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ICT as a Tool for Screening Student with Specific Learning Disabilities

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Abstract

Screening of student that may be at risk for specific learning disabilities (SLD) can be an initial step to assist them overcome barriers to learning, hence preventing academic failure, school dropout, and peers rejection. Despite of concerted guideline frameworks and models for disability recognitions such as Individuals with Disabilities Education Improvement Act (IDEA), Ability–Achievement Discrepancy, Response to Intervention (RtI) and Pattern of Strengths and Weaknesses (PSW), the integration of information and communication technologies (ICT) for supporting the screening and suitable education plan for student with SLD has not received adequate attention. Thus in this study, an Ontology-based Specific Learning Disabilities Screening tool has been designed and developed. This ICT-supported tool plays a notable role for parents and teachers to identify their children or students at risks for SLD, as well as to recommend appropriate educational activities to assist their learning process. The research methodology utilized is based on Agile software development method. The initial evaluation result obtained from parents and teachers indicated the tool acceptance in terms of the reliability result of early screening student that at risk of having dyslexia, dysgraphia or dyscalculia, and suitable educational activities.

Keywords: Specific Learning disability, ontology model, dyslexia, dyscalculia, dysgraphia, ICT tool

Introduction

The concerns in special education for students with disabilities have increased in many nations. The aim to educate students with special needs is to enhance their quality of life in terms of academic, social and emotional development (Mitchell, 2010)(Aziz, Aziz, Paul, Yusof, & Noor, 2012). Based on Education for All 2015 National Review report, special needs students are categorized into three main disabilities; the hearing impaired, the visual impaired and the learning disabilities students (UNESCO, 2015). Learning disabilities students are those with specific learning difficulties such as dyslexia, dysgraphia and dyscalculia, which are classified in the Specific Learning Disabilities (SLD) group.

Screening of student that may be at risk for SLD can be an initial step to assist them overcome barriers to learning, hence preventing academic failure, school dropout, and peers rejection. There are several well-known guideline frameworks and model that have been widely implemented manually for recognizing students with SLD such as Individuals with Disabilities Education Improvement Act (IDEA) (Trohanis, 2008), Ability–Achievement Discrepancy (Kavale & Flanagan, 2007), Response to Intervention (RtI) (Hoover, 2010) and Pattern of Strengths and Weaknesses (PSW) (Schultz, Simpson, & Lynch, 2011). Despite of these concerted efforts for disability recognitions, the integration of information and communication technologies (ICT) for supporting the screening for student with SLD has not received adequate attention. Lack of screening tools that are accessible among teachers

and parents makes them unaware and less knowledgeable on how to properly guide in educating their children or student that may be at risk for specific learning difficulties (Garry, Jean, & Atkinson, 2013; Habib, 2015; Lim & Chia, 2017).

Thus in this paper, an ICT tool known as Ontology-based Specific Learning Disabilities Screening has been designed and developed. The tool plays a notable role for parents and teachers to identify their children or students at risks for SLD, as well as to recommend appropriate educational activities to assist their learning process. Hence, the aims to increase awareness and guided knowledge among them can be achieved.

The rest of the paper is organized as follows. First, the Related Works section presents the state-of-the-art of current ICT tools for supporting teaching and learning in special education environment. Meanwhile, the subsequent section outlines the overall framework of the research methodology. The proposed architecture of Ontology-based Specific Learning Disabilities Screening is discussed next and followed by the implementation of prototype. Finally, the last section concludes with a summary of this paper and future research directions.

Related Work

ICT-supported tools have played an important role in supporting special education environment. Several tools have been proposed by researchers using various information technology such as interactive multimedia, computerize handwriting assessment, game and web-based application as summarized in Table 1.

Table 1.
Related Work for Identifying Children with Learning Disabilities.

Tool	Author & year	Aim
Smart Lexic	Ekhsan et al., 2012	To identify children with dyslexia
Computerized handwriting assessment	Chea, Ming, Khalid & Fai, 2012	To identify writing stroke and direction
Game with multiple platform	Facoetti et al., 2014	To identify children with dyslexia
MyLexics	Eze Manzura Mohd Mahidin, 2014	To support children in reading
Web application (10 test of askisi)	Zygouris et al., 2015	Screening for LD children

Smart Lexic is an interactive multimedia tool which has been developed to identify students with dyslexia (Ekhsan et al., 2012). This Smart Lexic is a computer-based screening tool that implement multimedia elements that suitable for dyslexic students. Meanwhile, Chea et al. has proposed a new evaluation method to assist in detecting handwriting problem based on the identification of errors in stroke type, sequences, and direction when forming an alphabet (Chea, Ming, Khalid, & Fai, 2012).

