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Instructional Material Development using Ontology Learning

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ABSTRACT

In a university setting, lecturers are instructional designers responsible to design and develop instructional materials to be used in class. Textbooks and presentation slides are among the sources used in the delivery of knowledge. However, in order to facilitate different students' learning styles, alternatives for textbooks must be considered, allowing the course content to be organised in smaller chunks. This paper describes the development ontology process using ontology learning technique. Ontology is a set of knowledge which contains objects, concepts, entities, and the relationships among them in a particular domain. In this study, the course chosen to analyse the development of ontology is Fundamentals of Computer Science (CSC401). This is an introductory course taken by students during semester one in the Faculty of Computer and Mathematical Sciences. Textbook is the source used in developing this ontology. The technique chosen in this study is a semi-automatic ontology development that can accelerate the process of producing a new ontology, while the development phases involved are the 'extraction of important concepts' and 'representation of ontology'. The result shows that an ontology can be represented in the form of visual graph such as mind map. This matches the learning preference of visual learners and enrich their learning experiences.

Keywords*: instructional design, instructional material, ontology, ontology learning, ontology development*

INTRODUCTION

Facilitating learners in the age of technology means delivering contents through different medium such as interactive mind map. However, there are barriers involved in order to create useful learning materials, for example it is costly, time consuming, and labour intensive even with the existence of detailed course description (Casey & McAlpine, 2002). In this case, ontology is seen as a potential source of solution. Ontology is described as an explicit specification of conceptualisation of objects, concepts, and other entities in the same domain and the relationship between them (Tim Berners-Lee, James Hendler, & Lassila, 2001). It has been praised for its abilities to share and reuse knowledge communicated between human and software agents (Bontas, Mochol, & Tolksdorf, 2005). Existing studies also support the usage of ontology as instructional material (Boyatt & Joy, 2012). One of the ways in which ontology can be represented is through visual graph which resembles the common mind map. Most relevant for instructional designers, the development of ontology can be accelerated through the usage of tools that automate a lot of processes involved in producing ontology of a particular field. This helps instructional designers to reduce the time and effort needed to prepare new instructional materials.

RELATED RESEARCH

This research is inspired by earlier works from other researchers. In a paper entitled 'Developing Learning Materials Using Ontology of Mathematical Logic', Boyatt and Joy (2012) explained how an ontology of mathematical logic is developed. This ontology, which consists of over 500 concepts and 60 categories and subcategories was used to guide the development of units and materials on mathematical logic topics. Next, in another related research to the usage of ontology in the education field, Saad and Shaharin (2016) posited that ontology represents the knowledge in the lesson plan domain. It serves as a guideline for educators to develop their lesson plan by having a central source of information to refer to, hence eliminating the need to filter the abundant amount of information via search engines. This reduces educators' workload and the time taken for them to prepare the needed lesson plan. Meanwhile, in supporting learners to integrate well in non-formal situations, a group of researchers proposed the usage of STUDIO,

which is a domain of ontology-based solution for knowledge discovery in learning and assessment (Weber, Neusch, & Vas, 2016). STUDIO supports learners in allowing for adaptive learning and self-assessment using domain knowledge via self-assessment, reflection, and learning (Weber *et al.*, 2016).

RESEARCH BACKGROUND

In this study, an introductory course in Computer Science is chosen to develop the ontology. Fundamentals of Computer Science (CSC401). Students take this course during semester one in the Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA Malaysia (UiTM). This course, just like all other courses taught in UiTM, is delivered fully in English. Students enrolling in the course come from various backgrounds of computer and English literacy level. It is therefore important that they are supported with instructional materials that can cater to their diverse needs. Textbook used in this course is a popular textbook for teaching any introductory courses in Computer Science. The study focuses on the first chapter of the book, a comprehensive chapter that summarises all subsequent chapters. It is also part of topic one in CSC401's syllabus.

