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Assessing the Role of General Chemistry Learning in Higher Education

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Abstract

The inclusion of General Chemistry (GC) in the curricula of higher education courses in science and technology aims, on the one hand, to develop students' skills necessary for further studies and, on the other hand, to respond to the need of endowing future professionals of knowledge to analyze and solve multidisciplinary problems in a sustainable way. The participation of students in the evaluation of the role played by the GC in their training is crucial, and the analysis of the results can be an essential tool to increase success in the education of students and improving practices in various professions. Undeniably, this work will be focused on the development of an intelligent system to assess the role of GC. The computational framework is built on top of a Logic Programming approach to Knowledge Representation and Reasoning, complemented with a problem solving methodology moored on Artificial Neural Networks. The results so far obtained show that the proposed model stands for a good start, being its overall accuracy higher than 95%.

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Keywords: General Chemistry; Higher Education; Logic Programming; Knowledge Representation and Reasoning; Artificial Neural Networks

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1. Introduction

Education is to be able to reason, to use one's ability to gain our spectrum of knowledge, which is nowadays increasingly dependent on science and technology (American Association for the Advancement of Science, 1990; National Research Council, 1996). The inclusion of *General Chemistry* (*GC*) in the curricula of higher education courses in the area of science and technology, intends to form future professionals with the necessary skills to analyze and solve problems in a sustainable way. Furthermore, another important goal that should be taken into account is related with the development of expertise required for the subsequent disciplines on course plans.

Indeed, the assessment of the role played by *GC* in different courses in higher education is an essential tool to increase the students' success and to improve good practices in various professional domains. The involvement of students in the evaluation of the role of *GC* in Higher Education courses is of utmost importance, since they are the aimed targets.

Artificial Intelligence based methodologies and techniques for problem solving in educational context are still considered a new paradigm and a promising challenge. A few studies that illustrate the applicability of these tools to different problems in educational field can be found in literature. Şen & Uçar (2012) used *Artificial Neural Networks* (*ANNs*) and *Decision Trees* (*DTs*), in order to study the students' achievements. Şen, Uçar & Delen (2012) developed models to predict secondary education placement test results using *DTs*, support vector machines, *ANNs* and logistic regression. Recent studies described the development of decision support systems based on soft computing approaches to evaluate the quality of learning (Neves *et al*., 2015) and potential situations of school dropout (Figueiredo, Vicente, Vicente & Neves, 2014; Neves, Figueiredo, Vicente & Vicente, 2016).

The present work reports on a computational framework that uses knowledge representation and reasoning techniques to set the structure of the information and the associate inference mechanisms. It will be centered on a *Logic Programming* (*LP*) based approach to knowledge representation and reasoning (Neves, 1984; Neves, Machado, Analide, Abelha, & Brito, 2007), complemented with a computational framework based on *ANNs* due to their dynamic characteristics like adaptability, robustness and flexibility (Cortez, Rocha, & Neves, 2004), which makes possible the handling of unknown, incomplete or even contradictory data or knowledge.

2. Background

2.1. Knowledge Representation and Reasoning

The *Logic Programming* (*LP*) paradigm has been used in knowledge representation and reasoning in different areas, such as Model Theory (Kakas, Kowalski, & Toni, 1998; Pereira & Anh, 2009), and Proof Theory (Neves, 1984; Neves *et al*., 2007). In this work the proof theoretical approach is followed in terms of an extension to *LP*. An Extended Logic Program is a finite set of clauses in the form:

$$
\begin{aligned}
\{ \quad & p \leftarrow p_1, \cdots, p_n, not\ q_1, \cdots, not\ q_m \\
& ?\,(p_1, \cdots, p_n, not\ q_1, \cdots, not\ q_m) \quad (n, m \geq 0) \\
& exception_{p_1} \quad \cdots \quad exception_{p_j} \quad (0 \leq j \leq k), \quad being\ k\ an\ integer \\
\} & :: scoring_{value}
\end{aligned}
$$

where "?" is a domain atom denoting falsity, the p_i, q_j, and p are classical ground literals, i.e., either positive atoms or atoms preceded by the classical negation sign $\neg$ (Neves, 1984). Under this formalism, every program is associated with a set of abducibles (Kakas *et al*., 1998; Pereira & Anh, 2009), given here in the form of exceptions to the extensions of the predicates that make the program. The term $scoring_{value}$ stands for the relative weight of the extension of a specific *predicate* with respect to the extensions of the peers ones that make the overall program.