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Ontology Model for Classifying Students with a Learning Disability: A Preliminary Study

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Abstract: Recently, learning disability has been classified manually based on student's Intelligence Quotient (IQ) and achievement score. The available evidence shows that accurate student's identification with a specific type of learning disability is a difficult process due to the high dependency on a domain expert's diverse and unstructured knowledge and experience. This has led to the building of a new model based on ontology for classifying learning disability students and recommending the appropriate type of educational service and required support. The objective of this study is to have a preliminary discussion on the proposed ontology model. Methontology is applied to construct the ontology model. Currently, the ontology model is under evaluation and an initial prototype is being developed to demonstrate the applicability of the model. The prototype is expected to classify children with disabilities based on their dominant characteristics, thus giving a suggested suitable teaching method to teachers and parents.

Key words: Classification, learning disability, ontology, special education, experience, IQ , recommending

INTRODUCTION

Education plays an important role in individual's cognitive, social and emotional development. Over the past decade, under the Early Childhood Care and Education (ECCE) as advocated by UNESCO, various public education programs have been established in helping children develop to their full potential starting from as early as childhood as seen in the United States, European countries, India, New Zealand and Malaysia. However, children with cognitive, psychology and behavioral problems are unable to accommodate the education programs. These children are identified as special education children.

Children with special education needs are required to learn and enhance their quality of life (Mitchell, 2010; Aziz *et al*., 2012). These children need to go to schools that are specialized for them. In Malaysia, the Ministry of Education's Special Education Program has been established to ensure students with disabilities in preschool, primary and secondary schools receive a free and appropriate special education.

Meanwhile, the Government of Tanzania had initiated an inclusive education of students with a disabilities program in primary schools in 1998 (Lehtomaki *et al*., 2014). In the United States, the Individuals with Disabilities Education Improvement Act (IDEA) is the federal education program that provides guidelines for disability classifications and eligibility processes for students with disabilities (Matthews *et al*., 2014). Despite these converted efforts to provide special educational services, the challenge in recommending the appropriate and quality special education for the students with learning disabilities is a main challenge for special education teachers. Various criteria are used as a guideline to determine a special education program. For example in Malaysia, the Salamanca Framework of Action 1994 identifies seven important criteria for conducting special education which are policy and organization, school factor, information and research, recruitment of educational personnel, external services and priority areas.

In addition, IDEA has divided special education into thirteen categories namely specific learning disability, speech or language impairment, visual impairment, multiple impairment, autism, traumatic brain injury, deaf-blindness, deafness, emotional disturbance, hearing impairment, intellectual disability, orthopedic impairment,

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and other health impairments (Mizen and Cooper, 2012). Specific learning disability is the main focus in this study which includes a group of children that have a problem with their education. It can be categorized into three general groups: dyslexia, dyscalculia and dysgraphia. Most researchers try their best to group the children into the categories as mentioned before. However, accurate student identification with a specific type of learning disability (Aaron *et al*., 2008) either by a special education teacher or medical practitioners (domain experts) is a difficult process (Geary *et al*., 2007). According to Shifrer *et al*. (2011), the disproportionate identification of a learning disability is due to the subjective definitions of a learning disability and the inconsistent criteria in differentiating types of learning disabilities. The identification of a learning disability highly depends on the domain expert's diverse and unstructured knowledge and experience. Meanwhile, racism is also considered a factor that could contribute to the disproportionate identification of a learning disability (Skiba *et al*., 2008). It tends to influence a biased decision from domain experts.

In order to overcome this issue, information and knowledge are the most important components in supporting the decision-making process in the special education domain, especially, to precisely classify students with a specific type of learning disability and to recommend the appropriate special education plan. However, the existence of information and knowledge in a subjective, diverse and unstructured manner requires having a uniform knowledge representation model. Expert system is an intelligent computer program that uses knowledge and inference procedures to solve a problem and requires significant human expertise for the solutions.

