

Computational Approaches in Supporting Special Education Domain: A Review

Rosmayati Mohamad, Nur Fadila Akma Mamat, Noor Maizura Mohamad Noor and Arifah Che Alhadi
*Software Technology Research Group (SofTech), School of Informatics and Applied Mathematics,
Universiti Malaysia Terengganu, 21030, Kuala Nerus, Terengganu, Malaysia.*
rosmayati@umt.edu.my

Abstract—Children with learning disabilities, emotional and behavioral problems are unable to accommodate with the standard educational programs. They are known as special children. Thus, special education is needed to support teaching and learning for this special children. In recent years, there has been an increase in the use of computational approaches to simplify various issues in special education. However, a comprehensive review that gives an overview about to what extent computational approaches are integrated and applied to support various issues in special education domain is still lacking. Thus, the objective of the paper is to explore to what extent the existing computational approaches are used in supporting the field of special education recently especially in categorizing children with learning disabilities and recommending an appropriate technique to increase their quality of life. Systematic Literature Review (SLR) is applied to perform this study. As a consequence, only studies from the year 2009 onwards have been searched. In summary, the main finding of this work shows that learning disabilities are the most recent topic that gets attention to research and there is a few research using an ontology to classify children with learning disability.

Index Terms—Computational Approach; Learning Disability; Special Education; Systematic Literature Review.

I. INTRODUCTION

Education is one of the fundamental factors for a national development and economic growth, thus playing a vital role in developing a country. Over the past decade, under Early Childhood Care and Education (ECCE) as advocated by UNESCO, various traditional educational programs have been established in helping children develop to their full potential starts as early as childhood [1]. However, children with learning disabilities, emotional and behavioral problems are unable to accommodate with the standard educational programs. These children are called special children as they require special supports and accommodation suitable for them, especially in educational needs. Children with special needs are unable to give full attention in the traditional learning approach [2]. They have a unique characteristic that needs to be supported with special educational programs. Based on Individuals with Disabilities Education Act (IDEA), special education is divided in thirteen categories as depicted in Figure 1 [3].

Special education is essential to support teaching and learning for special children. Various critical issues in this domain have been continuously discussed among researchers. One of the issues is the lack of awareness and knowledge among communities and parents that lead to the negative attitude in accepting limitations in the potential of special

children and unconscious about the significance of special education for such children [4],[5]. In addition, the lack of knowledge also creates misunderstanding among parents and practitioners in deciding on appropriate diagnosis and treatment for their children with disabilities [6].

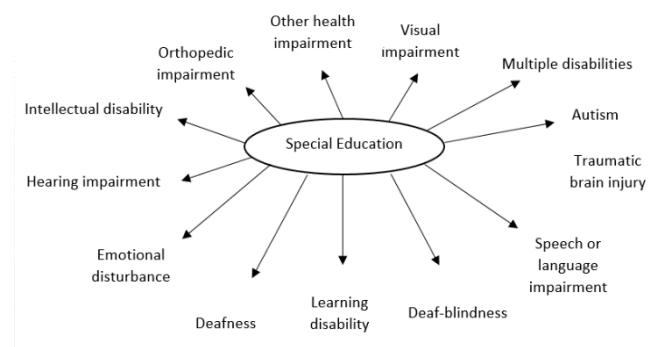


Figure 1: Thirteen Categories of special education based on IDEA

In recent years, there has been an increase in the use of computational approaches to simplify various issues in special education. Technological advancement has led to the use of various computerized approaches in identifying children with special needs [7]–[21] and recommending appropriate activity to help the students based on their needs [22]. Moreover, the advancement of new technology also has helped them learn in school [23]–[31]. For example, the integration of computer technology as an assistive tool in the classroom appears to attract special children to acquire knowledge, help them confront society and achieve their true potential [2]. However, a comprehensive review that gives an overview about to what extent computational approaches are integrated and applied to support various issues in special education is still lacking.

Thus, this paper has the objective of exploring to what extent the existing computational approaches are used in supporting the field of special education especially in categorizing children with learning disabilities and recommending an appropriate technique to increase their quality of life. Systematic Literature Review (SLR) is conducted in this study in order to gather evidence on which the strengths and limitations of the existing computational techniques used in supporting special education domain are synthesized.