Facoetti et al., developed a set of games with a multiplatform approaches (web-based and mobile platform) (Facoetti et al., 2014). Data retrieved from the game is then analyzed by experts. Another researcher, develop a web E-Z Dyslexia courseware (MyLexics) that contain 4 theory that is Orthon's multisensory, cognitive, mayer dual coding, phonological and visual theory to give suitable teaching and learning methods for dyslexic children (Manzura & Mahidin, 2014). The new web neurocognitive screening tools that call "askisi"

has been developed to screening measure learning difficulties (Zygouris et al., 2015). The children will test in reading, arithmetic, spelling and cognitive skills.

Even though ICT tool has shown significant contribution on recognizing student with SLD, but it is still lacking in providing guided knowledge to parents and teachers on proper educational activities that can be practiced for helping their child or student overcomes the barrier in learning.

Research Methodology

This section describes the overall framework of research methodology carried out in this study. To date, various methodologies of software development have been applied to build the system software (Leau, Loo, Tham, & Tan, 2012)(Sharma, Sarkar, & Gupta, 2012). In this study, process of developing software is carried out based on Agile software development method using extreme programming approach, in which it is based on the combination of iterative and incremental process models. As depicted in Figure 1, the overall research methodology consists of four phases including exploration, planning, iteration to release, and production and maintenance.

