



INTEGRATION OF MACHINE LEARNING TECHNOLOGY IN DIGITAL LEARNING MEDIA TO IMPROVE ELEMENTARY SCHOOL STUDENTS' READING LITERACY

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Abstract

The development of information technology in the Industrial Revolution 4.0 era has driven innovation in education, including the integration of Machine Learning (ML) into digital learning media. Elementary school students' low reading literacy is a major challenge, considering that this ability is the foundation for cognitive development and academic success. This study aims to analyze the effectiveness of ML-based digital learning media in improving elementary school students' reading literacy. The research used a pretest-posttest control-group design, with 15 students in the experimental class and 15 in the control class. The Decision Tree algorithm was used to analyze initial scores, classify literacy levels, and recommend reading materials based on students' abilities. The results showed a significant increase in the experimental class, with an average literacy score rising from 62.0 to 86.7 (+24.7 points), while the control class increased only from 59.2 to 64.5 (+5.3 points). The results of the paired sample t-test showed significant improvement in both classes ($p < 0.05$), with greater improvement in the experimental class. The independent sample t-test also showed a significant difference between the two groups ($p < 0.05$). These findings confirm that integrating ML and digital learning media can enable adaptive, personalized learning and real-time feedback. ML-based digital learning media has proven effective in significantly improving elementary school students' reading literacy.

Keywords: Literacy, Machine Learning, Digital Learning Media, Decision Tree, Elementary School.

A. INTRODUCTION

The development of information and communication technology (ICT) in the Industrial Revolution 4.0 era has had a significant impact on various aspects of life, including education. One major breakthrough in the use of educational technology is the adoption of digital learning media that provide a more interactive, personalized, and adaptive learning experience for students. Amidst this development, Machine Learning (ML) technology, as part of Artificial Intelligence (AI), is starting to attract attention for integration into the education sector, such as assessing the soft skills of university students¹, prediction of student retention and

¹ Agostino Marengo, Alessandro Pagano, and Vito Santamato, "A Machine Learning Framework for Soft Skills Assessment: Leveraging Serious Games in Higher Education," *Computers and Education: Artificial Intelligence* 9, no. October 2024 (2025): 100469, <https://doi.org/10.1016/j.caeai.2025.100469>.

graduation in education², as well as digital learning systems³, especially in efforts to improve the reading literacy skills of elementary school students.

Reading literacy skills at the elementary school level are an important foundation for students' cognitive development.⁴ Reading literacy is not limited to the ability to recognize letters and words, but also includes understanding meaning, interpreting texts, and connecting reading to the context of everyday life.⁵ On the other hand, the use of conventional learning media, which is still dominant in elementary schools, often faces limitations.⁶ Lectures or textbooks can sometimes be less appealing to digital generation students, who have been familiar with gadgets, apps, and various digital platforms since childhood. This is where the integration of machine learning technology into digital learning media holds great potential.⁷⁸ Machine learning can make predictions⁹, analyze student learning patterns, automatically adjust the difficulty level of the material, and provide personalized feedback. For example, an ML-based learning system can detect pronunciation errors while reading, measure reading speed, and recommend materials tailored to each student's ability.

Several previous studies have shown that the application of digital technology can increase students' motivation to learn. However, there is little research specifically examining how the integration of machine learning into digital learning media can significantly impact elementary school students' reading literacy. However, machine learning can provide a personalized learning experience, allowing each student to learn at their own pace and style.

In addition, the COVID-19 pandemic, which hit the world, also accelerated the adoption of digital learning media.¹⁰¹¹¹² Although in-person learning has now returned to normal, this experience has opened many eyes to the crucial role technology plays in maintaining

² Kingsley Okoye et al., "Machine Learning Model (RG-DMML) and Ensemble Algorithm for Prediction of Students' Retention and Graduation in Education," *Computers and Education: Artificial Intelligence* 6, no. January (2024): 100205, <https://doi.org/10.1016/j.caeai.2024.100205>.

³ J. Mercader, C., & Gairín, "University Teachers' Perception of Barriers to the Use of Digital Technologies: The Importance of the Academic Discipline," *International Journal of Educational Technology in Higher Education* 17, no. 1 (2020): 4.

