INTERNATIONAL JOURNAL OF SOCIAL SCIENCE, EDUCATIONAL, ECONOMICS, AGRICULTURE RESEARCH AND TECHNOLOGY (IJSET) | ISSN (E): 2827-766X
Website: https://ijset.org/ | Volume 5 No. 10 (2026)

DEVELOPMENT OF A REACT–OBE-BASED VIRTUAL LAB WITH AI INTEGRATION FOR INDONESIAN LANGUAGE LEARNING AMONG COMPUTER SCIENCE STUDENTS

Rizki Fadila Nasution[1]*, Endra Ary Prasasty Marpaung[2], Wira Apriani[3], Defan Syahputra[4], Allya Dwi Cantika[5]
[1]Teknologi Informasi, STMIK Pelita Nusantara, Medan, Sumatera Utara, Indonesia
[2,3,4,5]Teknik Informatika, STMIK Pelita Nusantara, Medan, Sumatera Utara, Indonesia
E-mail: rizkifadila231@gmail.com[1]*, indra_only85@ymail.com[2], wiraaprianii@gmail.com[3], defansyahputr[4]@gmail.com[4], cantikallyadwi@gmail.com[5]
*Author Correspondence

Received: 25/07/2026 | **Revised:**03/08/2026 | **Accepted:**20/08/2026 | **Published:** 06/09/2026

Abstract

Advances in digital technology and the implementation of Outcome-Based Education (OBE) require learning resources that can enhance student engagement, support the attainment of competencies, and provide rapid and continuous feedback. However, the process of learning Indonesian at the university level is still dominated by conventional methods and thus has not yet been able to fully accommodate the need for interactive and adaptive learning. This study aims to develop and evaluate a REACT-based (Relating, Experiencing, Applying, Cooperating, and Transferring) Virtual Indonesian Language Learning Lab integrated with Artificial Intelligence (AI) and the OBE approach. The study employs a Research and Development (R&D) methodology using the ADDIE model, which includes the Analysis, Design, Development, Implementation, and Evaluation phases. The developed product was validated by media and subject matter experts, then tested on 100 students in the Computer Science program. The research instruments included an expert validation sheet, the System Usability Scale (SUS), and a learning outcome test using a one-group pretest-posttest design. The results showed that the developed Virtual Lab achieved a very high level of validity, with a media expert validation score of 92.83% and a content expert validation score of 94.44%. Usability test results showed a SUS score of 86.15, which falls into the "Excellent" category. Furthermore, the use of the Virtual Lab was able to improve student learning outcomes, as evidenced by an increase in the average score from 61.84 on the pretest to 85.76 on the posttest, with an N-Gain value of 0.63. These findings indicate that the integration of REACT, OBE, and AI in the Virtual Lab creates an interactive, user-friendly learning environment that is effective in enhancing students' competencies. Thus, the AI-integrated REACT–OBE Virtual Lab has the potential to serve as an innovative alternative for supporting Indonesian language learning in higher education during the era of digital transformation.

Keywords: Virtual Lab, REACT, Outcome-Based Education, Artificial Intelligence, Indonesian.

INTRODUCTION

Digital transformation in higher education has driven universities to develop learning environments that are more flexible, interactive, and focused on learning outcomes. Advances in information technology, artificial intelligence (AI), and digital-based learning provide opportunities for educational institutions to improve the quality of the learning process through the use of smart learning platforms and virtual laboratories. In the context of 21st-century higher education, students are expected not only to master academic competencies but also to develop critical thinking, communication, collaboration, creativity, and digital literacy skills relevant to the needs of the workforce. (Adams et al., 2023; Bond et al., 2021; Crompton & Burke, 2023).

The Computer Science program features a learning approach closely tied to the use of digital technology. However, the teaching of Indonesian as a required general education course still frequently faces various challenges, such as low student engagement, a lack of contextual learning activities, limited individual feedback from instructors, and difficulties in connecting language material to students' academic contexts. These conditions result in learning

outcomes not always being optimally achieved, particularly in the areas of academic communication skills, scientific writing, and critical thinking. (Alanoglu et al., 2026; Anthonysamy et al., 2020; INOVASI, 2011; Patrinos, 2022). One approach considered effective in increasing student engagement is the REACT (Relating, Experiencing, Applying, Cooperating, and Transferring) learning model. This model is a contextual learning approach that connects course material to real-world experiences, encourages students to discover concepts through hands-on experiences, apply their knowledge to problem-solving, collaborate with peers, and transfer the knowledge they have gained to new situations (Nizar Zulfikar et al., 2025). Various studies show that the implementation of REACT can improve learning outcomes, reasoning abilities, problem-solving skills, interest in learning, and students' active engagement in the learning process. (Mahajani et al., 2024) found that the REACT strategy is more effective than conventional instruction in improving students' mathematical reasoning skills and interest in learning. In addition, (Nguyen et al., 2026) reported that the implementation of REACT significantly improved academic achievement, mathematical problem-solving skills, interest in learning, and student engagement in the learning process. These findings indicate that REACT can serve as an effective alternative learning strategy to support active, contextual, and student-centered learning.