Ontology is a technology used to represent knowledge domain in an understandable form and can be manipulated by a machine. It is developed to share common understanding of the structure of information among people to enable the reuse of domain knowledge, to make domain assumptions explicit to separate domain knowledge from the operational knowledge and to analyze the domain knowledge. Several ontology models have been developed in education environment such as e-Learning (Colace and Santo, 2010; Chung and Kim, 2012), university course retrieval (Malviya *et al*., 2011) and technological education (Manessi and Dendrinos, 2014). These literatures however show the absence of an ontology design for the special education domain, especially in supporting the classification type of a learning disability and recommending the type of educational service and support needed. Thus, this study aims to build a new ontology model in the special education domain.

Literature review: Many researchers use technology to support and help in solving problems that occur in many areas such as business, management, education, etc. Education is always being improved by new technologies especially with the emerging computer related information technology (Alsultanny, 2006). Ontology is the substance of cooperation and the semantic understanding between computers and the cooperation between computers and humans (Cakula and Salem, 2013). It has been used in various domains, however, the use of ontologies in education is more for classifying the children with special needs with a suitable learning method. Based on previous research, no method has used ontology to classify learning disability and to recommend the type of education service and support needed. Alsobhi *et al*. (2015) proposed ontology to personalize learning materials based on dyslexia types. These researchers examined the assistive technology that can be used by dyslexic children. A research done by Peleg *et al*. (2009) combines ontological methods and clustering analysis to identify a group of comorbidities for development disorders. These researches do not have a recommended method to help students improve their quality of life.

Meanwhile, a personalization approach using the disability ontology has been proposed by Nganji and Nggada (2011). It helps disabled students to choose suitable learning resources based on their specific needs. Besides using ontology in learning resources classification, it is also being used to assist educational learning. For example, a research has been done by Venkatesan *et al*. (2013) using a hybrid ontology to teach children with autism and to analyze the children's (user) needs in their learning.

Besides using ontology as a method, other researchers have used the expert systems such as the decision tree, fuzzy rule-based, Artificial Neural-Network (ANN) and others. Palacios *et al*. (2009) presented a rule-based method that is used to diagnose dyslexic students with quality data combined with genetic fuzzy systems. Julie and Kannan (2010) did some research to predict the learning disabilities of school-age children using the decision tree. They used the algorithm J48 to classify children with a learning disability. In addition, Wu *et al*. (2011) used the Artificial Neural Network (ANN) to classify children with learning disabilities.

Based on this related work summary, there are more advantages using ontology compared to the expert system. By using ontology, "the conceptualization is explicit to make authoring systems literate and intelligent" (Gascuena *et al*., 2006). Expert systems can cause knowledge-based concepts to be implicit. Standardization

with ontology will facilitate the reusability of components and enable a common sharable and formal specification of a domain using terms and relationships. Ontology can share knowledge among people and software agents and it can even be applied to problem solving. In the expert system, the different terminologies can cause a misunderstanding in the respective systems (Gascuena *et al*., 2006).

This is one of the main factors that prevents reusability. On the other hand, the ontology can be reused in the semantic web era where most of the knowledge and data useful to support a decision is available (in heterogeneous formats) on the web. Ontology can properly differentiate attributes or characteristics that are ambiguous. Theory-awareness in ontology makes authoring systems knowledgeable rather than an expert system. Ontology can use the latest reasoning service some of the inference steps of the decision support system can be performed via. the state of the art logical reasoning services for instance, rule engines or ontology reasoners.

MATERIALS AND METHODS

The research methodology consists of five phases: feasibility study, design of the ontology model, development of the ontology model, development of the ontology-based supporting tool for the special education domain and evaluation as seen in Fig. 1. First step is to identify issues that have occurred in special education from all over the country from journals, articles, websites, and reports. These current issues will be focused on pecial education especially for identifying the type of learning disabilities students. Existing ontologies were also analyzed to find out the relationship between the current issues and the existing ontologies. Next step is to design an ontology model by getting information based on attributes and properties obtained from journal reviews and a series of domain expert interviews. Comprehensive reviews in researches are also important to identify the purposes and concrete justification of designing the ontology model. The ontology model's static knowledge and dynamic knowledge can be formulated by defining the concepts, semantic relationships and attributes and by constructing formal axioms and logic rules. In this phase, the methodology for constructing a model is identified as methontology. These methodology was proposed because many other ontology tools and tool suite can be used (Park *et al*., 2008; Iqbal *et al*., 2013). If there is a problem occurring after an activity, we can return to any of the previous activities to solve the problem. Figure 1 shows the phases of the methodology to build an ontology model.

