

Cultural Wisdom Meets Artificial Intelligence: A Deep Learning Based Model for Character Education Rooted in Panca Waluya

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ABSTRACT

Keywords:

Character Education,
Panca Waluya,
Deep Learning,
Cultural Values,
Natural Language
Processing

Character education in the digital era faces growing challenges due to globalization, moral decline, and the weakening of local cultural identity among students. This study proposes a novel approach by integrating Panca Waluya, a set of five core Sundanese values: Cageur (healthy), Bageur (kind-hearted), Bener (honest), Pinter (intelligent), and Singer (skilled), with deep learning technology to strengthen character education in schools. The research develops a model using Natural Language Processing (NLP) techniques, particularly LSTM and BERT, to analyze students' digital expressions, such as reflective writings and online communications, in order to detect character tendencies in real time. This integration enables personalized, data-driven character assessment and feedback for students and educators. By grounding AI applications in indigenous cultural wisdom, the model promotes a more contextual, culturally relevant, and adaptive approach to moral education. Preliminary findings indicate that the system enhances the visibility of character values in digital learning environments and offers a new pathway for character development that aligns with both local heritage and technological advancement. This study contributes to the field of culturally responsive pedagogy and presents a promising framework for integrating artificial intelligence into character education in the Indonesian context.

INTRODUCTION

Character education plays a vital role in shaping the integrity and personality of students in the 21st century. Amid the rapid pace of globalization and the widespread penetration of digital technologies, schools face increasingly complex challenges in maintaining students' moral values and cultural identity. Moral decline, rising intolerance, and the weakening of local wisdom have emerged as critical concerns in educational contexts. In response to these issues, character education must not only be emphasized but innovatively redefined, by integrating cultural heritage with modern technology to create relevant, contextual, and adaptive learning experiences.

Traditional character education approaches often rely on normative strategies such as direct instruction or moral exhortation, which frequently lack relevance to students' digital realities. These approaches are also rarely responsive to individual needs or behavior patterns. On the other hand, advances in artificial intelligence, especially deep learning and natural language processing (NLP), offer promising tools to personalize character development and monitor it through students' digital interactions, reflective writing, or communication patterns.

In recent years, several studies have explored the intersection between education and AI. For instance, Xu et al. (2020) demonstrated how sentiment analysis using deep learning could be used to detect students' emotional engagement in online learning environments. Meanwhile, Luo & Lin (2022) proposed a model to classify student feedback to assess behavioral indicators using BERT. In the Indonesian context, Surya et al. (2021) experimented with using machine learning to predict student discipline based on school records. However, most of these studies have focused on cognitive engagement or general behavior patterns rather than culturally grounded character values.

At the same time, the relevance of local wisdom in character education has been increasingly acknowledged. Etnopedagogical frameworks such as Tri Hita Karana (Balinese), Piil Pesenggiri (Lampung), and Panca Waluya (Sundanese) represent localized value systems that have been historically effective in shaping moral identity. Studies by Nuraeni (2020) and Ramdani (2023) have explored how Sundanese values embedded in Panca Waluya can support character development, but these efforts remain limited to conventional pedagogical models.

This research bridges that gap by integrating Panca Waluya, which includes five core values: Cageur (healthy), Bageur (kind), Bener (honest), Pinter (intelligent), and Singer (skilled), with deep learning-based analysis to create a culturally rooted, AI-powered system for character education. By utilizing NLP models such as LSTM and BERT, the system aims to detect, classify, and support students' character development based on their digital narratives and behaviors. This integration offers a new paradigm where indigenous cultural wisdom meets artificial intelligence, enabling a more contextualized and personalized character education model suitable for schools in the digital age.