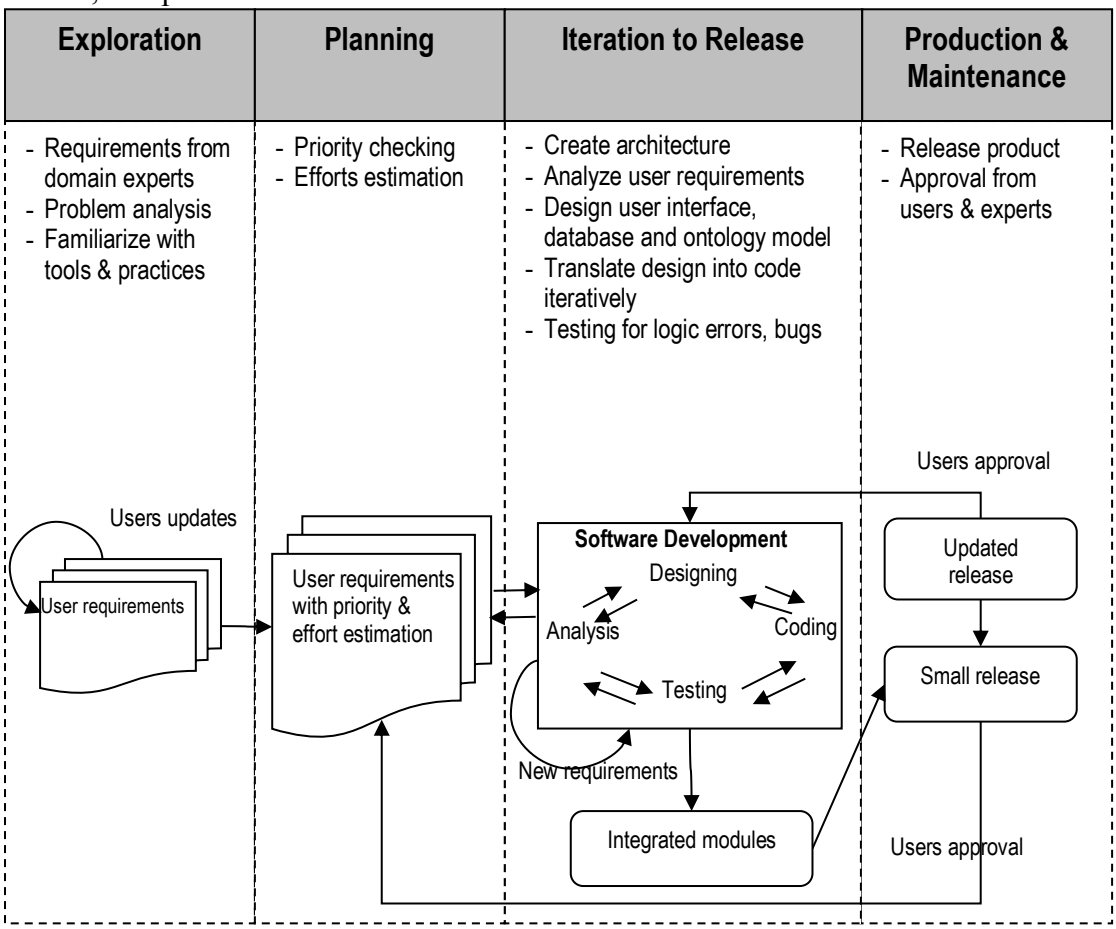

Figure 1. The Framework of Research Methodology

In the exploration phase, requirements are collected from the domain experts consisting of medical practitioners, occupational therapist and special education teachers. Several series of meetings are conducted with the experts in order to obtain consensus requirements that need to be included in the first release. Based on the requirements obtained, development process is divided into several small number of modules. At the same time, tools such as NetBeans IDE 8.2, MySQL and TopBraid Composer are familiarized.

These three tools are essential to build an initial prototype. In addition, the technology possibilities for supporting the development of prototype are explored as well.

The planning phase sets the priority order for the user requirements obtained in the previous phase and an agreement of the contents of the first small release is made. Estimation amount of effort and schedule each module requires are also determined.

Meanwhile, the iteration to release phase contains several cycles of the software development for each module before the first release. Each cycle of software development includes several iterative steps such as planning, design, coding and testing. The first iteration creates the architecture of the whole modules as a baseline structure. This is achieved by combining the requirements identified. In the planning, details analysis of each module is done. Subsequently, user interfaces, database and ontology model are designed for each module. Coding is an implementation step that serves to translate design representation into programming language. The last iterative step is testing where each developed module is tested for any logic errors and bugs. If any errors or bugs are detected, they will be removed in the next cycle. During software development process, new user requirements may come and the cycle pelan should be adjusted according to that. At the end of the last cycle of the last module, the whole modules are integrated into a system and is ready for production.

In the production and maintenance phase, pilot testing and checking of the system performance are required before it can be released to the user. At this phase, feedbacks from users are taken into account. Here, new changes may still be discovered and the previous phases need to be revisited.

The Architecture

This section discusses the architecture of Ontology-based Specific Learning Disabilities Screening. The architecture is composed of four major layers namely presentation, application, data and semantic layer. Figure 2 presents the architecture proposed in this study.

