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EDULEXYA: Development of Educational Gamification Application with Interactive Card Media to Improve Learning Outcomes for Children With Dyslexia on The Android Platform

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ABSTRACT

This study addresses the learning challenges faced by children with dyslexia, particularly in writing, spelling, and reading. The objectives are: (1) to analyze user needs and determine suitable application features to support dyslexic children's learning; (2) to design a mobile application, EduLexya, incorporating gamification and interactive card-based multisensory learning methods; and (3) to evaluate the application's effectiveness in enhancing learning outcomes. Employing a Research and Development (R&D) framework with the Software Development Life Cycle (SDLC) waterfall model, the study involved dyslexic children aged 7–15 years from Somoitan (experimental) and Giriharjo (control) elementary schools. Data collection involved observation, interviews, questionnaires, and pretest-posttest assessments. Statistical analysis included validity, normality, homogeneity, and hypothesis testing via the Independent Samples T-Test. Findings identified essential features—writing, spelling, reading, quizzes, schedules, settings, guides, and feedback. The application was rated highly by material experts (5.00), media experts (4.81), and beta testers (4.81). Posttest results showed a significant improvement in the experimental class (M = 84.37, Sig. 0.000) over the control class (M = 74.33, Sig. 0.043), confirming EduLexya's effectiveness in improving dyslexic learners' academic outcomes.

Keywords: Dyslexia, *EduLexya*, Gamification, Multisensory Method, Interactive Cards

INTRODUCTION

The increase in population in Indonesia is directly proportional to the increase in the number of people with disabilities. Of Indonesia's 270 million population, there are 22.5 million people with disabilities (Ministry of Social Affairs, 2020). Persons with disabilities include individuals with physical, sensory and intellectual limitations, where one category that requires special attention is sensory disabilities. Disability cases in Indonesia are still a hot topic of discussion in society, as supported by Google Trends analysis data from August to September, as shown in Figure 1.

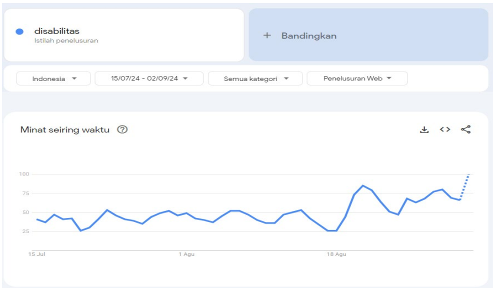


Figure 1. Analysis results on Google Trends

In Indonesia, the prevalence of dyslexia is quite high. Rachmawati and Nurhayati (2022) reported that around 50% of students from 24 elementary schools in one sub-district showed signs of dyslexia. Chodijah (2014) also emphasized that in Indonesia 5 to 10 percent of school children have dyslexia. Unfortunately, conventional learning methods that are still widely applied by teachers are not effective enough to meet the learning needs of children with dyslexia.

The large number of schools and agencies is inversely proportional to the availability of gamification-based learning applications which are limited and less optimized in meeting students' needs, especially for children with dyslexia (Santi et al., 2021). Gamification is the implementation of game elements in the learning process, so as to increase student motivation and involvement. In addition, multisensory methods, which optimize the visual, auditory and tactile senses, have been proven effective for helping children with dyslexia understand learning material more thoroughly.

This research aims to develop an Android-based educational application called "*Edulexya*" which integrates the concept of gamification with multisensory methods to help children with dyslexia. This application is equipped with interactive card media to create an adaptive and effective learning experience, so that it can increase children's motivation and learning outcomes. Research was conducted at the elementary school level in Girikerto, Turi, Sleman, DIY, targeting children aged 7-15 years who have dyslexia. By involving a minimum of 40 samples, this research is expected to maximize the results of the "EduLexya" software innovation, as an educational medium that can be applied universally. broad, especially to support basic learning such as writing, spelling and reading.

METHODS

Types of research

This research applies the Research and Development (R&D) model. The Research and Development Model (R&D) is applied to conduct systematic research in designing, developing and evaluating the results obtained. Based on Brog & Gall (1983:772), "educational research and development (R&D) is a process used to develop and validate educational products", Research and Development (R&D) refers to educational research and development which involves a learning process as well as testing to produce educational products.

Location, Population, and Research Sample

This research was carried out from 20 October 2024 to 31 October 2024. This research was conducted in several elementary schools (SD) in D.I. Yogyakarta. The study population included children with dyslexia aged 7–15 years from grade 1 and above. The research sample was selected using purposive sampling with the criteria of children having difficulty reading, spelling or writing, involving 10–30 students in each location to ensure diversity of responses. Teachers and parents were also involved to provide input to strengthen the research results.