⁴ Nabil Adel, "The Impact of Digital Literacy and Technology Adoption on Financial Inclusion in Africa, Asia, and Latin America," *Heliyon* 10, no. 24 (2024): e40951, <https://doi.org/10.1016/j.heliyon.2024.e40951>.

⁵ Lars Bo Andersen et al., "Infrastructuring Digital Literacy in K-12 Education: A National Case Study," *International Journal of Child-Computer Interaction* 42, no. March (2024), <https://doi.org/10.1016/j.ijcci.2024.100697>.

⁶ Maedche, "How Games Induce Co- Operation? A Study on the Relationship between Game Features and We- Intentions in an Augmented Reality Game," *Computers in Human* 77, no. 1 (2017): 169-83.

⁷ A Checa, D., & Bustillo, "A Review of Immersive Virtual Reality Serious Games to Enhance Learning and Training," *Multimedia Tools and Applications* 79 (2020): 5501-5527.

⁸ A. M. Gomez, R. L., & Suarez, "Gaming to Succeed in College: Protocol for a Scoping Review of Quantitative Studies on the Design and Use of Serious Games for Enhancing Teaching and Learning in Higher Education," *International Journal of Educational Research Open* 2, no. 1-7 (2021).

⁹ Dovel Pirmanto, "Double Exponential Smoothing Forecasting Food Crop Yields Using Geographic Information Systems," *Jurnal Sisfokom (Sistem Informasi Dan Komputer)* 13, no. 2 (2024): 179-85, <https://doi.org/10.32736/sisfokom.v13i2.2069>.

¹⁰ L. M. Resende, M. A. A., Fonseca, M. C., Freitas, J., Gesteira, E. C. R., & Rossato, "Impacts Caused by the Use of Screens during the COVID-19 Pandemic in Children and Adolescents: An Integrative Review," *Revista Paulista de Pediatria*, 2024, <https://doi.org/https://doi.org/10.1590/1984-0462/2024/42/2022181>.

¹¹ Dovel Pirmanto et al., "Educational Transformation during the Pandemic in the Learning Process," *Cendekiawan: Jurnal Pendidikan Dan Studi Keislaman* 4, no. 1 (2025): 585-93, <https://doi.org/10.61253/cendekiawan.v4i1.273>.

¹² S. Bano J. Aman, M. Nurunnabi, "The Impact of Social Media on Learning Behavior for Sustainable Education: Evidence of Students from Selected Universities in Pakistan," *Sustainability* 11, no. 6 (2019): 1683.

educational continuity. The challenge now is how technology, particularly machine learning, can be integrated sustainably to improve the quality of learning.¹³ Especially in the area of reading literacy, which is the key to students' academic success at the next level of education.

Within the existing research landscape, it is important to emphasize that this study does not simply adopt the general concept of technology use in education, but specifically focuses on the integration of machine learning as an adaptive approach to improving reading literacy. Unlike previous research, which tends to assess the effectiveness of digital media in general, this study emphasizes the data-driven personalization mechanisms generated by students' interactions with the learning system. Thus, this study seeks to fill an empirical gap by examining how ML technology can directly influence students' cognitive processes in understanding texts, rather than simply increasing motivation or learning engagement. Thus, this research is crucial to address the need for technology-based educational innovation. The integration of machine learning into digital learning media is expected not only to improve 'students' technical reading skills but also to expand their understanding and critical thinking skills.

B. RESEARCH METHODS

This research was conducted at 45 Kerinci public elementary school, involving students in grades IVA and IVB. This research began with a Needs Analysis and ML Media Design to identify problems and design appropriate learning media solutions. Next, a Reading Literacy Pretest was conducted for both groups: the Experimental Class (grade IVB), which would use ML media, and the Control Class (grade IVA), which would not use it, to measure students' initial abilities. The next stage was the Implementation of ML Digital Learning Media in the experimental class, according to the design. After the implementation period, a Student Reading Literacy Posttest was administered to both groups to assess the development of their literacy skills. The collected data were then analyzed through the Data Analysis and Results Evaluation stages to determine the effectiveness of the media used. Finally, the research concluded with Conclusions and Recommendations that summarized the research results and offered suggestions for further development.

¹³ Abderahman Rejeb et al., "Exploring the Impact of ChatGPT on Education: A Web Mining and Machine Learning Approach," *International Journal of Management Education* 22, no. 1 (2024): 100932, <https://doi.org/10.1016/j.ijme.2024.100932>.

