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<AT>An Ontological Approach to Chemical Engineering Curriculum Development

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<ABS-HEAD>Highlights► An ontology (ChEEdO) was developed to model the chemical engineering curriculum. ► ChEEdO models taught modules, learning outcomes and topics in the curriculum. ► The object, context and levels of the learning outcomes specified learning. ► The functionality of semantic reasoning via the ontology was demonstrated. ► The ontology was used for curriculum development and learning integration.

<ABS-HEAD>Abstract

<ABS-P>Continuous reflection and evolution of curricula in chemical engineering is beneficial for adaptation to evolving industries and technologies and for improving student experience. To this end it was necessary to develop a method to enable a holistic reflection on the curriculum and to examine potential areas of improvement and change. The curriculum was modelled using knowledge modelling through the development of an ontology, Chemical Engineering Education Ontology (ChEEdO) in the Protégé 3.5 environment. ChEEdO models topics, taught modules and the learning outcomes of the modules within the domain of chemical engineering. The learning outcomes were related to the topics using verb properties from Bloom's taxonomy and the context of each learning outcome. The functionality of semantic reasoning via the ontology was demonstrated with a case study. The modelling results showed that the ontology could be successfully utilised for curriculum development, horizontal and vertical integration and to identify appropriate pre-requisite learning.

<KWD>Keywords: Knowledge modelling; Curriculum development; Ontology; Chemical engineering; Education.

<H1>1. Introduction: Knowledge Modelling in Education

Knowledge modelling features in curriculum development historically in the form of ontologies, as well as concept maps. Conceptual curriculum mapping was used as a tool to develop and validate engineering curricula based on the program outcomes (Morsi et al., 2007) with proven benefits of facilitating validation, enabling student and teacher conceptualisation of the course, and improving quality and alignment. Similarly, concept maps were used for curricula in school education, which encouraged alignment, integration and communication amongst teachers and are still used in the UK high school education (Koppang 2004; BBC 2015). Whilst concept mapping is a valid tool for knowledge modelling for curricula, we argue that the additional use of properties, restrictions and inferences in ontology engineering provides more scope to probe and interrogate the curriculum structure.

The term ontology originates from philosophy and it is the explanation (λόγος - logos) of being (ον - on); today it is used in computer science and knowledge engineering. The most common definition in literature has been coined by Struder et al., (Struder et al., 1998) which builds on previous definitions by Uschold and Gruninger (Uschold & Gruninger 1996) and Gruber (Gruber 1993), among others, who define ontology as ``*a formal explicit specification of a shared conceptualisation*". Formal means that it is machine readable. Explicit specification refers to the explicitly defined concepts, properties, restrictions and instances of the ontology. The term shared acknowledges that the described knowledge must be commonly accepted by a group of people. Finally, the term conceptualisation is by definition an abstract model of some phenomenon. In simpler terms, an ontology is a knowledge model that contains a group of concepts/terms that describe a specific domain, and more importantly, which is machine processable (Trokanas et al., 2014). These concepts are organised in a taxonomy associated through class-subclass relations (*isA*), and characterised