On the other hand, the implementation of the Outcome-Based Education (OBE) paradigm is increasingly becoming the standard in higher education management because it emphasizes the achievement of measurable learning outcomes that align with the needs of stakeholders. OBE enables every learning activity, assessment, and evaluation to be designed based on clear and measurable graduate learning outcomes (Program Learning Outcomes). This approach has proven effective in enhancing the accountability of the learning process, the quality of assessment, and the relevance of graduates' competencies to the needs of industry and society (Bhat et al., 2022; Harden, 2007; Spady, 1994).

Advances in artificial intelligence technology are also opening up new opportunities for personalized learning. AI can provide automated feedback, recommendations for learning materials, analysis of student performance, and real-time support for self-directed learning. The use of AI in education is not intended to replace the role of instructors, but rather to enhance the learning process by providing adaptive support services that respond to students' needs (Luckin et al., 2023; Spady, 1994; Zawacki-Richter et al., 2019). The emergence of Generative Artificial Intelligence technology also offers opportunities to improve the quality of language learning through writing assistance, text evaluation, and faster, more personalized feedback (Kasneci et al., 2023a; Lo, 2023).

The integration of virtual labs, the REACT model, the OBE approach, and AI technology offers a promising combination for creating a more effective learning ecosystem. Virtual labs enable students to explore and practice independently without being constrained by time or space, while also providing an interactive and measurable learning environment. Previous research has shown that the use of virtual labs can enhance student engagement, learning outcomes, learning efficiency, and the learning experience across various disciplines (Lundberg et al., 2020; Makransky & Petersen, 2021).

Based on these needs, a REACT-OBE-Based Virtual Lab with Artificial Intelligence Integration was developed for Indonesian language learning among Computer Science students. This system is designed as a web-based learning application that supports the implementation of the REACT stages, OBE-based measurement of learning outcomes, and the provision of automated feedback through AI technology. The Virtual Lab provides features such as learning paths, learning modules, exercises, simulations, evaluations, revisions, and AI feedback, all integrated into a single digital learning platform. This system enables students to learn Indonesian language material interactively while receiving more adaptive learning support. The system description indicates that the platform was developed to support the implementation of REACT-based learning integrated with OBE, as well as AI services acting as learning assistants and providers of automated feedback.

Therefore, this study aims to develop and evaluate the implementation of a REACT-OBE-based Virtual Lab integrated with AI in Indonesian language learning for Computer Science students. The contribution of this study lies in the integration of three main approaches-REACT, OBE, and AI-within a virtual lab environment designed to enhance student engagement, learning effectiveness, and the achievement of learning outcomes.

LITERATURE REVIEW

2.1 Digital Learning and Virtual Labs in Higher Education

Digital transformation has shifted the paradigm of learning in higher education from a conventional approach toward a more flexible, collaborative, and student-centered approach. The use of digital technology enables the delivery of course material, learning interactions, and assessments to be conducted more effectively, without being constrained by time or place. Various studies show that digital learning environments can increase student

engagement, improve access to learning resources, and enhance the effectiveness of learning outcomes when supported by appropriate instructional design (Bond et al., 2021; Crompton & Burke, 2023). One form of digital learning innovation that is growing rapidly is the use of Virtual Laboratories (Virtual Labs). Virtual Labs provide a simulated environment that allows students to explore, practice, and conduct experiments independently through digital media. (Lundberg et al., 2020) In their systematic review, the authors found that Virtual Labs and virtual reality technology have a positive impact on students' conceptual understanding, motivation to learn, and learning experience. Similar findings were reported by (Makransky & Petersen, 2021) which shows that virtual environments can enhance students' cognitive and affective engagement compared to traditional learning methods.

However, some studies have also shown that the effectiveness of Virtual Labs is greatly influenced by the design of the learning activities implemented. Virtual environments that serve merely as a medium for delivering content, without structured learning strategies, tend to yield only insignificant improvements in learning outcomes (Lundberg et al., 2020). Therefore, the integration of Virtual Labs with activity-oriented learning models and learning outcomes is a crucial aspect that must be considered. Based on these findings, the development of Virtual Labs for Indonesian language learning requires more than just providing digital media; it must also integrate learning strategies that can foster active student engagement and the achievement of measurable competencies.