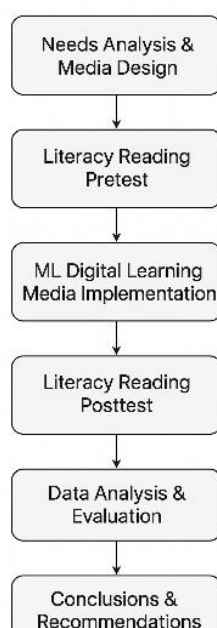


Figure 1. Research Stages

This research begins with the identification of a problem, namely, the low reading literacy of elementary school students. To address this, this study aims to improve reading literacy by leveraging digital media powered by Machine Learning (ML). Data collected from students includes various parameters such as Number of Readings, Scores, Errors, and Reading Time. This data is then processed using a machine learning algorithm, specifically a decision tree, to analyze and classify each student's literacy level. The Decision Tree algorithm is widely used in several cases for classification and prediction, including in the health sector¹⁴, education¹⁵, and manufacturing¹⁶ which shows good results.

The expected impact of implementing this system is two-way. For teachers, it provides in-depth insight into each student's abilities. Students will receive adaptive reading recommendations tailored to their ability level, which are expected to ultimately improve their literacy. The final output of this system is the categorization of each student's literacy level into three levels: Beginner, Intermediate, and Advanced, allowing for more personalized and effective learning interventions.

This research will be strengthened by adding a justification for the sample size (n=30) based on the limited population available at the research site and referring to relevant small-scale experimental studies. Furthermore, the experimental procedure will be explained in more detail, including the treatment stages in the experimental and control classes, the duration of the intervention, and the control of external variables. The validity and reliability of the instrument will also be strengthened through content validity testing by experts and reliability testing using the Cronbach's Alpha coefficient. In data analysis, this study will be supplemented with inferential statistical tests, such as the t-test (independent sample t-test), to compare the pretest and posttest results between the two groups, thus providing a stronger basis for

¹⁴ Pu Song et al., "Analyzing Psychological Resilience in College Students: A Decision Tree Model," *Heliyon* 10, no. 11 (2024): e32583, <https://doi.org/10.1016/j.heliyon.2024.e32583>.

¹⁵ Vesna Skrbinjek and Valerij Dermol, "Predicting Students' Satisfaction Using a Decision Tree," *Tertiary Education and Management* 25, no. 2 (2019): 101–13, <https://doi.org/10.1007/s11233-018-09018-5>.

¹⁶ S. Park, "Identification of Overall Innovation Behavior by Using a Decision Tree: The Case of a Korean Manufacturer," *Sustainability* 11, no. 22 (2019).

drawing causal conclusions. Furthermore, the use of data analysis software, such as SPSS or Python, will be explained along with the analysis techniques used in detail to ensure transparency and replication of the research.

C. RESULTS AND DISCUSSION

Machine Learning Integration

The process of integrating ML and digital learning media, analyzing and classifying students' literacy levels, is carried out through several systematic stages using a decision tree algorithm. The first stage begins with collecting student data, including reading volume, comprehension scores, error counts, and reading time. This data serves as the primary input variable in the machine learning process. Next, the data is processed through a decision tree algorithm to conduct initial analysis. At this stage, attribute selection is performed to identify the most relevant and influential attributes for determining literacy levels. The selected attributes are then used to construct a decision tree by forming nodes and branches. This process breaks the data into branches based on specific attribute values.

Concurrently, tree growing is performed to ensure that all patterns and relationships in the data are optimally accommodated. Once the tree is formed, pruning is performed to reduce model complexity and avoid overfitting. Pruning removes branches or nodes that do not significantly contribute to classification accuracy. The final stage of this process produces an output classification of students' literacy levels into three categories: low, medium, and high. This output can be used as a basis for evaluating literacy skills and for decision-making regarding more appropriate learning interventions.