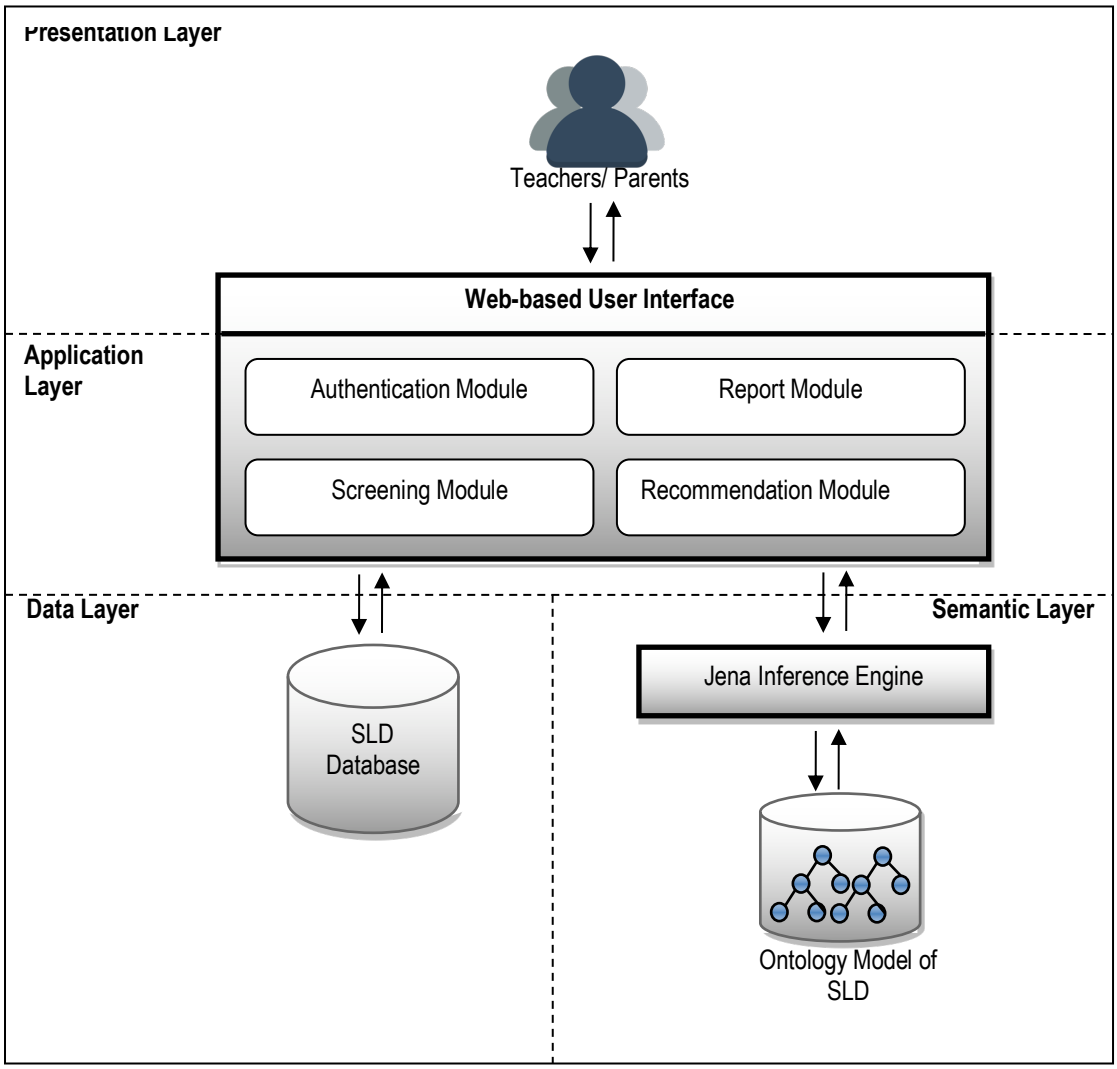

Figure 2. Architecture of Otology-based Specific Learning Disabilities Screening

In the presentation layer, the web-based user interface is a dialog component that serves to manage the interaction between users such as teachers, parents and system. It is the gateway to the application layer. It can be accessed either using web or android browser. Interface design is essential to determine the usability of the system and control the information flow.

Application layer coordinates the logics of application and processes commands. It moves and processes data between presentation, data and semantic layer. The layer consists of four logical applications, including authentication, screening, recommendation and report modules.

In the data layer, a relational database serves to store information on authentication, SLD screening answers and the results inferred from semantic layer. Figure 3 shows the entity relationship diagram for SLD database design. The database consists of eight tables which are Registration, Student, DyslexiaScreening, DyscalculiaScreening, DysgraphiaScreening, ScreeningResult, Problem and RecommendationActivity. The data retrieved in DyslexiaScreening, DyscalculiaScreening and DysgraphiaScreening tables are processed by inference rules in the semantic layer and the inferred results will be passed back to store in the ScreeningResult, Problem and RecommendationActivity tables.