The rest of this paper is organized as follows. Section II describes each of the process conducted in SLR. Meanwhile, Section III discusses the results and output of each of the process in the SLR. Finally, Section IV concludes with a summary of this paper and future research directions.

II. THE PROCESS

A Systematic Literature Review (SLR) is a process of gathering evidence by comprehensively identifying, critically evaluating and interpreting available research related to a research question, topic area or phenomenon of interest [32]. Baumeister [33] suggests that to achieve a good systematic review, information should be analyzed first to get a precise method or technique and for a suitable output for the research.

The guidelines and the systematic review protocol template as proposed by Ridley [34] is applied. It consists of several steps to follow including a comprehensive search, identification of inclusion and exclusion criteria to retrieve articles, critical evaluation of articles, data extraction, synthesis of evidence, recommendation and conclusion, peer review process, and lastly dissemination of the results and recommendation. The whole process of SLR is shown in Figure 2.

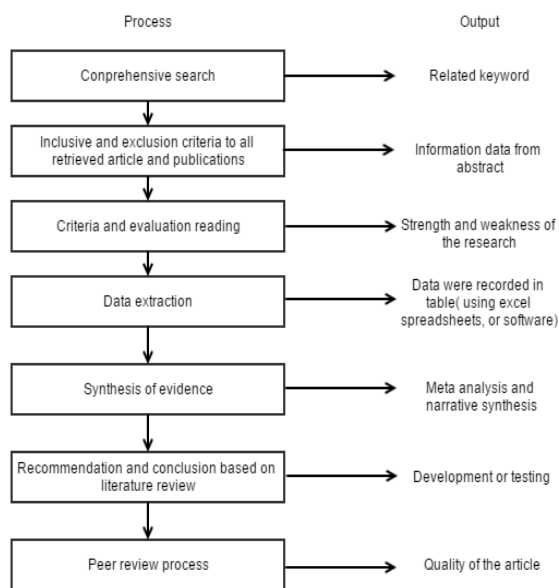


Figure 2: Process of systematic literature review

The need for conducting a systematic review is to identify to what extent computational approaches are integrated and applied in categorizing children with learning disabilities and recommending an appropriate technique to increase their quality of life. Thus, this process is intended to answer the following main research questions:

RQ1. To what extent a computational approach facilitate and support issues in special education domain?

RQ2. Are there any suitable solutions using computerization to help identify children with a learning disability?

Each process in the systematic literature review has an output with an answer to the research question.

A. Comprehensive Search

The comprehensive search depends on a few factors such as the formulation of appropriate keywords, identification of types of database, date-based categorization, and a number of hints. Formulation of the appropriate search keywords is essential to optimize searching. In this step, the articles were firstly obtained using the following terms: 1) “education”, 2) “special education”, 3) “learning disability” or “learning disabilities”, 4) “dysgraphia”, 5) “dyslexia” and 6)

“dyscalculia”. In addition, the conjunctions were used as advanced search by adding ‘OR’ or ‘AND’ between keywords.

The comprehensive search strategy included an only electronic database. It refers to any organized collection of scholarly information that can be searched and accessed in the electronic format. It can be categorized into subscription and non-subscription databases. Subscription database is a fee-based scholarly information source (normally paid by the library) such as ScienceDirect, Scopus, Springer, ACM Digital Library and IEEE Explore. It deals with peer-reviewed and published information including magazines, journals, proceedings, newspapers, e-books, encyclopaedia, and economic data. Meanwhile, the non-subscription database is a free access scholarly information retrieved by search engine such as Google Scholar. Table 1 shows the number of studies obtained from various electronic databases according to the related keywords such as “education”, “special education”, “learning disability”, “dyslexia”, “dyscalculia” and “dysgraphia” from the year 2009 until 2017.

Table 1
Number of articles obtained from the electronic databases

Keywords	Journal	Proceedings	Books	Report
Education	5 160 000	2 850 000	5 100 000	5 430 000
Special education	1 660 000	1 160 000	1 460 000	1 620 000
Learning disability	95 200	19 700	39 900	95 000
Dyslexia	24 200	15 600	18 500	20 800
Dyscalculia	8 070	2 910	3 050	6 040
Dysgraphia	5 490	1 970	2 730	4 700

Date is one of the important criteria to categorize the retrieved articles. Date-based categorization was used to organize articles based on their published year.

