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Enhancing Distance Learning Through Client-Server-Based Learning Media in Object-Oriented Programming Education

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Abstract: This study aims to develop and test the effectiveness of client-server-based learning media for Object-Oriented Programming courses in the Informatics Study Program at PGRI University of West Sumatra. The research employed the Research and Development method with the ADDIE model. Validation was conducted by media and material experts, with media validation reaching 77.55% (valid category) and material validation 83.90% (highly valid category). Practicality testing by lecturers showed a practicality level of 87.00% and by students 86.31% (very practical category). Learning effectiveness was measured through learning outcome tests with a classical completeness rate of 96.67% and an N-Gain value of 0.687 (medium category). The results indicate that the developed client-server-based learning media is valid, practical, and effective for distance learning in Object-Oriented Programming courses.

Keywords: ADDIE; Client-server; Distance learning; Learning media; Object-oriented programming

Introduction

The rapid advancement of digital technology has significantly transformed the educational landscape, particularly in the realm of distance learning (Siemens, 2005; Garrison & Vaughan, 2008). This transformation presents both opportunities and challenges in optimizing the learning process (Rosenberg, 2001). While mobile technology has become an integral part of modern education, its implementation still encounters various technical and pedagogical obstacles (Sari & Priatna, 2020; Bates, 2019). Several studies indicate that mobile learning enhances flexibility, yet it requires well-structured instructional design to maintain student engagement (Salmon, 2013; Reeves et al., 2002).

One of the main challenges in distance learning is the limited functionality of mobile applications, which can hinder access and interaction during learning activities (Adhani & Nazurrail, 2022; Anderson & Dron, 2011). These limitations not only affect device performance but also significantly impact learning effectiveness (Meyer, 2014;Richardson & Swan, 2003). Sun et al. (2008) highlighted that technical constraints, such as unstable internet connections and device compatibility issues, often disrupt learning continuity, thereby diminishing the overall quality of students' educational experiences (Widiastika et al., 2020).

The development of Information and Communication Technology (ICT) has encouraged the transition toward more flexible and adaptive learning approaches (Laurillard, 2012; Pappas, 2015). Rosenberg (2001) identified fundamental shifts in learning, including the movement from conventional classroom-based instruction to digital learning environments accessible anytime and anywhere. Additionally, this transition involves shifting from static, physical media to dynamic, network-based learning (Bonk & Graham, 2012). The Learning Management System (LMS) has played a critical role in integrating various elements of distance learning (Moore & Kearsley, 2011; Picciano, 2017). However, LMS implementations still face

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challenges such as accessibility issues and suboptimal learner engagement (Sholihah et al., 2023).

A preliminary study conducted through observations and interviews with Informatics lecturers at the University of PGRI West Sumatra revealed specific problems in learning the Object-Oriented Programming (OOP) course. Students frequently encounter difficulties in accessing e-learning platforms due to server overload during peak hours (Fauzi et al., 2021). This issue is further exacerbated by the reliance on separate applications with limited mobile functionality, which hinders seamless interaction between students and instructors (Ahmad, 2020; Rovai, 2002).

Furthermore, the excessive use of PowerPoint slides in distance learning has been identified as another limitation (Fadillah et al., 2021). While PowerPoint presentations aid in delivering visual information, excessive dependence on them can reduce instructional variety and limit student engagement (Nurfadhillah et al., 2021; Aryanti et al., 2023). Previous studies suggest that client-server-based learning media can provide a solution to these issues (Natsir, 2021; Setiawan et al., 2022). An analysis of nine studies that implemented client-server architecture in learning showed positive results in improving learning interactions, as illustrated in Figure 1.

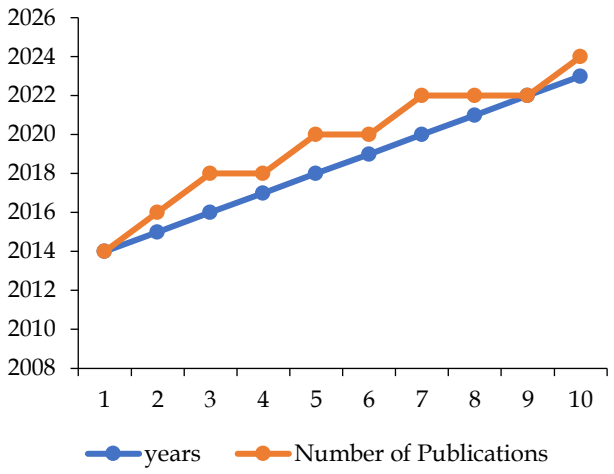

Figure 1. Dimensions data

The client-server architecture offers several advantages for distance learning (Mishra & Panda, 2007; Means et al., 2010). First, it optimizes mobile application performance by distributing computing loads between clients and servers, thereby enhancing efficiency and minimizing device limitations (Febriana et al., 2021). Second, the client-server approach ensures consistent access to learning materials and facilitates more effective content management (Pappas, 2015). Third, the integration of interactive features through a server-managed platform significantly enhances interaction and engagement in distance learning (Pratomo & Irawan, 2015; Al-Qahtani & Higgins, 2013).

