https://research.adra.ac.id/index.php/multidisciplinary
P - ISSN: 3048-2461
E - ISSN: 3048-1708

Analysis of the Effectiveness of AI-Based Chatbot as a Learning Assistant for Students with Visual Learning Style

Eni Rakhmawati[1], Al Malikul Ikhwanda Putra[2], Al Shakib Ahmed[3]
[1]Institut Agama Islam Bakti Negara Tegal, Indonesia
[2]Universitas Dumai, Indonesia
[3]University of Dhaka, Bangladesh

ABSTRACT

Background. The background of this research is based on the development of AI-based learning technology that opens up opportunities to create a more personalized and adaptive learning experience. Students with visual learning styles often do not get maximum support in conventional learning methods, so a technological approach that suits their characteristics is needed.

Purpose. The purpose of this study is to analyze the effectiveness of AI-based chatbots as learning assistants for students with visual learning styles, both in terms of improving learning outcomes and students' perception of the learning experience provided by chatbots.

Method. The method used was quasi-experimental with a pretest-posttest control group design. The study population consisted of junior high school students with a dominant visual learning style. The research instruments include learning outcome tests and perception questionnaires. Data analysis was carried out using statistical tests and case studies.

Results. The results of the study showed a significant improvement in the learning outcomes of students who used AI-based chatbots. Students also responded positively to the chatbot's visual features, especially in terms of information clarity, attractive appearance, and interface interactivity. Case studies reinforce quantitative data through more meaningful learning experience narratives.

Conclusion. The conclusion of this study is that AI-based chatbots are effective as learning assistants for students with visual learning styles and have great potential to be integrated into more inclusive and adaptive digital learning systems.

KEYWORDS

Adaptive Learning, Chatbot, Visual Learning Style

Citation: Rakhmawati, E., Putra, I, M, A., & Ahmed, S. (2025). Analysis of the Effectiveness of AI-Based Chatbot as a Learning Assistant for Students with Visual Learning Style. *Journal of Multidisciplinary Sustainability Asean*, *2*(2), 76-86. https://doi.org/10.70177/multidisciplinary.v2i2.2249

Correspondence:

Eni Rakhmawati,
enirakhmawati1@gmail.com

Received: October 7, 2024

Accepted: March 19, 2025

Published: April 17, 2025

INTRODUCTION

Learning style is one of the important aspects of the educational process that affects the way students receive, process, and remember information (Casheekar dkk., 2024). In the context of modern education, visual learning styles are one of the categories that are often found among students. Students with visual learning styles tend to absorb information better through graphic displays, colors, images, and other visual representations. Therefore, a learning approach that is in accordance with the visual learning style is needed so that the learning process becomes more effective and enjoyable (Luo dkk., 2022).

Advances in digital technology have brought various innovations in the world of education, including the use of artificial intelligence (AI) as a learning tool (Gm dkk., 2024). One of the fastest-growing AI implementations is the use of chatbots as learning assistants (Bhirud dkk., 2019). AI-based chatbots are able to provide interactive and personalized responses to students' learning needs. Its presence provides new opportunities to deliver learning materials flexibly and responsively, including for students with certain learning preferences (Schlimbach dkk., 2022).

The use of chatbots as learning assistants has been applied at various levels of education, from elementary school to higher education (Deng & Yu, 2023). Previous research has shown that chatbots can increase learning motivation, provide immediate feedback, and help manage learning time independently (Devi dkk., 2022). However, the effectiveness of chatbots as a learning aid has not been studied specifically based on students' learning styles, especially for those with visual learning styles (Eden dkk., 2024).

An effective learning experience depends not only on the content of the material, but also on the way in which information is delivered that suits the characteristics of the student (Zhang dkk., 2024). Chatbots designed to accommodate visual learning styles need to include visual elements that support student understanding, such as graphs, diagrams, or interactive visualizations (Ashfaque dkk., 2020). This adjustment aims to ensure that the interaction between students and chatbots can take place optimally and have a positive impact on learning outcomes (Kerimbayev dkk., 2023).