Procedure for Creating an Artificial Intelligence Model

The development of the EduLexya system in the "Reading" menu using the application of artificial intelligence, was made through several designed stages. Each step is designed to address specific challenges, such as the diversity of handwriting forms in dyslexic children, the need for high accuracy in text recognition, and the importance of a user-friendly application interface. These stages are in Figure 2.

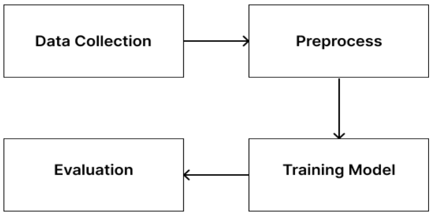
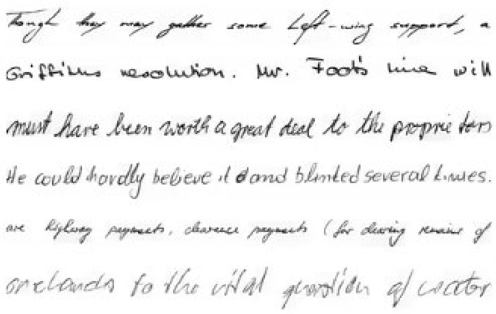


Figure 2. Stages of AI model development



Partitions	Characters	Words	Lines
Train	274,964	53,728	6,161
Validation	40,770	7,899	900
Test	81,676	17,616	1,861
Total	397,410	79,246	8,922

Figure 3. IAM and real-time datasets used

The description of this stage is,

1. Data Collection: Collection of datasets of dyslexic children's handwriting as training and test data, covering various types of handwriting that are relevant to learning material, either from children's direct writing, photos, or online sources such as IAM as shown at Figure 3.

2. Preprocess: The preprocessing process involves converting the image to grayscale format, removing noise, and normalizing the image size. Data is labeled with correct text to be used as ground truth.
3. Training Model: Development of an OCR model using CNN-LSTM technology to recognize handwriting, and an LSTM model to correct text errors. Training is carried out using the categorical crossentropy loss function, Adam optimizer, and evaluation with accuracy, precision, recall and F1-score metrics.
4. Evaluation: Evaluation was carried out using a test dataset to measure the accuracy of OCR and text correction by the LSTM model. The

evaluation results are used to optimize the model, such as adding dropouts or adjusting hyperparameters, before being integrated into the EduLexya application for further testing and improvements based on user feedback.

Application Development Procedure

SDLC (System Development Life Cycle) is a stage in designing and modifying a system, as well as methods and models applied in system or software development (T. Pricillia & Zulfachmi, 2021). This research will use software development procedures with the SDLC waterfall model, which can be seen in the Figure 4.

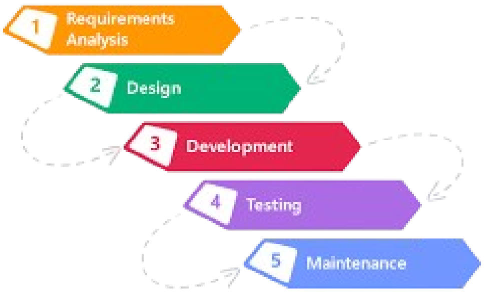


Figure 4. Software development life cycle waterfall model

The following is an explanation of the stages used in application development in this research:

1. Requirements: Explore and find out user software needs, produce clear and detailed software requirements documents.
2. Design: Create architecture and technical specifications, including system planning, flowcharts, use case diagrams, and User Interface (UI) design.
3. Development: Software coding using the Dart language and the Flutter framework, carried out in Visual Studio Code.
4. Testing: Testing the system with alpha testing, application validation by experts, and beta testing to maximize the system.
5. Maintenance: Post-release system maintenance, including bug fixes, updates, and functionality improvements according to user needs.

Data Collection Techniques

Data collection techniques in this research include non-participant observation at SD N Somoitan and SD N Giriharjo, free directed interviews with research subjects (teachers, parents), the use of closed questionnaires to assess the feasibility of the application based on the assessment of material and media experts, and learning tests in the form of a pretest and posttest to evaluate the learning outcomes of students with dyslexia before and after using the "EduLexya" application with a multisensory approach.

Research Instrument

Research instruments are used as a medium for collecting and searching for data in the research carried out. This is done to collect data and information, then the data is processed and the results analyzed. The instruments used are black box test instruments, material expert validation test instruments, media expert validation tests, beta test instruments, pretest and posttest instruments.