After designing a model, the next step is to develop the model. There are many ontology editors that can be used such as Protege, SWOOP, NeOn Toolkit, TopBraid composer and others. For this model, the ontology model will be built using the TopBraid composer. The concepts, semantic relationships, attributes, formal axioms, rules, and individuals are coded into the Web Ontology Language (OWL) format.

The fourth phase is to design an ontology-based supporting architecture and to develop ontology-based supporting tools for the special education environment. After that, the ontology model will be evaluated by checking the consistency automatically. Moreover, this ontology model will evaluate its usefulness in the developed tool by getting feedbacks from experts using interviews.

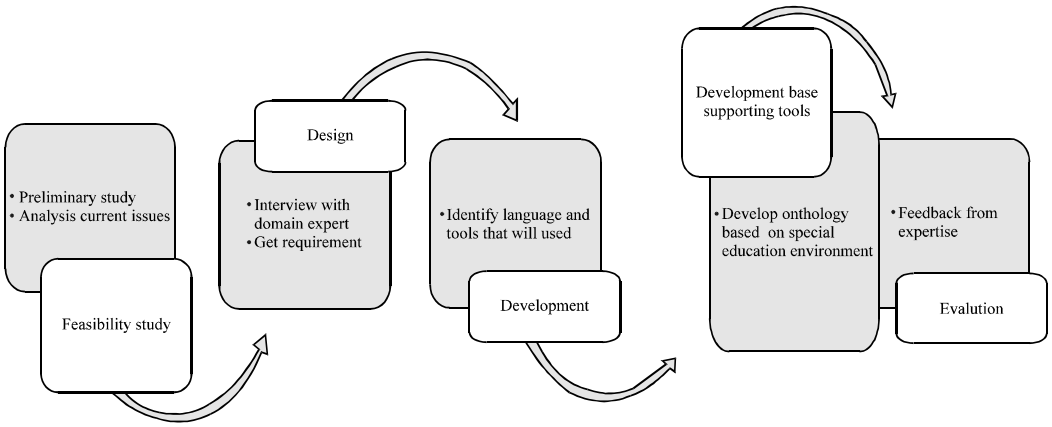

Fig. 1: Phase of methodology to build an onthology model

RESULTS AND DISCUSSION

Preliminary ontology model: The main purposes of building the ontology model is to assist domain experts in observing the students in order to identify their problems and to categorize them based on their characteristics. Thus, ontology plays a vital role to structure domain expert's knowledge in machine-readable format. Ontology model describes any customized relation between different types of classes class is a concept.

As the initial result, a preliminary learning disability ontology model has been designed as depicted in Fig. 2. It is used to classify students with dyslexia, dyscalculia and dysgraphia. A customized structure as well as classes, subclasses and properties were defined. It includes person, student, special education student, LD student (dyslexia student, dysgraphia student and dyscalculia student), characteristics, special education characteristicsmand LD characteristics (dyslexia, dysgraphia and dyscalculia characteristics). The Person class includes a person with characteristics. Based on Fig. 2, a student with dyslexia has student dyslexia characteristics. Dyslexia students have to fulfil the entire attributes to categorize it. It is the same as the class of dysgraphia student and the class of dyscalculia student.

Development of the ontology on learning disability was built using the top braid composer. Relationship can be represented by using OWL properties such as object property and datatype property. Object property represent relationship between two individuals. It used to define relations between classes. Properties are the characteristic of a class that has a certain type of values and data type property. Datatype properties are used to link individuals to data values. All datatype property in the model have primitive type as Boolean. The user just have to know either the student have or not the characteristics that's given. This ontology used the modelling language OWL (Web Ontology Language) because it is of W3C standard (Burger and Stieger, 2010).

