ELOHIKA: AN EXPERTS SYSTEM LOGICAL ANALYSIS USING K-NEAREST NEIGHBOR ALGORITHM

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Abstract— Logical analysis shows the attributes of an individual decision making, problem solving and verbal ability. Furthermore, it provides significant information to schools and companies to strategically develop relevant interventions towards the improvement of individual logical capability skills. This is the reason why logical test is given, basically to measure the thinking level of an individual. However, experts in this field make tedious process in generating the result thus consuming time and effort. With this current situation, the study aims to develop an online logical test to automatically generate score and skills analysis results in real-time. The study used descriptive method to understand the process and interpretation of skills to ensure its accuracy and the Rapid Application Development model was adopted to accomplish the technical requirement of the application. And this application was evaluated by the experts in terms of functionality, reliability, usability, and efficiency with the over-all weighted mean result of 4.29 "Very Satisfactorily".

Keywords— Logical analysis; logical skills; logical test; skill analysis;

1. INTRODUCTION

Logical thinking is a process of problem solving, decision making, verbal reasoning, metacognitive process, and adaptation ability and purely needed in science and mathematics. [42][22] [10] [30] [46]. In the information technology it is one of the foundational skill of an ITE students [34].
Furthermore, logic help students and graduates to achieve higher levels in their study and profession and able to effectively handle leadership role [33] and perform well in their courses especially in decision, solving real world problems, and understand what they read and see [45] [40]. In a programming tasks and activities students need logical skill to perform accurately by doing abstractions and generalization [6] [47]. Moreover in in writing programming codes, testing software and searching and fixing the 'bugs' in their programs [28]. Several studies reveal that students have different logical thinking levels where they have different abilities to use in performing problem solving and analysis [9]. Different logical thinking levels explains why some of the students succeed in subjects that uses problem solving skills and logic while others do not [20]. Reasons why logical test must be conducted. Logical test are used to measure the logical thinking level of the students. The tests are composed of ability test such as quantitative reasoning, verbal reasoning, verbal comprehension and figural reasoning skills. The score is computed by using norms [7] [8] [29] and the result can be also used as basis for the teachers to create intervention to specific student [27] [39]. For the technical application of the result, the study utilized a suitable algorithm that will classify the skills of the students and provide a comparative result with to the skill of a students to other students using a K-Nearest Neighbor Algorithm mostly applied in document classification, where in the method makes use of training documents [52][43], economic forecasting [24], used in diagnosing which marked high accuracy rate[44] and used in measuring the accuracy level of automatic answer identity formation and search similarity answer[17].

A. Project Context

Logical assessments are widely used to assess the skills of the individual and this can be observed in schools and companies. In companies, the logical assessment is one of their criteria to identify and assess candidates during their recruitment process in order produce capable worker to handle certain tasks. In school it is also important to identify what type of student they want to develop and what kind of intervention should be employed. In this regard, the study will focus on the school setting practices. With this the researchers conducted an interview to schools namely: Saint Michael's College of Laguna, STI Sta.Rosa, and University of Perpetual Help System Laguna-JONELTA to gather relevant information that will support the study and make the study suitable and applicable.

B. Statement of the Problem

1) General Problem: The researchers found out that the psychologists are taking a hard time in assessing the logical skills of students.
2) Specific Problem:
   • Time consuming to generate logical thinking test result
   The researchers conducted a group discussion with the psychologist with regards to the process in conducting a logical test and generation analysis result. According to them, they set a date on when to give exam to the students. Tests are given to the students per classroom for an hour. After the student took the exam, the school psychologist collect the exams and check it manually using a pattern answered sheet to check the papers of the examiners which they need more time and effort. Then the individual score of the students is manually encoded using spreadsheet application with set formulas based on the standardized norms. Other schools, manually write the scores in a paper then compare the scores using the hardcopy of their respective standardized norms used. Most of them only produced report based on the scaled score, SAI, percentile rank and stanine conversion to interpret the skills analysis and the results with regards to the strength and weaknesses are verbally communicated to the students which means no print copies is provided. The process took about 3-6 months to generate the results because the norms have to deal with various area of assessing the skills. On the other hand, As observed schools used different norms such as OLSAT and LSAT. It differs with regards to the computation but with the same type of results such as scaled score, standard ability index, percentile rank and stanine conversion which is needed in assessing logical thinking of students. In addition, OLSAT and LSAT are purchased by versions and only registered psychologists are allowed to buy.

