# An expert system to diagnose Learning Disorders in children

***Abstract* – This paper contains discussions of implementing an expert system to diagnose the learning disorders such as Dyslexia, Dysgraphia, Dyspraxia, and Dyscalculia. A brief overview of learning disorders is described. The knowledge to diagnose these learning disorders is gathered from various resources such as books and human experts such as psychiatrists. The AI method used is backward chaining rule-based expert system and implemented using the 'e2gRuleEngine' system shell. This expert system's success rate is determined on two aspects accuracy and usability, and the passing score for both aspects is 75%. Results of the tests and discussion for further studies are also elaborated in this paper.**

## Introduction

Expert systems are computers with intelligent programs which is capable of using knowledge and inference procedures to solve problems which are difficult enough to require expertise from human [12]. Expert systems is created either to replace the expert or use as a highly experienced assistant [13]. The learning disorders in children have a huge impact on their academic life, and it is vital to identify them early important. Because with the right training for a specific learning disorder, a child with a learning disorder can reach the university level [3]. Thus, an expert system that is capable of diagnosing learning disorders in children is easy to use is decided to implement, which can bring more benefits for the children with disability.

To diagnose the learning disorders in children and provide ease of use is the main objective of this expert system. The expert system will use the inputs from users, which are the response to the queries in yes or no format. The system will prompt the users for each symptom of the learning disorders, and the users will have to respond to those prompts. The system will then process those input data using the knowledge base and give whether a child has a learning disorder.
The background of learning disorders, the implementation, and design of the expert system, similar works in the past studies, the description of AI methods and tools used in this expert system and the reasons to choose these tools and methods, evaluation to test the performance of the expert system, results, and discussions for the future studies is elaborated in this paper.

## Background

Learning disorder is difficulty with learning despite having normal intelligence [1]. It is a neurobiological disorder that disturbs the ability to think and remember of the brain [6]. People with learning disorders usually have problems in processing speed, working memory, sequencing, auditory, visual perception, speaking language, and motor skills [5]. Learning disorders cannot be cured completely [7]. But alternative teaching ways and treatments are available to reduce the impact of the disorders [5]. They are four types of learning disorders- Dyslexia, Dysgraphia, Dyscalculia, and Dyspraxia.

Dyslexia is defined as the problem with reading [4]. It's a combination of "dy" which means the difficulty, and "slexia," which means words [2]. So it means the problem with words. The common symptoms are difficulties in reading aloud and spelling [3].

Dysgraphia is defined as the problem with writing [8]. It also shows difficulties in transcription skill such as spelling, presenting thought on paper, and bad handwriting [9]. The typical symptom of dysgraphia is messy handwriting [10].

Dyscalculia is defined as the problem with arithmetical skills. People with dyscalculia have problems in understanding the concepts of numbers, remembering arithmetic facts, calculation, the reasoning of math and procedures [11].

Dyspraxia is defined as difficulties with motor learning. People with Dyspraxia have problem in judgment, coordination, and cognitive skills as well as the immunity and nervous system of the body [10].

Some young people with learning disorders can still reach the university level, while some people ended with minimal education [3]. So it is important to identify learning disorders in children as early as possible because the way to teach children with disorders is different from normal children [5]. Because of this statement, an expert system to diagnose the learning disorders in children is decided to develop.

The main objective of this expert system is to give reliable results of diagnosing learning disorders based on the inputs of the end-users. Jayaram and Shilpa [8] developed a similar expert system to diagnose learning disorders. They acquired the required knowledge from the human experts and the textbooks and created a knowledge base and formed a knowledge net from it, and used a forward-chaining rule-based for the inference engine. But there was no method or ways to evaluate their expert system was described.

## AI Method and Tools

This expert system's primary goal is to diagnose the learning disorder in children and, if a child had a learning disorder, give feedback about the learning disorder as mild, moderate, and severe stages. The system shell used to develop this expert system is 'e2gRuleEngine' and the AI method used is backward chaining rule-based expert system.

Backward chaining rule-based system was chosen for developing this expert system because of its goal-driven reasoning [14]. It means it starts with a goal which is a hypothetical solution meaning that it works back from consequent to antecedent to prove the goals and another reason to choose this backward-chaining rule-based system is it can provide accurate results by cross-referencing a few precise conclusion which is suitable of diagnosis system [15].
The reason 'e2gRuleEnigne' was chosen for development because it is backward chaining expert system. In addition to that, it is easier to use than any other expert system shells which results in providing more error-free system than the others.