OWL allows the meaning of properties to be enriched through the use of property characteristics that is functional property, inverse functional property, transitive property, symmetric property, etc., the relations between entities were used to created rules that gives the model result for user. Based on model, for all student that have characteristics of learning disability, it means that the student is a learning disabilities students. For all student that have characteristics of dyslexia, the student is a dyslexia student. For all student that have characteristics of dysgraphia, the student is a dysgraphia

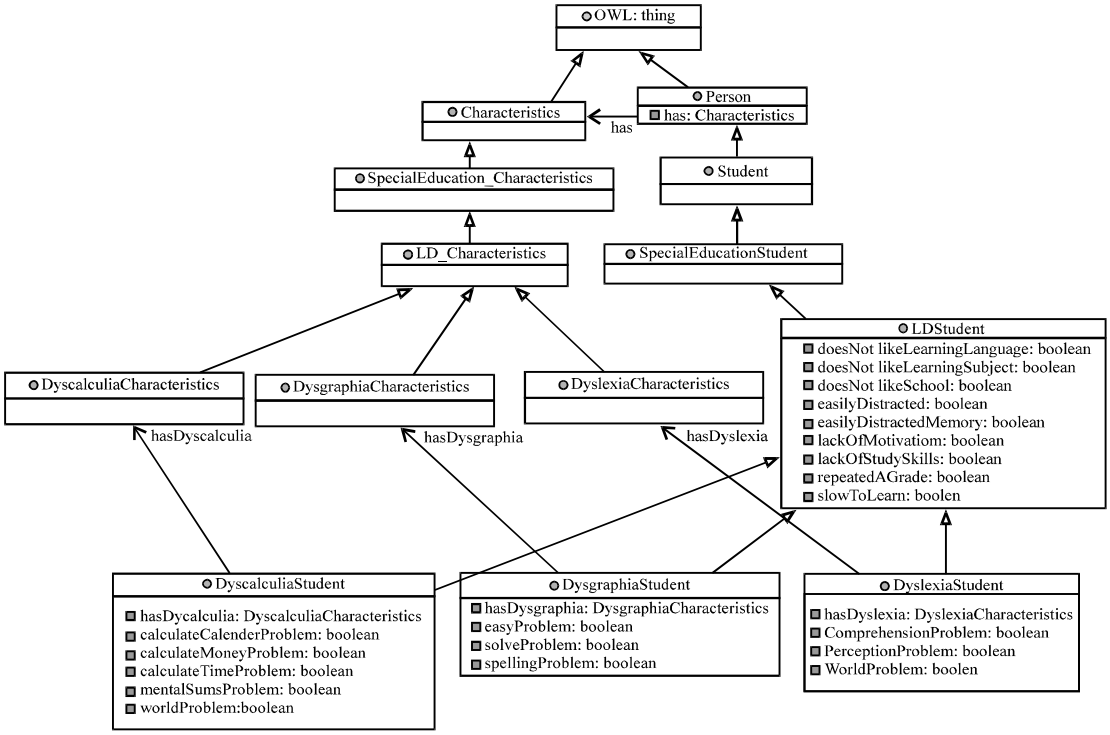

Fig. 2: Class hierarchy of learning disability model

student. For all student that have characteristics of dyscalculia, the student is a dyscalculia student.

CONCLUSION

A new ontology model for special education environment is proposed to classify the type of learning disability and to recommend the type of educational service. This research only included 3 categories of learning disabilities including dyscalculia (more problems with mathematics), dysgraphia (more problems with writing) and dyslexia (more problems with reading). These categories can be classified based on their characteristics and appearance. An ontology-based supporting tool is developed in order to evaluate the applicability of the ontology model proposed. The significant output of this research is to educate students with special needs in enhancing their quality of life in terms of academic, social and emotional development.

Ontologies are considered a prominent technique to represent knowledgeb and advantage in the learning disability environment. It is important as supportive tools to an expert. Thus, the learning disability ontology model is aimed to support decision-making process in recommending an appropriate special education plan for qualified students with disabilities.

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