2.2 The REACT Learning Model

The REACT (Relating, Experiencing, Applying, Cooperating, and Transferring) learning model is a contextual learning approach developed to connect academic concepts with students' real-life experiences. (Crawford, 2001) explains that REACT emphasizes active learning through five main stages: relating the material to prior experiences, gaining hands-on learning experiences, applying knowledge, cooperating in groups, and transferring knowledge to new contexts.

Various studies have demonstrated the effectiveness of the REACT model in improving learning outcomes and higher-order thinking skills. (Karasubaşi & Güngör Seyhan, 2023) reported that the REACT-based contextual learning approach was able to significantly improve students' conceptual understanding compared to conventional teaching methods. In addition, (Nguyen et al., 2026) In their systematic review, the authors found that the implementation of REACT contributes to improvements in students' problem-solving abilities, communication skills, and motivation to learn.

However, most REACT research still focuses on the fields of science and mathematics education. The implementation of REACT in Indonesian language instruction, particularly for Computer Science students, remains relatively limited. Furthermore, previous studies have generally applied REACT in face-to-face learning or conventional Learning Management Systems (LMS), so there has been little exploration of its integration into a Virtual Lab environment supported by artificial intelligence technology.

These conditions indicate a research opportunity to develop a REACT learning model within a Virtual Lab environment capable of supporting more interactive, contextual, and adaptive learning activities.

2.3 Outcome-Based Education (OBE) in Higher Education

Outcome-Based Education (OBE) is an educational approach that emphasizes the achievement of learning outcomes as the primary focus of the entire learning process. According to (Spady, 1994), All learning activities, teaching strategies, and assessment methods in OBE must be designed to ensure that the established competencies are achieved.

In the context of higher education, OBE has become one of the most widely adopted approaches for improving the quality of graduates and ensuring that their competencies align with the needs of the workforce. (Harden, 2007) states that OBE provides a systematic framework for designing curricula, learning processes, and assessments based on measurable outcomes. Research (Mufanti et al., 2024) It also shows that the implementation of OBE can improve the transparency of assessment, the accountability of the learning process, and the quality of evaluations of student learning outcomes.

Although the adoption of OBE is becoming more widespread, several studies have identified challenges in the implementation process. One of the main issues is the difficulty in continuously monitoring the progress of students' learning outcomes, as well as the limitations of systems capable of providing rapid and accurate feedback. In addition, the process of documenting and measuring learning outcomes often requires a significant amount of time and resources (Mufanti et al., 2024).

Therefore, a digital learning system is needed that can integrate learning activities with automatic monitoring of learning outcomes so that the implementation of OBE can be more effective and measurable.

2.4 The Integration of Artificial Intelligence in Education

Advances in Artificial Intelligence (AI) have brought about significant changes in the world of education. AI enables more personalized learning through the analysis of learning data, content recommendations, automated assessments, and real-time feedback. (Luckin et al., 2022) explains that AI has the potential to support adaptive learning that can be tailored to the needs and characteristics of each student.

A systematic review conducted by (Zawacki-Richter et al., 2019) This shows that AI in higher education is widely used for recommendation systems, learning analytics, automated assessment, and intelligent learning support. Recent developments in Generative Artificial Intelligence technologies, such as ChatGPT, are further expanding the use of AI in education. (Kasneci et al., 2023b) dan (Lo, 2023) reports that generative AI can assist students in the writing process, understanding course material, reflecting on their learning, and providing feedback on academic assignments.

However, there is some debate regarding the use of AI in education. Some researchers highlight the potential for students to become dependent on AI, the risk of plagiarism, and the validity of the results produced by AI systems (Kasneci et al., 2023b; Tlili et al., 2023). Therefore, the use of AI should be designed as a learning assistant rather than as a substitute for the role of instructors or students' critical thinking processes.

In the context of Indonesian language learning, the use of AI still has significant room for development, particularly in providing automated feedback on writing assignments, assessing language proficiency, and offering individualized learning support.

2.5 Literature Review and Research Gaps

Based on the literature review conducted, it can be concluded that Virtual Labs, the REACT learning model, Outcome-Based Education (OBE), and Artificial Intelligence (AI) each make a significant contribution to improving the quality of learning. Virtual Labs have proven capable of creating a flexible and interactive learning environment; REACT supports student-centered, contextual learning; OBE ensures the achievement of measurable learning outcomes; and AI provides adaptive and personalized learning services.

