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# Transforming Economics Learning in Phase E at Inclusive Senior High Schools: Developing the EcoLearn Application Based on M-Learning

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Keywords

*EcoLearn, M-Learning, Phase E Economics, Instructional Media, Differentiated Learning*

**Abstract**

The learning process should encourage students' initiative, creativity, and independence in line with their potential and developmental stages. Economics learning in Phase E of Grade X senior high school serves as a fundamental basis for understanding core economic concepts. This study developed and evaluated the EcoLearn application, an adaptive and interactive m-learning–based medium, using the ADDIE model. A quasi-experimental design with nonequivalent control groups was implemented at SMAN 4 Sidoarjo (35 students per class) and SMAN 2 Sidoarjo (40 students per class). Expert validation confirmed high feasibility (content 87.82%, media 95.71%, language 95.38%). The experimental classes showed significant improvement in conceptual understanding compared to the control classes, with N-Gain scores of 0.7775 and 0.7592 (high category). Student responses were highly positive (92.14% and 93.13%), highlighting ease of use and increased motivation, particularly for inclusive students. The findings demonstrate that EcoLearn is effective, feasible, and impactful in strengthening differentiated learning, while also supporting inclusive education for students with mild learning difficulties such as slow learners and physically disabled students.

## Introduction

In the era of digital transformation and the implementation of the *Merdeka Curriculum*, education is required to be more adaptive, inclusive, and oriented toward the development of 21st-century competencies (Surjanti et al., 2018). These competencies serve as the main foundation for creating individuals who are adaptable to change and competitive at the global level. The learning process is not only centered on teachers and subject matter but also emphasizes students' active engagement through enjoyable, flexible, and relevant approaches and methods (Mufida et al., 2022). Learning is viewed as a complex interaction between teachers and students, grounded in systematically designed strategies, methods, and media. This perspective aligns with the spirit of differentiated learning, which provides space for the diversity of students' characteristics, potentials, and learning needs, including those in inclusive environments (Langgi & Hakim, 2021).

Ministerial Regulation No. 70 of 2009 requires every district/city to designate at least one elementary school, one junior high school in each subdistrict, and one senior high school/vocational school to provide inclusive education (Permendikbudristek, 2022). In its implementation, regular schools are mandated to admit students with special needs, with a minimum proportion of 10% of the total number of students accepted each academic year (Arifin et al., 2023). This policy aims to ensure that children with special needs have equal access to education and receive adequate support in their learning process. Recent data indicate that as of December 2023, there were 40,164 formal schools in Indonesia accommodating students with special needs (Sulasmi et al., 2025). However, only 5,956 schools, or about 14.83% of the total, had special education teachers assigned to support them. Furthermore, the number of inclusive schools increased from 35,802 in 2021 to 44,477 in 2023, with the number of students with special needs enrolled in regular schools reaching 146,205 (Sulasmi et al., 2025).

Major challenges are still being faced, including the low level of inclusive culture, limited adaptive media, a shortage of competent teachers, and inadequate infrastructure and technology (Mat Redhuan et al., 2018). Although inclusive policies have been implemented, many regular schools continue to rely on conventional methods that are less adaptive. The main obstacles include the lack of innovative learning media tailored to students' sensory, cognitive, and motor needs (Denisa & Hakim, 2021). Existing media are generally limited in visual elements, lack interactivity, and are inflexible in delivering information. Furthermore, the implementation of differentiated learning, which emphasizes student-centered approaches, remains suboptimal, primarily due to limitations in teacher competence, resources, and supporting facilities. In fact, adaptive and differentiated learning strategies are crucial for creating inclusive learning environments (Mat Redhuan et al., 2018).