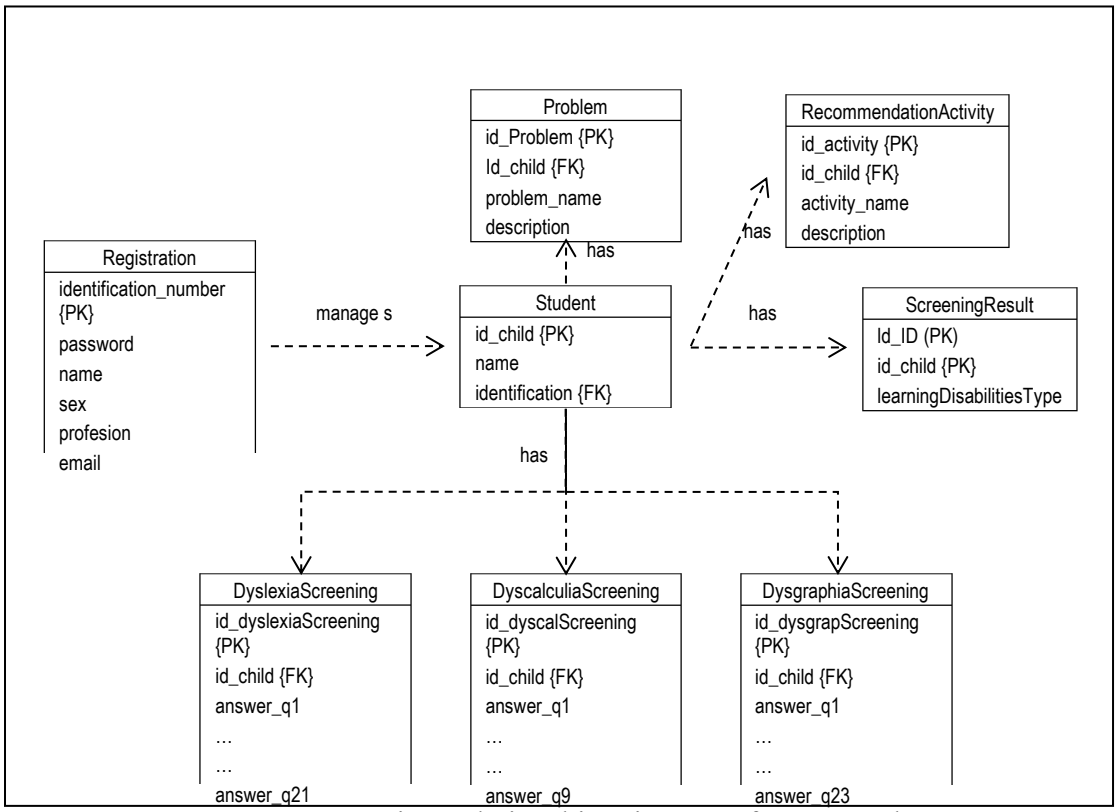

Figure 3. Entity-Relationship Diagram of SLD Database

Semantic layer consists of Jena inference engine and SLD ontology model. The purpose of building the ontology model is to support teachers and parents to recognize their children or students that may has potential of having learning disabilities based on specific characteristics. The advantage of using ontology is it enables the creation of a set of concepts, properties and individual, which can be understood by both humans and machines. Figure 4 shows the design of SLD ontology model. It represents the knowledge on the characteristics of SLD and suitable educational activities for the children or student. The model starts with owl:Thing. Meanwhile, the class of sld:characteristics includes the characteristics of dyslexia, dyscalculia, dysgraphia and learning problems. The properties of hasProblem will connect class sld:learningProblem with subclass of sld:characteristics. Based on the model, with the specific learning problem, the children or student will be recommended with the suitable activities that have been defined in class sld:activity.

