Kirkuk University Journal- Humanity Studies

Using Ontology in Planning an Educational Web

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Abstract

In recent years, some important steps have been taken to bring the educational semantic web to its full potential. In this paper, we address the design and implementation of ontology based system that helps the Information Technology (IT) teachers in Iraq generating their courses. The system constitutes an ontology, ITONTO that merges the domain knowledge of the IT subject, pedagogical concepts and web learning materials (Learning Objects). The IT educational goals are briefly explored. We have focused on technical details based ontology design to explore its application in Educational domain.
Keywords: Course generation, Ontology, Planning, E-Learning, Pedagogy.

1. Introduction

In Iraq, there are few IT specialist teachers who have difficulties in obtaining necessary knowledge and skills to facilitate the teaching process. The web which is a huge repository of data can provide limited access to learners. The availability of educational resources (Learning Objects) on the web is invaluable. Accessibility to these resources promotes the effectiveness of teaching and learning outcome, thus the opposite could have an ineffective academic and pedagogical result. Modeling the LO by using the knowledge needed to explore ontology will enable students to see the materials presented to them in a more clear way. It helps them to relate the new knowledge to the real world. In this paper, we present a framework of educational semantic web application. By using an ontology that represents the core component of the system, which includes knowledge of the following three main concepts:

1. Domain Knowledge of IT Selected Subject
2. Pedagogical Concepts
3. Learning Objects

Ontology as a branch of philosophy, that is related to the study of being, is instantiated by using a reasoning tool RACER, which would enable us to validate the new educational design. A teacher, by integrating the system components, can enter the main concept of topics of his/her course to easily generate a suitable design for the course he or she teaches.

The paper is organized as follows section one, the introduction, presents the general context of the presented work,and section two explores some of the existing approaches used in enhancing educational web , while section three describes the education pedagogy. Section four describes the structure of the proposed system and a prototype implementation of the approach,where section five presents the literature survey and related work; and section six concludes the paper and presents suggestions for future work.

2. General Context

2.1 Semantic Web

The semantic web extends typical web abilities by providing meaning to web resources and produces information of well-defined semantics. In addition to the artificial intelligence difficulties of programming machines in order to behave intelligently, the semantic web approach develops languages for delivering information in a more lucid form [3, 4].
Producing semantic web standards is an ongoing phenomenon by the W3C. See (Figure-1 below). It depicts the architecture of Semantic Web Layer Cake as introduced by the inventor of the Web Tim Berners-Lee. The lowest layer of three layers represents the web languages standards. It includes the basis for presenting and structuring web data.

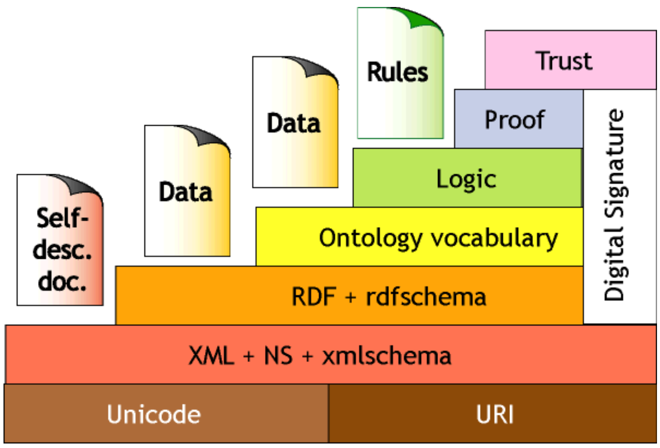

Figure-1: **The semantic Web Layer Cake -1998**
© Tim Berners-Lee, http://www.w3.org/2000/Talks/1206-xml2k-tbl

An ontology layer is to provide a lucid description that provides a clear definition to ontological publications on the web or elsewhere. One advantage of using ontology is the availability of tools that can rationalize the concepts.
The following sections will explore the benefits of the ontological semantic web standards in education.

2.2 E-learning

Clark Adrich (2004) defines e-learning as a broad combination of processes, contents, and infrastructures to use computers and networks to assess and improve significant parts of learning value chain, including management and delivery.

E-learning would contribute to:

1. Enrich learning by combining traditional and innovative learning models to provide more learning opportunities.
2. Explore multi-media as a utensil for conceptualizing new information.
3. Standardize and present educational contents with more clarity.
4. Individualize learning experiences to device better learning strategies.
5. Integrate academic and administrative fields in order to provide a better learning environment.
6. Ensure quality education to promote student performance [12].