The utilization of client-server architecture brings several significant advantages (Amalia et al., 2023). First, optimizing the use of mobile applications through interaction with servers can increase efficiency and reduce the load on devices (Febriana et al., 2023). Second, the client-server approach allows for more consistent access to learning materials and more effective content management (Natsir 2021). Third, the integration of interactive features managed by servers can overcome the limitations of interaction in distance learning (Widiastika et al., 2020).

The novelty of this research lies in the development of client-server-based learning media specifically designed for Object-Oriented Programming courses, with a strong focus on optimizing distance learning. Unlike previous studies that separately examined technical and pedagogical aspects, this study integrates both to provide a comprehensive learning solution (Mayer, 2009; Richardson & Swan, 2003).

This study aims to develop and evaluate the effectiveness of a client-server-based learning platform that addresses the challenges of distance learning in OOP courses. The research follows a systematic development model to ensure validity, practicality, and effectiveness (Rovai 2002; Meyer, 2014). The expected outcome is to provide a scalable model that can be applied to similar learning environments in other disciplines.

The urgency of this research is reinforced by the increasing need for innovative learning solutions that overcome mobile application limitations, optimize learning interactions, and provide a more adaptive and responsive learning experience (Moore & Kearsley, 2011; Reeves et al, 2002). By implementing a client-server-based approach, this study aims to enhance the quality of distance learning and offer an effective, scalable solution for higher education institutions worldwide (Bonk & Graham, 2012).

Method

This research employed the Research and Development (R&D) approach to develop a client-server based learning media for distance learning. The ADDIE (Analysis, Design, Development, Implementation, Evaluation) model was adopted as the development framework, following a systematic process to ensure the quality and effectiveness of the final product.

Analysis Phase

The analysis phase involved a thorough needs assessment conducted at the Informatics Education Study Program of PGRI University of West Sumatra.

This assessment focused on three main areas: first, the evaluation of existing learning media, which identified gaps in the current distance learning practices. Second, a detailed content analysis was carried out to examine the Object-Oriented Programming curriculum and its material requirements, ensuring that it met the academic standards and learning goals. Finally, a user requirements analysis was conducted by gathering input from both faculty and students, allowing for a comprehensive understanding of their needs and challenges in the learning process. This phase was crucial in providing insights to guide the development of effective and relevant educational tools.

Data collection during this phase utilized observation and structured interviews with stakeholders. This systematic approach helped identify specific requirements for the client-server based learning media.

Design Phase

The design phase focused on creating detailed specifications for the learning media. This phase incorporated several key activities: Content Structure Design: Learning objectives mapping, Material organization and sequencing, Assessment strategy development; and Technical Architecture Design: Client-server infrastructure planning, User interface wireframing, Database schema design.

Table 1 presents the design specifications framework used in this phase.

Table 1. Validity questionnaire grid and assessment indicators

Aspect	Indicator
Quality and Purpose	Accuracy, Interest, Completeness, Balance, Interest/attention, Justice, Compliance with situation student
Quality Instructional	Give chance Study, Give help Study, Quality motivation, Flexibility instructional, Connection with other learning programs, Quality social interaction instructional, Quality tests and assessments, Can give impact for student, Can carry impact for lecturers and their learning
. Technical Quality	Legibility, Easy used, Quality display/impression, Quality Handling answer, Quality management the program, Quality its documentation

Development Phase

The development phase involved the actual creation of the client-server based learning media. This process followed these steps: Frontend Development: User interface implementation, Client-side functionality development, Responsive design implementation; Backend Development: Server architecture setup, Database implementation, API development; Content Integration: Learning material digitization, Assessment system implementation, Media elements integration.

Implementation Phase

The implementation phase utilized a controlled rollout approach with the following steps: Initial Testing: System functionality verification, Performance testing, Security testing; User Training: Faculty orientation sessions, Student training workshops, Technical support setup; Pilot Implementation: Small group testing, Feedback collection, System optimization.

Evaluation Phase

The evaluation phase employed a comprehensive assessment approach using both quantitative and qualitative methods: Validity Testing: Expert review by media specialists (n = 2), Content validation by subject matter experts (n = 2), Technical validation by IT professionals; Practicality Assessment: Faculty usability testing (n = 2), Student experience evaluation (n = 30), System performance analysis; Effectiveness Measurement: Pre-test and post-test comparison, Learning outcome analysis, User satisfaction surveys.

The effectiveness was measured using the N-Gain (g) Score formula:

$$g = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}} \times 100 \quad (1)$$

Where:
S_{post} = Post-test average score
S_{pre} = Pre-test average score
S_{max} = Maximum possible score

Table 2. Effectiveness evaluation criteria

Level of Achievement	Category
0–0.666	In Valid
≥ 0.667	Valid

This methodology was designed to ensure a systematic and comprehensive development process, with clear validation and evaluation procedures at each stage. The research employed both qualitative and quantitative data collection methods, providing a robust framework for developing and assessing the effectiveness of the client-server based learning media.