The integration of technology into learning media has become a key driver of modern educational transformation in the digital era. Educational technology has been proven applicable across various levels and subjects, including Economics (Hakim et al., 2020), in line with 21st-century learning that emphasizes personalization, flexibility, and active student engagement (Surjanti et al., 2020). Technology has given rise to dynamic learning models such

as mobile applications and interactive platforms (Gómez-Ramirez et al., 2019). This study aligns with previous research that developed m-learning media using Articulate Storyline applications (Octavia et al., 2021), electronic media based on textbooks (Hakim et al., 2024), the influence of online learning media (Karwati et al., 2022), gamification-based learning media (Andriani et al., 2023), interactive e-books (Fatihasari & Hakim, 2019), and CAI-based multimedia (Ariska & Hakim, 2021). These studies underline the importance of technological innovation in enhancing the effectiveness of Economics learning by strengthening conceptual understanding and analytical thinking skills. M-learning, through audio, visual, and kinesthetic elements, has been shown to improve student motivation, engagement, and comprehension (Alyoussef, 2021). M-learning applications equipped with mini-games, adaptive quizzes, videos, and visual materials not only make learning more engaging and inclusive but also integrate theory and practice effectively (Shah et al., 2019). As a result, m-learning based applications have emerged as a strategic solution to create Economics learning that is engaging, enjoyable, and effective (Efrina et al., 2020), while significantly improving students' knowledge, motivation, and learning outcomes (Swanson, 2020).

Research conducted by (Shukla, 2021) demonstrated that m-learning based applications are effective as learning tools. This effectiveness is primarily supported by the visualization features designed within the application. Such visualization not only presents the material more clearly and attractively but also serves as a driver of students' learning motivation, thereby enhancing their participation and comprehension. A similar study by Hwang (Hwang, 2020) reinforced these findings by emphasizing that the strong flexibility embedded in m-learning applications enables students to grasp complex concepts more effectively through the use of images, illustrations, and engaging designs. Other studies also revealed that m-learning applications improve not only students' knowledge but also their skills, including in economics learning. This is consistent with the findings of (Octavia et al., 2021) and (Chien, 2020), which highlighted that m-learning applications create enjoyable learning experiences and help reduce students' psychological stress.

Previous studies have shown that students require innovative and interactive learning media and materials to make learning more engaging, enjoyable, and meaningful. In response to this need, the EcoLearn application was developed as an m-learning based medium that integrates interactive quizzes, adaptive exercises, group discussions, learning materials, and instructional videos. The application supports differentiated learning and allows students to learn flexibly according to their individual needs. It presents Phase E Economics material through visual, auditory, and kinesthetic approaches, helping students grasp abstract concepts in a more concrete and contextual manner. Accessible via Android devices, laptops, and websites, EcoLearn promotes student-centered learning and self-directed learning, while adapting to differences in students' abilities and characteristics.

## Method

This study employed the Research and Development (R&D) method by adopting the ADDIE development model, which consists of five systematic stages: Analysis, Design,

Development, Implementation, and Evaluation (Sugiyono, 2017). The detailed explanation of each stage of the ADDIE model implementation is presented as follows:


**Figure 1** Research Design

The trial of the EcoLearn m-learning application was conducted in two types of educational institutions, namely an inclusive school (SMAN 4 Sidoarjo) and a regular school (SMAN 2 Sidoarjo), in order to examine the applicability and inclusiveness of the developed learning media. Data were collected using several techniques: (1) interviews with Economics teachers; (2) classroom observations of learning dynamics; (3) product review; (4) expert validation to assess feasibility; and (5) questionnaires to capture students' responses. The details of the data collection methods and research analysis are presented as follows:

**Table 1** Data Collection Criteria

| Criteria | Required Data | Data Collection Method |
|---|---|---|
| Feasibility | Media quality | Expert validation sheet |
| Effectiveness | Learning outcomes | Test |
| Student response | Ease of use, attractiveness, and efficiency | Student response questionnaire |

Source: Author's compilation (2025)

**Table 2** Expert Validation Score Interpretation

| Percentage Score (%) | Interpretation Criteria |
|---|---|
| 0% – 20% | Very unfeasible |
| 21% – 40% | Unfeasible |
| 41% – 60% | Fairly feasible |
| 61% – 80% | Feasible |
| 81% – 100% | Highly feasible |