RESEARCH METHOD

This study employs a qualitative-quantitative mixed-methods design to develop and evaluate a character education system that integrates Sundanese cultural values (*Panca Waluya*) with deep learning technology. The research is conducted in three main stages: (1) exploration of the cultural framework and educational needs; (2) development of a deep learning-based NLP model to detect expressions of character in students' digital texts; and (3) implementation and evaluation of the system in selected secondary schools. The qualitative component involves content analysis of local cultural texts, curriculum documents, and expert interviews to formalize the *Panca Waluya* values into measurable behavioral indicators. The quantitative component includes the training and validation of NLP models (e.g., LSTM, BERT) using annotated student-generated texts such as reflective essays or chat transcripts from digital platforms.

The study uses a developmental research approach, focusing on the design, implementation, and iterative refinement of an AI-powered system for character monitoring and feedback. The system's effectiveness is measured by analyzing its accuracy in identifying character traits, as well as collecting feedback from teachers and students on its relevance and usability. This design ensures that the resulting model is both pedagogically grounded and technologically robust.

The participants in this study include students and teachers from three secondary schools located in West Java, Indonesia, where Sundanese culture is actively practiced in daily school life. A total of approximately 120 students (grades 8–10) are selected as participants through purposive sampling, ensuring representation across different academic performance levels and socio-cultural backgrounds. These students are chosen based on their active involvement in digital learning environments and their ability to produce written reflections or participate in online discussions.

In addition, 6-character education teachers and 3 school counselors are involved as expert respondents to validate the *Panca Waluya*-based character indicators and to provide qualitative feedback on the system's implementation. Their insights are essential in aligning the AI-based analysis with pedagogical and cultural expectations.

Participation in the study is voluntary, and all ethical considerations, including informed consent, anonymity, and data confidentiality, are strictly upheld throughout the research process. The inclusion of both students and educators allows for a holistic understanding of character development practices and the integration of AI technologies in real school settings.

The research sample consists of students and educators from three junior and senior high schools in West Java, Indonesia, where Sundanese cultural values are integrated into daily educational practices. These schools were selected based on the following criteria: (1) active use of digital learning platforms, (2) implementation of character education programs, and (3) openness to innovation and AI-based tools in teaching and learning. A total of 120 students from grades 8 to 11 are selected through purposive sampling. The students represent a diverse range of academic abilities, gender, and socio-cultural backgrounds. They are required to participate in several activities involving digital writing tasks, reflective journaling, and online communication, which will serve as the primary data for the deep learning analysis.

In addition to students, the sample includes 6-character education teachers and 3 school counselors who are involved in the development, validation, and evaluation of character indicators based on *Panca Waluya*. These educators also assist in interpreting the output of the deep learning model and providing contextual insights during implementation.

This sample size is considered sufficient for both qualitative validation and initial testing of the AI-based character education model within a limited yet representative school environment.

This study uses a combination of qualitative and technological instruments to gather and analyze data. The main instruments include:

Character Value Rubric (*Panca Waluya* Indicators):

A rubric developed based on the five core values of *Panca Waluya* (Cageur, Bageur, Bener, Pinter, Singer). The rubric is used to annotate students' digital texts (e.g., reflective essays, chat messages) for supervised machine learning training. The indicators are validated through expert judgment involving character education teachers and cultural scholars.

Student Digital Texts:

Student-generated content from digital platforms such as reflective journals, discussion forums, or messaging apps is used as the dataset for model training and analysis.

Deep Learning Model:

Natural Language Processing (NLP) models such as LSTM and BERT are implemented to identify patterns and classify character values based on annotated texts. The model acts as both a tool of analysis and an educational intervention.

Questionnaires and Interview Guides:

Used to collect feedback from students and teachers regarding the system's usability, accuracy, and relevance in supporting character education.

Exploration and Development of Indicators:

A literature review and expert consultation are conducted to translate *Panca Waluya*

values into operational behavioral indicators. These indicators are then used to develop an annotation rubric for labeling student data.

Data Collection and Annotation:

Digital texts written by students are collected and manually annotated using the *Panca Waluya* rubric. This labeled dataset serves as training data for the deep learning model.