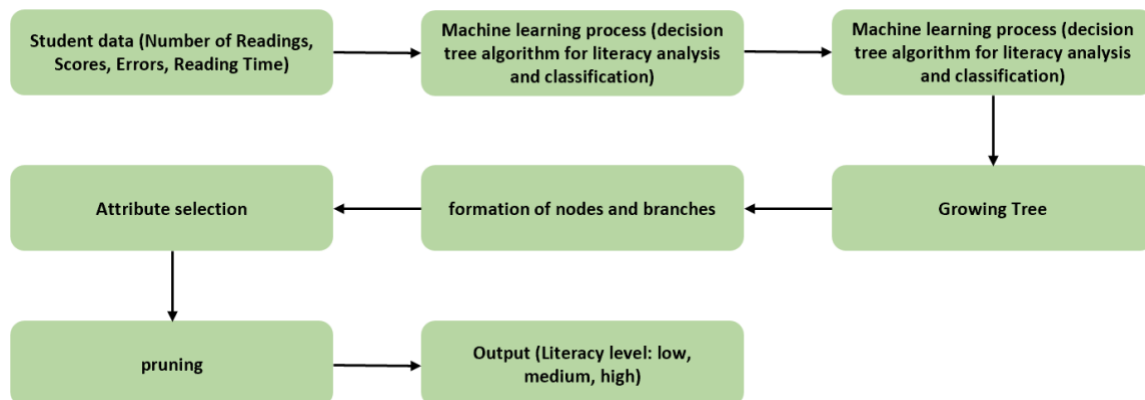


Figure 2. Machine Learning Integration

Initial data collection in this study involved predicting and classifying students' literacy skills using a decision tree machine learning algorithm. This classification was conducted on two classes: a control class and an experimental class. This data served as the baseline or pretest before implementing digital learning media in the experimental class. To predict students' abilities, a platform was created in Python using a decision tree algorithm to classify students' literacy skills.

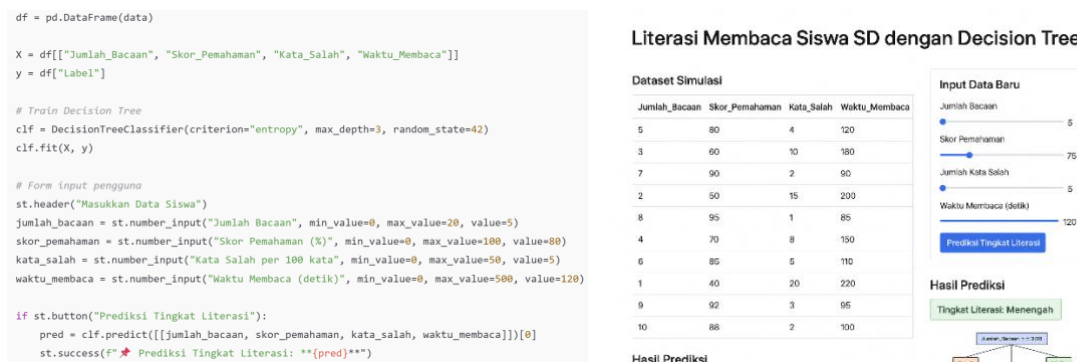


Figure 3. Python code with decision tree algorithm

Figure 3 above shows the implementation of a decision tree algorithm using Python to predict the reading literacy level of elementary school students. The input data includes the number of readings, comprehension scores, the number of misspelled words, and reading time. The prediction results are displayed in the interactive Streamlit application, organized into specific literacy categories.

Table 1. Student Literacy Skills (Pre-Test)

Students	Control Class	Experimental Class
S1	58 (Low)	60 (Low)
S2	60 (Low)	62 (Low)
S3	57 (Low)	55 (Low)
S4	65 (Low)	70 (Medium)
S5	62 (Low)	68 (Low)
S6	59 (Low)	64 (Low)
S7	55 (Low)	58 (Low)
S8	60 (Low)	61 (Low)
S9	63 (Low)	66 (Low)
S10	58 (Low)	59 (Low)
S11	61 (Low)	63 (Low)
S12	56 (Low)	57 (Low)
S13	60 (Low)	65 (Low)
S14	59 (Low)	62 (Low)
S15	57 (Low)	60 (Low)

The Decision Tree algorithm used in this system can analyze students' pretest scores, classify their literacy levels, and recommend reading materials tailored to each student's abilities and learning needs. For example, students with low pretest scores will receive simpler reading materials, while those with high pretest scores will receive more challenging materials. This personalized approach allows each student to learn at their own pace, thereby increasing motivation and minimizing difficulties in understanding texts.