2.2.1 E-learning Standards

Mohan and Brooks (2003) define a Learning Object (LO) as a digital learning resource that facilitates a single learning objective—a resource that can be used again for various educational context.

Learning Object Metadata (LOM) has been introduced to enable employing and sharing different learning objects across the learning spectrum. However, this standard only allows descriptions of resources from instructional perspectives, such as diagrams, figures, tables, drills and exams as types of the LOM without relying on a specific structure. The current standards may not cover all the instructional features and functions of educational resource, because they are not entirely designed to operate with the semantic web. However, the full e-learning potentials of the web will be at the learners' disposal if semantic web techniques are promoted.

Unlike the LOM, ontology provides an efficient representation of these learning objectives as a set of instructions that give relational structures by providing concrete concepts, properties and the degree of relationships that exists. On the other hand, ontology is considered as an integration of various metadata standards similar to the LOM, Dublin Core Metadata Initiative (DCMI), and the Digital Object Identifier (DOI).

2.2.2 Benefit of Using Ontology in E-Learning

Ontology is an explicit knowledge of shared conceptualizations. As Studer clearly stated, "*Conceptualization* refers to an abstract model of some phenomena in the world by having identified the relevant concepts of those phenomena. *Explicit* means that the type of concepts used, and the constraints on their use, are explicitly defined. *Formal* refers to the fact that ontology should be machine-readable. *Shared* reflects the notion that an ontology captures consensual knowledge, that is not limited to certain individuals, rather it is shared and used by a group." [5]. Ontology's benefits in education can be summarized in the following items:

1. Offers advantages to both teachers and learners by providing shared vocabularies of the instructional technology about the learning objects for a given domain .
2. Facilitates steps of conducting an accurate search for materials related to explicit instructional features and functions that lead to a less repetition and a more reliable way to design and redesign a curriculum.

3. Explores implicit knowledge embedded in the learning contents and helps to internalize it.
4. Enables learners to use the concepts again when needed.
5. It can be used to describe instructional procedures that underline the necessity of an integrated curriculum.

3. Learning Pedagogy

To provide a sound and effective education, it is essential to be familiar with the pedagogical concepts that promote understanding about human behavior and how these concepts indirectly help to comprehend student learning. Pedagogy is defined as methods of transforming knowledge to learners. It affects how learners retain and use the knowledge when needed.

According to Bloom's cognitive taxonomies, learning has the following measures:

1. Reception of Information: Learner's interest, willingness and ability to engage in the learning process present the primary factors that affect the reception of information. Furthermore, the teacher's ability to create a learning environment that will involve the learners' interest is essential to this process.

2. Different students have various learning styles. This requires teachers to develop various teaching methods to different learning styles in order to facilitate learning and help students to develop critical thinking ability [2]. The use of different learning styles primarily improves the teaching and learning process.

Learning styles can take the following forms:

1. Processing: when students process information given to them, they may be active or passive learners, it depends mainly on the teaching method used. Kinesthetic/active learners learn best by being actively engaged in the learning process, whereas passive learners can learn without being actively involved.

2. Perception: Sensitive learners prefer data and facts, whereas intuitive learners prefer theories and interpretations of factual information.

3. Input: Input is either visual or verbal. Visual learners prefer charts, diagrams and pictures, whereas verbal learners prefer the lectures.

4. Understanding takes sequential or holistic form. Sequential learners prefer seeing every step in order to be able to make connections to see the whole picture, whereas holistic learners see the whole picture without having the entire information [2].

Therefore, it is essential to adopt learning materials to different teaching styles where they complement students' learning styles.
The IT different learning facets is displayed below in Figure 2. It explores steps to achieve these goals.
Using the IT- education method and pedagogical aspects, we can classify IT courses into two types (Type I, introductory, advanced, and technical course)

and (Type II, holistic understanding learner, sequential understanding learner, and visual learner).