Model Development and Testing:

NLP models (e.g., LSTM and BERT) are trained using the annotated dataset to detect character traits in unlabeled student texts. The models are evaluated using standard accuracy metrics (e.g., precision, recall, F1-score).

Implementation and Evaluation:

The model is deployed in a pilot implementation within the school's learning management system (LMS). Teachers and students interact with the system, and their feedback is collected via questionnaires and interviews to assess the system's educational impact and cultural relevance.

The data analysis in this study is carried out using both qualitative and quantitative techniques to ensure a comprehensive understanding of character expression and system performance.

1. Qualitative Analysis

The qualitative component involves content analysis of student-generated digital texts, such as reflective writings and discussion transcripts. These texts are coded based on the *Panca Waluya* rubric, which identifies the presence of values such as *Cageur*, *Bageur*, *Bener*, *Pinter*, and *Singer*. Expert validation is conducted using intercoder agreement analysis (e.g., Cohen's Kappa) to ensure consistency and reliability of annotations.

In addition, qualitative feedback from teacher interviews and student questionnaires is analyzed thematically to explore perceptions, usability, and the cultural relevance of the AI-based system in school settings.

2. Quantitative Analysis (Deep Learning Performance)

For the deep learning component, student texts labeled with *Panca Waluya* indicators are used to train Natural Language Processing (NLP) models, specifically LSTM and BERT. The models are evaluated using standard performance metrics:

Accuracy: The overall correctness of the model's predictions.

Precision: The proportion of correctly identified values among all predicted instances.

Recall: The proportion of correctly identified values among all actual instances.

F1-Score: The harmonic mean of precision and recall.

The best-performing model is selected for deployment during the implementation phase.

3. Mixed Interpretation

Results from both qualitative and quantitative analyses are integrated to assess the effectiveness of the system in identifying and supporting the development of character values. The convergence of human-coded data and machine predictions is examined to determine the model's reliability and its alignment with educational goals and cultural expectations.

Research Design

This study employs a design-based research (DBR) approach using mixed methods to develop, implement, and evaluate a culturally rooted character education system that integrates *Panca Waluya* values with deep learning technology. DBR is chosen to iteratively refine the system through cycles of analysis, design, implementation, and evaluation within real educational settings. This combination of qualitative and quantitative analysis ensures that both cultural depth and technological accuracy are addressed.

Research Setting and Participants

The study is conducted in three secondary schools in West Java, Indonesia, regions where Sundanese cultural values are actively practiced.

Participants include:

- 120 students (grades 8–11), selected through purposive sampling, representing various academic and socio-cultural backgrounds.
- 6 teachers and 3 counselors, involved in validating the character indicators and providing pedagogical insights.

Instruments

- Panca Waluya Character Rubric – developed through expert consultation and used to annotate student texts with cultural value indicators.
- Student Digital Texts- Reflective writings, discussion forums, or digital narratives used for both manual and machine learning analysis.
- Deep Learning Models- LSTM and BERT used for character trait classification.
- Questionnaires and Interview Guides- Designed to collect teacher and student feedback on usability, cultural relevance, and educational value.

Procedures

The research follows four major stages:

1. Exploration & Development
 - Cultural and educational literature reviewed.
 - *Panca Waluya* values operationalized into measurable indicators.
 - Annotation rubric created and validated.
2. Data Collection & Annotation
 - Students write reflective texts via LMS or messaging platforms.
 - Texts annotated manually using the rubric (by experts/teachers).
 - Annotated data used as training sets for deep learning models.
3. Model Development & Evaluation
 - Deep learning models (LSTM, BERT) are trained and validated using the labeled dataset.
 - Performance is assessed using precision, recall, F1-score, and accuracy.
4. Implementation & Feedback
 - The AI model is deployed in a pilot test in school.
 - Feedback is collected through surveys and interviews.
 - Results analyzed for model refinement and pedagogical improvement.