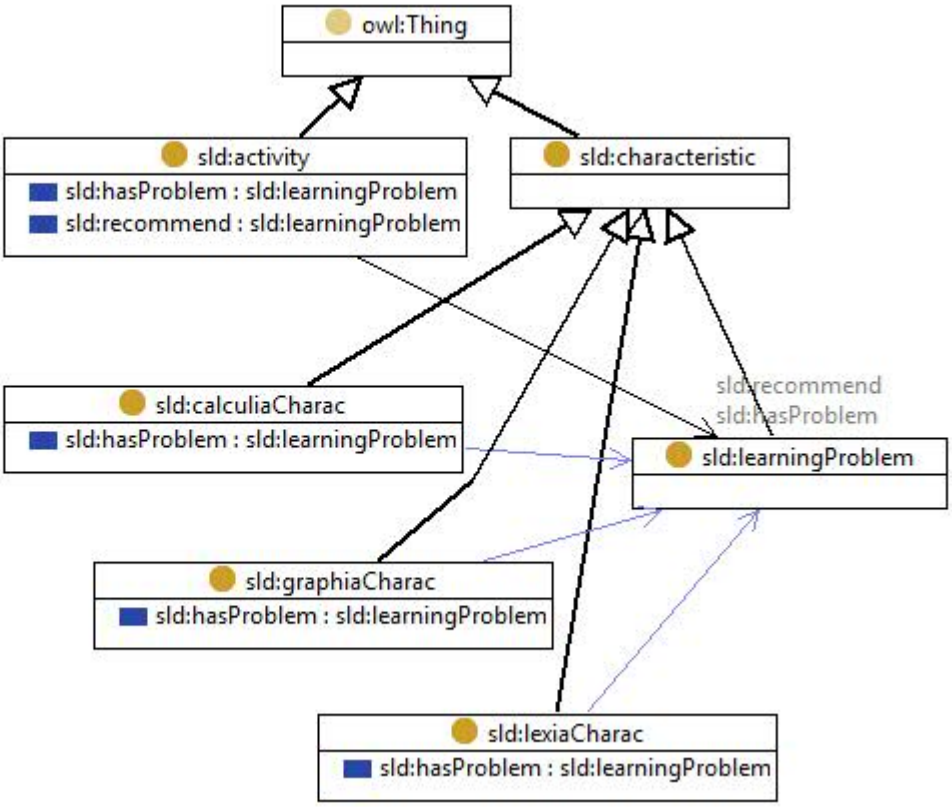

Figure 4. Ontology Model of SLD

The Implementation of Ontology-based Specific Learning Disabilities Screening

A prototype of Ontology-based Specific Learning Disabilities Screening has been developed. The prototype aims to support parents and teachers for recognizing their children or students that may have SLD and recommend suitable educational activities. It is developed using NetBeans and TopBraid Composer. The interface design and the algorithm are coded based on Java programming language. Meanwhile, TopBraid Composer is used to model the concept of SLD in the form of ontology. Concepts, relationships, axioms and rules are encoded based on web ontology language OWL and supported by RDF and RDFS. There are four modules in the prototype of Ontology-based Specific Learning Disabilities Screening which are authentication, screening, recommendation and report.

Authentication module requires unregistered users to sign up the system before they are allowed to use other modules. Figure 5 shows the registration form. The registered users need to login by using their identification number and password as depicted in Figure 6.

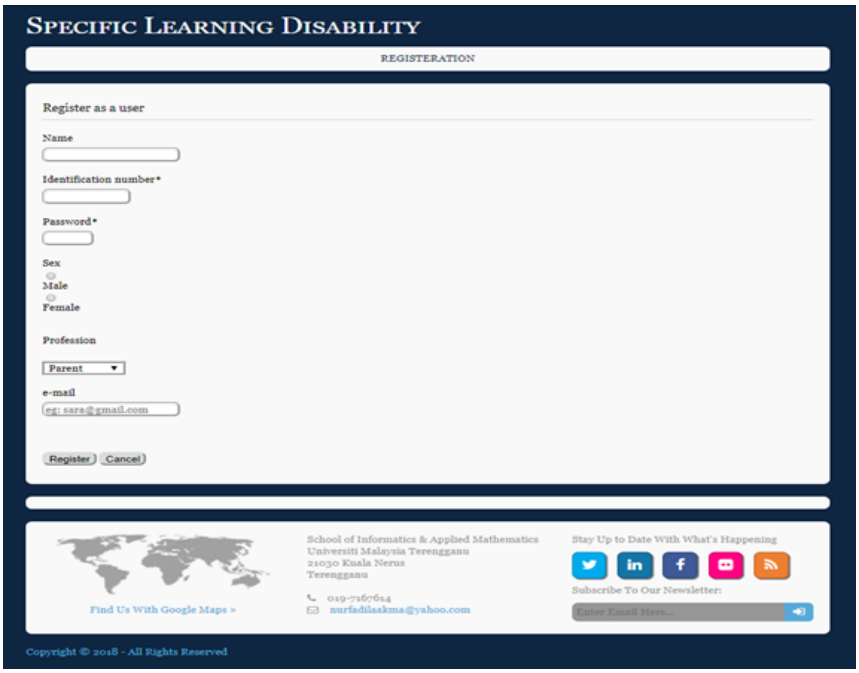

Figure 5. Authentication Module (Registration)

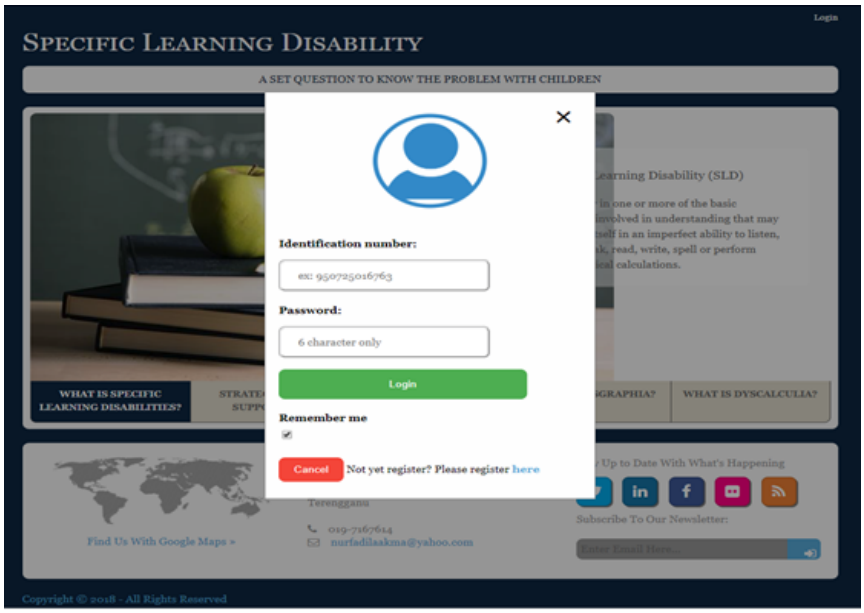

Figure 6. Authentication Module (Login)