The main challenge in using chatbots for visual learning styles lies in the technology's ability to convey information visually and attractively (Rooein dkk., 2022). Not all chatbot platforms currently support the presentation of visual content to the maximum. Therefore, it is important to analyze the effectiveness of AI-based chatbots in supporting students with visual learning styles to find out the extent to which this technology can be optimized in the world of education (Janati dkk., 2020).

This research is based on the learning style theory developed by Fleming and Mills through the VARK (Visual, Auditory, Reading/Writing, Kinesthetic) model (González-Castro dkk., 2021). This model classifies students' learning styles based on sensory preferences in receiving information (Alshmrany, 2022). Students with visual learning styles are more responsive to the presentation of information in the form of images, graphs, colors, and other visual forms. In this context, chatbots as AI-based tools can be adapted to visually present learning materials, thus supporting the basic principles in VARK's learning style theory (Gligorea dkk., 2023).

Many studies have discussed the effectiveness of chatbots in supporting the learning process in general, but very few have specifically highlighted the suitability of chatbots for a particular learning style (Sandu & Gide, 2019). The dominant focus still revolves around the technical aspects of chatbots such as response accuracy, ability to answer questions, and user satisfaction levels without considering the diversity of students' learning styles (Davar dkk., 2025).

It is still unknown in depth to what extent AI-based chatbots are able to support students with visual learning styles. Information related to how chatbots effectively present visual content, as well as how visual learners respond to the format, is still very limited (Ayeni dkk., 2024). This lack of exploration raises questions about whether chatbots can really be maximized to meet the unique needs of visual-learning learners (Hwang dkk., 2022).

The existing literature rarely evaluates the visual features available in chatbots and their impact on students' understanding of visuals (Kaswan dkk., 2024). Most chatbots still focus on text-based interactions, without visual components such as infographics, concept maps, or animations

that can improve understanding. This gap indicates a mismatch between the available technology and the needs of visual learners (Aldoseri dkk., 2023).

The lack of an integrated approach between visual design and chatbot technology leads to a knowledge gap in the development of adaptive educational chatbots. The need for chatbots that are responsive to visual learning styles is becoming increasingly important amid the increasing use of technology in online and independent learning (Liu dkk., 2022).

Richard Mayer's Multimedia Learning Theory is one of the important references to understand this gap. According to Mayer, learning will be more effective when information is presented through visual and verbal channels simultaneously (Kamruzzaman dkk., 2023). This theory shows the importance of visual elements in the learning process, especially for students who have a visual learning style. The absence of visual components in chatbots can hinder the optimal integration of knowledge, so this research is important to fill the gap in the application of multimedia learning principles to chatbot technology (Vadisetty & Polamarasetti, 2024).

The importance of filling this gap lies in the fact that each learning style has unique characteristics that require a different approach. Students with visual learning styles need a form of information delivery that is based on images, colors, or diagrams to maximize comprehension (Vashishth dkk., 2024). The use of text-based chatbots has not necessarily been able to answer these needs optimally, so it is necessary to conduct an in-depth analysis of its design and effectiveness in the context of visual learning styles (Saaida, 2023).

This study aims to evaluate the extent to which AI-based chatbots can act as effective learning assistants for students with visual learning styles (Kabudi dkk., 2021). The focus of the research is directed at the visual design aspect in the chatbot, the students' response to the visual elements provided, and their impact on learning outcomes (Strielkowski dkk., 2024). The findings of this study are expected to contribute to the development of chatbots that are more inclusive and adaptive to different learning styles of students (Bhartiya dkk., 2019).

Sweller's Cognitive Load Theory supports the urgency of this research. This theory states that the presentation of information that is appropriate to the cognitive capacity of students will reduce mental workload and increase learning effectiveness (Gubareva & Lopes, 2020). In this context, the presentation of appropriate visual information through chatbots can reduce the cognitive load of visual learners and strengthen information processing. This research tries to prove that the integration of visual features in chatbots is not only relevant, but also crucial for visual learners (Nasir dkk., 2024).