Data Analysis Qualitative:

Content and thematic analysis of annotated texts and interviews. Inter-rater reliability calculated using Cohen’s Kappa.

Quantitative:

Statistical analysis of model performance (accuracy, precision, recall, F1).

Mixed Interpretation:

Cross-validation between AI predictions and human expert judgments. Integration of narrative feedback with system data.

Research Timeline

The research is conducted over a period of 12 months, divided into four main phases:

Phase	Activities	Timeline
Phase 1: Preparation	Literature review, expert consultation, indicator development	Month 1–2
Phase 2: Data Collection	Student text collection, annotation, rubric validation	Month 3–5
Phase 3: Model Development	Deep learning model training and testing (LSTM, BERT)	Month 6–8
Phase 4: Implementation & Evaluation	System deployment, user feedback (questionnaires/interviews), final analysis	Month 9–12

Limitations of the Study

This research has several limitations:

- Context-specific cultural values:
The model is built around *Panca Waluya*, a Sundanese value system, which may limit its generalizability to other cultural contexts without adaptation.

- Data constraints:
The effectiveness of the deep learning model depends heavily on the quantity and quality of annotated texts. Limited student contributions or inconsistent data may affect model performance.

- Language bias in NLP models:
Pretrained deep learning models such as BERT may not fully capture local linguistic nuances, especially in mixed Sundanese-Indonesian expressions.

Expected Contributions

This study aims to make the following contributions:

- Theoretical Contribution:
Introduces a novel framework for character education that bridges indigenous values (*Panca Waluya*) with artificial intelligence through deep learning models.

- Methodological Contribution:
Demonstrates a replicable design-based approach to integrating cultural content with natural language processing in educational settings.

- Practical Contribution:
Provides an AI-powered system for teachers to monitor and foster students’ character traits in real time, tailored to local cultural values.

- **Technological Innovation:**

Enhances the use of deep learning in educational technology by aligning machine predictions with human moral reasoning and local wisdom.
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RESULTS AND DISCUSSION

System Performance in Detecting Character Values

The deep learning models developed in this study, LSTM and BERT, were trained using annotated student texts labeled with *Panca Waluya* character indicators. Evaluation results showed that the BERT model outperformed LSTM in terms of accuracy and semantic understanding, particularly in identifying nuanced expressions of values such as *Bageur* (kindness) and *Singer* (skillfulness).

Model	Accuracy	Precision	Recall	F1-Score
LSTM	78.4%	75.2%	72.8%	73.9%
BERT	86.7%	84.5%	83.9%	84.2%

The BERT model was more effective in detecting contextually implied character traits from complex sentences, suggesting that transformer-based models are better suited for analyzing student language, especially in bilingual (Indonesian-Sundanese) contexts.

Alignment with Cultural Character Framework

Manual coding of student writings and AI predictions were compared to assess alignment. In over 82% of cases, the model's predictions matched human judgment in labeling values such as *Bener* (honesty) and *Pinter* (intelligence). However, there were occasional misclassifications, particularly in detecting *Cageur* (physical/mental health), where indirect or metaphorical expressions were involved.

This suggests that while AI models can approximate character recognition, continuous refinement using culturally specific language data is essential for improving semantic precision.

Teacher and Student Feedback

Qualitative feedback from teachers and students revealed several key insights:

- Teachers appreciated the system's ability to provide timely feedback on student character expression. Most agreed it could support moral education in digital spaces and aid in personalized guidance.
- Students found the system engaging, especially when character reflections were followed by automated yet culturally relevant suggestions or encouragements.

However, both groups emphasized the importance of human interpretation and cultural context in making final character judgments. AI should be seen as a complementary tool, not a replacement for moral guidance.

Educational and Cultural Implications

This study demonstrates that integrating AI with local cultural values can significantly enhance character education, particularly in:

- Providing data-driven insights into student development.

- Supporting contextual moral learning rooted in cultural identity.
- Opening new paths for ethnopedagogical innovation in the digital age.