C. Research Objective

1) General Objective: The researchers aim to develop an expert system to assess the logical skills of an individual using a K-Nearest Neighbor Algorithm.
2) Specific Objective:
   • To create an online logical test that generates accurate and real time result.
   The system will automatically generate the result of Student Ability Index (SAI) that refers to the standardized comparison of student’s score according to their age, the Percentile rank that refers to the percentage of other examiners in which the student is higher and the Stanine that refers to the conversion of test scores into a single digit for determining the level of the student’s thinking. For the Skills analysis result the K-Nearest Neighbor Algorithm is used to find the Euclidean distance of the score of the student who take the exam then compared the score to the rest of examiners then it will be sorted from furthest to nearest and get the 30 % of the student from the nearest distance to produce the accurate result. From the 30 %, it produced the characteristics depending on the most similar characteristics being generated. These characteristics will serve as the data to analysis of skills of the student in particular their strength and weakness and be part of the data sets for the next comparison.
In addition, the system will allow the authorized users to upload the norms in a CSV file format sequentially that contains the raw score, scaled score, student ability index, percentile rank and the stanine conversion. Furthermore, it allows the users to upload various version of norms. The norms will be used to generate score analysis.

D. Scope and Limitations

1.) Scope: The study mainly focused on verbal reasoning, verbal comprehension, figural reasoning and quantitative reasoning and skills analysis to purposely use for assessing the logical thinking.
   - Login module. This module allows the user to access the system using their assigned username and password;
   - Manage account module. This module allows the user to add, update and deactivate users account
   - Report module. This module allows the authorize users to view exam result module such as the scaled score, percentile rank stanine, SAI and skills analysis;
   - Schedule exam module. This module allows the psychologist to set schedule of the logical test

2.) Limitation:
   - The size of the CSV file is limited to 2mb and must followed accordingly based on the specified format.

E. Significance of the Study

1.) Students: The result of the logical test will greatly provide relevant information which would make them identify what skills to be improved.
2.) Faculty: The result of the assessment will be used as basis to study the student's capability thus help them create interventions.
3.) Institution: The study will be beneficial to the institutions since the system will provide information in the logical thinking status of their students that will be an input to develop new approaches and techniques.
4.) Future Researchers: The study will benefit the future researchers to serve as a basis to improve their studies related to this concept.

II. METHODOLOGY

The researchers used Rapid Application Development (RAD) with iterative approach and applied of joint application requirement and joint application design in developing the system to ensure the accuracy, efficiency and effectiveness of the system.

![Fig.1 Rapid Application Development with Iterative Approach](image)

- **Analysis and Planning**
  The researchers conducted one on one interview to the school psychologists of University of Perpetual Help System Laguna- Jonelta, STI Sta.Rosa and Saint Michael's College of Laguna and STI regarding the process of their logical test from taking the exam up to the generation and distribution of reports in order to identify what process needs to improve. Also, focal group discussion is applied to get the consensus of the process owners to comply the requirements in developing the system. Most importantly, the concept is presented to the psychologists to ensure that the system is in accordance with their expected requirements.

- **Design**
  In this phase, the process are graphically drawn as guide for the development of the system: the context diagram, use-case diagram, data flow diagram, class diagram, flow chart, and entity relationship diagram. These diagram is thoroughly check to ensure its confirmity of the requirements. Also in this phase, the user interface is carefully plan together with the process owner and the technical expert to check to check the labels, the color combination, the arrangement of results and what to be display in every form.

- **Development**
  The researchers build the system using XAMPP to run the PHP files and creating the database structure, Sublime text editor and a browser. Sublime text editor is used in coding the system and the browser is used to run the system. While coding the each module the researchers/developer check the code structure and evaluate its efficiency.
Implementation
The researchers installed the system and schedule the training on how to use the system. The students are used the system by taking the online logical test examination while Psychologist used the system by uploading the norm, setting the schedule of logical test and view the result of the students.

