. Since its invention, tens of thousands of teachers have used WebQuests and this model has spread around the world, with special enthusiasm in Brazil, China, Australia and Holland and the country where this work comes from, Spain (Dodge, 2007).

WebQuest serves to organize the learning process (Chalmers, 2003) and they are designed so that students can

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http://dx.doi.org/10.1016/j.ece.2015.06.004
1749-7728/

make good use of their time focusing on using information rather than looking for it. In addition, this method is very attractive because it provides structure and guidance for both students and teachers (Dodge, 2001a,b).

Students can build upon a shared information base with information gathered from the Internet, and the integration of classroom activities with the use of the Internet can thus make traveling on the Web a meaningful experience (Segers and Verhoeven, 2009).

Dodge (1997) refers to the dimensional learning theory of Marzano (1992) with its roots in cognitive science as the theory underlying the WebQuest concept. This model is based on Bloom's taxonomy of educational objectives (Marzano and Kendall, 2007) describing six levels of cognitive processes: knowledge, comprehension, application, analysis, synthesis and evaluation. The higher order thinking skills involves the last three cognitive processes and it is assumed that they are stimulated by most WebQuests (Marzano and Kendall, 2007). However, web-related activities that appeal to only the former three cognitive processes are considered web exercises (March, 2004).

1.2. *STSE education*

Science, Technology, Society and Environment (STSE) education was originated from the Science, Technology and Society (STS) movement in science education born in North America in the sixties and seventies due to the need to recover the interest in the scientific subjects in students. It is a vision of science education that emphasizes the teaching of scientific and technological developments in their economic, social, cultural and political contexts. In this view of science education, students are encouraged to participate in issues related to the impact of science in everyday life and make responsible decisions about how to address this kind of themes (Solomon, 1993; Aikenhead, 1994). The STSE education can be loosely defined as a movement that seeks to achieve an understanding of the interface between science, society, technology and environment. A key goal of STSE is to help students realize the importance of scientific advances in their daily lives (Pedretti and Forbes, 2000).

1.3. *Content Language Integrated Learning (CLIL)*

The use of a different language as a teaching medium of non-language subjects is already a common practice in schools across Europe. The CLIL methodology allows content and language learning at the same time responding to the objective of the European Union to ensure that all citizens can communicate in at least two languages in addition to the mother tongue. According to Professor Wolff (2009) at the University of Wuppertal from Germany, through CLIL students learn more and are more motivated than in the traditional teaching of specific subjects. In addition, this specialist in bilingual education stresses that CLIL offers many advantages to both students and teachers due to students process the foreign language more deeply and intensely and with greater cognitive level. CLIL provides an appropriate learning environment to enhance learner autonomy (Wolff, 2011).

1.4. *Integration of WebQuest, STSE and CLIL*

If the STSE, CLIL and WebQuest teaching approaches are joined together, a powerful tool can be developed integrating real experiments with virtual simulation in a second language. This new methodology could result much more attractive for students and thus, improve their learning outcomes. The union of the WebQuest with CLIL is what Fontecha, 2010 called CLILQuest. The WebQuest bound to CLIL allows to solve some common problems in CLIL teaching such as the lack of precise guidelines and instruments to implement the foreign language appropriately (Räsänen et al., 1996; Hartiala, 2000). However, no previous studies, which integrate STSE, CLIL and WebQuest, can be found in the literature.

2. Material and methods

2.1. *Participants*

The WebQuest developed in this work (http://biorreactores.webs.com) was experienced with a class of 40 students who were enrolled in the course "bioreactors" at the Catholic University of Valencia "San Vicente Mártir". All participants were Spanish, between 20 and 22 years old and half of them were men. No distinction was done in the student selection.

2.2. *Methodology*

WebQuest was the kind of methodology chosen to conduct perfectly guided lab sessions using internet resources in order to create interest among students and be able to embrace very important concepts with the new technologies in a practical and fun way under a STSE–CLIL approach.

Currently, there are many websites to design typical WebQuests (Dodge, 2007). However, the website to design web pages named Webs (2015) was chosen in this work due to the great free design possibilities offered by this platform. This kind of WebQuest was designed considering all the items of the WebQuest evaluation rubric published by Dodge (2001b) to obtained the maximum score.

A WebQuest gives structure to the learning process usually through a series of six web pages: introduction, task, process, resources, guidance and conclusion. The introduction provides students with information on the subject to work explained in an attractive and fun manner in order to motivate them and maintain their interest during this activity. The following page describes the task to be done at the end of the WebQuest. The resources page describes the steps students must follow to perform the task. The fourth page provides information sources (web links) which are necessary for students to perform the task focusing their attention on the issue instead of surfing the net without a clear task in mind. The fifth page explains how to organize the information acquired and finally the conclusion page usually summarizes the learning experience (Dodge, 1997).

The WebQuest of this work was also structured with six web pages resembling as much as possible the WebQuest defined by Dodge (1997). Thus, this platform contains introduction, tasks, evaluation and conclusions quite similar to those of Dodge. However, process and sources are both included in both STSE real and CLIL virtual laboratory sessions web pages (see Fig. 1).

What stands in the STSE–CLIL WebQuest is that not only virtual processes are included as usual, there are also STSE real processes. In addition, the virtual processes are CLIL.

Gorter and Cenoz, 2011 affirmed that little research has been done on multilingualism practice focused on the use of