RESEARCH METHODOLOGY

This study uses a quantitative approach with a quasi-experimental design of the pretest-posttest control group design (Suárez dkk., 2022). This design was chosen to measure the effectiveness of AI-based chatbots in improving students' understanding of visual learning styles. Two groups of students were used in this study, namely the experimental group that used chatbots as learning assistants, and the control group that used conventional learning methods without chatbots (Aldahwan & Alsaeed, 2020).

The population in this study is high school students in grade XI at one of the high schools in the city of Bandung who have been identified as having a visual learning style through the VARK instrument. The sample was taken purposively as many as 60 students, consisting of 30 students in the experimental group and 30 students in the control group. The selection of samples was based on the suitability of learning style characteristics and the availability of digital devices to access the chatbot (Hashim dkk., 2022).

The research instrument consists of two types, namely cognitive tests and perception questionnaires. Cognitive tests are used to measure students' understanding before and after the use of chatbots, compiled based on indicators of basic competencies in the subjects taught. Perception questionnaires are used to find out students' responses to visual features in chatbots as well as their effectiveness as learning assistants. The instrument has been tested for validity and reliability before being used in data collection (Limna dkk., 2023).

The research procedure began with the implementation of a pretest in both groups to determine the initial ability of students. The experimental group was then given access using an AI-based chatbot that had been adapted to visual elements, while the control group followed learning with conventional methods. After a two-week intervention, both groups were given a posttest to determine the improvement in learning outcomes. Data from the test and questionnaire were then analyzed using statistical tests to determine significant differences between the two groups and evaluate the effectiveness of chatbots for visual learning style students (Essel dkk., 2022).

RESULT AND DISCUSSION

Student learning outcome data was collected through pretest and posttest for both groups, namely an experimental group using an AI-based chatbot and a control group that learned by conventional methods.

Table. descriptive statistical table of the pretest and posttest scores of the two groups

Group	N	Rat-rata Pretest	SD Pretest	Rate-Rate Posttest	SD Posttest
Eksperimen	30	64,3	6,1	82,5	5,4
Control	30	63,7	6,4	74,2	6,8

The average posttest score of the experimental group showed a higher improvement than that of the control group. The difference in pre- and post-treatment scores was also more significant in the experimental group. This data is the basis for the analysis of the effectiveness of chatbots on visual student learning outcomes.

Data normality and homogeneity tests have been carried out and show that the data is distributed normally and homogeneously. Therefore, further tests using paired t-tests and independent t-tests are feasible to test the significance of differences between the two groups.

The results of the paired t-test showed that there was a significant difference between the pretest and posttest scores in the experimental group with a significance value of $0.000 < 0.05$. The increase in grades shows that the use of chatbots has a positive impact on students' understanding of visual learning styles.

The control group also showed a significant improvement, but the significance value was 0.045, which although significant, was not as large as the experimental group. This shows that conventional learning methods still contribute to improving learning outcomes, but to a lesser extent.

The results of the independent t-test between the posttest values of the two groups showed a significance value of 0.002, which means that there was a significant difference between the experimental and control groups. This reinforces the finding that AI-based chatbots are more effective in assisting visual learners in understanding material than conventional methods.

A perception questionnaire was given to 30 students in the experimental group to find out their views on the chatbot features used during learning. There are five main indicators in the questionnaire: ease of use, visual appeal, interactivity, clarity of visual information, and support for material comprehension.

Table 2. Questionnaire recapitulation results

Indicator	Average Score (Scale 1–5)
Ease of Use	4,3
Visual Appeal	4,5
Interactivity	4,1
Visual Information Clarity	4,4
Support for Understanding	4,6

Most students state that visual elements such as images, illustrations, and interactive diagrams in chatbots help them understand the material better. This reflects a high level of satisfaction with the visual features in the chatbot.

The highest score is seen in the "support for comprehension" indicator, which indicates that the visual features of chatbots directly impact the improvement of visual students' comprehension. Students find it helpful by the way information is presented in an attractive and easily digestible visual form.

Visual features such as light animations, contrasting colors, and clear information structures are also mentioned in the open comments as the main reasons for the increased focus and concentration of learning. This supports the theory that visual learners need visual stimulus in absorbing information.