In the screening module as depicted in Figure 7, a set of question needs to be answered by users based on their observation on the children or student. The purpose of this module is to enable parents and teachers screening their potential children or students who may show learning disabilities symptoms. The answers are then processed by Jena inference engine and the screening result of learning disabilities types is retrieved from the knowledge stored in the SLD ontology model. The snapshot of the screening result is displayed in Figure 8.

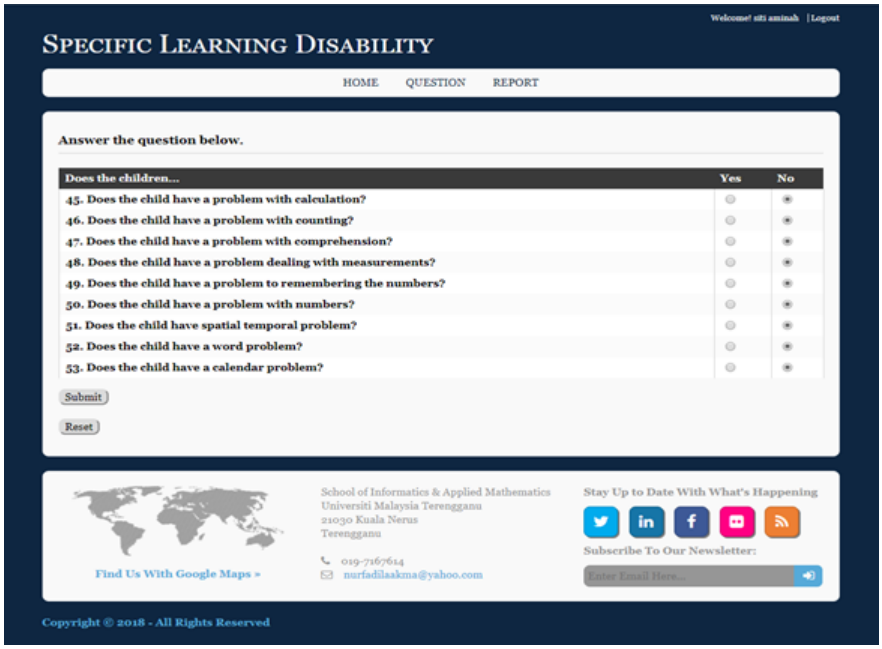

Figure 7. Screening Module

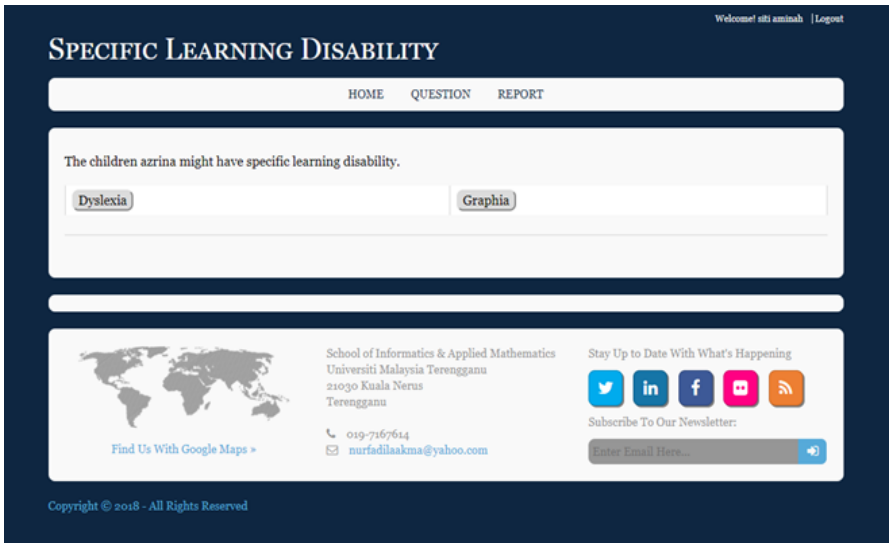

Figure 8. Screening Result

Based on the answers retrieved in the screening module, the ontology model is also able to identify the specific problems of learning disabilities and recommend suitable educational activities. The snapshot of recommendation module is shown in Figure 9.