The technique used to develop the ontology chosen in this study is semi-automatic ontology development. Semi-automatic ontology development is less costly and saves a lot of time compared to manual development (Brusa, Caliusco, & Chiotti, 2006). The ontology learning tool used in the ontology development is Text2Onto since the system calculates a confidence for each learned object which is suitable in CSC401's ontology development and can be used for the extraction of important terms (Cimiano & Völker, 2005). Discussions on the rationale and background of these decisions had already been discussed in a previously published paper on a similar project (Ismail, Shahbudin, & Ahmadon, 2017). This paper's focus is on the ontology development stage.

CSC401 ONTOLOGY DEVELOPMENT

The ontology development stage consists of two phases namely the 'extraction of important concepts' and 'representation of ontology' as illustrated in Figure 1.

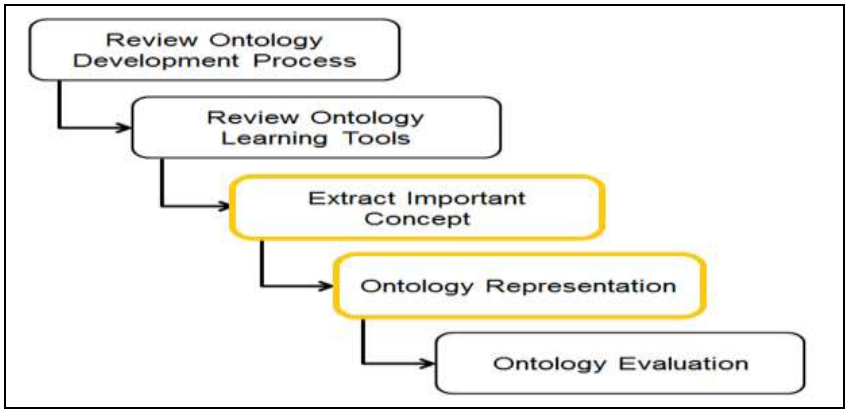

Figure 1: CSC401's ontology development Phases

Phase 1: Extraction of Important Concepts

In this phase, important concepts were extracted and instructional designers were assisted with the usage of Text2Onto as shown in Figure 2. This ontology learning tool is capable of automatically extracting important concepts within the pages of knowledge source.

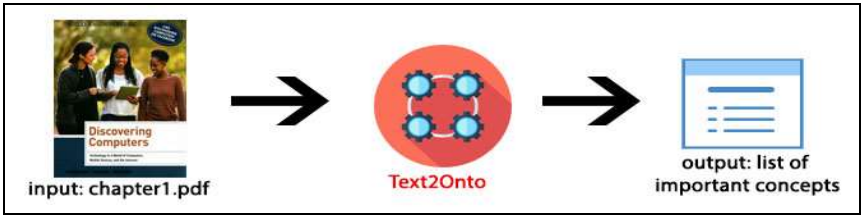

Figure 2: Extracting Important Concepts using Text2Onto

In this study, a softcopy file of the chapter from the textbook was fed into Text2Onto as input. As illustrated in Figure 3, Text2Onto then processed the file and produced an important output list of concepts.