B. Inclusion and exclusion criteria to all retrieved articles and publications

The identification of inclusion and exclusion criteria are necessary to obtain the desired information in order to prevent bias from a selection of articles and publications. The inclusion and exclusion criteria of the article are shown in Table 2.

The articles were entitled for inclusion in the review if they represented peer-reviewed primary study on the computational method in the special education field, published in between 2009 and 2017, and written in English. Meanwhile, the articles were excluded if they were secondary studies, non-peer-reviewed, duplicated, non-English written and if they are not focusing on special education field.

Inclusion and exclusion criteria were applied at two levels which are first, during reading the title and abstract, and then proceed by reading the entire article. All the articles and publications have titles, abstracts (for the paper journal), and contents. Some of the publication titles do not represent the content. Therefore, reading the abstract shows a summary of the publication’s content and furthermore, it can save time before reading the whole article. Besides, it helps us to understand what the publication is about and states the aim or purpose of the publication rather than reading the entire article to get information.

Table 2
Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
<ul style="list-style-type: none"> • Primary studies • Peer-reviewed studies • Studies in special education field • Studies of computational method applied in special education • Study published between 2009 and 2017 • English written papers 	<ul style="list-style-type: none"> • Secondary studies • Non-peer-reviewed studies • Non-English written papers • Studies that not in special education field • Studies that related with learning aid • Duplicate studies

Inclusion criteria are only used on the surface of the research to find related article in research scope whereas critical evaluation used deep in the research to analyze the content of the article in more detail. Critically evaluation is discussed in part C below.

C. Critically evaluating articles read

Approaches to reading and note taking include the reason for an efficient reading technique, the adoption of a critical, analytical, and evaluative approach to the text, strategies for note taking, techniques for writing an effective summary, ways of observing, and noting connections between different source texts. Reading can help to identify and understand a topic for the research. It can also help to find out what other researchers have been done in the field that supports the researcher's views and arguments.

Based on Ridley [34], a framework is known as SQ3R (Survey, Question, Read, Recall, Review) is adopted in this step. A survey was used to identify either the articles obtained were relevant to the conducted research or not. The process is to read the important parts such as the title, abstract, and conclusion of an article so the result of analyze can be done quickly. Those irrelevant articles were excluded. The second step is to relate to the research questions in order to identify either it is relevant to read for more details or not. The third is to read the article and to make the connection with other texts in others article that were read before. After reading the article, the last process is to recall and review the article by writing the main points and related data, and to summarize it. Mind mapping and table were used to summarize the article content. This technique is used to ensure the understanding of the article's content and to remember it.

The researcher needs to be a critical reader by reading actively and analytically, making connections with what he/she already knows, and evaluating the strengths and weaknesses of an author's research and arguments [34].

D. Data extraction

Data extraction was performed by collecting the data that related the current issues in special education. During this step, all the articles that published were analyze in terms of their strengths and weaknesses. From extraction of the data, articles are categorized based on the method used to classify children with learning disabilities. After that, the author's name and most importantly, the year the article was published are recorded. The strengths and weaknesses of the article are added to analyze the article if it is able to offer an advantage to the researcher in finding a suitable method to classify children with learning disabilities.

E. Synthesis of evidence

Synthesis of evidence uses meta-analysis (synthesis of numerical result) and a narrative synthesis (qualitative data).

It explores the personal perspective of the issue that arises in research and a final matrix where the data is compared one by one to get the findings. These combinations of the techniques allow findings from different types of research studies.

F. Recommendation and conclusion based on Literature Review

Based on the analysis of the literature review, the testing is conducted to get a preliminary result that can give an output to the research and it can be evidence that the method used is a suitable and accurate method compared to others based on previous research. A systematic literature review can provide data to analyze accurately based on the steps that were followed.

G. Peer Review Process

Peer review process is an important part of the process. It is a final draft of the article reviewed by peers before the article is published. This enables the researcher to get feedback related to the field. The quality of the systematic review is supported through the peer review process. Peer review is intended to ensure that the quality of journal articles, books, and web pages is maintained. It is important to make your own judgments. Supervisors or professionals in the field can give comments and recommendations to improve the article. After finishing the literature review, the article is accepted for publication.