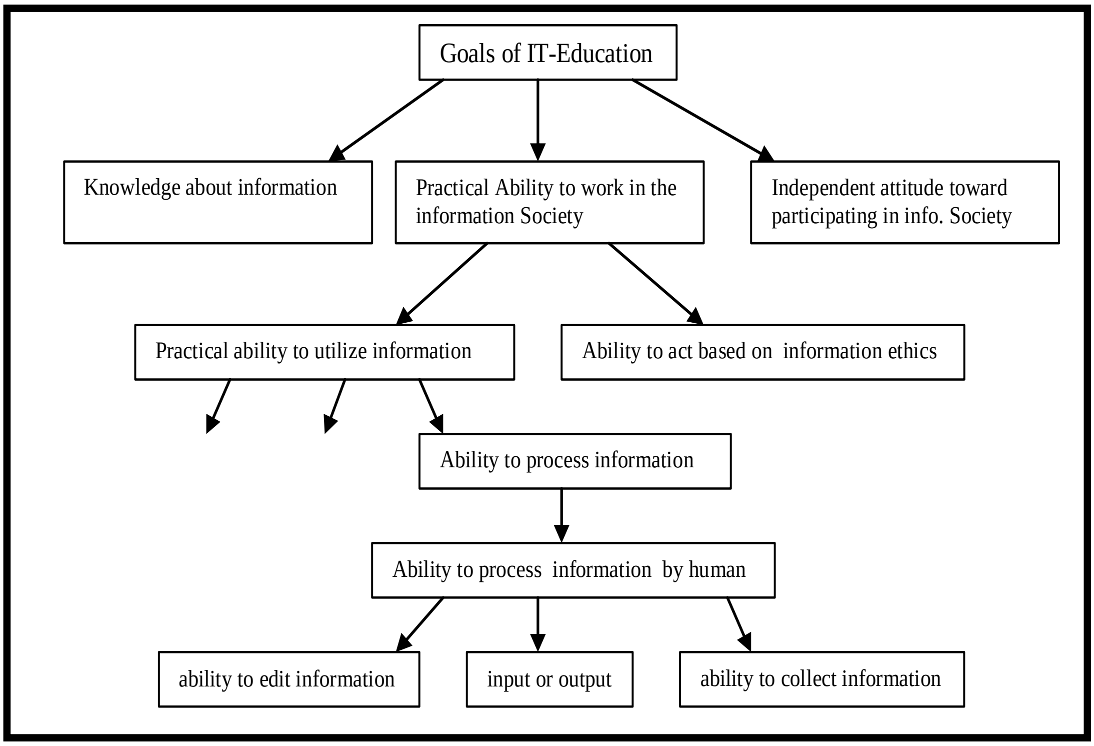

Figure-2 Part of IT education Goals Hierarchy

In the following section, we will present the main system architecture and explore a way that ontology can be used for effective course generation.

4. General System Architecture

Figure-3 shows the main modules of the system ontology represents the core module that captures the knowledge of the learning materials. The local learning objects repositories contain the learning objects on the form of .pdf, .ppt, .html, and .doc.

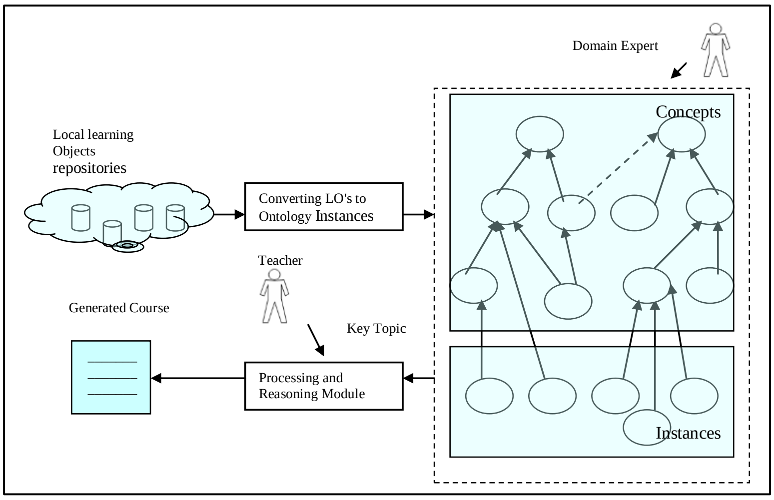

Figure-3 General System Structure

At the inception of the process, these learning objects should be converted to ontology instances.

An important module in the system tightly related to the ontology is "Processing and Reasoning module". The main function of this module is to infer new knowledge from the statements asserted by the ontology designer using a Description Logic reasoning RACER. RACER (Renamed ABox and Concept Expression Reasoning) is a knowledge system that implements a highly optimized tableau calculus for a descriptive logic (DL). RACER offers reasoning approaches for multiple TBoxes and ABoxes. In this system, the reasoning inference services are used to answer queries. For example, the ABOX reasoning service, "*Instance Checking,*" verifies what concept of an instance of a specified concept was used for retrieving instances related to a given concept that provides an answer to the query about the concept.

