

Chatbot Optimization in Education: Improving Learning Experience and Competency Development

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Abstract—This study explores the application of chatbots as an innovative tool in education to enhance the learning experience and development of student competencies. With the advancement of information and communication technology, chatbots have emerged as a potential solution to improve the traditional learning process. This study aims to examine the effectiveness of using chatbots in providing easy and interactive access to learning materials, as well as their impact on student motivation and learning outcomes.

The methodology used includes the development and implementation of a chatbot based on natural language processing (NLP) technology in an educational environment. The research stages include needs analysis, system design, chatbot development, and effectiveness evaluation. Data were collected through student surveys and analysis of chatbot performance in handling questions and providing responses that are in accordance with the subject matter.

The results of the study indicate that the use of chatbots increases student engagement with learning materials, accelerates access to information, and supports independent learning. In addition, chatbots have proven effective in providing instant feedback, which contributes to increased student motivation and understanding. This study also highlights the challenges in integrating chatbots into learning systems and provides recommendations for further optimization. Chatbots can serve as effective learning tools by increasing interactivity and flexibility in the educational process. The application of chatbots in education not only facilitates access to materials but also supports the development of student competencies more efficiently. This study recommends the adoption and further development of chatbot technology to improve the quality of education at various levels).

Keywords — Chatbot, Learning Experience, Information and Communication Technology

I. INTRODUCTION

Technological advancements in the field of education, particularly in artificial intelligence (AI), are increasingly driving improvements in the teaching and learning process. Traditional methods of teaching operating systems are often less engaging and interactive, which can ultimately reduce students' motivation and learning outcomes [1]. The integration of AI-based chatbots in education enables the delivery of materials tailored to individual students' needs while providing quick and accurate feedback. AI has become a key innovation with a significant impact on the world of education, particularly through chatbot applications that can interact with humans via text [2], [3].

A chatbot is a computer program designed to simulate human conversation using artificial intelligence (AI). One of the main components of AI is machine learning (ML), which allows chatbots to independently process and learn from data through a training process. Chatbots function by understanding the messages they receive from users, processing spoken words, determining and executing the requested commands, and delivering the results to the user. Additionally, chatbots have the potential to be developed as interactive learning tools that can assist students in learning independently [4], [5].

In the context of today's education, many schools still face challenges, especially in providing adequate learning services to meet students' needs. Factors such as limited human resources and inadequate infrastructure, particularly in remote areas, can be major causes. SMA Negeri 2 Binjai, as one of the educational institutions in Binjai City, faces challenges in meeting the increasingly diverse needs of its students. Therefore, the appropriate use of technology is expected to enhance the effectiveness of learning at the school.

This research aims to develop a chatbot as a learning medium with a focus on character education materials, which is expected to help students learn independently and interactively at SMA Negeri 2 Binjai. The development of the chatbot in this research uses a feed-forward neural network architecture, considering the neural network's ability to learn patterns from provided data and give accurate responses.

II. RESEARCH METHODS

The CRISP-DM (Cross Industry Standard Process for Data Mining) method is an approach used to help professionals develop data mining systems and models effectively and efficiently [7]. This method divides the system development process into six main stages, namely:

- 1) Business Understanding Stage: In this stage, data mining professionals must thoroughly understand the business problem at hand, as well as the goals and requirements of the system to be developed. This includes identifying the business problem, project objectives, and available resources.
- 2) Data Understanding Stage: This stage involves a deep understanding of the available data, including data collection, evaluation of data quality, and initial analysis to understand the structure and characteristics of the data to be used.



- 3) Data Preparation Stage: At this stage, data is prepared for further analysis. Activities include data cleaning, data balancing, changing data formats, and transforming data to ensure it is ready for use in the model.
- 4) Modeling Stage: In this stage, the data mining model is built based on the prepared data. Professionals use appropriate data analysis algorithms and techniques to develop a model that can provide insights and solutions to the identified problem.
- 5) Evaluation Stage: This stage involves evaluating the developed model. Data mining professionals test the model's reliability and accuracy, and identify any errors and improvements needed to ensure the model meets the set objectives.