Data Analysis Techniques

Application Validation Test

The assessment system used as a reference in the questionnaire is the Likert scale (scale 5). The scale in question starts from 1 to 5 with categories STS (Strongly Disagree), Disagree (TS), Neutral (N), Agree (S), and SS (Strongly Agree), (Eko Putro Widyoko: 236). Alternative answers provided in the questionnaire are shown at Table 1.

Table 1. Assessment using a Likert scale

Criteria	Score
SS (Strongly Agree)	5
S (Agree)	4
N (Neutral)	3
TS (Disagree)	2
STS (Strongly Disagree)	1

The data that has been collected will be analyzed using an average calculation of the scores obtained, using the formula:

$$\bar{X} = \frac{\sum x}{n}$$

Information:

$\bar{X}$ = Average score

$\sum x$ = Total score

n = Number of assessors

The average assessment obtained will be converted or changed back into the application eligibility category. The aim of this is to draw conclusions regarding the quality of the application by referring to the idea conversion guidelines put forward by Mr Sukardjo (2005:53) as shown at Table 2.

Table 2. Ideal conversion guidelines by Sukardjo (2005:53)

No	Formula	Category
1.	X > $\underline{X}$and + 1.8SBi	Very Worth It
2.	Xi + 0,6SBi < X ≤ Xi + 1,8SBi	Worth it
3.	Xi - 0.6SBi < X ≤ Xi + 0.6SBi	Enough
4.	Xi – 1,8SBi < X ≤ Xi - 0,6SBi	Ineligible
5.	X ≤ Xi - 1,8SBi	Very Inadequate

By using this formula, we can convert quantitative values in the range 1 (one) to 5 (five), into qualitative categories that will provide an idea of the suitability of the media or application being developed. The conversion guidelines presented by Sukardjo (2005: 53) as shown at Table 3.

Table 3. Conversion of actual scores into qualitative

No	Formula	Category
1.	X > 4,2	Very Worth It
2.	3,4 < X ≤ 4,2	Worth it
3.	2,6 < X ≤ 3,4	Enough
4.	1,8 < X ≤ 2,6	Ineligible
5.	X ≤ 1,8	Very Inadequate

Normality Test

The normality test was carried out to determine the distribution of data in the pretest, posttest and gain from the control and experimental classes. Testing uses the Kolmogorov-Smirnov and Shapiro-Wilk tests at a significance level of 5% with the following criteria:

- Significant score (sig.) < 0.05, distribution is not normal
- Significant score (sig.) ≥ 0.05, distribution is normal.

Homogeneity Test

The homogeneity test aims to ensure the equality of variance between the control and experimental classes. Testing uses the Test of Homogeneity of

Variance via SPSS version 26, with the following criteria:

- Sig. > 0.05: data homogeneous.
- Sig. ≤ 0.05: data is not homogeneous.

Hypothesis Testing (Independent Samples T-Test)

Hypothesis testing was carried out to measure increases in student learning outcomes between groups that received treatment and those that did not. This test is only carried out if the control and experimental class data meet the requirements for normal distribution and homogeneity. The testing stages start with data normality testing, data homogeneity testing, and data hypothesis testing using the Independent Samples T-Test.

RESULTS AND DISCUSSION

1. Requirement

Based on the results of observations at schools, EduLexya was designed with interactive features and uses multisensory learning methods as shown at Figure 5. Analysis of the material presented is adjusted to the Merdeka Curriculum Phase A. Based on this analysis, the features developed are writing, spelling, reading, quizzes, feedback, schedule, guide and profile as shown at Figure 6.