Nevertheless, there are several research gaps that still need to be addressed. First, most research on Virtual Labs focuses on the fields of science and engineering, while its implementation in Indonesian language learning at the university level remains limited. Second, research on the REACT model is generally conducted in conventional learning environments and has not yet been widely integrated into web-based Virtual Lab platforms. Third, the implementation of OBE still faces challenges in continuously monitoring learning outcomes and providing timely feedback to students. Fourth, research on AI in education has largely focused on the general use of AI, while the integration of AI as a learning assistant that supports the REACT model and OBE-based assessment has received relatively little attention.

Thus, this study aims to bridge this gap through the development and implementation of a REACT–OBE-Based Virtual Lab with Artificial Intelligence Integration for Indonesian Language Learning among Computer Science Students. This study is expected to provide a theoretical contribution in the form of a model integrating REACT, OBE, and AI within a Virtual Lab environment, as well as a practical contribution in the form of a learning platform capable of enhancing student engagement, the quality of feedback, and learning outcomes.

METHOD

1. Prosedur Penelitian

Penelitian ini menggunakan metode Research and Development (R&D) dengan model pengembangan ADDIE (Analysis, Design, Development, Implementation, Evaluation) untuk mengembangkan Virtual Lab Pembelajaran Bahasa Indonesia berbasis REACT–OBE dengan integrasi Artificial Intelligence (AI) (Sinaga et al., 2026). Model ADDIE dipilih karena memberikan alur pengembangan media pembelajaran yang sistema- tis, iteratif, dan berorientasi pada kebutuhan pengguna serta kualitas produk yang dihasilkan.

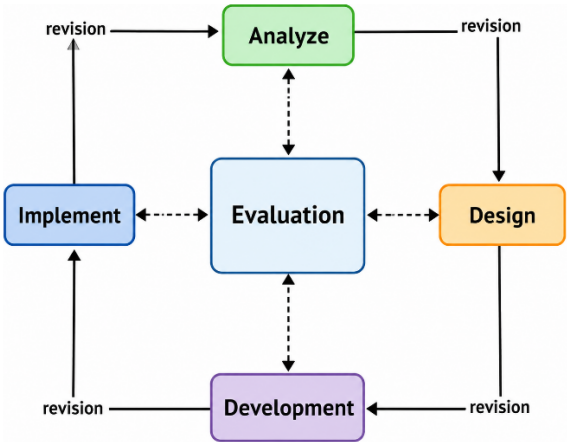

Figure 1. The ADDIE Model Development Process

The research stages were designed to ensure that the Virtual Lab developed is relevant to the characteristics of Computer Science students and aligned with the OBE-based curriculum. The following stages were carried out:

a. Analysis

Identifying the Indonesian language learning needs of Computer Science students at STMIK Pelita Nusantara. The analysis examined the learning outcomes of the course, the characteristics of online learning, students' difficulties with academic writing and formal communication, and the limitations of the learning media used to date.

b. Design

At this stage, a concept for a Virtual Lab integrated with AI features for Indonesian language learning was developed, including interface design, navigation structure, a REACT–OBE-based learning flow, and learning scenarios for academic writing and formal communication.

c. Development

The development phase involved building a web-based Virtual Lab prototype that includes learning modules, interactive writing exercises, learning simulations, and AI-powered feedback features. During this phase, alpha testing was conducted to ensure that the system's basic functions were working properly.

d. Implementation

The Virtual Lab that has been developed was tested by Computer Science students through beta testing. The implementation was carried out to evaluate the system's functionality, usability, and the Virtual Lab's suitability for OBE-based Indonesian language learning.

e. Evaluation

The evaluation phase aims to assess the effectiveness of the Virtual Lab in improving students' academic literacy, scientific writing skills, and formal communication skills. The evaluation is based on pilot test results, user feedback, and a comparison of learning outcomes before and after using the Virtual Lab.

2. Data Collection Techniques and Instruments

Data collection in this study was conducted using three main methods: questionnaires, observation, and interviews. Feasibility validation was conducted using a Likert-scale questionnaire (1–5) administered to three experts in the fields of Indonesian language education and educational technology to assess the appropriateness of the content, functionality, and interactivity of the Virtual Lab. Additionally, limited testing (alpha testing) was conducted internally to ensure that the Virtual Lab's basic functions worked properly. To assess effectiveness, extensive testing (beta testing) was conducted with 30–50 students, using Likert-scale questionnaires, observations, and interviews with students and instructors to measure accessibility, interactivity, and students' level of understanding in learning using the Virtual Lab. Furthermore, the Virtual Lab will be used in the learning process to determine its effectiveness in the learning process.