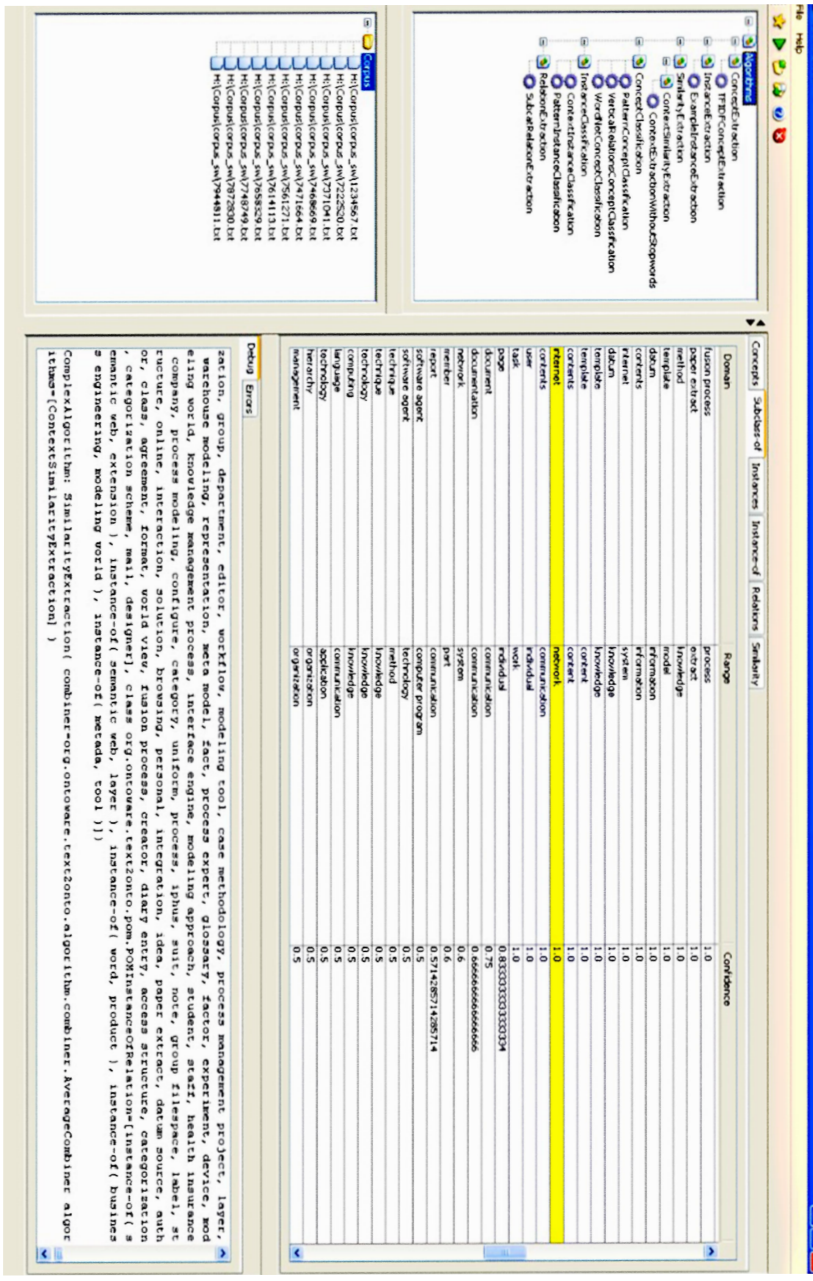

Figure 3: Important Concepts Extracted in Text2Onto Interface

Next, as shown in Figure 4, Text2Onto suggested relevant percentage in determining the concept selection. This phase was done automatically with little input needed from user. From the 92 pages of chapter one from the textbook, Text2Onto highlighted 139 concepts as important.