2. Design

a. Flowchart

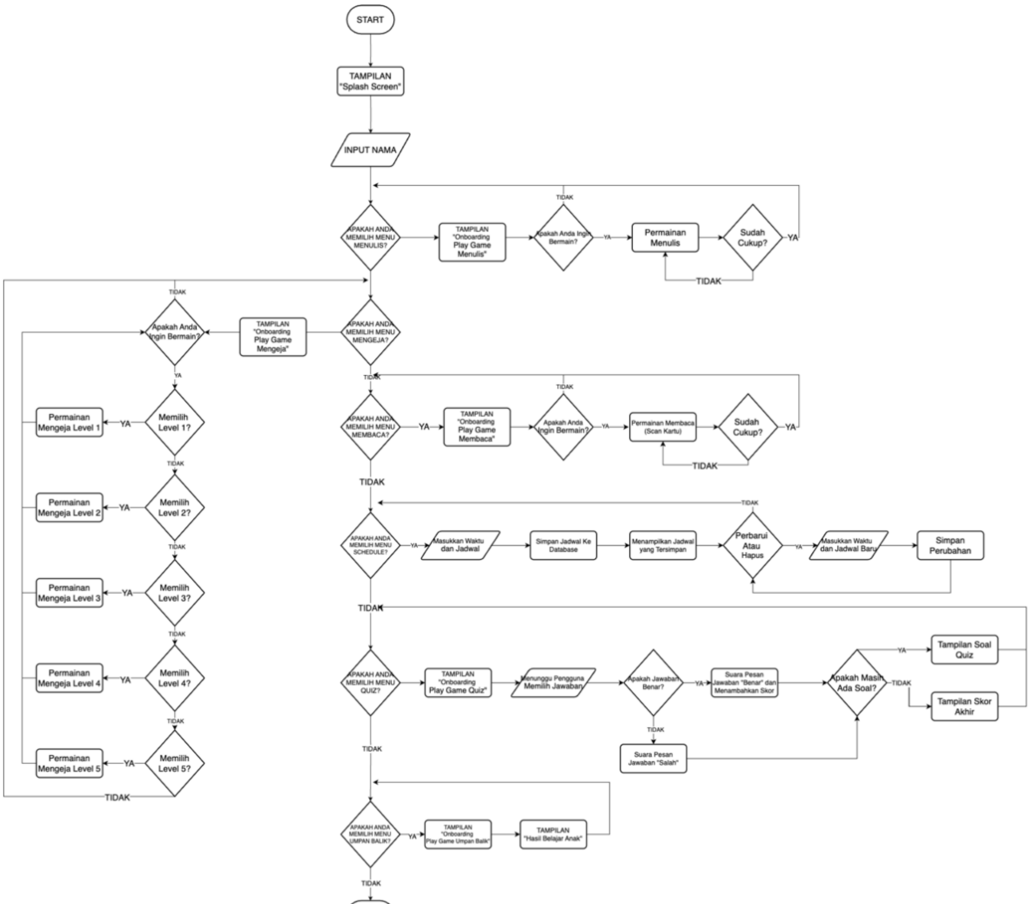


Figure 5. Application flowchart

b. Usecase Diagram

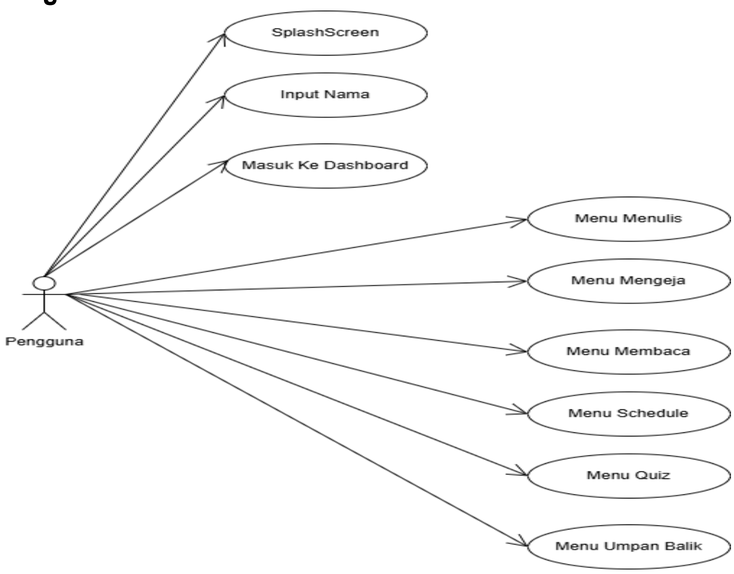


Figure 6. Use case diagram

c. Application Design

Dashboard

The dashboard in the EduLexya application consists of main features consisting of writing, spelling, reading, quiz, schedule and feedback features as shown at Figure 7.

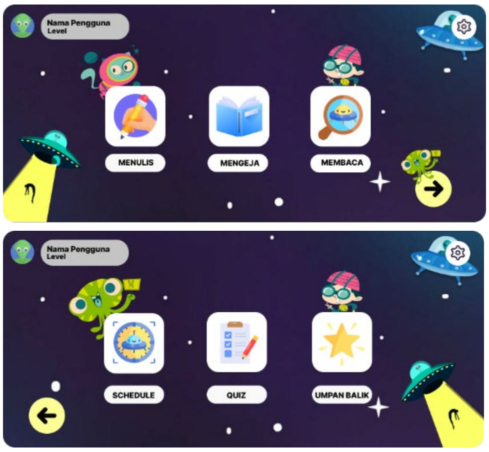


Figure 7. Dashboard page on the EduLexya application

Writing Features

The writing feature in the EduLexya application is designed to train the skills of dyslexic children through gapped text and bold words, in order to strengthen fine motor coordination and understanding of letters as shown at Figure 8.