4.1 The scope of the ontology ITONTO

In fact, there is no reliable methodology for developing an ontology, but there is one good process for developing an ontology which is an iterative approach to ontology development. It starts with an initial introduction to ontology and then revises and refines the ontology which is already processed, and re-describes it in detail.

The ontology, ITONTO that is described here is constructed to use the ontology editor Protégé 3.1. The Protégé is a knowledge acquisition system which provides an efficient way to build logical expressions that are used in the DL languages. ITONTO provides vocabularies that facilitate understanding the knowledge of IT-subjects such as pedagogical aspects and

IT learning goals. We have identified the following main concepts:

CS-Topics, Course, Lectures, LOs (for Learning Objects). For developing a class hierarchy we used a top-down development process starting with the definition of the most general concepts in the domain and subsequent specialization of the concepts, such as CS-Topics, which is defined as a class subsumed by top class Thing. CS-Topics is a super class of the IT topics that are used in the learning objects, furthermore, all these topics are defined as primitive concepts. We have identified the following relationships between the topics classes:

1. The " is-a relationship" defines a hierarchy over the classes, its transitive property provides the basis for the inheritance of concepts and properties.
2. The "similarTo" object property relates two topics with the same semantic meaning.
3. The "related-with relationship" connects keywords that have scientific relationship.

The last two are symmetric relationships. The domain and range of each of these relationships are CS-Topics. Declaration of the primitive concept Operating System in the Ontology Web Language OWL is given in the code below:

```
<owl:Class rdf:ID="OperatingSystemParts">

    <rdfs:subClassOf>
        <owl:Class rdf:ID="OperatingSystem"/>
    </rdfs:subClassOf>
</owl:Class>
```

The Course concept is of two types (Type I ,Introductory, Advanced, and Technical course) and Type II (holistic Understanding Learner, Sequential Understanding Learner, and Visual Learner)).
The concept Lectures has several lecture types; this classification is based on the type of the course described above.

The concept LOs has several subclasses like (Definition, Table, Example, Figure, Comparision). Here, each learning object serves a specific pedagogical role that helps to identify various resources and their use, and classify learning styles to facilitate learners' choices.

In general, we can define the concepts Los and Lectures as follows:

LOs ≡ ∃ has URL
Lectures ≡ ∃ contains LOs

The following figure is a snapshot of Protégé describing the definition of a lecture in an introductory course.

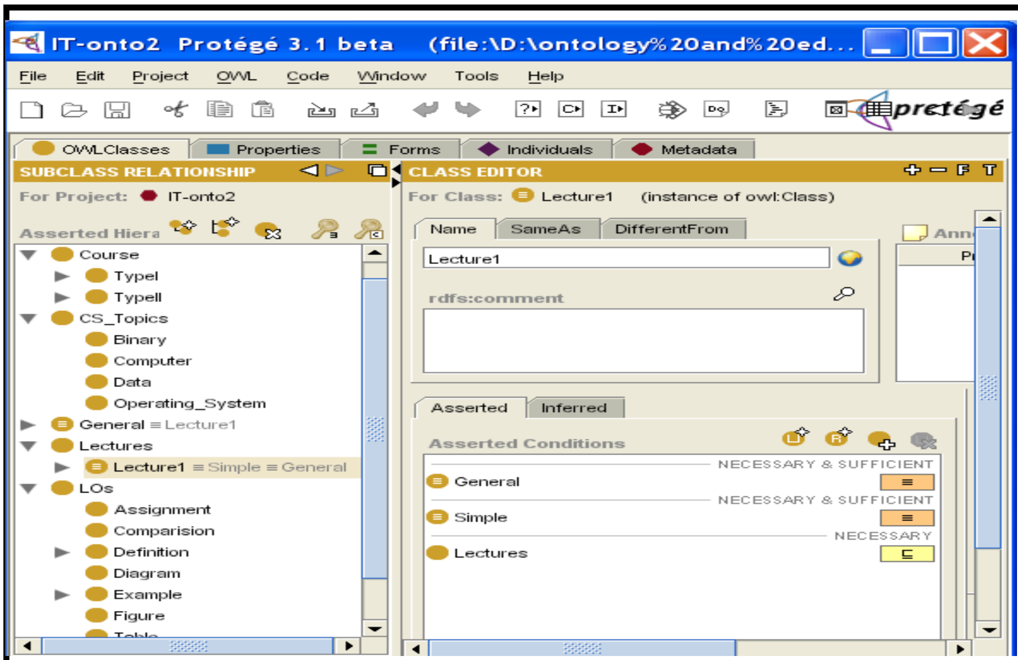

Figure-4 Protégé interface (classes and definitions)