3. Data Analysis Techniques

The data collected were analyzed using both quantitative and qualitative approaches. The survey results were analyzed using percentage calculations to assess the feasibility of the Virtual Lab, using the formula (∑ Scores obtained / ∑ Maximum scores) × 100%. Data from observations and interviews were analyzed qualitatively using content analysis to identify usage patterns, challenges encountered, and feedback from students and faculty to refine

the Virtual Lab prior to full implementation. The results were categorized as highly feasible (≥ 81%), feasible (61–80%), or in need of revision if the score was below 60%. Meanwhile, to measure the effectiveness of the Virtual Lab in learning, a paired t-test was used to compare pre-test and post-test results.

RESULTS AND DISCUSSION

4.1 Results of the Development of the AI-Integrated REACT–OBE Virtual Lab

This research resulted in a REACT–OBE-Based Virtual Lab application with Artificial Intelligence (AI) integration, developed to support Indonesian language learning for students in the Computer Science program. The system was developed as a web-based application that integrates the REACT learning model (Relating, Experiencing, Applying, Cooperating, and Transferring) with the Outcome-Based Education (OBE) approach and Artificial Intelligence services as a learning assistant. The application provides various key features such as a Dashboard, REACT Learning Path, Learning Modules, Exercises, Simulations, AI Feedback, Revision, Evaluation, and Learning Outcomes. The structure and functions of these features are designed to support structured, learning-outcome-oriented learning.

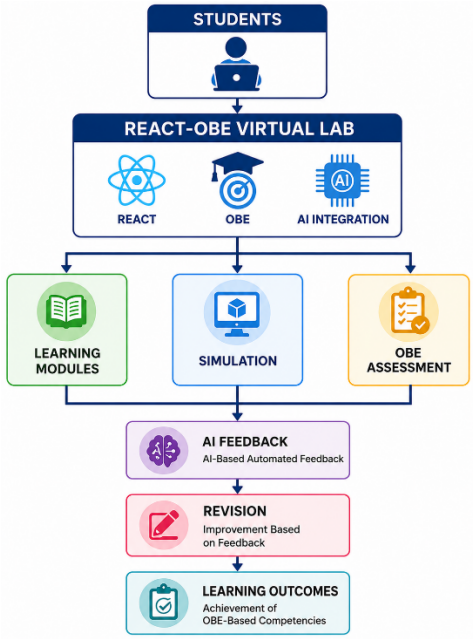

Figure 2. AI-Integrated REACT–OBE Virtual Lab Architecture

System development follows the ADDIE model, which consists of the Analysis, Design, Development, Implementation, and Evaluation phases. All features are designed to support the implementation of REACT-based learning integrated with OBE-based learning outcome assessment.

4.1.1 Implementation of the Login Page

The Login Page is the main gateway for users to access the system. This page provides authentication via email and password, as well as login integration using a Google account. In addition, the login page displays the application's identity, the system's development objectives, and the main features available in the Virtual Lab.

Figure 3. REACT–OBE AI-Integrated Virtual Lab Login Page

The login screen is designed with a user-friendly interface, featuring a predominantly blue color scheme that reflects the institution's identity and conveys a professional image. Users can access the system via both desktop and mobile devices, thereby supporting flexible learning.

4.1.2 Implementation of the Learning Dashboard

After successfully logging in to the system, users will be directed to the Dashboard page. The Dashboard serves as a learning information hub that displays students' learning progress, the current REACT stage they are in, activity schedules, notifications, recent activities, and quick access to the system's main features.

Figure 4. REACT–OBE AI-Integrated Virtual Lab Dashboard

The dashboard clearly shows that the system is capable of visualizing the REACT stages through the indicators Relating, Experiencing, Applying, Cooperating, and Transferring. Additionally, students can monitor their learning progress in real time through the learning completion percentage indicator. The AI Assistant feature at the bottom of the dashboard allows students to receive immediate assistance and feedback during the learning process.

The dashboard also serves as a mechanism for monitoring OBE implementation, as every learning activity performed by students is recorded and linked to the targeted learning outcomes.

4.1.3 Implementation of the AI Feedback Page

One of the standout features developed for the AI-Integrated REACT–OBE Virtual Lab is AI Feedback, a feature that utilizes artificial intelligence technology to provide automatic feedback on assignments completed by students. This feature is designed to help students improve the quality of their academic writing through real-time evaluation and recommendations for improvement.

Figure 5. Artificial Intelligence-Based AI Feedback Page

Based on Figure 5, the system analyzes the text uploaded by students and generates various pieces of information that can be used as a basis for improving assignments. The analysis results include a writing quality score, identification of the text's strengths, areas needing improvement, recommendations for improvement, and the level of alignment with the course's learning outcomes (CPMK).