CRISP-DM is a flexible system development method that can be applied to various types of data mining projects, whether academic, commercial, or non-profit. This method also allows for the adjustment and modification of stages according to the specific needs and goals of the project being undertaken.

III. RESULTS AND DISCUSSION

A. PIECES Analysis

The PIECES analysis is used to assess the feasibility of a new system by evaluating several key criteria, including Performance, Information, Economy, Control, Efficiency, and Services. The following table shows the results of the PIECES analysis for the developed system.

Factor	Old System	
Performance	Learning currently uses conventional methods with modules and books, which are less appealing to students.	The use of chatbots improves learning performance by providing instant and easy access to learning materials.
Information	Learning materials are limited to books and modules, making it difficult for students who do not have access to them.	With the new system, students can access learning materials anytime and anywhere without needing to carry books or modules.
Economy	Students often incur additional costs to purchase or photocopy learning books.	The use of chatbots reduces long-term costs by providing materials without the need for printing or other physical resources.
Control	Access to materials requires a visit to the library, and if the book is borrowed, students must wait for its return.	Chatbots give students greater control, allowing them to access and select materials as needed at any time.
Efficiency	The time students need to find answers is longer because they have to search through books.	With chatbots, students can get instant responses, reducing the time spent searching through books or waiting for answers from teachers.
Service	Service is inadequate because the number of books in the library is limited.	With chatbots, all students can access the desired materials without worrying about limited availability.

This table illustrates the comparison between the old system and the new system based on the PIECES analysis, showing how the new system can improve various aspects of learning

B. Model Design

a) Business Understanding

SMAN 2 Binjai is a high school committed to providing quality education for its students. Currently, the learning process at SMAN 2 Binjai still relies on books and modules as the primary media. The limitation of these learning media causes students to experience boredom and a decline in motivation to study. In the current digital era, technology has become an important aspect of education. Students now tend to search for study information online rather than reading books. Therefore, developing a chatbot as a learning medium can be an innovative solution to enhance students' learning experience and expand the accessibility of materials by providing an online learning platform.

b) Data Understanding.

In this study, the data used consists of text organized into three main parts: tags (labels or classes), patterns (question patterns within the tag), and responses (answers to the question patterns). The data is collected from the book "Pendidikan Karakter Peluang Dalam Membangun Karakter Bangsa" (Character Education: Opportunities in Building the Nation's Character). The dataset structure is as follows:

1. Intents: A set of question-and-answer data used to train the chatbot.
2. Tags: Grouping of question patterns with a specific type of answer.
3. Patterns: Contains various question patterns for training, the more patterns, the better the results.
4. Responses: Answers to the question patterns.

c) Data Preparation.

After collecting the data, it is converted into vectors using text processing methods and split into two parts: 85% for training data to train the model and 15% for validation data to evaluate the model's ability to generalize and predict on new data, as well as to prevent overfitting.

d) Data Preprocessing.

Before modeling, text data is converted into vectors. SMAN 2 Binjai's chatbot uses the Bag of Words (BoW) text processing method. This method learns the vocabulary from the entire text data (corpus) and counts the occurrence of each word. The preprocessing steps carried out are:

1. Case Folding: Converts all uppercase letters to lowercase.
2. Tokenization: Breaks down sentences into individual words.
3. Ignore Word: Ignores irrelevant words such as punctuation.

e) Modeling.