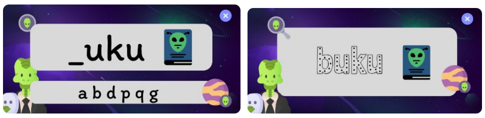


Figure 8. Writing feature in the EduLexya application

Spelling Features

The spelling feature in the EduLexya application consists of 5 gradual levels, starting from recognizing letters to words with four syllables. Each level is designed to improve students' literacy skills progressively, from recognizing letters to forming more complex words, such as “ke-bun bi-na-tang” as shown at Figure 9.

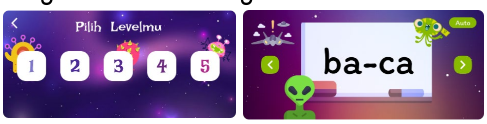


Figure 9. Spelling feature in the EduLexya application

Reading Features

The reading feature in the EduLexya application trains students' literacy skills with interactive cards, where students write the names of objects from pictures and then read them. This feature uses AI technology to scan student answers and provide automatic feedback. If the answer is correct, the system gives a sound "hooray, your answer is right!", and if it is wrong, a sound appears "yes, your answer is wrong. Let's try again!" This process supports independent learning in an interactive and fun way as Shown at Figure 10.

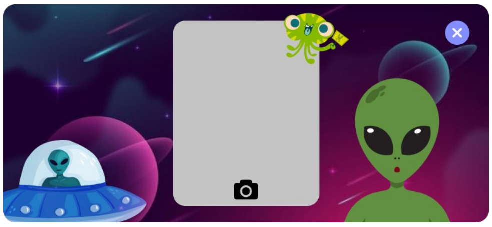


Figure 10. Reading features in the EduLexya application

Quiz feature

The quiz menu in the EduLexya application is designed to test dyslexic students' understanding through writing, spelling and reading questions as shown at Figure 11. The system provides immediate feedback in the form of a score and voice motivational messages, such as "Hooray, your answer is correct!" or "let's try again........!"

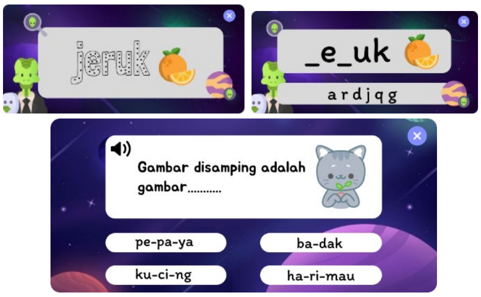


Figure 11. Quiz feature in the EduLexya application

3. Development

a. Creating Artificial Intelligence Models

Optical Character Recognition (OCR) has two categories that can be applied to the EduLexya application model creation process as shown at Figure 12. The first category is online, where the input images used are taken in real-time. Meanwhile, the offline category uses text recognition in the form of typing and manuscripts. This classification can be seen in the image below.

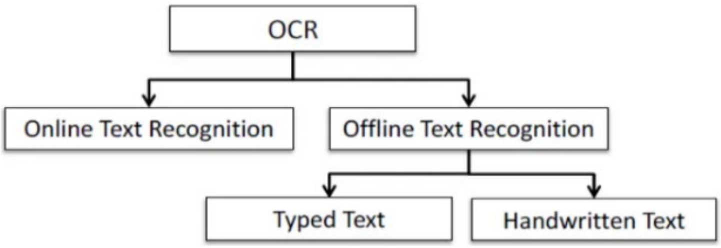


Figure 12. Classification of optical character recognition

OCR classification improves model accuracy by expanding dataset coverage, both real-time and manuscript. The process begins by feeding input images into a CNN layer, followed by applying LSTM and RNN to propagate information on the training data as shown at Figure 13. The matrix produced by RNN and CTC is used to calculate the loss value and finalize the text. The following are the stages in model development,