All the required knowledge to build this expert system is obtained and collected from various resources such as books, human experts such as psychiatrists, and research papers. By using these resources, the required rules, prompts, and conditions are created. Then a knowledge base was created by inserting those rules, prompts, and conditions. A rule has a specific set of conditions,

which are the supports to prove the rule. In another way, they are a set of THEN and IF statements [12]. Prompts are the question to the user which ask them about the symptoms they observed or discovered in their children. Then the answer to the prompt will become the input conditions. Then the interference engine will search the conditions which match the input conditions in the knowledge base, and if they matched the specific conditions set of a rule, it would print out the rule as a result. In this expert system, the rules refer to the learning disorders, and the conditions refer to the symptoms of each of them.

For example,
Learning Disorder: Dyslexia

| | | |
|---|---|---|
| Conditions: | Difficulty in reading aloud | AND |
| | Confusion in q-p-d-b | AND |
| | Spelling difficulties | AND |

If the learning disorder is Dyslexia and the user's input conditions matched all these symptoms, it will result in Dyslexia. If it matched two of them, the result would be moderate Dyslexia, and if it matched only one condition, the result would be mild Dyslexia. Even if there was a situation where a child has more than one learning disorder, this expert system is still capable of diagnosing all the learning disorder that particular child has.

**User Interface:** The user interface will be straightforward. The user will be posed with questions relating to the learning disorder's symptoms, and the answer will be in "True" or "False" form. There will also be a button named "Why Ask?" and if this is selected. The system will explain these input conditions them will work on finding the correct rules. These will be shown in the pictures of a trial run shown in Appendix' A'.

## Evaluation Method

The success of the expert system will be determined in two aspects. A passing score for both aspects will be 75%.

Due to the current pandemic outbreak, it is hard to find the real end-users to carry out the testing. So all the tests are carried out using peers and classmates as end-users in order to get the raw results and performance of the expert system.

**Accuracy:** The accuracy of the expert system is tested by creating ten random learning disorder cases. The results are then compared to the historical data and results of similar expert systems such as the learning disorders test of "mentalup" website (Available at: https://www.mentalup.co/blog/do-learning-difficulties-test).

**Usability:** After a test is done, questionnaires about experience and satisfaction with using the system are provided to the users to determine the usability of the system. The questionnaire used for this test is shown in Appendix' B'.
The final score of the expert system will be determined by the average score of each aspect on 10 cases tested.

## Results

A total of 10 test cases were done, and each testing included both accuracy and usability testing. The results for all test cases are presented in the graph below.