This questionnaire shows a positive correlation between visual design in chatbots and learning effectiveness, especially in facilitating visual learning styles. Thus, chatbots not only serve as interactive tools, but also as visual media that can adapt to students' learning styles.

The correlation between the posttest results and the results of the perception questionnaire showed a positive relationship with a correlation coefficient of 0.69. This indicates that the higher the positive perception of students towards the visual features of the chatbot, the higher the value of their learning outcomes.

Students who scored high on the "support for comprehension" indicator were generally included in the group with significant posttest score improvements. These findings show a close relationship between the perception of comfort and ease of visualization and learning effectiveness.

This analysis reinforces the hypothesis that visual design in chatbots plays an important role in improving students' understanding of visual learning styles. The effectiveness of chatbots is not only seen in terms of interaction, but also from the suitability of the form of presentation of information to students' learning preferences.

One of the case studies was taken from a student named RZ, a grade XI student who belonged to the experimental group. Prior to the use of chatbots, RZ had difficulty in understanding visual materials such as text structures and abstract scientific concepts. The RZ pretest score was 60, below the group average.

After two weeks of using the chatbot, RZ showed a significant increase in the value to 85 on the posttest. In an interview, RZ revealed that the chatbot feature that features flowcharts, concept maps, and infographics really helps him understand concepts that were previously considered difficult.

RZ also stated that he is more interested in learning independently with chatbots because they look more attractive than printed books or PDF modules. RZ's learning experience reflects the real benefits of using AI-based chatbots tailored to visual learning styles.

Significant changes in RZ's performance indicate that the visual features in the chatbot provide concrete support for the learning process. RZ felt motivated to learn because the information presented felt "more alive" and easy to understand than the usual methods.

The improvement in comprehension is also supported by the chatbot's ability to provide repetitive visual explanations when students do not understand. This feature is not available in conventional methods, which rely only on teachers or static teaching materials.

RZ's case shows that AI-based chatbots have the potential to be adaptive and personalized learning companions, especially for students with visual learning needs. This success provides a real example of the benefits of technology-based learning personalization.

Findings from the case study support the results of statistics and questionnaires the perception that chatbots are effective in helping students with visual learning styles. Quantitative and qualitative data show a similar pattern, namely that visual students need learning media that combines text and visual elements in harmony.

The experiences of individuals like RZ reflect the same trend in the experimental group, namely improved learning performance and a high interest in visual content. This emphasizes that the effectiveness of chatbots is not the result of chance, but rather part of the suitability of the method with the characteristics of learning.

The relationship between case studies, quantitative data, and student perceptions forms a holistic picture that AI-based chatbots designed visual-friendly can be an innovative solution in the world of education, especially to accommodate visual learning styles.

This research shows that the use of AI-based chatbots significantly improves student learning outcomes with visual learning styles. The average posttest score of the experimental group was higher than that of the control group, which indicates that the chatbot has a positive contribution to the understanding of the material. Students' perception of the visual design of chatbots is also very positive, especially in terms of information clarity and visual appeal.

The results of the statistical test reinforced this claim by showing a significant difference between the pretest and posttest scores in the experimental group. Students who use chatbots not only show an increase in academic grades, but are also more motivated in the learning process. The correlation between positive perception of visual features and improved learning outcomes further strengthens the effectiveness of this technology.

Case studies on individuals like RZ also show the real impact of visual chatbot features on visual learners. Improved grades and a more enjoyable learning experience are an indication that chatbots can meet learning needs that are individualized and based on learning style preferences.

This research is in line with previous studies that highlighted the effectiveness of chatbots in learning, such as those conducted by Winkler and Söllner (2018) who stated that chatbots can increase student learning engagement. However, this research makes a new contribution with a special focus on students' visual learning styles and visual features in chatbot design.

Different from the general research on chatbots that focus more on text-based interactivity, this study emphasizes the use of visual media as an important element in supporting visual learning styles. This is a significant differentiator because it connects the effectiveness of learning not only to technology, but also to the suitability of learning styles.