The discussion of prediction results using the Decision Tree algorithm also demonstrates the algorithm's relevance in education. The Decision Tree maps the relationships among students' pretest scores, grades, and posttest reading literacy scores well. From the data simulation, students with low pretest scores in the experimental class are predicted to reach the medium or high literacy category, while students with high pretest scores are predicted to reach the high literacy category. This prediction proved consistent with the actual posttest results, indicating high accuracy in assessing students' potential literacy development. On the other hand, predictions for the control class showed that the majority of students remained in the low or medium category, reflecting the limitations of conventional learning methods in maximizing student learning potential.

Comparison of Students Reading Ability

One factor supporting the effectiveness of ML-based digital media is its ability to adapt learning materials to each student's ability level. The Decision Tree algorithm used in this system can analyze students' pretest scores, classify their literacy levels, and recommend reading materials appropriate to each student's abilities and learning needs. For example, students with low pretest scores will receive simpler reading materials, while those with high pretest scores will receive more challenging materials. This personalized approach allows each student to learn at their own pace, thereby increasing motivation to learn and minimizing difficulties in understanding texts.

Table 2. Comparison of Literacy Skills (Pre-Test and Post-Test)

Students	Control Class		Experimental Class	
	Pre Test	Post Test	Pre Test	Post Test
S1	58 (Low)	65 (Low)	60 (Low)	85 (High)
S2	60 (Low)	66 (Low)	62 (Low)	88 (High)
S3	57 (Low)	63 (Low)	55 (Low)	80 (Medium)
S4	65 (Low)	70 (Medium)	70 (Medium)	92 (High)
S5	62 (Low)	68 (Low)	68 (Low)	90 (High)
S6	59 (Low)	64 (Low)	64 (Low)	86 (High)
S7	55 (Low)	60 (Low)	58 (Low)	82 (Medium)
S8	60 (Low)	65 (Low)	61 (Low)	87 (High)
S9	63 (Low)	69 (Low)	66 (Low)	89 (High)
S10	58 (Low)	63 (Low)	59 (Low)	83 (Medium)
S11	61 (Low)	66 (Low)	63 (Low)	88 (High)
S12	56 (Low)	61 (Low)	57 (Low)	81 (Medium)
S13	60 (Low)	66 (Low)	65 (Low)	90 (High)
S14	59 (Low)	64 (Low)	62 (Low)	85 (High)
S15	57 (Low)	62 (Low)	60 (Low)	84 (Medium)

This study aims to analyze the effect of integrating Machine Learning (ML) technology into digital learning media on elementary school students' reading literacy. The results showed a significant increase in students' reading literacy skills when learning with ML-based digital media compared to conventional learning methods. Pretest and posttest data collected from 15 students in the experimental class and 15 students in the control class served as the basis for analyzing the research results. In the experimental class, the average pretest reading literacy score was 62.0, and the posttest showed an increase to 86.7, or approximately 24.7 points. In contrast, the control class only experienced an average increase of 5.3 points, from 59.2 to 64.5. These findings indicate that integrating ML into digital learning media can make a greater contribution to improving reading literacy than conventional methods.

Table 3. Average score

Class	Pretest	Posttest	Improvement
Experimental	62.0	86.7	+24.7
Control	59.2	64.5	+5.3

The experimental class using ML-based digital learning media showed an average increase in reading literacy of ± 24.7 points. The control class, using only conventional methods, improved by ± 5.3 points. This indicates that integrating machine learning into digital learning media has the potential to significantly improve elementary school students' reading literacy.