As shown in Figure-4, the concept `Lecture 1` is part of the concept `Lectures` and is equivalent to the concepts `General` and `Simple`. In other words, it is a subcategory of lectures that have a general definition and simple example.

4.2 IT Course Generation

The learning objects (.pdf, .html, .doc, .ppt) are used to instantiate the concepts learning objects for a given topic. Each entry is translated into several individual methods. Each individual method is considered as an instance of a category of the ontology. For example, the following web page can be translated into the instance of a `Definition` concept and instance of `Figure` concept.

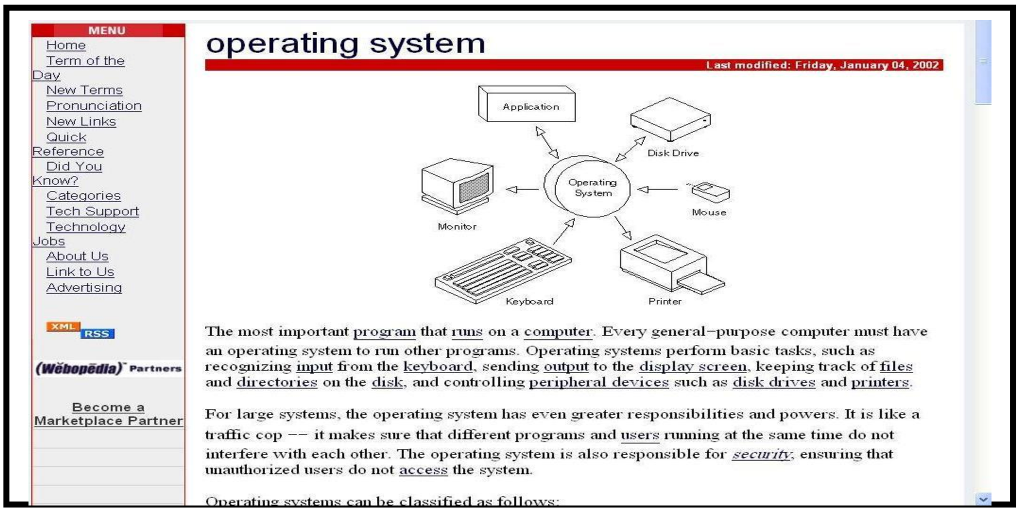

Figure-5 Example of Learning objects

4.2.1 Semantic Querying

Queries that have more than one criterion are called terminological queries. In order to define such queries we used a method for translating these queries into the concept expression to classify new concepts. Using standard inference services to check whether an individual method as an instance of the query expression will provide an answer to the aforementioned query.

Query Example:

$$\text{Lecture1} \subseteq \text{Lectures}$$
$$\text{Lecture1} \equiv \text{General} \cap \text{Simple}$$

Thus the query about lecture in an introductory course is translated into the concept `Lecture1`.

By invoking RACER reasoning, the ABox reasoning service the "*Instance Checking*" is activated to retrieve all instances that satisfy new concepts. Instance retrieval service provides a means to answer the query for lecture type 1 by finding all individuals that are instances of the concept `Lecture1` .

Figure-6 shows a view of Protégé 3.1, RACER is working in the background. By computing the inferred types to retrieve instances of the concept `Lecture1`.