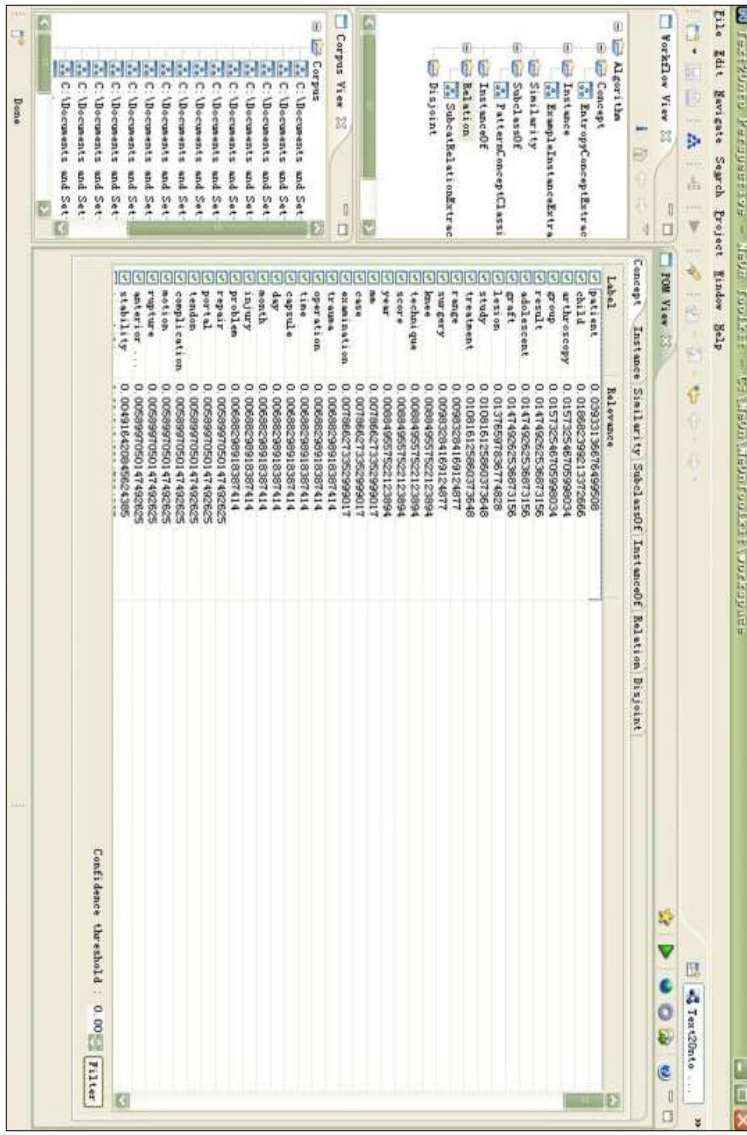

Figure 4: Suggestion of Relevance Percentage in Text2Onto Interface

Phase 2: Representation of Ontology

While the extraction of important concepts phase was done automatically, in the representation of ontology phase, instructional designers as the subject domain experts must manually define the relationships between concepts extracted in previous phase using a selected ontology editor. In this study, Protégé was selected as the ontology editor and the process is visualised in Figure 5.

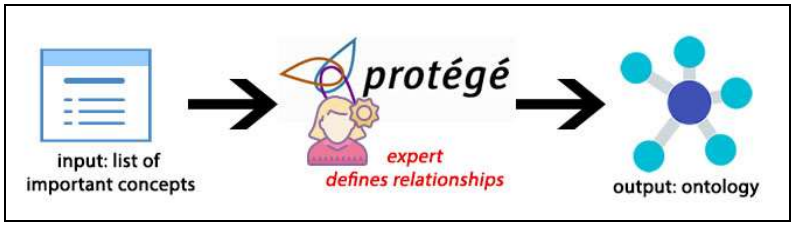

Figure 5: Representation of Ontology using Protégé

The important concepts extracted by Text2Onto from the previous phase were imported into the Protégé ontology editor. Once the concepts were already inside the editor, lecturers teaching CSC401 (subject domain experts) were asked to define relationships between each concept in Chapter One as illustrated in Figure 6. In this study, the subject domain experts adopted 124 out of 139 concepts extracted by Text2Onto and used the relationships hasTopic in defining the ontology.