The results of this study also complement Mayer's theory of Multimedia Learning, which states that learning will be more effective if it is delivered in visual and verbal formats. These findings show that the theoretical principles can be applied in the context of AI-based chatbots for modern learning.

The results of this study are an indicator that personalization in technology-based learning is increasingly relevant to be implemented. Individual learning styles need to be considered in the development of learning media so that the knowledge transfer process becomes more effective. Chatbot designs that pay attention to visual aspects have been proven to meet the needs of students who were previously less accommodated in the conventional learning system.

This finding also signals that learning technology is not enough to be interactive, but must be able to adapt to the characteristics of students. Chatbots that are able to present information in visual form have proven to have a deeper impact on visual learners than regular text-based chatbots. This indicates the importance of integrating psychopedagogic aspects in the development of educational technology.

The importance of an adaptive and learning style-based approach reinforces the idea that the effectiveness of educational technology lies not only in its sophistication, but in the extent to which it is aligned with the needs of users. This research marks a shift from a uniform approach to technology towards more personalized and flexible learning.

The practical implication of this research is the need for educational technology developers to design chatbots that pay more serious attention to visual elements. The design of the interface, colors, animations, and the way of presenting information must be adapted to the needs of visual students so that learning becomes more effective and engaging. Schools and educational institutions can consider using these kinds of chatbots as part of differential learning strategies.

The results of this research can also be a reference for educators in determining technology-based learning methods that suit students' learning styles. The use of AI-based chatbots can not only help in the delivery of material, but also in building a more enjoyable learning experience and according to student preferences. Integrating chatbots into the curriculum can be done gradually with proper teacher training.

In the context of education policy, these results suggest that investment in educational technology should consider pedagogical aspects, not just technological ones. The government and education policymakers should encourage the development of AI-based learning media that is inclusive and adaptive to students' learning styles.

The effectiveness of chatbots on visual learning style students occurs because the visual approach corresponds to the way the brains of visual students process information. Visual learners are quicker to understand information presented in the form of images, diagrams, or animations than textual information alone. Chatbots that are able to present visual elements provide a more natural and intuitive learning experience for them.

Chatbots also provide a flexible and personalized learning experience, allowing students to access information repeatedly without the time pressure or sometimes limiting social interactions. This feature is very helpful for visual students in setting their own tempo and learning style. The ability of chatbots to visually represent information also plays a role in strengthening long-term memory.

The interface design that supports visual interactivity adds to the effectiveness of this medium. Elements like infographics, interactive illustrations, and concept maps make the learning process more engaging and less boring. All of these factors contribute to improved student learning outcomes and positive perceptions of the use of chatbots as learning assistants.

Chatbot development in the future needs to be more specific and responsive to diverse learning styles, not only visual, but also auditory, kinesthetic, and others. Advanced research can test the effectiveness of chatbots for other learning styles as well as at different levels of education

such as junior high school or college. Trials in different cultural and curricular contexts will also enrich the generalization of research results.

It's important to build collaboration between technological, educational, and psychological experts in designing a truly adaptive chatbot. The design of chatbots should not only be developed by programmers, but also involve educators and learning style experts so that their functions are more optimal. Regular evaluation from users is also important to update chatbot features to stay relevant and effective.

Educational institutions are expected to start facilitating AI-based learning more broadly and in-depth. The use of chatbots can be one of the innovative strategies in building inclusive and personalized learning, especially in the digital era that demands high flexibility and adaptation. Thus, this research opens up great opportunities for a more effective and humane learning transformation.

CONCLUSION

The most important finding of this study is that AI-based chatbots with interactive visual features have proven to be effective in improving student learning outcomes with visual learning styles, demonstrated by a significant increase in posttest scores and positive perceptions of the learning experience.

This research provides more value in the form of the contribution of technology-based learning concepts that are adaptive to students' learning styles, as well as the visual design approach to chatbots as an innovative pedagogical strategy that can be integrated into the formal education system.