III. RESULT AND DISCUSSIONS

Research in special education is lacking and not many researchers are interested in this domain. In Malaysia, there is special education that educates special children in schools with special programs. Children who have a special ability need to go through a screening process by practitioners to identify the special problem. Practitioners normally come to school and carry out certain processes through which the teacher is able to identify students with problems in education, for example, problems in writing, reading, and other special problems.

There is a problem in identifying children with learning disabilities. The main issue is the definition of learning disability itself which is confusing and unclear, making it difficult to classify [35] with implicit characteristics that have to be considered [13]. Another problem is the experts still use a manual process to identify the problem leading to increased manpower and time consumption [15],[16]. Identifying the children requires the help of experts given their knowledge and experience. Based on these problems, SLR was used to get in depth information by analyzing previous researches in the special education domain and to find a suitable solution using a computational approach.

The systematic literature review went through each process to get the required output. Step one was to do a comprehensive search. Six electronic databases were used to find articles and to extract data for the research. The resources are IEEE, ScienceDirect, Scopus, Google Scholar, Springer and ACM digital library. From these resources, the outputs were articles, reports, journals, web pages, manuscripts, and books that could be used as references for the research [36]. The main keyword search was 'special education' followed by the keyword that had the same meaning as 'special needs'. Other keywords are as shown in Figure 3. All the connections as shown in the figure are related to special education as a

type of special education. Based on the analysis, there are many problems with a learning disability. Thus, the next keyword focused on learning disability.

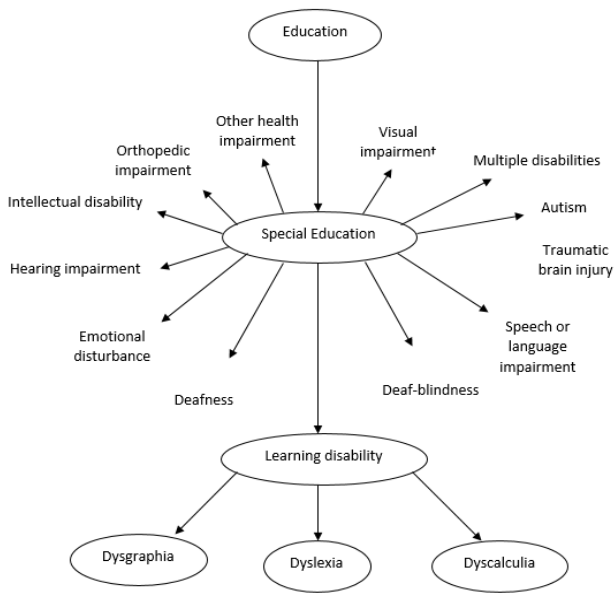


Figure 3: Hierarchy of education

It goes in-depth into types of learning disabilities based on the analysis of the data. The keyword focused on three types of learning disability namely dysgraphia (problem with writing), dyslexia (problem with reading), and dyscalculia (problem with mathematics). The scope was decreased based on the amount of data retrieved during the internet search as shown in Figure 4.

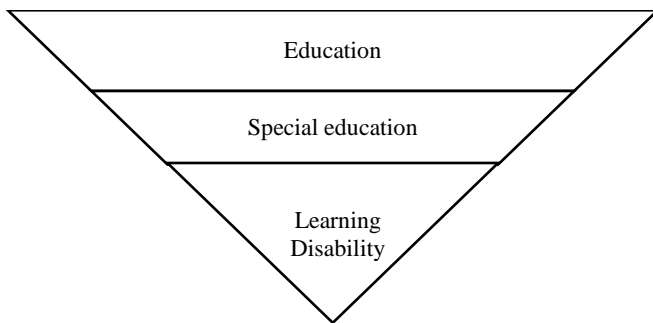


Figure 4: Domain to search

In the special education domain, there are different techniques or methods that use computational approaches to classify, screen, identify tools used for learning and devices used for special education, and more. Based on the findings, there are many methods in the expert system area, ontology area, and the use of normal techniques to identify and recommend tools to use in special education. The similarities and differences among the expert system, ontology, and normal technique were compared to find out the method with the most advantages.