Data preprocessing is the data preparation stage before training. In this system, preprocessing is divided into several stages: tokenization, case folding, and ignore word. Afterward, the text data is converted into vectors using the Bag of Words method.

```

Model: "sequential"
Layer (type)                Output Shape              Param #
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dense (Dense)                (None, 512)              231424
dropout (Dropout)            (None, 512)              0
dense_1 (Dense)              (None, 128)              65664
dense_2 (Dense)              (None, 64)               8256
dropout_1 (Dropout)          (None, 64)               0
dense_3 (Dense)              (None, 58)               3770
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Total params: 309,114
Trainable params: 309,114
Non-trainable params: 0

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Figure 2. Arsitektur Feed forward neural network

Table 2. Text Processing Results into Vectors:

Word	Bag of Word Vector
apa	1 0 0 0
definisi	0 1 0 0
pendidikan	0 0 1 0
karakter	0 0 0 1

The architecture used is a feed forward neural network with four layers, each consisting of 512, 128, 64, and 58 units. A dropout rate of 0.5 is applied to the first and third layers to prevent overfitting. The activation function used is ReLU (Rectified Linear Unit) to convert negative values to zero, and Softmax is used to calculate multi-class classification probabilities. The model is trained with 100 epochs, a batch size of 7, and a learning rate of 0.001.

Figure 3: Accuracy and Loss Results

f) *Evaluation*

Figure 5 shows the accuracy and loss graphs using Tensorboard. The graph indicates that both training and validation values are approaching one, while the loss approaches zero. This demonstrates that the model is performing very well without experiencing overfitting or underfitting.

g) *Deployment*

Figure 6 shows the chatbot conversation room interface. On this page, students can submit questions by typing a message and pressing the send button. The chatbot will process the question through stages such as tokenization, case folding, ignoring irrelevant words, and converting the text into vectors using the Bag of Words method, then provide answers based on the trained model.

h) *Testing*

This is the model design tailored for SMAN 2 Binjai, covering business understanding, data collection and preparation, text processing, modeling, evaluation, and system deployment for chatbot-based learning.

The system testing was performed using the Black Box Testing method. The results of the system testing are displayed in the following table.

Table 3. Test Results

No	Case Tested	Scenario	Expected Result	Test Result
1	Accessing the conversation page	Press the "Start Conversation" button	Display the Conversation Room page	Success
2	User input to call response for the "greeting" tag	Enter the message "hello"	Provide response based on the "greeting" tag	Success
3	User input to call response for the "what" tag	Enter the message "what can you do?"	Provide response based on the "what" tag	Success
4	User input to call response for the "don't understand" tag	Enter the message "is this really asuwsdhua"	Provide response based on the "don't understand" tag	Success
5	User input to call response for the "main topics" tag	Enter the message "what does character education teach?"	Provide response based on the "main topics" tag	Success
...	...	...	...	...
48	User input to call response for the "education etymology" tag	Enter the message "what is education in terms of language?"	Provide response based on the "education etymology" tag	Success
49	User input to call response for the "education etymology" tag	Enter the message "what is meant by education?"	Provide response based on the "education etymology" tag	Failure
50	User input to call response for the "education etymology" tag	Enter the message "explain the etymology of education"	Provide response based on the "education etymology" tag	Success

C. *Testing Effectiveness*

Effectiveness = (Number of Successful Cases / Number of Cases Tested) × 100% = (45 / 50) × 100% = 90%

After conducting 50 tests, the chatbot system for character education learning achieved an effectiveness rate of 90%. This result indicates that the chatbot system is considered highly effective based on the Black Box Testing method.

This table presents the results of the testing, the testing scenario, the expected outcome, and the actual results from the chatbot system testing

IV. CONCLUSION

Based on the research and analysis of the implementation of a chatbot system as a character education learning tool at SMAN 2 Binjai, it can be concluded that this new system provides significant advantages compared to conventional methods. The use of chatbots has proven to enhance learning performance by providing instant and easy access to materials, making it more engaging and interactive for students.

Additionally, the system improves the accessibility of learning materials, allowing students to access information anytime and anywhere without relying on physical books. By reducing the need for printed materials and other physical resources, the chatbot also helps lower long-term costs associated with purchasing or photocopying books.

In terms of efficiency, the chatbot offers immediate answers to student questions, reducing the time needed to search for information in books or wait for a response from the teacher, creating a faster and more efficient learning process. System evaluation using the Black Box Testing method showed that the chatbot had an effectiveness rate of 90%, indicating highly effective performance across various testing scenarios. The Feed Forward Neural Network architecture and the Bag of Words (BoW) method used in modeling have proven effective in processing data and providing accurate responses. Overall, the chatbot system as a character education learning tool at SMAN 2 Binjai shows very positive results and can be an innovative solution to improve the quality of education in various institutions.

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