Source: (Riduwan, 2016)

Based on the data analysis, the EcoLearn application was declared feasible for use with a feasibility score of ≥ 61%. The effectiveness test was conducted to measure the extent to which EcoLearn improves learning outcomes in differentiated Economics learning for Phase E. This study employed a quasi-experimental design using the nonequivalent control group model. The design is illustrated as follows:

**Table 3** Nonequivalent Control Group Design

| Group | Pretest | Treatment | Posttest |
|---|---|---|---|
| Experimental | O1 | X (EcoLearn m-learning application) | O2 |
| Control | O3 | – (No treatment) | O4 |

Description:

O1 : Experimental group before treatment O2 : Experimental group after treatment

O3 : Control group before treatment O4 : Control group without treatment

X : Treatment using the EcoLearn m-learning application

To assess the effectiveness of EcoLearn, normality testing (Kolmogorov–Smirnov), homogeneity testing, and hypothesis testing were conducted. The normality test ensured the distribution of data, while the homogeneity test examined the equality of variances between groups. Effectiveness was tested using the Independent Sample T-Test at a 5% significance level or the Wilcoxon Signed Rank Test if the data were not normally distributed.

**Table 4** N-Gain Criteria

| N-Gain Score | Criteria |
|---|---|
| G ≥ 0.71 | High |
| 0.70 ≥ g ≥ 0.31 | Medium |
| G ≤ 0.30 | Low |

Source: (Rangkuti, 2016)

**Table 5** Interpretation of Student Response Scores

| Percentage Score (%) | Interpretation Criteria |
|---|---|
| 0% - 20% | Very poor |
| 21% - 40% | Poor |
| 41% - 60% | Fair |
| 61% - 80% | Good |
| 81% - 100% | Very good |

Source: (Riduwan, 2016)

## Results and Discussion

### Results

1. **Analysis Stage**

   The EcoLearn m-learning application was developed using the ADDIE model, validated by experts, and subsequently tested through a limited trial (20 students) and a field trial (75 students across two senior high schools). Performance analysis was carried out through teacher interviews, revealing that learning remained dependent on worksheets (LKS) and textbooks, with low student participation, particularly in inclusive classes. The lack of adaptive and interactive media served as the background for developing the EcoLearn m-learning application, which was designed to support active engagement, flexible learning, and diverse student needs.

2. **Design Stage**

   In the design stage, the researcher formulated the specifications of the EcoLearn m-learning application as a solution to the limited interactivity of conventional media. The application was designed to be accessible via Android devices, laptops/computers, and the web to ensure flexibility, and featured a user-friendly interface. Its main features included interactive materials, videos, discussion forums, quizzes, and pre post tests based on learning indicators. The initial design was developed through storyboards and thematic visual layouts to enhance an adaptive learning experience.

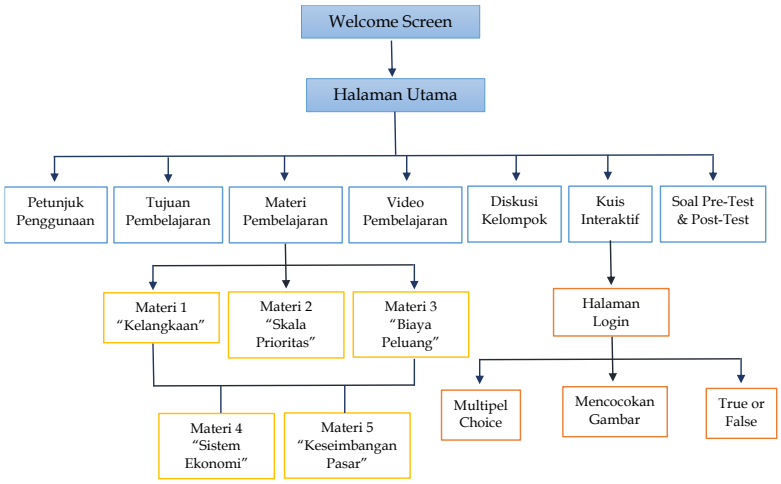



**Figure 2** Prototype of the Initial Product Design

## 3. Development Stage

At this stage, the EcoLearn m-learning application was materialized into a concrete product and has been under development since January 2025.