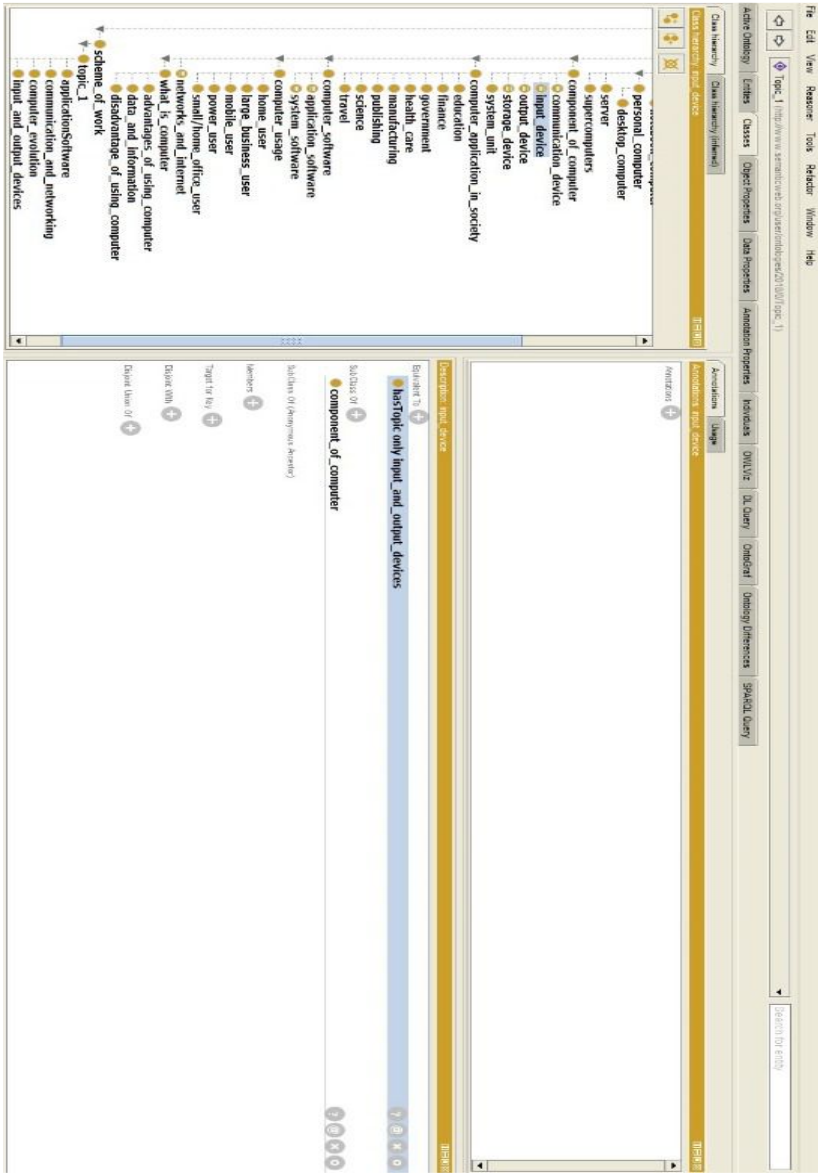

Figure 6: Defining the Relationships Between Concepts in CSC401 Ontology

Relationships between concepts in CSC401 ontology that had been defined in the representation of ontology phase could also be connected to each other in which they became triples. Further connections between triples result in a knowledge of this particular domain; also known as ontology. In addition, using Protégé allows CSC401 ontology to be viewed interactively as shown in Figure 7.