In the example of the analysis results shown, the system assigns an AI score of 88/100, categorized as "Good." In addition, the system identifies five aspects that meet academic writing criteria and three aspects that still require improvement. The AI also generates four recommendations to improve writing quality, such as using more

effective sentence variation, strengthening arguments based on theory or prior research, and refining paragraph structure to make it more systematic.

Another advantage of this feature is its ability to link analysis results to the Outcome-Based Education (OBE) approach. The system displays the level of alignment between assignments and the CPMK established for each course. In an implementation example, a 90% alignment rate was achieved, indicating that the assignments completed by students met most of the targeted competency indicators.

In addition to providing a summary of the analysis results, the system also highlights the specific text sections that need improvement. This feature helps students understand the exact location of errors, enabling them to revise their work independently and continuously. Thus, AI Feedback serves not only as an evaluation tool but also as a learning assistant that supports the improvement of learning quality.

The implementation of the AI Feedback feature aligns with the REACT learning principles, particularly in the Applying, Cooperating, and Transferring stages, as students have the opportunity to apply the concepts they have learned, receive feedback on their work, and make improvements before entering the final evaluation stage.

4.1.4 Implementation of the Learning Outcomes Page

The Learning Outcomes page is a key feature that supports the implementation of Outcome-Based Education (OBE). This page displays various indicators of student learning outcomes, including provisional GPA, graduation rates, grade trends, competency achievement, learning activities, and AI-powered learning recommendations.

Figure 6. OBE-Based Learning Outcomes Page

As shown in Figure 6, the system is capable of presenting visualizations of students' competency achievements in the form of radar charts and grade progression charts. These visualizations make it easier for students and instructors to continuously monitor academic progress.

In addition, the AI-based recommendation feature provides personalized learning suggestions based on students' evaluation results. Thus, the learning process is not only focused on delivering course material but also supports adaptive competency development tailored to each student's individual needs.

4.2 Media Expert Validation Results

The media was validated by three experts: a professor of educational technology, a professor of software engineering, and a practitioner in the development of educational applications.

Table 1. Media Expert Validation Results

Evaluation Criteria	Skor (%)
User Interface Design	93.33
Ease of Navigation	92.00
Design Consistency	91.67
Functionality Quality	94.00
System Interactivity	92.67
System Performance	93.33
Average	**92.83**

Based on the validation results, an average score of 92.83% was obtained, which falls into the "Highly Valid" category. The validators stated that the system interface is easy to use, navigation is clear, and the AI features are well integrated into learning activities.

Figure 7. Media Expert Validation Results

4.3 Results of Subject Matter Expert Validation

The materials were validated by three Indonesian language instructors with experience in OBE curriculum development and digital-based learning.

Table 2. Results of Subject Matter Expert Validation

Assessment Aspects	Skor (%)
Content Alignment	95.33
CPMK Alignment	94.67
OBE Alignment	95.00
REACT Implementation	93.67
Language and Communication	94.33
Accuracy of Evaluation	93.67
Average	**94.44**

The average expert validation score of 94.44% indicates that the material presented is highly aligned with the Indonesian language learning outcomes for Computer Science students.

4.4 Usability Test Results Using the System Usability Scale (SUS)

Usability testing was conducted on 100 computer science students who used the app for one semester.

Table 3. SUS Test Results

Parameter	Value
Number of Respondents	100
Average SUS Score	86.15
Standard Deviation	5.82
Minimum Value	72.50
Maximum Value	97.50

According to Bangor et al. (2009), a SUS score of 86.15 falls into the “Excellent” category and is classified as Grade A.

Table 4. Distribution of SUS Scores

SUS Range	Frequency
70–79	15
80–89	58
90–100	27
Total	**100**

A total of 85% of respondents scored above 80, indicating that the app has a very high level of ease of use and user satisfaction.

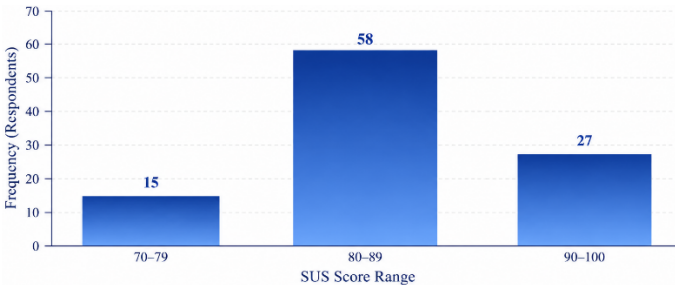

Figure 8. Distribution of SUS Scores

4.5 Learning Effectiveness Results

The effectiveness of the system was evaluated using a one-group pretest–posttest design involving 100 students.