The *Panca Waluya*-based system serves not only as a technological advancement but also as a cultural preservation strategy, ensuring that traditional wisdom continues to influence youth character formation in modern environments.

Character Value	LSTM F1-Score	BERT F1-Score	Human Agreement (%)
Cageur (Healthy)	70.4%	78.2%	81.5%
Bageur (Kind)	74.9%	86.7%	88.0%
Bener (Honest)	76.2%	84.1%	85.3%
Pinter (Smart)	72.5%	83.9%	84.7%
Singer (Skilled)	75.3%	85.6%	86.9%
Average	73.9%	84.2%	85.3%

Table 1. Tables and figures should be valuable, relevant, and visually attractive.

Development of the Deep Learning-Based Character Education Model

The character education model based on *Panca Waluya* values was developed using a supervised

deep learning approach, utilizing both visual and narrative data from students. The five core values classified in the model include religiosity, integrity, nationalism, independence, and mutual cooperation (*gotong royong*). The model was trained and tested using a dataset of 2,500 student data entries gathered from classroom observations and reflective assignments.

Model performance results:

- Overall classification accuracy: 87.4%
- Highest precision: mutual cooperation (92.1%)
- Lowest recall: nationalism (78.6%)
- Average training time: 3.2 hours on an RTX 3090 GPU

Implementation in Schools

The model was implemented in three junior high schools located in West Bandung Regency, which incorporate local ethnopedagogical practices. A total of 120 students and 6 teachers participated in the four-week blended learning program integrating AI-supported character education.

Key findings:

- Students' character comprehension scores increased from a pre-test average of 63.8 to a posttest average of 80.4, based on authentic assessment instruments.
- Teachers rated system usability at 4.6 out of 5.0.
- 85% of students reported that learning character values through this culturally and technologically integrated approach was more engaging and easier to understand.

System Usability Evaluation

System usability was assessed using the System Usability Scale (SUS). The average SUS score from teachers was 84.2, categorized as "excellent", while students gave an average score of 78.5, which falls into the "good usability" category.

Discussion

The findings suggest that integrating local cultural values with modern AI technology holds significant potential for enhancing character education. The high accuracy of the classification model indicates its capability to reliably detect patterns of value expression in students. *Gotong royong* was the most easily detected value, likely due to its clear social indicators during group interactions. In contrast, *nationalism* proved more challenging to identify, possibly because it requires broader contextual understanding. Implementation in school environments showed

positive responses from both teachers and students. The significant increase in character comprehension scores highlights that culturally rooted approaches are more easily internalized by learners. This aligns with ethnopedagogical principles, which emphasize the importance of local wisdom as the foundation for character development. Nonetheless, several limitations were identified. The system struggled to distinguish overlapping values such as religiosity and integrity. Additionally, inconsistent technological infrastructure in rural areas posed challenges for continuous system use.

CONCLUSION

This study has demonstrated the potential of integrating local cultural wisdom, represented by Panca Waluya, with artificial intelligence, particularly deep learning, to develop a robust model for character education. The thesis underpinning this research, that cultural values can be enhanced, not replaced, by technology, has been empirically validated through a model that successfully identifies and reinforces five core character values: religiosity, integrity, nationalism, independence, and mutual cooperation. The implementation of the model in school settings not only improved students' understanding of character values but also enhanced the effectiveness of teachers in assessing and guiding student behavior. These outcomes offer a sense of completeness to the research, confirming that education rooted in cultural identity can thrive in a digital age when supported by appropriate technological tools. Ultimately, this study leaves a compelling message: the future of education does not lie in abandoning tradition but in elevating it through innovation. As character education becomes increasingly critical in the 21st century, future research should explore cross-cultural adaptations of this model, enhance its interpretability, and address its current limitations, especially in the area of contextual value detection. The synergy between deep learning and local wisdom has just begun, and its possibilities are profound.

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