Step two (2) was to identify the inclusion and exclusion criteria of all the retrieved articles and publications. The title or the keywords in the articles might have terms such as special education, special children, problems in special education, etc. The data from the search is shown in Table 3. Based on the data, special education needs more focus on identifying special education, especially with learning

disabilities.

Table 3
Current issues in special education

Special education	Author & Year	Aim
Development disorder	Peleg et al. (2009)[7]	Identify group of comorbidities (development disorders)
Learning difficulties	Hernandez et al. (2009) [8]	Diagnose of Learning difficulties in children's basic education
Dyslexia	Palacios et al. (2009) [9]	Diagnose dyslexia students
Learning disability	David and Balakrishnan (2010) [10]	Prediction of Learning Disabilities
Learning disability	Muangnak et al. (2010) [11]	Classify student with Learning Disabilities
Dyslexia	Kohli and Prasad (2010) [12]	Recognized dyslexia
Learning disability	Wu et al. (2011) [13]	Identify Student with learning disability
Handwriting difficulty	Chea et al. (2012) [14]	Identify writing stroke and direction
Learning disability	ElSayed (2012)[15]	Diagnose learning disabilities
Dyslexia	Ekhsan et al. (2012) [16]	Early screening of dyslexia using interactive multimedia
Motor dysgraphia	Martins et al. (2013) [17]	Screening for motor dysgraphia in public schools
Epilepsy type	Kassahun et al. (2014) [18]	Automatic classification of epilepsy types
Dyslexia	Facoetti et al. (2014) [19]	Multiplatform games for dyslexia identification in preschoolers
Learning disability	David and Balakrishnan (2014) [20]	To predict the learning disability using ANN and ANFIS
Learning difficulties	Zygouris et al. (2015) [21]	Learning difficulties screening

After that, all the collected articles are critically read and evaluated to identify and understand the articles. The understanding must be critical in order to get precise results from the reading. Based on this evaluation of reading, there are problems faced in special education especially in learning disability. Therefore, the research should be in that area to propose a solution for the problem.

Table 4 shows the analysis of the literature review that was done by focusing on the current problem in special education that is to identify the strengths and weaknesses of the research.

Next step is to extract the data from all the articles that have been collected. Based on Table 4, the strengths and weaknesses of the articles were analyzed. The table shows that research on the learning disability domain has attracted a lot of attention from previous researchers. After that, the data is extracted and categorized as a normal method, an expert system, and ontology. These three methods are used to identify children with learning disabilities or to categorize them into three (3) types of learning disabilities (dyslexia, dyscalculia, and dysgraphia) as shown in Table 5.

Table 4
Analysis of the literature review

Author & year	Strength	Weakness
Peleg et al. (2009)[7]	-	All of the real data are from same institute
Hernandez et al. (2009) [8]	Analyze and identify student problem in academic	-
Palacios et al. (2009) [9]	-	High percentage of misclassification and needs improvement
David and Balakrishnan (2010) [10]	Generates simpler rules and removes irrelevant attributes at a stage prior to a tree induction	It can give wrong predictions when inconsistent data are present
Muangnak et al. (2010) [11]	-	-
Kohli and Prasad (2010) [12]	Saving time and resources	-
Wu et al. (2011) [13]	-	Not accurate and inefficient in time
Chea et al. (2012) [14]	Good to classify and identify line that involve straight line input	Not improved in analyzing curve lines and complex lines involving smooth corner
ElSayed (2012)[15]	Recommend best educational activities	-
Ekhsan et al. (2012) [16]	Multimedia elements can influent performance of dyslexic student compared to manual	-
Martins et al. (2013) [17]	-	-
Kassahun et al. (2014) [18]	-	-
Facoetti et al. (2014) [19]	Children interest with interactive games	-
David and Balakrishnan (2014) [20]	-	-
Zygoris et al. (2015) [21]	-	-

All the information, such as the area of research, type of sample used, methodology, technique of evaluation, type of participant, and related matters, was recorded. This will help the researchers to analyze the data and to check if the article is related. The data was saved as a table to get a different view of the publications and to identify the gap in the research among the articles. Thus, how is it related? It should answer a research question. Figure 5 shows the subject that was focused on the learning disability domain.

Based on our findings on the existing literatures, none of the researchers have used the ontology method/model to classify children with learning disabilities. This helps to build a suitable model to classify children based on three (3) types of learning disabilities namely dyslexia, dyscalculia, and dysgraphia. It also helps in recommending an appropriate method for children with learning disabilities to their teachers and especially parents at home.