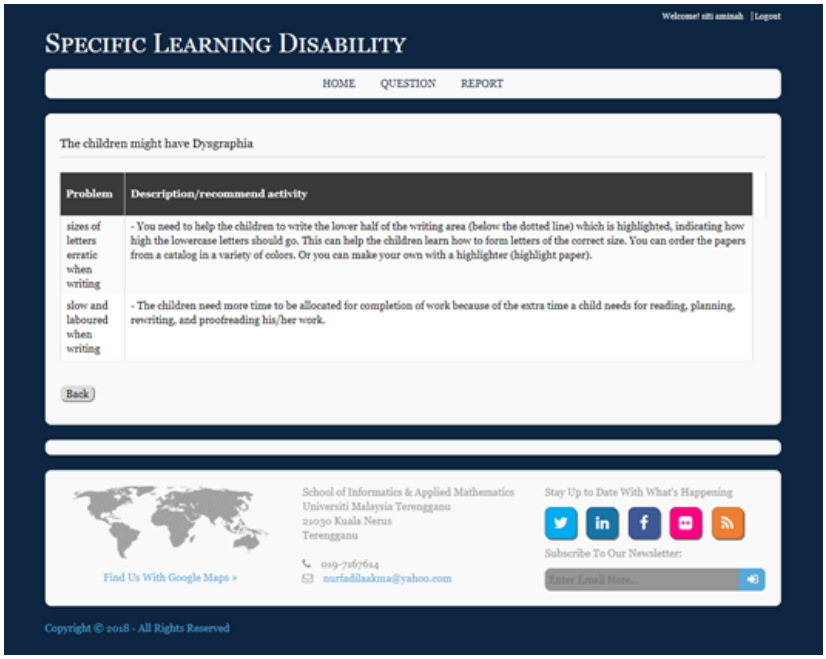

Figure 9. Recommendation Module

Finally, the report module as shown in Figure 10 provides the users to view the screening and recommendation results of different students for further analysis.

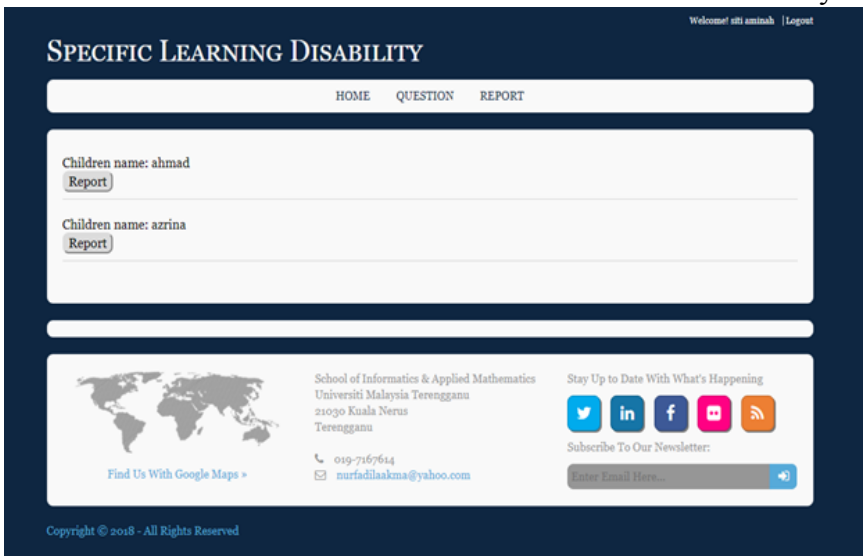

Figure 10. Report Module

Conclusion

Ontology-based Specific Learning Disabilities ia an ICT supporting tool for screening student that may at risk of having problem in reading, writing and mathematics and then recommending suitable educational activities based on the identified learning problems. The tool is equipped with the ontology model which represents knowledge on the characteristics of learning disabilities and guided educational activities. The significant benefit of this tool is parents and teachers can have guided knowledge to educate their child and student with special needs, hence contributing to enhance their quality of life in terms of academic, social, and emotional development. The initial evaluation result obtained from parents and teachers indicated the tool acceptance in terms of the reliability result of early

screening student that at risk of having dyslexia, dysgraphia or dyscalculia, and suitable educational activities.

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