4.5.1 Pretest and Posttest Results

Table 5. Descriptive Statistics

Variable	Mean	SD
Pretest	61.84	8.92
Posttest	85.76	6.37
Gain	23.92	7.11

There was an increase in the average score of 23.92 points after students used the AI-Integrated REACT–OBE Virtual Lab.

4.5.2 Results of the Paired t-Test

Table 6. Results of the Paired-Sample t-Test

Variable	t-statistic	Sig. (2-tailed)
Pretest–Posttest	29.431	0.000

A p-value less than 0.05 indicates that there is a significant difference between the pretest and posttest scores.

4.5.3 N-Gain Results

Table 7. N-Gain Calculation

Mean Pretest	Mean Posttest	N-Gain
61.84	85.76	0.63

An N-Gain value of 0.63 falls into the moderate-to-high category, indicating that the Virtual Lab is effective in improving student learning outcomes.

4.6 Analysis of REACT Learning Activities

An analysis of the system activity logs shows that all stages of REACT can be successfully implemented through the Learning Path available in the app.

Table 8. Completion Rate of REACT Phases

REACT Stages	Completion Percentage (%)
Relating	100
Experiencing	98
Applying	96
Cooperating	92
Transferring	89

The "Transferring" stage has the lowest percentage because students take longer to complete their final projects and present their learning outcomes.

4.7 AI Feedback Results

An analysis of AI feature usage shows that students actively use AI as a learning assistant.

Table 9. AI Feedback Usage Statistics

Parameter	Value
Number of Active Users	100
Average AI/Student Interactions	18.6
Assignments Revised Using AI	92%
AI Satisfaction Rate	88.7%

The AI Feedback feature helps students get quick feedback on the structure of their writing, language use, compliance with CPMK standards, and recommendations for improvement before they submit their assignments.

4.8 Discussion

The research findings show that integrating the REACT model, the Outcome-Based Education (OBE) approach, and Artificial Intelligence into a Virtual Lab can create a more interactive, adaptive, and student-centered learning environment. Implementing the REACT stages allows students to build understanding gradually, starting from connecting concepts to real-world experiences (Relating), exploring the material (Experiencing), applying knowledge (Applying), collaborating (Cooperating), and finally transferring the acquired skills to a broader context (Transferring). This approach makes the learning process more meaningful compared to learning that is solely focused on the delivery of material.

The AI Feedback feature plays a crucial role in supporting self-directed learning. Students can receive immediate feedback on their work without having to wait for an instructor's evaluation. This mechanism encourages a continuous process of reflection, revision, and improvement, enabling students to be more active in developing their academic writing and scientific communication skills. Additionally, the recommendations provided by the system help students understand the areas they need to improve to achieve the targeted competencies.

The implementation of OBE through the learning outcome monitoring feature also adds value to the evaluation process. The system allows students and instructors to continuously monitor competency development through CPMK indicators and learning outcomes that are visualized in an informative manner. Thus, learning evaluation serves not only as a tool for measuring final outcomes but also as a means of continuously monitoring the learning process.

The findings of this study show that the use of artificial intelligence technology in Indonesian language learning has great potential to improve the quality of students' learning experiences. The integration of AI does not replace the role of instructors but serves as a learning companion that helps students receive faster and more personalized feedback. Therefore, the development of an AI-integrated REACT–OBE-based Virtual Lab can be a relevant alternative for digital learning innovation that meets the needs of higher education in the era of digital transformation.

CONCLUSION

This study successfully developed and implemented a REACT–OBE-based Virtual Lab for Indonesian Language Learning integrated with Artificial Intelligence as a digital learning medium for Computer Science students. The developed system is capable of integrating learning activities, assessment, monitoring of learning outcomes, and automated feedback into a single integrated platform.

The research results indicate that the developed Virtual Lab meets the criteria for feasibility, ease of use, and learning effectiveness. The integration of the REACT model helps create a more active and contextual learning process, while the OBE approach supports the measurable monitoring of competency achievement. The AI Feedback feature provides added value by delivering rapid feedback and supporting the process of independent task improvement.

Overall, the REACT–OBE Virtual Lab integrated with Artificial Intelligence has the potential to become an innovative solution to support Indonesian language learning in higher education that is more adaptive, competency-oriented, and aligned with the demands of digital education transformation. Future research could focus on developing more personalized artificial intelligence features and implementing the system across various courses and other academic disciplines.