Results and Discussion

This study presents the development and evaluation of a client-server based learning media for distance education. The research implemented the

ADDIE development model, consisting of Analysis, Design, Development, Implementation, and Evaluation phases. The effectiveness of the developed learning media was assessed through validation testing, practicality evaluation, and effectiveness measurement.

Validation Analysis

The validation process involved both media and content experts to ensure the quality and appropriateness of the developed learning media. Table 3 presents the results of the media validation assessment based on three key aspects.

Table 3. Media validation results (Scale 0-1)

Assessment Aspects	Validation Values	Category
Content Aspects	0.736	Valid
Structural Aspects	0.817	Valid
Technical Aspects	0.77.4	Valid
Average	0.775529101	Valid

Note: Validation criteria: 0.00-0.20 (Invalid), 0.21-0.40 (Less Valid), 0.41-0.60 (Moderately Valid), 0.61-0.80 (Valid), 0.81-1.00 (Highly Valid)

The content validation assessment, conducted by two subject matter experts in object-oriented programming, yielded the following results.

Table 4. Content validation results (Scale 0-1)

Assessment Aspects	Validation Values	Category
Learning Aspects	0.839	Valid
Material Aspects	0.838	Valid
Average	0.896	Valid

These validation scores align with previous research by Astuti et al. (2019), who found that well-designed educational media typically achieve validation scores above 0.70 on similar assessment criteria.

Practicality Analysis

The practicality of the learning media was evaluated through assessments by both instructors and students. Table 5 presents the instructor practicality assessment results.

Table 5. Lecturer practicality assessment results

Indicators	Percentage (%)	Category
Ease of Use Aspect	90.00	Very Practical
Time-effectiveness	85.00	Very Practical
Product Appeal	90.00	Very Practical
Media performance	80.00	Very Practical
Equivalence	90.00	Very Practical
Average Percentage (%)	87.00	Very Practical

Note: Practicality criteria: 0-20% (Very Impractical), 21-40% (Impractical), 41-60% (Moderately Practical), 61-80% (Practical), 81-100% (Very Practical)

Student practicality assessment results revealed similar positive outcomes:

Table 6. Student practicality assessment results (n = 30)

Indicators	Percentage (%)	Category
Ease of use of media	93.33	Very Practical
Time-effectiveness	83.33	Very Practical
Product Appeal	82.89	Very Practical
Media performance	84.00	Very Practical
Equivalence	88.00	Very Practical
Average Practicality	86.31	Very Practical

Effectiveness Analysis

The effectiveness of the learning media was evaluated using two key metrics: learning mastery achievement and normalized gain scores. The learning mastery criterion was set at 75 based on the institution's minimum competency requirements.

Table 7. Learning mastery achievement (n = 30)

Number of students	Complete	Incomplete	Percentage Results (%)
30	29	1	96.67

The normalized gain score analysis showed the following results.

Table 8. Normalized gain score analysis

Class	N	Minimum G-Score value	Maximum G-Score Value	Average G-Score
I	30	0.27027027	0.930232558	0.6870291

Note: N-Gain criteria: $g > 0.7$ (High), $0.3 \leq g \leq 0.7$ (Medium), $g < 0.3$ (Low)

Implementation and User Response

The implementation phase revealed several key findings through user feedback. Students reported increased motivation and engagement with the learning material, consistent with findings by Pratomo & Irawan (2015) regarding the positive impact of client-server based learning systems on student engagement. The flexibility of accessing learning materials "anytime,

anywhere" was particularly appreciated, as noted in student feedback.

"The client-server based learning media facilitates better understanding of the material and allows for flexible learning schedules." - Student feedback.

This aligns with recent research on digital learning flexibility by Rosyid & Mubin (2024), who found that accessibility and flexibility are key factors in successful distance learning implementations.

System Improvements

Based on validator feedback, several improvements were implemented: Enhanced security through CAPTCHA implementation; Improved material presentation formatting; Enhanced user interface based on student feedback.

These improvements contributed to the high practicality scores observed in both instructor and student assessments.

Research Limitations

The study acknowledges several limitations: The implementation was limited to third-semester object-oriented programming courses; The study involved a relatively small sample size (n = 30); Time constraints in testing the complete range of system features.

These limitations suggest opportunities for future research with larger sample sizes and broader implementation contexts.

Conclusion

Research on the development of client-server-based learning media for Object-Oriented Programming courses has succeeded in producing valid, practical, and effective products. The validity of learning media is shown through the assessment of media experts with an average of 77.55% and material experts 83.90%, meeting the eligibility standards of learning media. The practicality aspect is evidenced by positive responses from lecturers (87.00%) and students (86.31%), showing the ease of use and effectiveness of learning time. The effectiveness of learning is reflected in the classical completeness level of 96.67% and the N-Gain value of 0.687, indicating a significant increase in student understanding.

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Author Contributions

Conceptualization, methodology, formal analysis, data curation, and writing—original draft preparation, H.P.B.Z.; supervision, validation, investigation, resources, writing—review and editing, visualization and software, M.M., D.I., and M.G. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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