Table 5
Identify method used to screen children with learning disability

Method	Technique	Author & Year	Aim
Computational approach	Interactive multimedia (Smart Lexic)	Ekhsan et al. (2012) [16]	To identify children with dyslexia
Computational approach	Data that retrieve from game were analyze by expert	Facoetti et al. (2014) [19]	To identify children with dyslexia
Computational approach	Web application (10 test of askiki)	Zygoris et al. (2015) [21]	Screening for LD children
Computational approach	Computerized handwriting assessment based on the identification of error in stroke type, sequences and direction when forming an alphabet	Chea et al. (2012) [14]	Identify writing stroke and direction
Expert system	Software SEDA (Expert System for Learning Difficulties) based on expert system design methodologies	Hernandez et al. (2009) [8]	Diagnose of Learning difficulties in children's basic education
Expert system	Fuzzy rule based system (FRBS)	Palacios (2009) [9]	Diagnose dyslexia students
Expert system	Data mining - decision tree	David and Balakrishnan (2010) [10]	To predict the LD of school age children
Expert system	Naïve Bayes Classifier and decision tree	Muangnak et al. (2010) [11]	Classify student with Learning Disabilities
Expert system	Artificial Neural Network (ANN)	Kohli and Prasad (2010) [12]	Recognized dyslexia
Expert system	Asynchronous parallel pattern search algorithm in artificial neural network	Wu et al. (2011) [13]	Identify Student with learning disability
Expert system	Intelligent agent based system	ElSayed (2012) [15]	Diagnose learning disabilities
Expert system	(Adapted) Analytical Dysgraphia Inventory (trace the graphic)	Martins et al. (2013) [17]	Screening for motor dysgraphia in public schools
Expert system	Artificial neural network (ANN) and Adoptive Neuro Fuzzy Inference system (ANFIS)	David and Balakrishnan (2014) [20]	To predict the learning disability using ANN and ANFIS
Ontology	Literature-based ontology and clustering	Peleg et al. (2009)[7]	Identify group of comorbidities (development disorders)
Ontology	Ontology-based classification and genetics-based data mining algorithm	Kassahun et al. (2014) [18]	Automatic classification of epilepsy types

In addition, based on the research, the researchers were able to find other ontology with more techniques or methods that

used the expert system to classify people based on characteristics. A systematic literature review makes the output of the analysis more accurate compared to the normal process of carrying out a literature review, and it enables getting more details from the data about the area of research. It helps to create a well-organized literature review. The last step is to produce an article or technical report regarding the entire process of the systematic literature review.

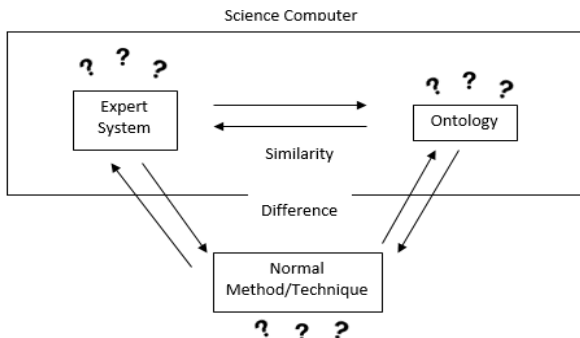


Figure 5: Difference and similarity of areas

IV. CONCLUSION

The process to do a literature review has to be systematic in order to get an accurate finding in the related research. A literature review may have to be regularly updated to get new information about the research (up to date) and to get new findings by other researchers.

ACKNOWLEDGMENT

This research is supported by the Malaysian Ministry of Higher Education, Fundamental Research Grant Scheme (FRGS) vote 59395.