a. Welcome Screen Design


The initial interface of the EcoLearn application was designed with a light blue, white, and yellow theme to create an elegant and comfortable appearance. A 3D cartoon logo was incorporated to visually clarify the function of each menu. The application is available on two platforms: the web version at (https://bit.ly/appecolearn) and the Android version at (https://www.mediafire.com/file/ycwf1b7w7fevy35/Ecolearn+APP.apk/file).

**Figure 3** Design of the Welcome Screen

b. Design of the Main Menu


The main menu of EcoLearn appears after pressing the Start button and consists of seven primary navigation features: user guide, learning objectives and outcomes, materials, videos, group discussions, interactive quizzes, as well as pre-test and post-test.

**Figure 4** Design of the Main Menu

c. Design of the User Guide Page

The user guide page in the EcoLearn m-learning application provides an introductory manual that helps students understand how to access and utilize each feature of the application.

**Figure 5** Design of the User Guide Page

d. Design of the Learning Objectives Page

The learning objectives page presents chapter based outcomes that are relevant to real life contexts, equipped with navigation to the learning materials and symbolic visuals to support students understanding.

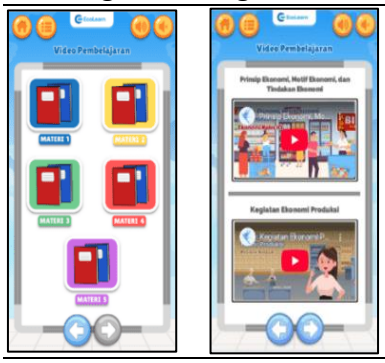
**Figure 6** Design of the Learning Objectives

e. Design of the Learning Materials Page

The learning materials page presents Phase E economics content for each chapter in a visual interactive format, complete with illustrations and navigation. The learning materials menu in EcoLearn covers five main topics of Phase E economics, ranging from scarcity to market equilibrium.

**Figure 7** Design of the Learning Materials Page

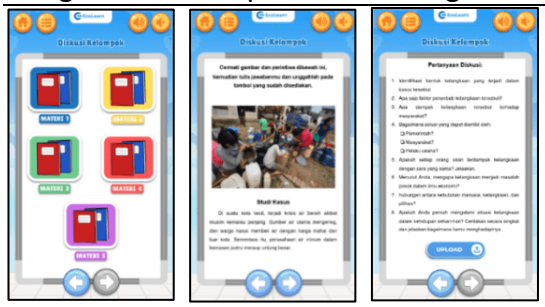
f. Learning Video Page



The learning video page features narrative and illustrative YouTube videos focused on conceptual understanding, equipped with chapter-based navigation, a back button, and supporting animations.

**Figure 8** Learning Video Page

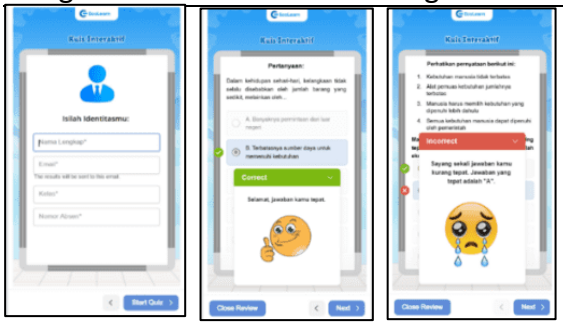
g. Design of the Group Discussion Page



The group discussion page is designed to be interactive, featuring worksheets that foster critical and collaborative thinking. Its engaging design is complemented by an upload feature for submitting discussion results in Word, PDF, or image formats.

