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Expert system based chatbot for enhancing learning outcomes in kebaya analysis among vocational students

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ABSTRACT

This study aimed to determine the validity and effectiveness of an expert system-based chatbot as a learning medium for improving students' learning outcomes in kebaya garment analysis at a vocational high school. A quasi-experimental study employing a nonequivalent control group pretest–posttest design was conducted with 60 Grade XI Fashion Design students, divided equally into experimental and control groups. Data were collected using expert validation sheets, cognitive achievement tests, and perception questionnaires, and analyzed using Aiken's V, classical mastery, Normalized Gain (N-Gain), and an Independent Samples t-test. The chatbot demonstrated good validity (Aiken's V = 0.84). The experimental group achieved 100% classical mastery, a moderate N-Gain (0.57), and significantly higher posttest scores than the control group ($p < 0.001$). Teachers and students also reported positive perceptions (87.27% and 86.20%, respectively). The expert system-based chatbot is a valid and effective instructional medium that enhances learning outcomes and supports independent learning in vocational fashion education.

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Introduction

The integration of digital technology and artificial intelligence (AI) into vocational education has created new opportunities to enhance higher-order thinking, procedural competence, and competencies required by modern industries (Covvey et al., 2023; Wang, 2025). In vocational fashion education, students must master garment construction while developing visual-spatial reasoning to analyze body measurements, patterns, aesthetics, and cultural characteristics. These competencies are particularly demanding in kebaya garment analysis because they require the integration of procedural and conceptual knowledge. However, conventional teacher-centered instruction and printed learning materials often provide limited individualized guidance, making it difficult for students to overcome procedural and visual-spatial learning challenges (Maula et al., 2025; Yusro et al., 2024).

Artificial intelligence has introduced intelligent tutoring systems, expert systems, and educational chatbots that provide adaptive instruction, immediate feedback, and personalized learning experiences (M. G. Munro et al., 2022b). Previous studies have shown that chatbots improve learning motivation, self-regulated learning, conceptual understanding, and academic achievement (Juliantika et al., 2026; Rosyanto et al., 2025). Nevertheless, most existing chatbots function as general conversational assistants without integrating structured

expert knowledge, limiting their ability to provide systematic procedural guidance required in vocational subjects such as kebaya garment analysis (Rakhmawati, 2025; Setyaningsih et al., 2025).

Preliminary observations at SMKN 3 Pekanbaru revealed that 55.6% of Grade XI Fashion Design students failed to meet the minimum competency standard in kebaya garment analysis. Classroom learning remained teacher-centered, with limited opportunities for individualized guidance, causing difficulties in identifying garment characteristics, interpreting patterns, and applying procedural knowledge independently. These findings indicate the need for an intelligent learning system capable of providing continuous and adaptive instructional support.

To address these challenges, this study develops an expert system-based chatbot for kebaya garment analysis in vocational education (Bakar et al., 2024; Kurnaedi, 2025). Unlike generative chatbot applications, the proposed system integrates a rule-based knowledge base, inference engine, and natural language interaction to deliver accurate, consistent, and pedagogically guided responses (M. G. Munro et al., 2022a; Palma & Cabello-Avilez, 2025). The chatbot diagnoses procedural errors, provides immediate feedback, and guides students through structured analytical processes, representing a novel application of expert knowledge representation in vocational fashion learning (Ahn et al., 2023; Shima et al., 2025).

Accordingly, this study evaluates the validity and instructional effectiveness of the proposed chatbot in improving students' learning outcomes in kebaya garment analysis. The study examines expert validity, learning achievement, classical mastery, normalized gain, and user perceptions to determine its educational effectiveness. The findings are expected to extend the application of expert system-based intelligent tutoring in vocational education while providing an evidence-based model for adaptive and personalized learning in fashion education.