REFERENCES

- [1] H. Yoshikawa and S. Kabay, *The Evidence Base on Early Childhood Care and Education in Global Contexts*. United Nations Educational, Scientific and Cultural Organization, 2015.
- [2] T. S. Hasselbring, T. S. Hasselbring, C. H. W. Glaser, and C. H. W. Glaser, "Use of computer technology to help students with special needs," *Futur. Child.*, vol. 10, no. 2, pp. 102–22, 2000.
- [3] B. C. Trolley, H. S. Haas, and D. C. Patti, "Special education terminology and disability categories," in *The School Counsellor's Guide to Special Education*, Corwin, 2009, Ch. 2.
- [4] H. Habib, "Awareness about special education in Hyderabad," *International Journal of Science and Research (IJSR)*, vol. 4, no. 5, pp. 1296–1300, 2015.
- [5] B. H. Lim and K. H. Chia, "From teachers and family to community: What support is available for our children with special needs," *European Journal of Special Education Research*, vol. 2, no. 4, pp. 46–58, 2017.
- [6] H. Garry, H. Jean, and M. Atkinson, *Controversial Issues in Special Education*. Cambridge: David Fulton Publisher, 2013.
- [7] M. Peleg, N. Asbeh, T. Kuflik, and M. Schertz, "Onto-clust-A methodology for combining clustering analysis and ontological methods for identifying groups of comorbidities for developmental disorders," *J. Biomed. Inform.*, vol. 42, no. 1, pp. 165–175, 2009.
- [8] J. Hernández, G. Mousalli, and F. Rivas, "Expert system for the diagnosis of learning difficulties in children's basic education," in *The 8th WSEAS Int. Conf. on Applied Computer and Applied Computational Science (ACACOS '09)*, 2009, pp. 67–71.
- [9] A. M. Palacios, L. Sánchez, and I. Couso, "Extending a simple genetic cooperative-competitive learning fuzzy classifier to low quality datasets," *Evol. Intell.*, vol. 2, no. 1–2, pp. 73–84, Oct. 2009.
- [10] J. M. David and K. Balakrishnan, "Prediction of learning disabilities in school age children using decision tree," in *Recent Trends in Networks and Communications*, N. Meghanathan, S. Boumerdassi, N. Chaki, and D. Nagamalai, Berlin, Heidelberg: Springer, 2010, pp. 533–542.
- [11] N. Muangnak, W. Pukdee, and T. Hengsanunkun, "Classification students with learning disabilities using naive bayes classifier and decision tree," in *Sixth Int. Conf. Networked Comput. Adv. Inf. Manag.*, pp. 189–192, 2010.
- [12] M. M. M. Kohli and T. V Prasad, "Identifying dyslexic students by using artificial neural networks," in *World Congress on Engineering*, 2010, pp. 1–4.
- [13] T. Wu, S.-C. Huang, W. Chiou, and Y.-R. Meng, "Customizing asynchronous parallel pattern search algorithm to improve ANN classifier for learning disabilities students identification," in *Seventh Int. Conf. Nat. Comput.*, 2011, pp. 1639–1643.
- [14] N. C. Chea, E. S. L. Ming, P. I. Khalid, and Y. C. Fai, "Algorithm for identifying writing stroke and direction," in *2012 Fourth Int. Conf. Comput. Intell. Model. Simul.*, 2012, pp. 94–98.
- [15] K. N. Elsayed, "Diagnosing learning disabilities in a special education by an intelligent agent based system," in *4th Comput. Sci. Electron. Eng. Conf.*, 2012, pp. 7–12.
- [16] H. M. Ekhsan, S. Z. Ahmad, S. A. Halim, J. N. Hamid and N. H. Mansor, "The implementation of interactive multimedia in early screening of dyslexia," in *2012 International Conference on Innovation Management and Technology Research*, 2012, pp. 566–569.
- [17] M. R. I. Martins, J. A. J. A. Bastos, A. T. Cecato, M. D. L. S. Araujo, R. R. Magro, and V. Alaminos, "Screening for motor dysgraphia in public schools," *J. Pediatr. (Rio. J.)*, vol. 89, no. 1, pp. 70–74, 2013.
- [18] Y. Kassahun, R. Perrone, E. D. Momi, E. Berghöfer, L. Tassi, M. P. Canevini, R. Spreafico, G. Ferrigno, and F. Kirchner "Automatic classification of epilepsy types using ontology-based and genetics-based machine learning," *Artif. Intell. Med.*, vol. 61, no. 2, pp. 79–88, 2014.