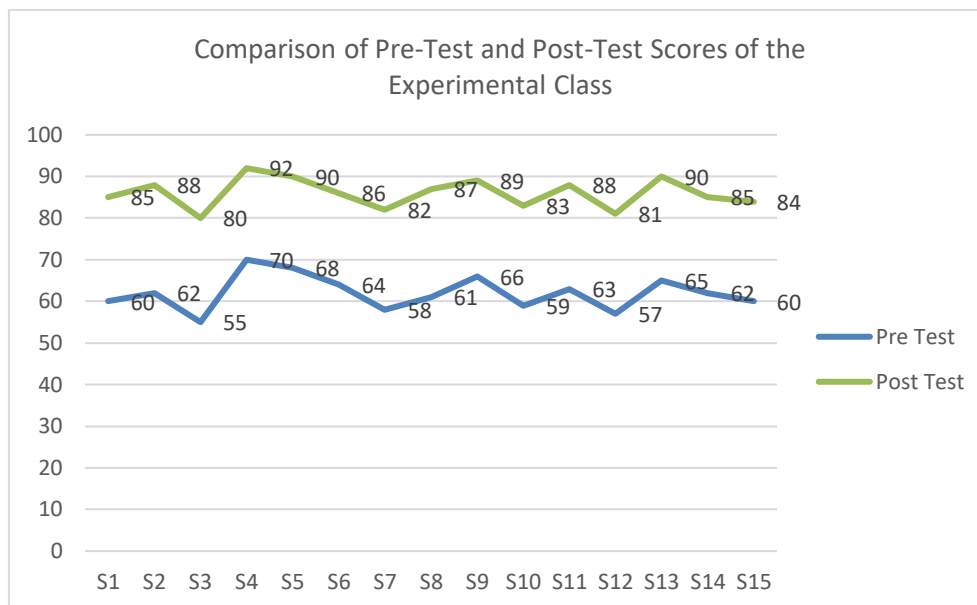


Figure 4. Comparison of Pre-Test and Post-Test Scores of the Experimental Class

The graph above shows a comparison of pretest and posttest reading literacy scores for 15 students in an experimental class who participated in learning with Machine Learning-based digital media. The green line represents the pretest score, while the blue line shows the posttest score after the learning intervention. In general, there was a significant improvement between the pretest and posttest results. In the pretest, students' scores ranged from 55 to 70, with an average of 62. This indicates that before the intervention, students' reading literacy skills were in the moderate to low category. However, after participating in ML-based learning, posttest scores increased sharply to 80–92, with an average of 87. This average increase of ± 25 points illustrates the effectiveness of using adaptive digital learning media.

Score improvements were also consistent across nearly all students. For example, a S3 student who initially had a low score (55) improved to 80, while a student with a relatively high pretest score, such as S4 (70), also improved to 92. This consistency demonstrates that ML-based media can adjust the reading difficulty level to suit students' initial abilities, so that every student, both low and high, receives optimal benefits. Thus, this graph reinforces the finding that integrating Machine Learning into learning can significantly improve reading literacy in the experimental class.

Paired Sample t-test

Control Class

t-count = 33.08

p-value = 1.08×10^{-14} ($\approx 0.0000000000000108$)

$p < 0.05 \rightarrow$ statistically significant

This means there is an increase, although it is small in practical terms.

Experimental Class

t-count = 68.21

p-value = 4.59×10^{-19} ($\approx 0.00000000000000000459$)

$p < 0.05 \rightarrow$ highly significant

This means the increase is very strong and convincing.

Independent Sample t-test

t-count = 18.03

$p\text{-value} = 1.88 \times 10^{-16}$ ($\approx 0.000000000000000188$)

$p < 0.05 \rightarrow$ there is a significant difference between the two classes

This means that the learning outcomes of the experimental class are much higher than those of the control class.

The results of this study also have important implications for teachers and learning media developers. Teachers can utilize ML-based digital media to support classroom learning, provide materials tailored to students' abilities, and monitor literacy development more effectively. Learning media developers can expand the use of ML algorithms, such as Decision Trees, to develop learning material recommendation systems across various subjects. The application of adaptive technology in learning not only improves academic outcomes but also supports more inclusive and personalized learning tailored to each student's characteristics.

Consistent with research by Ryan S. Baker and Kalina Yacef, a data-driven approach enables learning systems to tailor content to individual student needs, thereby improving engagement and learning outcomes. Another study by Xiaojun Chen demonstrated that adaptive learning systems based on classification algorithms, such as Decision Trees, can improve academic performance through personalized content. In the context of this research, the causal relationship can be formulated more structurally: Machine Learning integration $\rightarrow$ personalized learning $\rightarrow$ increased student engagement $\rightarrow$ improved reading literacy skills. Therefore, the findings of this study are not isolated but consistent with the literature, which shows that adaptive technology significantly contributes to learning effectiveness.¹⁷¹⁸