REFERENCES

Adams, C., Pente, P., Lemermeyer, G., & Rockwell, G. (2023). Ethical principles for artificial intelligence in K-12 education. *Computers and Education: Artificial Intelligence*, *4*. https://doi.org/10.1016/j.caeai.2023.100131

Alanoglu, M., Karabatak, S., & Yang, H. (2026). Understanding university students' self-directed online learning in the context of emergency remote teaching: the role of online learning readiness and digital literacy. *Journal of Computing in Higher Education*, *38*(2), 651–677. https://doi.org/10.1007/s12528-025-09458-0

Anthonysamy, L., Koo, A. C., & Hew, S. H. (2020). Self-regulated learning strategies in higher education: Fostering digital literacy for sustainable lifelong learning. *Education and Information Technologies*, *25*(4), 2393–2414. https://doi.org/10.1007/s10639-020-10201-8

Bhat, R., Kamath, C. R., Mathias, K. A., & Mulimani, P. (2022). Practical Implementation of Outcome-Based Education Practices in the Indian Engineering Institutes-Approach An Objective Based Investigation. In *Journal of Engineering Education Transformations* (Vol. 36, Number 1).

Bond, M., Bedenlier, S., Marín, V. I., & Händel, M. (2021). Emergency remote teaching in higher education: mapping the first global online semester. In *International Journal of Educational Technology in Higher Education* (Vol. 18, Number 1). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1186/s41239-021-00282-x

Crompton, H., & Burke, D. (2023). Artificial intelligence in higher education: the state of the field. *International Journal of Educational Technology in Higher Education*, *20*(1). https://doi.org/10.1186/s41239-023-00392-8

Harden, R. M. (2007). Outcome-based education: The future is today. In *Medical Teacher* (Vol. 29, Number 7, pp. 625–629). https://doi.org/10.1080/01421590701729930

INOVASI, P. (2011). Learning Recovery: Time for Action. *Pusat Penelitian Kebijakan (Puslitjak), Kementerian Pendidikan, Kebudayaan, Riset, Dan Teknologi Republik Indonesia*, 1–7.

Kasneci, E., Sessler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., Gasser, U., Groh, G., Günnemann, S., Hüllermeier, E., Krusche, S., Kutyniok, G., Michaeli, T., Nerdel, C., Pfeffer, J., Poquet, O., Sailer, M., Schmidt, A., Seidel, T., … Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences*, *103*, 102274. https://doi.org/https://doi.org/10.1016/j.lindif.2023.102274

Lo, C. K. (2023). What Is the Impact of ChatGPT on Education? A Rapid Review of the Literature. In *Education Sciences* (Vol. 13, Number 4). MDPI. https://doi.org/10.3390/educsci13040410

Luckin, R., Holmes, W., Griffiths, M., & Pearson, L. B. F. (2023). *Intelligence Unleashed An argument for AI in Education*.

Lundberg, A., de Leeuw, R., & Aliani, R. (2020). Using Q methodology: Sorting out subjectivity in educational research. In *Educational Research Review* (Vol. 31). Elsevier Ltd. https://doi.org/10.1016/j.edurev.2020.100361

Mahajani, R. S., Abbas, N., & Djakaria, I. (2024). React Strategy on Mathematical Reasoning Reviewed From Students' Interest In Learning Mathematics. In *Jurnal Inovasi Pendidikan Matematika* (Vol. 12).

Makransky, G., & Petersen, G. B. (2021). The Cognitive Affective Model of Immersive Learning (CAMIL): a Theoretical Research-Based Model of Learning in Immersive Virtual Reality. In *Educational Psychology Review* (Vol. 33, Number 3, pp. 937–958). Springer. https://doi.org/10.1007/s10648-020-09586-2

Nguyen, T. T., Nguyen Van, T., Tong, D. H., & Thi-Nga, H. (2026). Applying the REACT strategy in teaching derivatives to enhance students' academic achievements and mathematical problem-solving skills. *Cogent Education*, *13*(1). https://doi.org/10.1080/2331186X.2026.2636439

Nizar Zulfikar, R., Ralmugiz, U., Fatmawati, A., Aba, M. M., Syarief, N. H., & Ketty, F. (2025). Unlocking Higher Order Thinking With React Strategy: An Effective Solution For 21st Century Learning. *JTMT: Journal Tadris Matematika*, *6*(1), 15–21. https://doi.org/10.47435/jtmt.v6i1.3722

Patrinos, H. A. (2022). Learning loss and learning recovery. *DECISION*, *49*(2), 183–188. https://doi.org/10.1007/s40622-022-00317-w

Spady, W. G. (1994). *Outcome Base Education: Critical Issues and Answers*.

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? In *International Journal of Educational Technology in Higher Education* (Vol. 16, Number 1). Springer Netherlands. https://doi.org/10.1186/s41239-019-0171-0