**Figure 9** Design of the Group Discussion Page

h. Design of the Interactive Quiz Page



The interactive quiz page is designed to be engaging, featuring emoticons for each answer and providing immediate explanations as feedback and comprehension assessment.

**Figure 10** Design of the Interactive Quiz Page

i. Design of the Pre-Test and Post-Test

The evaluation page is designed to measure the impact of the application on learning outcomes. Students first log in, then complete a pre-test (score only) and a post-test (score, answers, and explanations). The evaluation results are used to quantitatively assess the effectiveness of the application.

**Figure 11** Design of the Pre-Test and Post-Test

The product validation stage involved expert analysis of three main aspects: content substance, media design, and language.

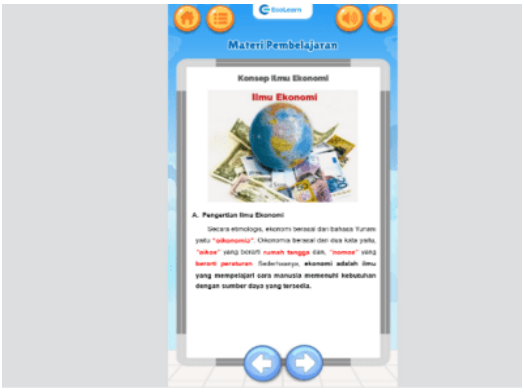
**Table 6** Recapitulation of Expert Validation Results

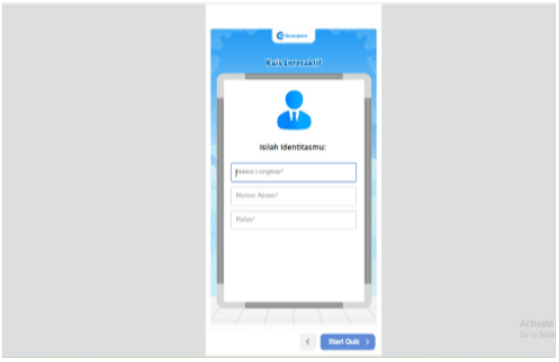
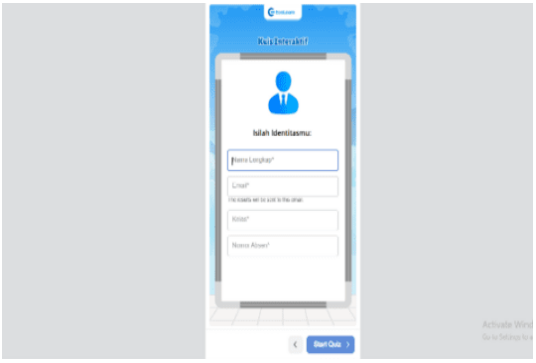
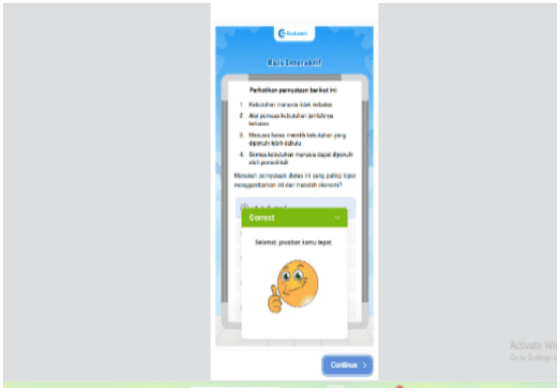
| No | Validator | EcoLearn Application | |
|---|---|---|---|
| | | Score (%) | Category |
| 1 | Content Expert (Prof. Dr. Waspodo Tjipto Subroto, M.Pd.) | 87.82% | Highly Feasible |
| 2 | Media Expert (Dr. Husni Mubarok, S.Pd., M.Sc.) | 95.71% | Highly Feasible |
| 3 | Language Expert (Andik Yuliyanto, S.S., M.Si.) | 95.38% | Highly Feasible |

Source: Data processed by the researcher (2025)

Based on the feedback, the researcher revised the EcoLearn application to improve its content, visual design, and language. The details of the revisions are explained in the following section.