Furthermore, in terms of analysis, this study was complemented by statistical validation using paired and independent t-tests, which demonstrated significant improvements in learning outcomes in the experimental class. This reinforces claims of effectiveness that were previously considered too descriptive. However, to increase scientific rigor, Machine Learning model evaluations, such as accuracy, precision, recall, and confusion matrices, should also be considered, as recommended by Tom M. Mitchell in a classic Machine Learning review. A study by Zachary A. Pardos also emphasized the importance of evaluating model performance in an educational context to ensure that predictions truly reflect students' abilities. Thus, although the results of this study show a highly significant impact ($p < 0.05$), integrating statistical analysis with ML model evaluation will yield a more comprehensive interpretation, not only of learning outcomes but also of the reliability of the prediction system used.^{19 20}

D. CLOSING

Conclusion

This study demonstrates that the integration of Machine Learning (ML) technology into digital learning media significantly improves elementary school students' reading literacy. Pretest and posttest analysis revealed that students in the experimental class using ML-based media increased their average score by 24.7 points, from 62.0 to 86.7. In contrast, the control class using conventional methods only saw an average increase of 5.3 points. This difference indicates that the ML-based approach is significantly more effective than traditional learning.

¹⁷ K. Baker, R. S., & Yacef, "The State of Educational Data Mining in 2019: A Review and Future Visions," *Journal of Educational Data Mining* 29, no. 1 (2019): 61–75.

¹⁸ G. J. Chen, X., Xie, H., Zou, D., & Hwang, "Application and Theory Gaps during the Rise of Artificial Intelligence in Education," *Computers & Education* 65 (2020): 102–13.

¹⁹ M. O Pardos, Z. A., Baker, R. S., & San Pedro, "Modeling Student Engagement in Intelligent Tutoring Systems," *User Modeling and User-Adapted Interaction* 54, no. 3 (2017): 343–356.

²⁰ T. M. Mitchell, "Machine Learning," *McGraw-Hill Education*, 2017, 1–25.

The results of the paired sample t-test showed significant improvement in both classes ($p < 0.05$), with greater improvement in the experimental class. The independent sample t-test also showed a significant difference between the two groups ($p < 0.05$).

The use of the Decision Tree algorithm in learning systems enables the analysis of students' initial abilities, the classification of literacy levels, and the provision of reading materials tailored to their individual abilities. This personalized approach allows each student to learn at their own pace, receive rapid feedback, and be more motivated to improve their reading skills. Thus, ML-based digital learning media not only enhance the technical aspects of reading but also support the development of comprehension, critical thinking, and student motivation. The implications of this research are significant for teachers, schools, and learning media developers. Teachers can utilize adaptive digital media as an effective strategy, while developers can develop ML-based systems across various subjects. Future research is recommended to expand the sample size and duration of interventions to strengthen the generalizability of the results.

Recommendations

Teachers and schools are advised to utilize machine learning-based digital learning tools as an adaptive learning strategy to improve students' reading literacy; developers need to refine personalization and learning monitoring features; and future researchers can expand the sample size, study duration, and model performance evaluation to strengthen the development of technology-based adaptive learning theory and enhance the validity of their findings.

E. REFERENCES

- Adel, Nabil. "The Impact of Digital Literacy and Technology Adoption on Financial Inclusion in Africa, Asia, and Latin America." *Heliyon* 10, no. 24 (2024): e40951. <https://doi.org/10.1016/j.heliyon.2024.e40951>.
- Andersen, Lars Bo, Ditte Amund Basballe, Lillian Buus, Christian Dindler, Thomas Illum Hansen, Mikkel Hjorth, Ole Sejer Iversen, et al. "Infrastructuring Digital Literacy in K-12 Education: A National Case Study." *International Journal of Child-Computer Interaction* 42, no. March (2024). <https://doi.org/10.1016/j.ijcci.2024.100697>.
- Baker, R. S., & Yacef, K. "The State of Educational Data Mining in 2019: A Review and Future Visions." *Journal of Educational Data Mining* 29, no. 1 (2019): 61–75.
- Checa, D., & Bustillo, A. "A Review of Immersive Virtual Reality Serious Games to Enhance Learning and Training." *Multimedia Tools and Applications* 79 (2020): 5501–5527.
- Chen, X., Xie, H., Zou, D., & Hwang, G. J. "Application and Theory Gaps during the Rise of Artificial Intelligence in Education." *Computers & Education* 65 (2020): 102–13.
- Dovel Pirmanto, Yora Haliza, Fahrel Yatul Firmansyah, and Dedek Subhani. "Educational Transformation during the Pandemic in the Learning Process." *Cendekiawan: Jurnal Pendidikan Dan Studi Keislaman* 4, no. 1 (2025): 585–93. <https://doi.org/10.61253/cendekiawan.v4i1.273>.
- Gomez, R. L., & Suarez, A. M. "Gaming to Succeed in College: Protocol for a Scoping Review of Quantitative Studies on the Design and Use of Serious Games for Enhancing Teaching and Learning in Higher Education." *International Journal of Educational Research Open* 2, no. 1–7 (2021).
- J. Aman, M. Nurunnabi, S. Bano. "The Impact of Social Media on Learning Behavior for Sustainable Education: Evidence of Students from Selected Universities in Pakistan." *Sustainability* 11, no. 6 (2019): 1683.