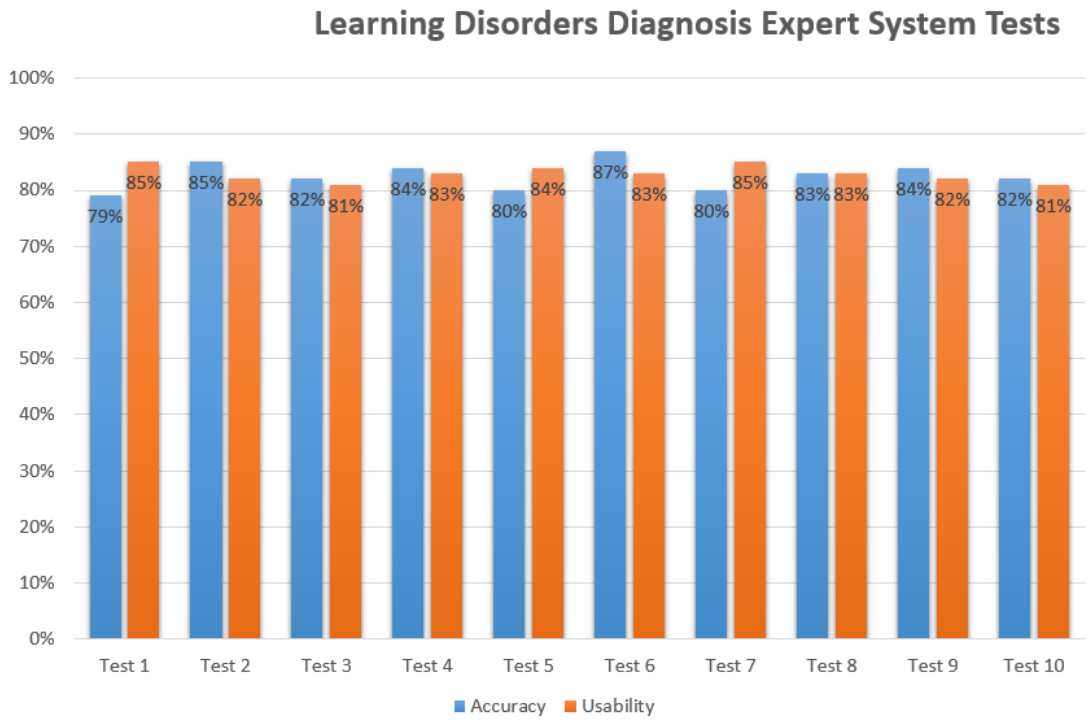


**Figure 1: The graph for the results of 10 test cases for both Accuracy and Usability**

### Accuracy

The percentage of accuracy for each test is as below.

Test 1 = 79%, Test 2 = 85%, Test 3 = 82%, Test 4 = 84%, Test 5= 80%

Test 6 = 87%, Test 7 = 80%, Test 8 = 83%, Test 9 = 84%, Test 10= 82%

The percentage of accuracy of each test is over 75% which indicates that this expert system is good enough for accuracy.

### Usability

The percentage of usability of each test is as below.

Test 1 = 85%, Test 2 = 82%, Test 3 = 81%, Test 4 = 83%, Test 5 = 84 %

Test 6 = 83%, Test 7 = 85%, Test 8 = 83%, Test 9 = 82%, Test 10 = 81%

The percentage of usability of each test is over 75% which indicates that this expert system is easy enough to use.

## Overall Result

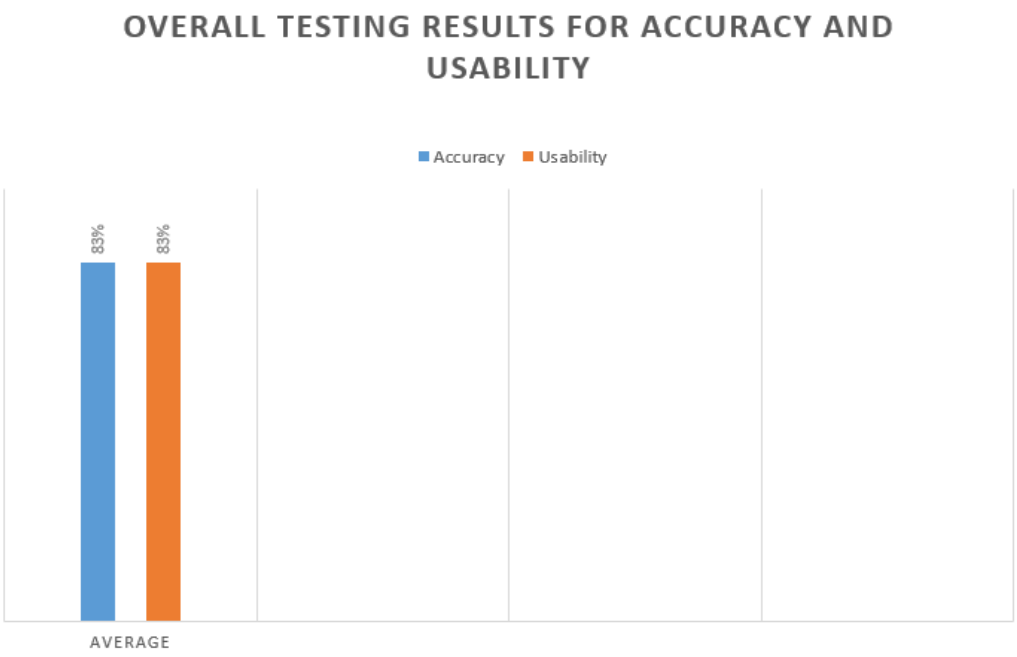


**Figure 2: The graph for showing the average score for both Accuracy and Usability in 10 test cases**

The above graph shows the average of both accuracy and usability for all test cases. Both of the aspects scored 83% for average percentage. The average of each aspect exceeds 75%, which is the passing score. Thus, this expert system passed the tests for both accuracy and usability.