The limitations of the study lie in the limited scope of the sample and focus only on visual learning styles, so further research is recommended to test the effectiveness of chatbots against other learning styles and expand the context of their use at various levels and educational backgrounds.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Aldahwan, N., & Alsaeed, N. (2020). Use of artificial intelligent in Learning Management System (LMS): A systematic literature review. *International Journal of Computer …*, *Query date: 2025-04-30 16:44:03*. https://www.researchgate.net/profile/Norah-Alsaeed/publication/346970541_Use_of_Artificial_Intelligent_in_Learning_Management_System_LMS_A_Systematic_Literature_Review/links/5fd6242245851553a0b1c10d/Use-of-Artificial-Intelligent-in-Learning-Management-System-LMS-A-Systematic-Literature-Review.pdf

Aldoseri, A., Al-Khalifa, K., & Hamouda, A. (2023). A roadmap for integrating automation with process optimization for AI-powered digital transformation. *Preprints. DOI: https://doi. org*

..., *Query date: 2025-04-30 16:44:03*. https://www.preprints.org/manuscript/202310.1055/download/final_file

Alshmrany, S. (2022). Adaptive learning style prediction in e-learning environment using levy flight distribution based CNN model. *Cluster Computing*, *Query date: 2025-04-30 16:44:03*. https://doi.org/10.1007/s10586-021-03403-3

Ashfaque, M., Tharewal, S., Iqhbal, S., & ... (2020). A Review on Techniques, Characteristics and approaches of an intelligent tutoring Chatbot system. *... Conference on Smart ...*, *Query date: 2025-04-30 16:44:03*. https://ieeexplore.ieee.org/abstract/document/9299583/

Ayeni, O., Hamad, N. A., Chisom, O., & ... (2024). AI in education: A review of personalized learning and educational technology. *GSC Advanced ...*, *Query date: 2025-04-30 16:44:03*. https://www.researchgate.net/profile/Nneamaka-Onyebuchi-4/publication/390163119_AI_in_education_A_review_of_personalized_learning_and_educational_technology/links/67e78c3049e91c0feac451e7/AI-in-education-A-review-of-personalized-learning-and-educational-technology.pdf

Bhartiya, N., Jangid, N., Jannu, S., Shukla, P., & ... (2019). Artificial neural network based university chatbot system. *2019 IEEE Bombay ...*, *Query date: 2025-04-30 16:44:03*. https://ieeexplore.ieee.org/abstract/document/8973095/

Bhirud, N., Tataale, S., Randive, S., & Nahar, S. (2019). A literature review on chatbots in healthcare domain. *Int J Sci Technol Res*, *Query date: 2025-04-30 16:44:03*. https://www.viit.ac.in/images/Quality/NAAC/NAAC-Data/Criteria-3/Research-Journal-Paper/JP-AY-2019-20-PART-1.pdf

Casheekar, A., Lahiri, A., Rath, K., Prabhakar, K., & ... (2024). A contemporary review on chatbots, AI-powered virtual conversational agents, ChatGPT: Applications, open challenges and future research directions. *Computer Science ...*, *Query date: 2025-04-30 16:44:03*. https://www.sciencedirect.com/science/article/pii/S1574013724000169

Davar, N., Dewan, M., & Zhang, X. (2025). AI chatbots in education: Challenges and opportunities. *Information*, *Query date: 2025-04-30 16:44:03*. https://www.mdpi.com/2078-2489/16/3/235

Deng, X., & Yu, Z. (2023). A meta-analysis and systematic review of the effect of chatbot technology use in sustainable education. *Sustainability*, *Query date: 2025-04-30 16:44:03*. https://www.mdpi.com/2071-1050/15/4/2940

Devi, J., Sreedhar, M., Arulprakash, P., & ... (2022). A path towards child-centric Artificial Intelligence based Education. *... Journal of Early ...*, *Query date: 2025-04-30 16:44:03*. https://www.researchgate.net/profile/Burada-Sreedhar/publication/361227279_A_Path_Towards_Child-Centric_Artificial_Intelligence_based_Education/links/62a428cfc660ab61f872a70a/A-Path-Towards-Child-Centric-Artificial-Intelligence-based-Education.pdf