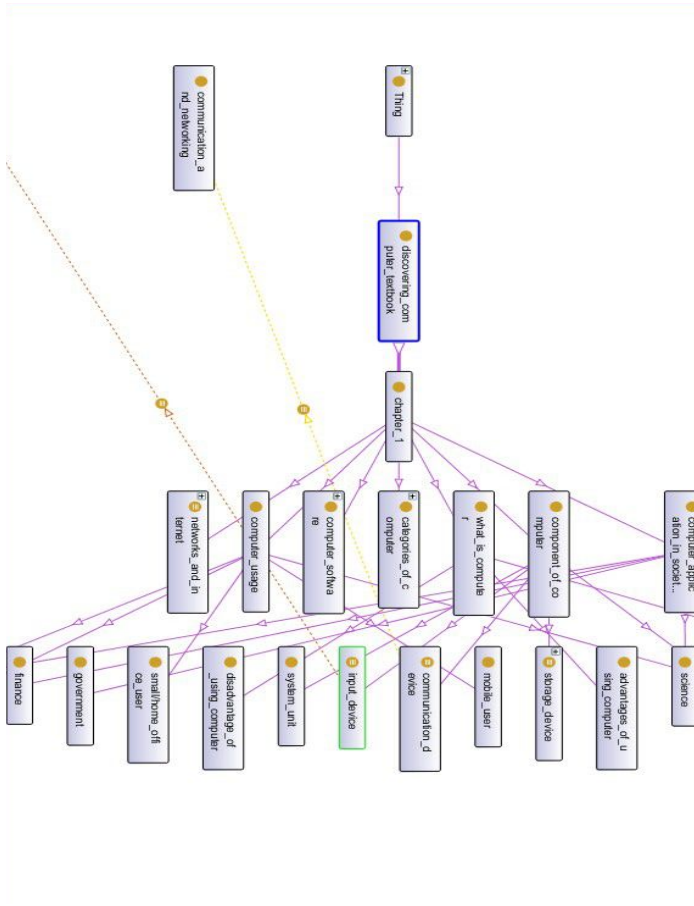

Figure 7: Protégé View of Topic 1

In Figure 7, boxes represent concepts and arrow lines represent relationships. Bold lines represent the subclass relationship while dotted lines represent has Topic relationship. The taxonomy for topic 1 of CSC401 is shown in Figure 8.

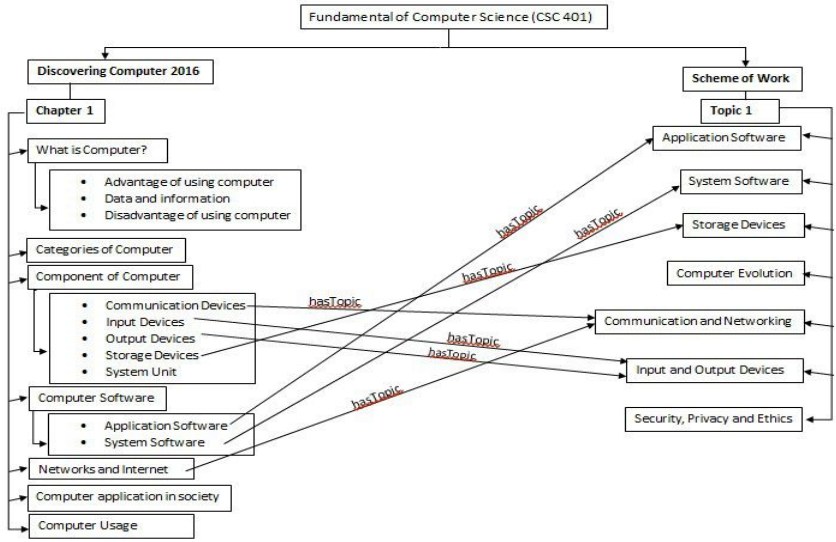

Figure 8: Taxonomy of CSC401 Ontology

CONCLUSION

This paper describes two important phases involved in the development of ontology for an introductory topic in the field of computer science. In total, there are five phases involved; the first two phases focus on deciding suitable methods and tools and were discussed in a previous paper. The third and fourth phases that are the focus of this paper, are centred on the development process of ontology itself. They relate to the 'extraction of important concepts' and 'representation of ontology' and describe the development of ontology using semi-automatic approach. The extraction of important concepts uses Text2Onto as the ontology learning tool and it automatically extracts important concepts from the textbook. Next, subject matter experts use Protégé ontology editor to manually define relationships and produce the ontology in the representation of ontology phase. This ontology, when viewed in the form of visual graph, resembles a mind map which is helpful for visual learner students.

In short, there is a learning curve for instructional designers wanting to employ ontology as a source of learning materials. Ontology enables common understanding of information and the reuse of domain knowledge. The usage of semi-automatic development method in ontology learning also enables the development time to be reduced compared to manual ontology development method. Thus, development of instructional materials via ontology serves as an alternative for instructional designers looking for methods to support their students' learning styles.

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