A. Algorithm
K-Nearest Neighbor (KNN) algorithm is typically need in large data sets to achieve accuracy and efficiency. KNN algorithm is used in various systems like text categorization where in the text is analyzed and compared to all other text documents and assign what is the category of the text document. This system proves that KNN is suitable for categorizing in a large data set. In this study, the K-Nearest neighbor algorithm perform first by finding the Euclidean distance. Euclidean distance is the distance of the score of the student who take the exam of the score of each student who also took the exam After getting the distance, then it will be sorted from furthest to nearest and get the K is a number of students which are the nearest to the examiner. To find the K, you will get the 30 % of the students who also take the exam. After getting the K, it will get the characteristics of the K number of students depending on who got the most number of similar characteristics. Those characteristics will be the analysis of the student who take the exam and placed it in the data set as a raw data.

\[ \text{Euclidean Distance} = \sqrt{(i_1 - a_1)^2 + (i_2 - a_2)^2 + (i_3 - a_3)^2 + (i_4 - a_4)^2} \]

<table>
<thead>
<tr>
<th>TABLE I - SYMBOLS</th>
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<tbody>
<tr>
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<td>a4</td>
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</table>

B. Result and Discussion
Fig 3 shows the conceptual framework of e-Lohika. The input value is the raw score of student who took the exam then it will be converted to a scaled score to determine the Student Ability Index (SAI) which determined by comparing scores of students within the same age group then the data will be stored in the data sets and the SAI will determine the Percentile rank which represent the percentage of students exam result to other examiners and the Stanine is a method of scaling the score of students on a nine point standard scale using the OLSAT standard scale with a mean of five and standard deviation of two. This standard deviation is a number used to tell how measurements for a group are spread out from the average (mean), or expected value. On the other hand, the raw score of a students will be analysed based on verbal reasoning, verbal comprehension, figural reasoning and quantitative reasoning then will be compared to each of the students who took the exam using the Euclidean distance After getting the distance, it will be sorted from furthest to nearest and get the K is a number of students which are the nearest to the examiner. To find the K, you will get the 30 % of the students who also take the exam.
After getting the K, it will get the characteristics of the K number of students depending on who got the most number of similar characteristics. Those characteristics will be the analysis of the student who take the exam and placed it in the data set as a raw data.

Fig. 4 System Architecture

Fig. 4 shows the system architecture of the e-lohika. MySQL is the main server to manage the database and the application. All users can access the application through the internet. The application is design for HTML 5 supported browser.

Fig. 5 Context Diagram

Fig. 5 shows the context diagram of eLOHIKA where the Admin of the system should register the authorized users of the system for them to access their respective account level: the students, faculty and the school psychologist. The school psychologist can add students, upload the norms, create questions then set the schedule of the exam to allow students when to take the exam. The results of the exam can be viewed by the psychologist, the faculty can only view analysis of their students and the students can also view their respective individual result.

Fig. 6 Use Case Diagram
Fig. 6 shows the activity of the users. The Admin can register Psychologists, add School, and add Courses. The Psychologists on the other hand, is allowed to register students, customize questions, customize norms, add schedule and view results and the student can only take exam as schedule and view the result of their logical test.

C. E-Lohika Web Interface

Fig. 7 Login Page

Fig. 7 shows the log-in page of the application which contains the username and password to access their respective account.

Fig. 8 Homepage (Admin)

Fig. 8 shows the homepage which contains the dashboard of the system: view results, add schools and courses and update the accounts.

Fig. 9 Homepage (Psychologist)

Fig. 9 shows the dashboard for the Psychologists which contains the list of students to view their analysis, list of course to view the analysis-per-course, the questions which composed of verbal comprehension, verbal reasoning, quantitative reasoning, and figural reasoning, the norms used in converting the score into a score analysis and schedule of the logical test.
Fig. 10  Question Module
Fig. 10 shows the questions for every category. Note: The psychologists can add or edit the questions.

Fig. 11  Add Schedule
Fig. 11 shows the add schedule module which contains the schedule information that needs to be filled up by the Psychologists including the schedule title, norm, question set, and time frame of the test.

Fig. 12  Students Information and Exam Schedule Module
Fig. 12 shows the student's basic information and date when the student take the exam. This will also to view the his/her skills analysis.
Fig. 13  Student Assessment Module

Fig. 13 shows the student assessment which contains the student's score analysis including the Student Ability Index, Percentile Rank, Stanine and Score Breakdown.

Fig. 14  Logical Thinking Analysis

Fig. 14 shows the logical thinking analysis which contains the score of the one student to other students in terms of Verbal Comprehension, Verbal Reasoning, Figural Reasoning and the Quantitative Reasoning. In this graph the red represents the score of one student and the blue represents the other student's scores.

Fig. 15  Students Skills Interpretation
Fig. 15 shows the interpretation of student skills which contains the interpretation of student strength and weakness in terms of verbal comprehension, verbal reasoning, quantitative reasoning, and figural reasoning. Note: The rectangle red symbol means the students strength and the blue symbol means the student’s weaknesses.