**Table 7** Product Revisions

| No | Before Revision | After Revision |
|---|---|---|
| 1. |  |  |
| | **Revision Note:** Place greater emphasis on the learning objectives. | **Revision:** Emphasize essential information in the "Learning Objectives" |
| 2. | **Before Revision** | **After Revision** |
| |  |  |
| | **Revision Note:** Incorporate both pre-test and post-test evaluation features. | **Revision:** Integrated pre-test and post-test evaluation featurs to enhance student participation. |
| 3. | **Before Revision** | **After Revision** |
| |  |  |
| | **Revision Note:** Emphasize key sentences by bolding them. | **Revision:** Enhanced content and emphasized important points. |

| 4. | **Before Revision** | **After Revision** |
|---|---|---|
| |  |  |
| | **Revision Note:** Incorporated a student email input in the interactive quiz login menu. | **Revision:** Incorporated student email feature to facilitate independent evaluation. |
| **5.** | **Before Revision** | **After Revision** |
| |  |  |
| | **Revision Note:** Include immediate feedback and explanations while the quiz is in progress. | **Revision:** Provide explanations for all questions. |

**4. Implementation Stage**

After being validated, the EcoLearn application was trialed with 20 students (small group) and 75 students (large group) from two senior high schools. The trial aimed to measure students' responses and engagement.

**Table 8** Small Group Trial

| Aspect Assessed | Percentage (%) | Criteria |
|---|---|---|
| Software Aspect | 89 | Very Good |
| Learning Aspect | 88,57 | Very Good |
| Visual Communication Aspect | 88,75 | Very Good |
| Overall Average | 88,75 | Very Good |

Source: Processed Data by Researcher (2025)

The small group trial with 20 students yielded an overall score of 88.75%. According to the interpretation criteria, this indicates that the EcoLearn application is feasible for use and can proceed to the large group trial.

**Table 9** Large Group Trial Results SMAN 4 Sidoarjo and SMAN 2 Sidoarjo

| **SMAN 4 Sidoarjo** | | | **SMAN 2 Sidoarjo** | | |
|---|---|---|---|---|---|
| **Aspect Assessed** | **(%)** | **Criteria** | **Aspect Assessed** | **(%)** | **Criteria** |
| Software Aspect | 94.28 | Very Good | Software Aspect | 95.00 | Very Good |
| Learning Aspect | 92.24 | Very Good | Learning Aspect | 91.78 | Very Good |
| Visual Communication Aspect | 89.28 | Very Good | Visual Communication Aspect | 93.12 | Very Good |
| Overall Average | 92.14 | Very Good | Overall Average | 93.13 | Very Good |

Source: Processed Data by Researcher (2025)

a. Normality Test

**Table 10** Recapitulation Normality Test Results for Pre-Test and Post-Test Data (SMAN 4 Sidoarjo and SMAN 2 Sidoarjo)

Tests of Normality

| | | SMAN 4 Sidoarjo | | | SMAN 2 Sidoarjo | | |
|---|---|---|---|---|---|---|---|
| | | Kolmogorov-Smirnova | | | Kolmogorov-Smirnova | | |
| | Class | Statistic | df | Sig. | Statistic | df | Sig. |
| Student Learning Outcomes | Experimental Pre-Test | .154 | 35 | .034 | .157 | 40 | .015 |
| | Experimental Post-Test | .157 | 35 | .029 | .155 | 40 | .017 |
| | Control Pre-Test | .173 | 35 | .010 | .169 | 40 | .005 |
| | Control Post-Test | .237 | 35 | .001 | .217 | 40 | .001 |