- Maedche. "How Games Induce Co- Operation? A Study on the Relationship between Game Features and We-Intentions in an Augmented Reality Game." *Computers in Human* 77, no. 1 (2017): 169–83.
- Marengo, Agostino, Alessandro Pagano, and Vito Santamato. "A Machine Learning Framework for Soft Skills Assessment: Leveraging Serious Games in Higher Education." *Computers and Education: Artificial Intelligence* 9, no. October 2024 (2025): 100469. <https://doi.org/10.1016/j.caeai.2025.100469>.
- Mercader, C., & Gairín, J. "University Teachers' Perception of Barriers to the Use of Digital Technologies: The Importance of the Academic Discipline." *International Journal of Educational Technology in Higher Education* 17, no. 1 (2020): 4.
- Mitchell, T. M. "Machine Learning." *McGraw-Hill Education*, 2017, 1–25.
- Okoye, Kingsley, Julius T. Nganji, Jose Escamilla, and Samira Hosseini. "Machine Learning Model (RG-DMML) and Ensemble Algorithm for Prediction of Students' Retention and Graduation in Education." *Computers and Education: Artificial Intelligence* 6, no. January (2024): 100205. <https://doi.org/10.1016/j.caeai.2024.100205>.
- Pardos, Z. A., Baker, R. S., & San Pedro, M. O. "Modeling Student Engagement in Intelligent Tutoring Systems." *User Modeling and User-Adapted Interaction* 54, no. 3 (2017): 343–356.
- Pirmanto, Dovel. "Double Exponential Smoothing Forecasting Food Crop Yields Using Geographic Information Systems." *Jurnal Sisfokom (Sistem Informasi Dan Komputer)* 13, no. 2 (2024): 179–85. <https://doi.org/10.32736/sisfokom.v13i2.2069>.
- Rejeb, Abderahman, Karim Rejeb, Andrea Appolloni, Horst Treiblmaier, and Mohammad Iranmanesh. "Exploring the Impact of ChatGPT on Education: A Web Mining and Machine Learning Approach." *International Journal of Management Education* 22, no. 1 (2024): 100932. <https://doi.org/10.1016/j.ijme.2024.100932>.
- Resende, M. A. A., Fonseca, M. C., Freitas, J., Gesteira, E. C. R., & Rossato, L. M. "Impacts Caused by the Use of Screens during the COVID-19 Pandemic in Children and Adolescents: An Integrative Review." *Revista Paulista de Pediatria*, 2024. <https://doi.org/10.1590/1984-0462/2024/42/2022181>.
- S. Park. "Identification of Overall Innovation Behavior by Using a Decision Tree: The Case of a Korean Manufacturer." *Sustainability* 11, no. 22 (2019).
- Skrbinjek, Vesna, and Valerij Dermol. "Predicting Students' Satisfaction Using a Decision Tree." *Tertiary Education and Management* 25, no. 2 (2019): 101–13. <https://doi.org/10.1007/s11233-018-09018-5>.
- Song, Pu, Xuan Cai, Dan Qin, Qingqing Wang, Xiangwei Liu, Mengmeng Zhong, Linying Li, and Yan Yang. "Analyzing Psychological Resilience in College Students: A Decision Tree Model." *Heliyon* 10, no. 11 (2024): e32583. <https://doi.org/10.1016/j.heliyon.2024.e32583>.