Eden, C., Adeleye, O., & ... (2024). A review of AI-driven pedagogical strategies for equitable access to science education. *... Research and Reviews*, *Query date: 2025-04-30 16:44:03*. https://pdfs.semanticscholar.org/3333/63765cb9f7cd8d083f3f7b9c7adab8c74bfc.pdf

Essel, H., Vlachopoulos, D., Tachie-Menson, A., & ... (2022). The impact of a virtual teaching assistant (chatbot) on students' learning in Ghanaian higher education. *... Journal of Educational ...*, *Query date: 2025-04-30 16:44:03*. https://doi.org/10.1186/S41239-022-00362-6

Gligorea, I., Cioca, M., Oancea, R., Gorski, A., Gorski, H., & ... (2023). Adaptive learning using artificial intelligence in e-learning: A literature review. *Education ...*, *Query date: 2025-04-30 16:44:03*. https://www.mdpi.com/2227-7102/13/12/1216

Gm, D., Goudar, R., Kulkarni, A., Rathod, V., & ... (2024). A digital recommendation system for personalized learning to enhance online education: A review. *IEEE ...*, *Query date: 2025-04-30 16:44:03*. https://ieeexplore.ieee.org/abstract/document/10445145/

González-Castro, N., Muñoz-Merino, P., & ... (2021). Adaptive learning module for a conversational agent to support MOOC learners. *... Journal of Educational ...*, *Query date: 2025-04-30 16:44:03*. https://ajet.org.au/index.php/AJET/article/view/6646

Gubareva, R., & Lopes, R. (2020). Virtual Assistants for Learning: A Systematic Literature Review. *CSEDU (1), Query date: 2025-04-30 16:44:03*. https://www.scitepress.org/PublishedPapers/2020/94176/94176.pdf

Hashim, S., Omar, M., Jalil, H. A., & ... (2022). Trends on technologies and artificial intelligence in education for personalized learning: Systematic literature. *... in Progressive Education ...*, *Query date: 2025-04-30 16:44:03*. https://www.researchgate.net/profile/Muhd-Omar/publication/358958588_Trends_on_Technologies_and_Artificial_Intelligence_in_Education_for_Personalized_Learning_Systematic_Literature_Review/links/6224230097401151d2008b25/Trends-on-Technologies-and-Artificial-Intelligence-in-Education-for-Personalized-Learning-Systematic-Literature-Review.pdf

Hwang, G., Tu, Y., & Tang, K. (2022). AI in online-learning research: Visualizing and interpreting the journal publications from 1997 to 2019. *... Research in Open and Distributed Learning*, *Query date: 2025-04-30 16:44:03*. https://www.erudit.org/en/journals/irrodl/2022-v23-n1-irrodl06775/1086461ar/abstract/

Janati, S. E., Maach, A., & Ghanami, D. E. (2020). Adaptive e-learning AI-powered chatbot based on multimedia indexing. *International Journal of ...*, *Query date: 2025-04-30 16:44:03*. https://www.academia.edu/download/103603880/Paper_38-Adaptive_e_Learning_AI_Powered_Chatbot.pdf

Kabudi, T., Pappas, I., & Olsen, D. (2021). AI-enabled adaptive learning systems: A systematic mapping of the literature. *Computers and education: Artificial ...*, *Query date: 2025-04-30 16:44:03*. https://www.sciencedirect.com/science/article/pii/S2666920X21000114

Kamruzzaman, M., Alanazi, S., Alruwaili, M., & ... (2023). AI-and IoT-assisted sustainable education systems during pandemics, such as COVID-19, for smart cities. *Sustainability*, *Query date: 2025-04-30 16:44:03*. https://www.mdpi.com/2071-1050/15/10/8354

Kaswan, K., Dhatterwal, J., & Ojha, R. (2024). AI in personalized learning. *... in higher education*, *Query date: 2025-04-30 16:44:03*. https://doi.org/10.1201/9781003376699-9

Kerimbayev, N., Umirzakova, Z., Shadiev, R., & ... (2023). A student-centered approach using modern technologies in distance learning: A systematic review of the literature. *Smart Learning ...*, *Query date: 2025-04-30 16:44:03*. https://doi.org/10.1186/s40561-023-00280-8