Source: Processed Data by Researcher (2025)

The normality tests at SMAN 4 and SMAN 2 Sidoarjo indicated that all pre-test and post-test data for both the experimental and control groups were not normally distributed.

b. Homogeneity Test

**Table 11** Homogeneity Test Results for Pre-Test – Post-Test (SMAN 4 Sidoarjo)

Test of Homogeneity of Variance

| | | SMAN 4 Sidoarjo | SMAN 2 Sidoarjo |
|---|---|---|---|
| | | Sig. | Sig. |
| Student Learning Outcomes | Based on Mean | .786 | .766 |
| | Based on Median | .760 | .739 |
| | Based on Median and with adjusted df | .760 | .740 |
| | Based on trimmed mean | .799 | .759 |

Source: Processed Data by Researcher (2025)

The homogeneity test at SMAN 4 and SMAN 2 Sidoarjo yielded significance values of 0.786 and 0.766 (> 0.05), indicating that the variances of the two groups were homogeneous.

c. Wilcoxon Signed Rank Test

The Wilcoxon Signed Rank Test was selected as the hypothesis testing method because the data from both the experimental and control classes were not normally distributed.

**Table 12** Recapitulation Wilcoxon Signed Rank Test Results for Pre-Test and Post-Test Data (SMAN 4 Sidoarjo and SMAN 2 Sidoarjo)

| School | Group | N | Negative Ranks | Positive Ranks (N) | Ties | Sig. (2-tailed) | Interpretation |
|---|---|---|---|---|---|---|---|
| SMAN 4 | Experimental | 35 | 0 (.00) | 34 (97.1%) | 1 | 0.001 | Significant improvement |
| | Control | 35 | 0 (.00) | 28 (80.0%) | 7 | 0.001 | Significant improvement, but lower than experimental |
| SMAN 2 | Experimental | 40 | 0 (.00) | 40 (100%) | 0 | 0.001 | Strong improvement |
| | Control | 40 | 2 (5.0%) | 31 (77.5%) | 7 | 0.001 | Moderate improvement |

Source: Processed Data by Researcher (2025)

The Wilcoxon test results showed a significance value of 0.001 (< 0.05) in both groups, indicating a significant improvement in learning outcomes.

d. N-Gain Test

**Table 13** Descriptive Statistical Test Results (SMAN 4 Sidoarjo and SMAN 2 Sidoarjo)

| School | N | Min (%) | Max (%) | Mean (%) | Std. Deviation | Interpretation |
|---|---|---|---|---|---|---|
| SMAN 4 | 35 | 0 | 100 | 77.75 | 20.61 | High category |
| SMAN 2 | 40 | 20 | 100 | 75.92 | 21.79 | High category |

Source: Processed Data by Researcher (2025)

Based on Tables 4.20 and 4.21, the average N-Gain scores at SMAN 4 and SMAN 2 Sidoarjo were 0.7775 and 0.7592, respectively, categorized as high (≥ 0.7). This indicates that EcoLearn effectively enhances students' understanding.

**5. Evaluation Stage**

Evaluation was conducted at each stage of development to minimize errors. After implementation, the summative evaluation showed positive student responses. Technical feedback, such as application lag, was addressed to optimize the app and better meet students' needs.

## Discussion

The discussion covers the development process, feasibility, effectiveness, and student responses to the EcoLearn m-learning application in Phase E economics learning.

**1. Analysis of the Development of the EcoLearn M-Learning Application for Differentiated Learning**

The development of the EcoLearn m-learning application provides several important implications both theoretically and practically. From the theoretical perspective, this research strengthens the view that learning in the 21st century must emphasize not only the mastery of concepts but also the cultivation of student autonomy, collaboration, and critical thinking. EcoLearn was designed with a differentiated learning approach aligned with the Merdeka Curriculum, thereby ensuring that learning accommodates students' different readiness levels, interests, and learning profiles. This confirms the relevance of Tomlinson's theory of differentiation, which emphasizes that effective learning requires flexible methods and materials tailored to diverse learners.