Method

This study employed a quantitative quasi-experimental approach using a nonequivalent control group pretest–posttest design to evaluate the effectiveness of an expert system-based chatbot in improving students' learning outcomes in kebaya garment analysis. The research was conducted during the second semester of the 2025/2026 academic year at SMKN 3 Pekanbaru, Indonesia. Participants consisted of 60 Grade XI Fashion Design students selected using intact class sampling and assigned into an experimental group (n = 30) and a control group (n = 30). The experimental group learned using the chatbot-based expert system, whereas the control group received conventional instruction through printed learning modules. Baseline equivalence between groups was examined using pretest scores before the intervention, followed by equivalent posttests to measure changes in cognitive achievement.

The chatbot was developed as a rule-based expert system integrating a knowledge base, inference engine, and web-based conversational interface for kebaya garment analysis. The knowledge base was constructed from expert knowledge and procedural learning materials, while inference rules were designed to provide step-by-step guidance and corrective feedback. The learning media were validated by two subject-matter experts and two instructional media experts using Aiken's V to evaluate content accuracy, interface design, usability, and pedagogical quality. Students' cognitive achievement was measured using a 20-item multiple-choice test developed from the learning objectives of kebaya garment analysis. Instrument testing confirmed acceptable item validity, moderate difficulty and discrimination indices, and good reliability (Cronbach's $\alpha = 0.77$). Teacher and student perceptions were collected using a five-point Likert-scale questionnaire.

Data were analyzed using IBM SPSS Statistics version 26. Descriptive statistics summarized students' learning outcomes before and after the intervention, while learning effectiveness was evaluated through classical mastery and Normalized Gain (N-Gain). Prior to hypothesis testing, data were examined for normality using the Shapiro–Wilk test and homogeneity using Levene's test. Differences in posttest achievement between groups were analyzed using an Independent Samples t-test at a significance level of 0.05, and the magnitude of the treatment effect was interpreted using Cohen's d to provide a more comprehensive evaluation of the chatbot's instructional effectiveness.

Results and Discussions

This study evaluated the validity and instructional effectiveness of an expert system-based chatbot designed to support learning in kebaya garment analysis. The findings are organized into five sections, including expert validation, descriptive learning outcomes, learning effectiveness, statistical assumption and hypothesis testing, and user perceptions. Together, these findings provide comprehensive evidence regarding the feasibility and effectiveness of the chatbot as an intelligent learning assistant in vocational fashion education.

Table 1. Expert Validation Results

Evaluation Aspect	Indicator	Result	Category
Content and Media Validation	Aiken's V	0.84	Valid

The expert evaluation demonstrated that the chatbot-based learning media achieved an overall Aiken's V coefficient of 0.84, indicating satisfactory content validity and instructional quality. This result confirms that the developed expert system fulfilled the required standards for implementation in vocational learning and was considered suitable for classroom use.

Table 2. Comparison of Learning Outcomes Between Experimental and Control Groups

Variable	Experimental (n=30)	Control (n=30)
Pretest Mean ± SD	77.00 ± 6.51	76.17 ± 6.65
Posttest Mean ± SD	90.17 ± 4.82	78.17 ± 5.00
Minimum–Maximum (Pretest)	60–85	60–85
Minimum–Maximum (Posttest)	85–100	70–85

Both groups demonstrated comparable baseline achievement before the intervention, with mean pretest scores of 77.00 and 76.17 for the experimental and control groups, respectively. Following the intervention, students who learned using the chatbot exhibited substantially higher achievement, reaching a mean posttest score of 90.17, whereas the control group improved only slightly to 78.17. The lower standard deviation observed in the experimental group also indicates more consistent learning performance after using the chatbot-assisted instruction.

Table 3. Learning Effectiveness Based on Classical Mastery and Normalized Gain

Indicator	Experimental	Control
Classical Mastery (Pretest)	66.7%	56.7%
Classical Mastery (Posttest)	100.0%	66.7%
N-Gain	0.57	0.30
Gain Category	Moderate	Low

The effectiveness analysis demonstrated clear differences between instructional approaches. Classical mastery in the experimental group increased from 66.7% to 100%, indicating that all students successfully achieved the minimum competency criterion after learning with the chatbot. In contrast, the control group improved only from 56.7% to 66.7%. Similarly, the experimental group achieved a moderate N-Gain (0.57), whereas the control group remained in the low improvement category (0.30), confirming greater learning improvement among students supported by the chatbot.