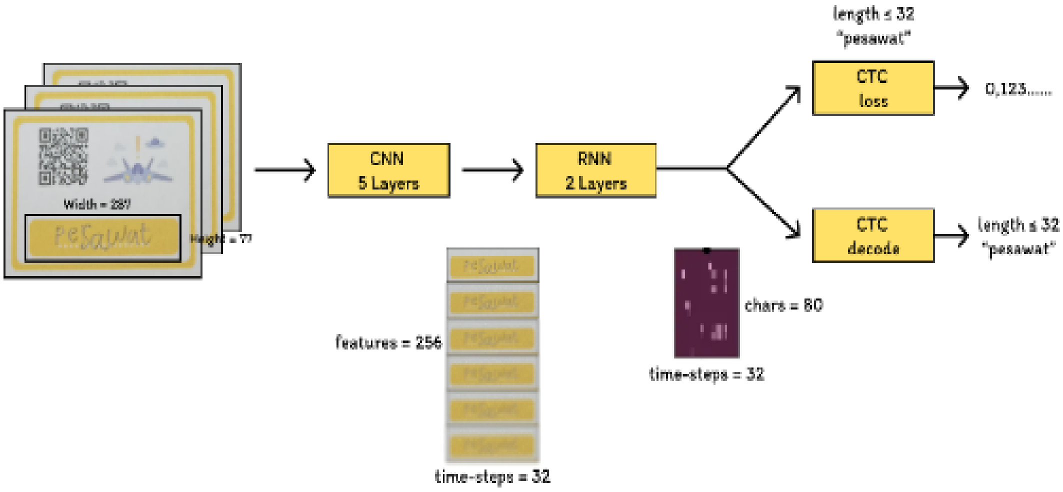


Figure 13. Developed neural network model

The architecture used in this research combines two architectures. The first architecture is CNN-BLSTM by Puigcerver and Gated-CNN-BLSTM by Blucher and Messina as shown at Figure 14. The combination was carried out to take maximum advantage of the two architectures above. This can maximize results that are compatible with the Puigcerver model, but with a lower number of parameters as in the model of Bluche et al. This architecture is

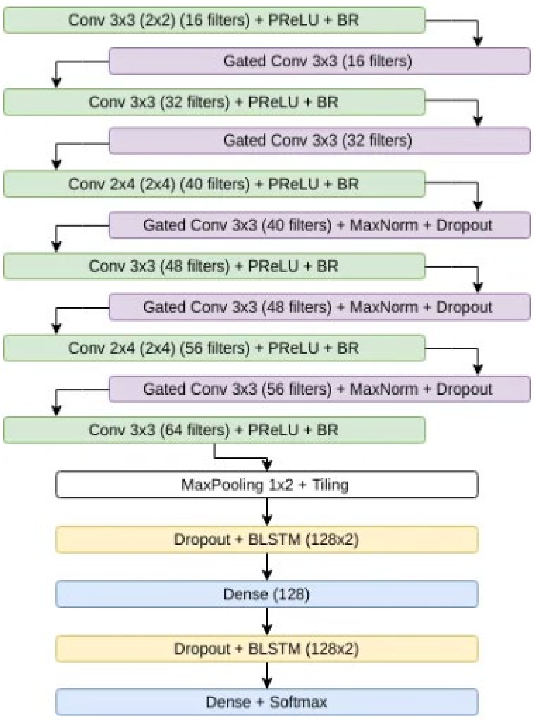


Figure 14. Architecture used in model development

The model will work by matching the letters entered one by one as shown at Figure 15. Then the letters will be arranged from left to right and then assembled to form 1 output unit, so that you will get 1 series of words. An example of the results of the model developed.

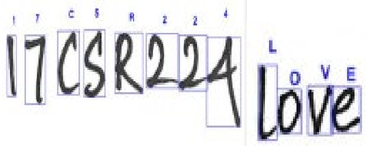


Figure 15. Test results on the developed model

The final test carried out in this process is analyzing the accuracy percentage of the model developed. The model developed obtained an accuracy value of 91.82% with system sensitivity of 93.98%, and system specificity of 85.42%, which means our system can provide very good measurement results.

4. Testing

a. Alpha Test

The method applied in alpha testing uses a black box testing approach as shown at Table 4. Functionality in EduLexya application development is maximized with testing scenarios using summary test cases.

Table 4. Alpha testing scenario for the EduLexya application

Tester Components	Testing Scenarios	Tester Type
SplashScreen	The system displays a splashscreen page	Black Box
	The system plays audio automatically	Black Box
Input Nama	Enter Name	Black Box
Dashboard	Access the 1st page dashboard menu	Black Box
	Access the 2nd page dashboard menu	Black Box
Writing	Access the writing menu	Black Box
	Accessing the writing menu, game 1 (Search for missing text)	Black Box
	Access the writing menu, game 2 (bold text)	Black Box
Spelling	Access the spell menu. initial page	Black Box
	Accesses the level 1-5 spelling menu	Black Box
Reading	Access the reading menu	Black Box
	The system can scan the card	Black Box
Schedule	Access the schedule menu	Black Box
	Make a schedule for studying	Black Box
Quiz	Access the Quiz menu	Black Box
Feedback	Access the feedback menu	Black Box

The total number of test cases planned for application testing is 16. Based on testing, the black box test results show that all test cases are valid, so the application can be considered to be functioning well.

b. Application Validation

Application Validation by Material Experts

Based on the results of validation tests by material experts, the EduLexya application received an average score of 5 (very decent) in all aspects tested: material, questions, language and implementation as shown at Table 5. The value for each aspect is in the range X > 4.2, which indicates that the application is assessed **very worthy** by experts.