Limna, P., Kraiwanit, T., Jangjarat, K., & ... (2023). The use of ChatGPT in the digital era: Perspectives on chatbot implementation. *... and Teaching*, *Query date: 2025-04-30 16:44:03*. https://journals.sfu.ca/jalt/index.php/jalt/article/view/797

Liu, L., Subbareddy, R., & ... (2022). AI intelligence Chatbot to improve students learning in the higher education platform. *Journal of Interconnection ...*, *Query date: 2025-04-30 16:44:03*. https://doi.org/10.1142/S0219265921430325

Luo, B., Lau, R., Li, C., & Si, Y. (2022). A critical review of state-of-the-art chatbot designs and applications. *Wiley Interdisciplinary Reviews ...*, *Query date: 2025-04-30 16:44:03*. https://doi.org/10.1002/widm.1434

Nasir, M., Hasan, M., Adlim, A., & ... (2024). Utilizing artificial intelligence in education to enhance teaching effectiveness. *... on Education*, *Query date: 2025-04-30 16:44:03*. https://jurnal.serambimekkah.ac.id/index.php/ice/article/view/1367

Rooein, D., Bianchini, D., Leotta, F., Mecella, M., & ... (2022). aCHAT-WF: Generating conversational agents for teaching business process models. *Software and Systems ...*, *Query date: 2025-04-30 16:44:03*. https://doi.org/10.1007/s10270-021-00925-7

Saaida, M. (2023). AI-Driven transformations in higher education: Opportunities and challenges. *International Journal of Educational Research and ...*, *Query date: 2025-04-30 16:44:03*. https://www.academia.edu/download/108045301/AI-Driven_transformations_in_higher_education_Opportunities_and_challenges.pdf

Sandu, N., & Gide, E. (2019). Adoption of AI-Chatbots to enhance student learning experience in higher education in India. *... based higher education and training (ITHET)*, *Query date: 2025-04-30 16:44:03*. https://ieeexplore.ieee.org/abstract/document/8937382/

Schlimbach, R., Rinn, H., Markgraf, D., & ... (2022). A literature review on pedagogical conversational agent adaptation. *... Asia Conference on ...*, *Query date: 2025-04-30 16:44:03*. https://www.researchgate.net/profile/Ricarda-Schlimbach/publication/361228223_A_Literature_Review_on_Pedagogical_Conversational_Agent_Adaptation/links/62a45e61a3fe3e3df86dc199/A-Literature-Review-on-Pedagogical-Conversational-Agent-Adaptation.pdf

Strielkowski, W., Grebennikova, V., & ... (2024). AI-driven adaptive learning for sustainable educational transformation. *Sustainable ...*, *Query date: 2025-04-30 16:44:03*. https://doi.org/10.1002/sd.3221

Suárez, A., Adanero, A., García, V. D.-F., & ... (2022). Using a virtual patient via an artificial intelligence chatbot to develop dental students' diagnostic skills. *International journal of ...*, *Query date: 2025-04-30 16:44:03*. https://www.mdpi.com/1660-4601/19/14/8735

Vadisetty, R., & Polamarasetti, A. (2024). AI-Augmented Skill Development Roadmaps: Tailoring 12-Month Learning Paths for Future-Ready Careers in Education 4.0 and Industry 4.0. *2024 13th International ...*, *Query date: 2025-04-30 16:44:03*. https://ieeexplore.ieee.org/abstract/document/10882483/

Vashishth, T., Sharma, V., Sharma, K., & ... (2024). AI-driven learning analytics for personalized feedback and assessment in higher education. *... methods to enhance AI ...*, *Query date: 2025-04-30 16:44:03*. https://www.igi-global.com/chapter/ai-driven-learning-analytics-for-personalized-feedback-and-assessment-in-higher-education/336700

Zhang, R., Zou, D., & Cheng, G. (2024). A review of chatbot-assisted learning: Pedagogical approaches, implementations, factors leading to effectiveness, theories, and future directions. *Interactive Learning Environments*, *Query date: 2025-04-30 16:44:03*. https://doi.org/10.1080/10494820.2023.2202704