- [19] A. Facoetti, S. Franceschini, O. Gaggi, G. Galiano, S. Gori, C. E. Palazzi, and M. Ruffino, "Multiplatform games for dyslexia identification in preschoolers," in *2014 IEEE 11th Consumer Communications and Networking Conference (CCNC)*, 2014, pp. 1152–1153.
- [20] J. M. David, K. Balakrishnan, C. G. by Acampora J M David, and K. Balakrishnan, "Learning disability prediction tool using ANN and ANFIS," *Soft Comput.*, vol. 18, pp. 1093–1112, 2014.
- [21] N. C. Zygouris, F. Vlachos, A. N. Dadaliaris, G. I. Stamoulis, D. Vavougiou, E. Nerantzaki and A. Striftou, "Learning Difficulties Screening Web Application," in *Proceedings of International Conference on Interactive Collaborative Learning (ICL)*, 2015, pp. 650–654.
- [22] H.-C. Chu, M.-J. Liao, T.-Y. Chen, C.-J. Lin, and Y.-M. Chen, "Learning case adaptation for problem-oriented e-learning on mathematics teaching for students with mild disabilities," *Expert Syst. Appl.*, vol. 38, no. 3, pp. 1269–1281, Mar. 2011.
- [23] K. Nandhini and S. R. Balasundaram, "Grade level classification of math word problems to improve readability for learning disability," in *2012 IEEE International Conference on Technology Enhanced Education (ICTEE)*, 2012, pp. 1–7.
- [24] Fernández-López, M. J. Rodríguez-Fórtiz, M. L. Rodríguez-Almendros, and M. J. Martínez-Segura, "Mobile learning technology based on iOS devices to support students with special education needs," *Comput. Educ.*, vol. 61, pp. 77–90, Feb. 2013.
- [25] M. S. Sidhu and E. Manzura, "An effective conceptual multisensory multimedia model to support dyslexic children in learning," in *Learning Tools and Teaching Approaches through ICT Advancements*, L. Tomei, Ed. IGI Global, 2013, pp. 188–205.
- [26] J. T. Njanji, and S. H. Nggada, "Disability-aware software engineering for improved system accessibility and usability," *Int. J. Softw. Eng. its Appl.*, vol. 5, no. 3, pp. 47–62, 2011.
- [27] J. Tang, "Using ontology and RFID to develop a new Chinese Braille learning platform for blind students," *Expert Syst. Appl.*, vol. 40, no. 8, pp. 2817–2827, 2013.
- [28] A. Y. Alsobhi, N. Khan, and H. Rahanu, "Personalised learning materials based on dyslexia types: ontological approach," *Procedia Comput. Sci.*, vol. 60, pp. 113–121, 2015.
- [29] J. T. Njanji and M. Brayshaw, "Designing and reflecting on disability-aware e-learning systems: the case of ONTODAPS," in *2014 IEEE 14th Int. Conf. Adv. Learn. Technol.*, 2014, pp. 571–575.
- [30] H. Abdellaoui, M. A. Ben Mohamed, K. Bacha, and M. Zrigui, "Ontology based description of an accessible learning object," in *Fourth International Conference on Information and Communication Technology and Accessibility (ICTA)*, 2013, pp. 1–5.
- [31] K. Venkatesan, S. Nelaturu, A. J. Vullamparthi, and S. Rao, "Hybrid ontology based e-learning expert system for children with autism," in *2013 International Conference of Information and Communication Technology, ICoICT 2013*, 2013, pp. 93–98.

- [32] B. Kitchenham and S. Charters, "Guidelines for performing systematic literature reviews in software engineering," in *Technical Report EBSE 2007-001*, Keele University and Durham University Joint Report, 2007.
- [33] R. F. Baumeister, "Writing a literature review," in *The Portable Mentor: Expert Guide to a Successful Career in Psychology*, 2nd Editio., M. J. Prinstein, Ed. New York: Springer Science+Business Media, 2013, pp. 119–132.
- [34] D. Ridley, *The Literature Review: A Step-By-Step Guide for Students*. Sage Publications, 2012.
- [35] K. E. Stanovich, "The future of a mistake: will discrepancy measurement continue to make the learning disabilities field a pseudoscience?," *Learn. Disabil. Q.*, vol. 28, pp. 103–106, 2005.
- [36] T. A. E. Eisa, N. Salim, and S. Alzahrani, "Existing plagiarism detection techniques," *Online Inf. Rev.*, vol. 39, no. 3, pp. 383–400, 2015.