![Fig. 15 Skill Analysis](image1)

Fig. 16 shows the skills analysis of the students which contains the score of the one student to other students in terms of the analytical skills, problem-solving skills, creativity, critical thinking skills, resilience reading comprehension, innovative, and persistence. In this graph, the red color represents the score of one student and the blue color represent the other student’s scores.

![Fig. 16 Skill Analysis](image2)

Fig. 17 shows the norms list that contains the list of norms version used by the Psychologist.

![Fig. 17 Norm List](image3)

Fig. 18 shows the raw score-scaled score conversion.
Fig.18 shows the raw-score scaled core conversion. Note: The psychologist can upload the CSV file of the conversion to update or add norm.

Fig. 19 SAI to Percentile rank and Stanine

Fig.19 shows the SAI to Percentile rank and Stanine conversion. Note: Psychologist can upload the table of conversion in a CSV file format to update the norms.

Fig. 20 Examination Module

Fig.20 shows the examination module page which contains the question that the student should answer the questions completely then the submit will activate and automatically compute the score. Note: The student can only take exam once per schedule.

D. Software Evaluation

<table>
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<tr>
<th>All Characteristics</th>
<th>Mean</th>
<th>Verbal Interpretation</th>
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</thead>
<tbody>
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<td>Functionality</td>
<td>4.45</td>
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</tr>
<tr>
<td>Reliability</td>
<td>4.18</td>
<td>Very Satisfactory</td>
</tr>
<tr>
<td>Usability</td>
<td>4.28</td>
<td>Very Satisfactory</td>
</tr>
<tr>
<td>Efficiency</td>
<td>4.30</td>
<td>Very Satisfactory</td>
</tr>
<tr>
<td><strong>Total Weighted Mean</strong></td>
<td><strong>4.30</strong></td>
<td><strong>Very Satisfactory</strong></td>
</tr>
</tbody>
</table>

Table 2 shows the result of the software evaluation: Functionality garnered an average of 4.4 weighted mean “Very Satisfactory”; Reliability garnered an average of 4.1 weighted mean “Very Satisfactory”; Usability garnered an average of 4.28 weighted mean “Very Satisfactory”; and Efficiency garnered an average of 4.30 weighted mean “Very Satisfactory” with an over-all result of 4.30 weighted mean “Very Satisfactory” level which means that the application meet the users requirements.
III. CONCLUSIONS

The study concluded that the system greatly helps the users to generate accurate and real time results thus improve its productivity and quality service to its clientele.

IV. RECOMMENDATIONS

The researchers will recommend this system to the schools in the Philippines to improve it services thus increase their productivity level however to further improve the system the following features will be added.

- Include other components of the aptitude test.
- Create a mobile version of the system.

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REFERENCES

12. Cannavo; Flavio; Cannata, Andrea; Cassisi, Carmelo; Di Grazia, Giuseppe; Montalto, Placidio; Prestifilippo, Michele; Privitera, Eugenio; Gambino, Salvatore; Coltelli and Mauro. (2017) An Expert System for Computer-aided Volcano Monitoring on Mt. Etna. [Online]. Available http://adsabs.harvard.edu/abs/2017EGUGA.19.7486C


22. V. Ho, et.al. (2013) Intelligence, General Psychology. [Online]. Available: https://www.slideshare.net/highclaszbhrattin/helalapychologyintelligence


30. M.C. Labiste, et.al. (2011) Nature of Intelligence, General Psychology. [Online]. Available: https://books.google.com.ph/books?id=HvXLcpQAACLb&pg=PA648&dq=Language+of+Intelligence|General+Psychology&pp=159&source=bl&ots=f6spJVkfBV&sig=pElg6SRXd6DgMo028212q5ogyY&hl=en&sa=X&ved=0ahUKEwJHvYXAhWlLwKHA4JdhvQ6AEIKA#v=onepage&q=Language%5Fof%5FIntelligence%5FG+General%5FPsychology%5FSor%5F1&f=false


33. S.R. Mathews. (2012) General psychology: Thinking and Intelligence. [Online]. Available: https://www.google.com.ph/books?id=HvXLcpQAACLb&pg=PA648&dq=Language+of+Intelligence|General+Psychology&pp=159&source=bl&ots=f6spJVkfBV&sig=pElg6SRXd6DgMo028212q5ogyY&hl=en&sa=X&ved=0ahUKEwJHvYXAhWlLwKHA4JdhvQ6AEIKA#v=onepage&q=Language%5Fof%5FIntelligence%5FG+General%5FPsychology%5FSor%5F1&f=false