Table 5. Application validation results by material experts

No	Assessment Aspects	Number of Values	Average Value	Category
1.	Material Aspects	90	5	Very Worth It
2.	Aspects of the Question	60	5	Very Worth It
3.	Language	20	5	Very Worth It
4.	Implementability	30	5	Very Worth It
Amount		200	5	Very Worth It

Application Validation By Media Experts

Based on validation by media experts, the Software aspect received an average score of 4.37 (Very Decent) and the Visual Communication aspect received a score of 4.91 (Very Decent) as shown at Table 6. Overall, the EduLexya app received an average score of 4.81, which shows that this app **very worthy** in terms of technical quality of software and visual communication.

Table 6. Application validation results by media experts

No	Assessment Aspects	Number of Values	Average	Category
1.	Software	123	4,73	Very Worth It
2.	Visual Communication	108	4,91	Very Worth It
Total		231	4,81	Very Worth It

c. Beta Test

The results of the beta test evaluation by 47 respondents in the school environment showed a total score of 1581 for 7 questions, with an average value of ($\overline{X}$) 4.81 as shown at Table 7. This value is above 4.2, which categorizes the EduLexya app as **Very Worth It**.

Table 7. Results of the EduLexya application assessment by respondents

No	Question Number	Number of Values	Average Amount
1.	Question 1	234	4,98
2.	Question 2	215	4,57
3.	Question 3	226	4,81
4.	Question 4	227	4,83
5.	Question 5	225	4,79
6.	Question 6	222	4,72
7.	Question 7	232	4,94
Number of Values			1581
Grade Average			4,81
Category			Very Worth It

d. Test for Improved Learning Outcomes

Based on the data analysis above, the significant difference between the pretest and posttest shows an increase in learning outcomes in both classes present on Table 8. Pretest evaluation is used to assess the initial abilities of dyslexic students before learning treatment using the EduLexya application, with the results of descriptive statistical calculations processed using SPSS.

Table 8. Average learning outcomes for dyslexic students

Mark	Control Class	Experimental Class
Pretest rate	66,66	65
Posttest rate	74,33	84,37

Table 9. Descriptive statistical results of pretest data for dyslexic students

Class	N	Mean	Min	Max	Variation	Standard Deviation
Control	24	66,6667	20,00	100,00	675,362	25,98773
Experiment	24	65,0000	20,00	100,00	591,304	24,31675

The average pretest score for the control class is 66.67, with the highest score being 100 and the lowest being 20 as shown at Table 9. Meanwhile, the average pretest score for the experimental class is 65, with a maximum score of 100 and a minimum of 20. The difference in the average between the two classes has not shown significant difference. To confirm whether this difference is statistically significant, further analysis using appropriate methods is needed. The aim is to identify whether there are significant differences between the two groups.

Data Normality Test

The normality test results show that the Sig value in the control class using Kolmogorov-Smirnov is 0.200 and Shapiro-Wilk 0.075 as shown at Table 10. In the experimental class, the Sig value using Kolmogorov-Smirnov reached 0.200 and Shapiro-Wilk 0.280. Because the Sig value in both classes is greater than α = 0.05 (0.200 > 0.05 & 0.075 > 0.05 for the control class; 0.200 > 0.05 & 0.280 > 0.05 for the experimental class), it can be concluded that the two data group has **normal distribution**.

Table 10.. Normality test results of student pretest data

Class	Kolmogorv-Smirnov		Shapiro-Wilk		Conclusion
	df	Say.	df	Say.	
Control	24	0,200	24	0,075	Normal
Experiment	24	0,200	24	0,280	Normal

Homogeneity Test

Table 11. Results of the homogeneity test of student pretest data

Control Class and Experimental Class	Levence Statistic	Say.	Conclusion
Based on Mean	0,124	0,726	Homogeneous
Based on Median	0,041	0,841	Homogeneous

Based on the data obtained from testing the homogeneity of pretest scores in the control class and experimental class, a Sig value of 0.726 "based on mean" was obtained. Sig value > α (0.726 > 0.05) as shown at Table 11. The results prove that based on the data, children's learning outcomes through the pretest come from groups or populations with **uniform variance (homogeneous)**.