To provide a concise visual comparison of post-intervention learning achievement, Figure 1 presents the classical learning mastery rates of the experimental and control groups using a connected Cleveland dot plot. This visualization highlights the substantial difference in mastery achievement between students receiving chatbot-assisted instruction and those receiving conventional instruction.

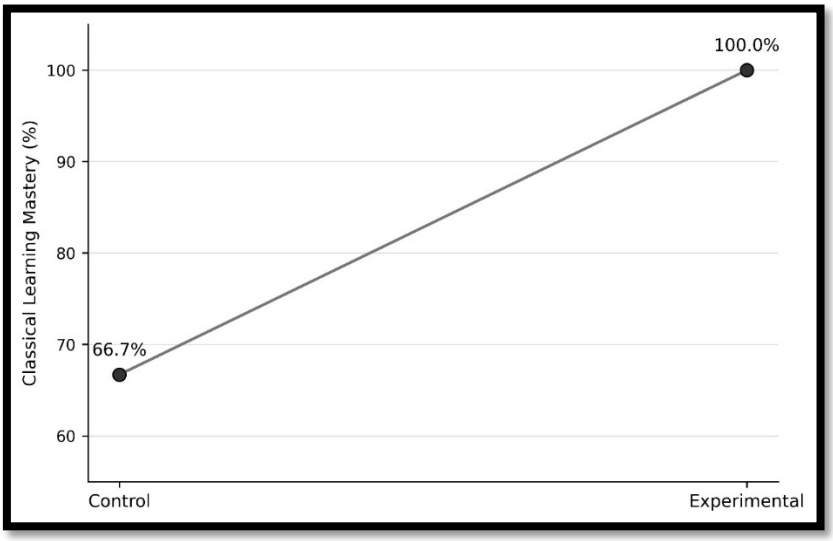

Figure 1. Classical Learning Mastery in the Experimental and Control Groups

Table 4. Results of Statistical Assumption Tests and Hypothesis Testing

Test	Result	Decision
Normality Test (Shapiro–Wilk)	$p > 0.05$	Normal distribution
Homogeneity Test (Levene)	$p = 0.590$	Homogeneous variance
Independent Samples t-Test	$t = 10.141$; $df = 58$	Significant difference
Significance	$p < 0.001$	H_a accepted

The statistical assumption tests confirmed that the dataset satisfied the requirements for parametric analysis. All variables were normally distributed and exhibited homogeneous variances across groups. The Independent Samples t-test further revealed a statistically significant difference between the experimental and control groups ($t = 10.141$, $p < 0.001$), supporting the effectiveness of the chatbot-based expert system in improving students' learning outcomes.

Table 5. User Perceptions of the Chatbot-Based Learning System

Respondent	Effectiveness (%)	Category
Teacher	87.27	Effective
Students	86.20	Effective

The perception survey revealed highly positive responses from both teachers and students regarding the chatbot-based learning system. Teachers reported an effectiveness score of 87.27%, highlighting the system's usability, accessibility, and instructional efficiency. Students similarly rated the chatbot highly (86.20%), indicating that it effectively supported conceptual understanding, independent learning, and problem-solving activities. The consistency of both evaluations reinforces the practical applicability of the developed expert system in vocational fashion education.

The expert validation result (Aiken's V = 0.84) indicates that the developed chatbot possesses adequate content accuracy, instructional design, usability, and technological feasibility for vocational learning. Unlike conventional learning media, the chatbot embeds expert knowledge into a rule-based inference mechanism, enabling students to receive structured procedural guidance during kebaya garment analysis. This characteristic is particularly important because the subject requires sequential reasoning involving body measurements, garment proportions, pattern construction, and cultural design interpretation. The findings reinforce previous studies showing that AI-assisted learning systems become more effective when instructional knowledge is systematically represented within expert systems rather than functioning solely as conversational tools (Ahn et al., 2023; Shima et al., 2025). Therefore, the validity results confirm not only the technical quality of the media but also its suitability for supporting procedural learning in vocational fashion education.