## Discussion & Conclusion

Even though the system is working perfectly, there might be some errors that are still undetected. As described above, the system passed the tests for both aspects. The results proved the results for learning disorders diagnosis is accurate to a level that is satisfactory. A bunch of knowledge and information about learning disorders is gained by doing this project. And it helps me get a deeper understanding of how rule-based expert systems work, how knowledge can be created, how the interference works in backward chaining and forward chaining, how to evaluate the results and how to analyze the results. A working expert system for diagnosing learning disorders was created completely, but there are a lot of things that can be done to improve. Firstly, the symptoms for each of the learning disorders are only three, which can be assumed as very little since there are more than three symptoms for each learning disorder. But the three symptoms used for this expert system are the main symptoms that are good enough to diagnose a learning disorder. Due to the time limit, only these three main symptoms are used. The expert system could provide more detailed results if all those symptoms could be included. Also, building that kind of expert

system will require more resources as well as more help from human experts. This expert system can be used as a prototype and with more added symptoms and behaviors by doing a lot of researches and by getting help from the psychiatrists, a better knowledge base can be built to give more precise and detailed answers. Also, it would be better to improve usability if the real end-users could be used in this project.

In conclusion, this expert system reached a level that can be assumed as sufficient to provide diagnosis results for learning disorders. Using the facts and suggestions described in the discussion to improve the system, a better and perfect expert system to give learning disorder diagnosis can be implemented in the future, which will help many children with learning disorders.

## References


[1] Ninds.nih.gov. 2020. *Dyslexia-Information-Page | National Institute Of Neurological Disorders And Stroke*. [Online] Available at: <https://www.ninds.nih.gov/Disorders/All-Disorders/Dyslexia-Information-Page/2921/organizations/1002> [Accessed 2 October 2020].

[2] A. G. Kamhi and H. W. Catts, *Language and reading disabilities*. Boston: Pearson, 2014.

[3] M. J. Snowling, "Early identification and interventions for dyslexia: a contemporary view," *Journal of Research in Special Educational Needs*, vol. 13, no. 1, pp. 7–14, 2012.

[4] G. Schulte-Körne, "The Prevention, Diagnosis, and Treatment of Dyslexia," *Deutsches Aerzteblatt Online*, 2010.

[5] P. Ott, *Teaching children with dyslexia: a practical guide*. Place of publication not identified: Routledge, 2015.

[6] Acree M.A. (1999) Is there a gender difference in fingerprint ridge density? Forensic Science International, 102: 35–44

[7] ]P. Manghirmalani, D. More, and K. Jain, "A Fuzzy Approach to Classify Learning Disability," *International Journal of Advanced Research in Artificial Intelligence*, vol. 1, no. 2, 2012.

[8] M.A.Jayaram, Shilpa.B, Intelligent System for Diagnosing Learning Disorders in Children, proceedings of World Congress on Engineering and Computer Science 2010, San Francisco, USA 20-22 October, 2010, 70-75.

[9] "What Is Dysgraphia?" *What Is Dysgraphia? | LD Topics | LD OnLine*. [Online]. Available: http://www.ldonline.org/article/12770/. [Accessed: 30-Sep-2020].

[10] T. U. Team, "Dysgraphia: What You Need to Know," *Dysgraphia in Children*, 16-Oct-2019. [Online]. Available: https://www.understood.org/en/learning-thinking-differences/child-learning-disabilities/dysgraphia/understanding-dysgraphia. [Accessed: 30-Sep-2020].

[11] "What is Dyscalculia?" *What is Dyscalculia? - The Dyslexia Association*. [Online]. Available: https://www.dyslexia.uk.net/specific-learning-difficulties/dyscalculia/. [Accessed: 30-Sep-2020].

[12] Joseph Giarratano, Gary Riley, *Expert Systems: Principles and Programming, Fourth Edition*

[13] S. Kusumadewi, Artificial Intelligence (Teknik dan Aplikasinya). Yogyakarta: Graha Ilmu, 2003.

[14] M. Negnevitsky, *Artificial intelligence: a guide to intelligent systems*. Essex: Addison-Wesley/Pearson, 2011.

[15] Techslang, "What is Backward Chaining? - Definition by Techslang," *Techslang*, 12-Nov-2020. [Online]. Available: https://www.techslang.com/definition/what-is-backward-chaining/. [Accessed: 16-Nov-2020].