Test of differences in pretest results for control class and experimental class

Based on the results of the T test (Independent Samples T-Test), Levene's Test shows a Sig value 0.726 which is greater than α = 0.05 as shown at Table

12, so the variance between the control and experimental classes is considered homogeneous. The T test results show a Sig value. 0.820 (greater than 0.05), which indicates **there is no significant difference** between the average pretest scores of the two classes. In conclusion, the initial abilities of students in both classes were the same before receiving treatment.

Table 12. T test results on pretest data

Variance Assumptions	Levene's Test (F)	Say.	t	Sig. (2-tailed)	Conclusion
Equal Variance Assumed	0,124	0,726	0,229	0,820	Not Significant
Equal Variance Not Assumed	-		0,229	0,820	Not Significant

Posttest Result Data

Based on the table 13, the highest posttest score for the control class is 100.00 with an average score of 74.33 and a standard deviation of 20.28 as shown at Table 13. In the experimental class, the highest posttest score was also 100.00, with an average of 84.38 and a standard deviation of 12.14. Descriptive analysis shows that there are significant differences between the two classes. The next step is to carry out statistical tests to ensure differences in learning achievement between the control and experimental classes.

Table 13. Descriptive statistical results of posttest data

Class	N	Mean	Min	Max	Variation	Standard Deviation
Control	24	74,3333	25,00	100,00	411,449	20,28421
Experiment	24	84,3750	58,00	100,00	147,375	12,13981

Data Normality Test

The results of the normality test show that the significance value in the control class and experimental class is greater than α = 0.05 as shown at Table 14, with the control class having a Sig value. 0.169 (Kolmogorov-Smirnov) and 0.050 (Shapiro-Wilk), as well as experimental classes 0.098 (Kolmogorov-Smirnov) and 0.063 (Shapiro-Wilk). Thus, it can be concluded that the data in both classes **distribute normal**.

Table 14. Posttest data normality test results

Class	Kolmogorv-Smirnov		Shapiro-Wilk		Conclusion
	df	Say.	df	Say.	
Control	24	0,169	24	0,050	Normal
Experiment	24	0,098	24	0,063	Normal

Homogeneity Test

The homogeneity test results on the posttest data show a Sig value. of 0.061 (based on "based on mean"), which is greater than α = 0.05 (0.061 > 0.05) as shown at Table 15. Thus, it can be concluded that the variance in learning achievement of dyslexic children between the control class and the experimental class is **homogeneous**.

Table 15. Posttest data homogeneity test results

Control Class and Experimental Class	Levence Statistic	Say.	Conclusion
Based on Mean	3,700	0,061	Homogeneous
Based on Median	3,574	0,065	Homogeneous

Test the Difference in Posttest Results for the Control Class and Experimental Class

Hypothesis testing continues by comparing posttest scores to assess differences in learning achievement between the two groups after receiving treatment as shown at Table 16. With the following test conditions,

1. If the significance value is smaller than 0.05, then H0 will be rejected
2. If the significance value is greater than 0.05, then H0 will be accepted

Based on the results of the T test (Independent Sample T-Test), the value of α = 0.05 is greater than Sig. (0.05 < 0.061), which indicates that the data has significant variance **homogeneous**. In addition, the value of Sig (2-tailed) = 0.043 is smaller than α = 0.05, indicating **there are significant differences** between posttest scores in the experimental group and the control group. Thus, H_0 **rejected**, and H_a (there are significant differences) **accepted**. As a result, students who used the multisensory learning method with the EduLexya application obtained better posttest results compared to students who used conventional learning methods.

Table 16. T test results on posttest data

Variance Assumptions	Levene's Test (F)	Say.	t	Sig. (2-tailed)	Conclusion
Equal Variance Assumed	3,700	0,061	-2,081	0,043	Significant
Equal Variance Not Assumed	-		-2,081	0,044	Significant

CONCLUSION

The EduLexya application, featuring writing, spelling, reading, quizzes, schedules, and feedback, is designed to support dyslexic children through interactive, adaptive, and multisensory-based learning. Incorporating gamification and interactive card media, the application enhances engagement, concentration, fine motor skills, and teacher-student interaction. Validation through alpha and beta testing yielded high feasibility scores—5.00 from material experts and 4.81 from both media experts and beta testers. Statistical analysis using the independent samples t-test confirmed EduLexya's effectiveness, with the experimental class achieving a significantly higher posttest score (M = 84.37) than the control class (M = 74.33;

Sig. 0.043 < 0.050), indicating a notable improvement in learning outcomes for dyslexic students.

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