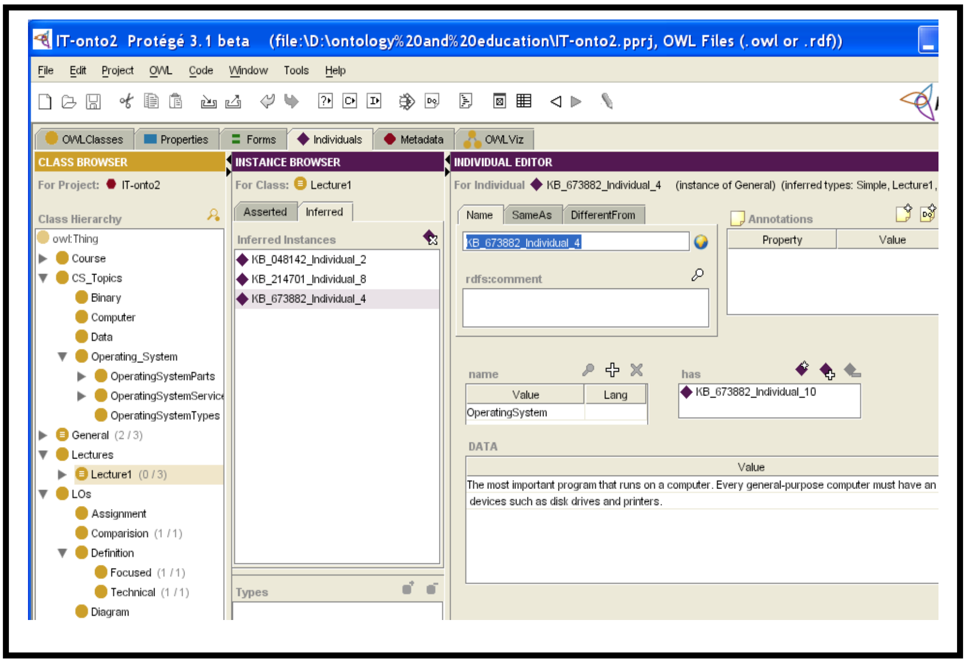

Figure-6 Example of Lecture 1 Inferred Instances

These three instances represent lecture1 in the IT subject Operating System in an introductory course. The lecture contains 2 general definitions of Operating System (instance1 is KB_048142_Individual_2 and instance2 is KB_673882_Individual_4)and one example of operating system (instance3KB_214701_Individual_8).

In the same way, it is important to define lecture 2 for visual learners, lecture 3 for active learners and etc.

In a technical course, the lecture is defined in a way that is different from previous definition as we should add to the definition of lecture one extra learning objects like tutorial and assignment features.

5. Related and Current Work

The practice of adding semantics to Learning Objects that are scattered on the web that uses ontology has been the focus of recent researches. [2] It gives an overview of the development of e-learning in construction, highlighting the key pedagogical and technical concepts and enables learners to master the semantic web technology. Also it describes an approach which is adopted for the development of 'ontology' within the construction domain and its integration to define the educational content, both semantically and pedagogically to provide a platform of independent architecture for both, learners and educators .

Researchers in [11] create ontology to achieve goals and objectives of the IT education. Its applications based on semantic web technology. This application was based on the alignment of the ontology to reuse the result of other researches.

6. Conclusion and Future Work

ITONTO bases its construction upon an ontology model of the objects that users may encounter in the real world applications. The effect of this is to provide an efficient approach to lucidly define the given information, particularly, by defining ontology that closely reflects the resources of the learning objects. Appropriate support for the learners and teachers is provided through these web resources that are used by experts. The relations represented in the ontology help to transform a weak linked collection of resources into a set of strong interconnected concepts. Other modules in the system are integrated with ontology to achieve the required functions.

The proposed prototype utilizes storage via concept instantiation. This provides query formulation and supports course generation. A semi-automatic process for which existing organized data of a domain will be used as starting elements for the ontology construction is envisaged. The ontology ITONTO presented in this paper can be considered as service ontology used by experts who are specialized in the course sequencing process.

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ملخص البحث

إن استعمال الانتولوجي في التخطيط التربوي بدات في الأونة الأخيرة ، من خلال بعض المحاولات الجدية للاستفادة القصوى من التكنولوجيا ، والمواقع الالكترونية في المجالات التربوية.
وهذا البحث محاولة جادة لتصميم وتنفيذ نظام الانتولوجي ، لمساعدة مدرسي تكنولوجيا المعلومات في العراق في تهيئة برامجهم الدراسية .
النظام مؤلف من لغة الانتولوجي التي تربط المعلومات الاساسية في تكنولوجيا المعلومات مع المبادئ التربوية ، والمواد التعليمية الاساسية والبحث يوضح الاهداف التربوية لتكنولوجيا المعلومات بشكل مختصر وتركز على التفاصيل التكنيكية في تعميم الانتولوجي وتطبيقها في المجالات التربوية .