The experimental group achieved substantially higher learning outcomes than the control group, with posttest scores increasing from 77.00 to 90.17 compared with 76.17 to 78.17 in conventional instruction. This improvement suggests that immediate feedback, structured explanations, and adaptive guidance enabled students to understand complex analytical procedures more effectively. The experimental class also achieved complete classical mastery (100%) and a moderate N-Gain (0.57), whereas the control group reached only 66.7% mastery with a low N-Gain (0.30). Although the gain remained in the moderate category, this finding is reasonable because kebaya garment analysis requires complex procedural and visual-spatial reasoning that generally develops progressively rather than instantly. These results support Cognitive Load Theory, which explains that adaptive instructional support facilitates the processing of complex information while reducing unnecessary cognitive burden (Ahmad et al., 2026; Wieczorek et al., 2026). Similar findings have been reported in AI-supported learning environments employing conversational agents and intelligent tutoring systems to improve conceptual understanding through personalized guidance and repeated practice (Alvarez et al., 2023; M. Munro et al., 2023; M. G. Munro et al., 2022c; Burvenich et al., 2023; Moreland-Head et al., 2026).

The inferential analysis further demonstrated that the chatbot produced a statistically significant improvement in learning outcomes ($t = 10.141$, $p < 0.001$), indicating that the observed differences were attributable to the instructional intervention rather than random variation. Compared with previous studies that generally reported improvements in motivation, engagement, or overall academic performance, the present study provides stronger empirical evidence by demonstrating significant gains in a vocational subject requiring procedural and visual-spatial competencies. This finding suggests that integrating a rule-based expert system with conversational interaction offers greater instructional value than conventional chatbot applications that primarily deliver generalized responses. Consequently, the developed chatbot functions as an intelligent learning facilitator capable of supporting higher-order thinking and procedural reasoning in vocational fashion education (Gosavi et al., 2024; Yu et al., 2025; Yuniati et al., 2025).

Positive evaluations from teachers (87.27%) and students (86.20%) indicate that the chatbot was perceived as useful, accessible, and supportive of independent learning. Teachers particularly benefited from the chatbot's ability to provide consistent procedural explanations, whereas students valued the immediate feedback and individualized assistance that facilitated conceptual understanding and problem solving. These findings are consistent with the Technology Acceptance Model, which emphasizes that perceived usefulness and perceived ease of use are fundamental determinants of technology adoption in educational settings (Gowri, 2025; M. G. Munro et al., 2023; Park et al., 2022). Similar conclusions have also been reported by recent studies highlighting that positive user acceptance is essential for sustaining the implementation of AI-based learning technologies in formal education (Abarkan et al., 2022; Jena et al., 2026; Liu et al., 2025).

This study contributes to vocational education by demonstrating that integrating a rule-based expert system with conversational AI provides structured instructional support for learning activities requiring procedural reasoning and visual-spatial analysis. Unlike conventional chatbot applications that primarily generate conversational responses, the proposed system utilizes explicit expert knowledge to guide students through systematic analytical processes, representing its principal contribution to vocational fashion education (Fu et al., 2023; Krutphong et al., 2023). Nevertheless, this study was limited to one vocational school and focused only on kebaya garment analysis; therefore, the findings should be interpreted within this context. Future studies should evaluate the chatbot across different vocational subjects, larger participant populations, and longer intervention periods to examine its broader effectiveness and long-term educational impact.

Conclusions

This study concludes that the expert system-based chatbot is a valid and effective learning medium for improving students' learning outcomes in kebaya garment analysis at vocational high schools. The media demonstrated satisfactory validity based on expert evaluation and significantly enhanced students' cognitive achievement, as evidenced by higher posttest scores, complete classical learning mastery, a moderate Normalized Gain, and statistically significant differences compared with conventional instruction. Furthermore, positive perceptions from both teachers and students indicate that the chatbot effectively supports independent learning, conceptual understanding, and problem-solving during the learning process. These findings suggest that integrating rule-based expert systems into vocational education provides an innovative and practical instructional approach for facilitating adaptive, personalized, and technology-enhanced learning, particularly in subjects requiring procedural and visual-spatial competencies.

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