In terms of motivation theory, the interactive and gamified features of EcoLearn reflect the principles of Self-Determination Theory (Deci & Ryan), which highlights the role of autonomy, competence, and relatedness in fostering intrinsic motivation. The application provides choice and flexibility (autonomy), structured guidance with adaptive difficulty (competence), and collaborative features that allow peer interaction (relatedness). These elements have been shown to significantly enhance student engagement and persistence in the learning process, as supported by findings in digital learning and gamification research.

Beyond theoretical reinforcement, this study contributes new scientific value in three aspects. First, it integrates the principles of differentiated learning with mobile technology in the context of economics education, a combination rarely explored in previous studies that often focused on STEM fields. Second, this study introduces a multi-format design (web, Android, HTML), demonstrating the feasibility of creating inclusive and cross-platform m-learning applications that remain consistent with the objectives of the Merdeka Curriculum. Third, EcoLearn's adaptive nature adjusting learning paths to student needs provides a practical model of how m-learning applications can operationalize the ideal of personalized learning in Indonesia's educational context.

When compared with previous studies, this research offers several distinctive contributions. Studies on m-learning applications in mathematics (Rahmatika & Wijaya, 2024) and science (Efrina et al., 2020) have demonstrated improvements in conceptual understanding and motivation but did not explicitly integrate differentiated instruction. Similarly, research on gamification in digital learning (Yaacob et al., 2024) highlights the positive effect of interactive features but often treats learning as a uniform process. EcoLearn bridges this gap by embedding gamification within a differentiated framework, thus addressing both motivational and pedagogical needs. Moreover, unlike studies that develop m-learning in a single platform, this research emphasizes cross-platform accessibility, which is crucial for ensuring equity in technology-based education across diverse school infrastructures in Indonesia.

The challenges encountered, such as resource limitations and technical constraints, further highlight the importance of collaboration between educators and technology professionals. This reinforces the idea that sustainable innovation in education requires interdisciplinary synergy. In practice, EcoLearn not only functions as a supplementary

learning medium but also represents a shift towards technology-driven pedagogy that promotes joyful learning, independence, and lifelong learning skills, all of which are central to the vision of 21st-century education.

Thus, this research does not merely produce a learning product but also extends the discourse on how differentiated instruction can be realized through adaptive m-learning. The contribution of this study lies in offering an empirically tested and contextually relevant model for integrating pedagogy, curriculum, and technology in Indonesian secondary education.

**2. Feasibility Analysis of the EcoLearn M-Learning Application for Differentiated Learning**

The feasibility analysis of the EcoLearn m-learning application highlights its strong alignment with both the Merdeka Curriculum and the principles of 21st-century learning. The validation process conducted by three groups of experts content, media, and language ensures that the application is pedagogically sound, technically reliable, and linguistically appropriate for students at Phase E. This multi-perspective validation process is essential, as the success of a digital learning tool depends not only on its technological sophistication but also on the extent to which it supports curriculum objectives and learner characteristics.

From the content validation, the systematic organization of economics material and its alignment with the expected learning outcomes confirm that EcoLearn can serve as a credible non-print teaching material. The revisions made such as integrating more contextual examples and improving illustrations reflect the importance of contextual learning theory, which emphasizes connecting abstract concepts with real-life applications to enhance student comprehension and retention. This demonstrates that the application is not merely a digital replication of textbooks but a tool designed to foster deeper understanding through interactive and contextualized resources.

From the media perspective, the application's responsive design and accessible navigation reinforce the principles of user experience (UX) design in education, which suggest that usability, aesthetics, and accessibility are critical in sustaining learner engagement. By incorporating user-friendly icons, structured navigation flow, and a visually appealing interface, EcoLearn addresses one of the common barriers in m-learning implementation: the cognitive load caused by poor interface design. This is consistent with Mayer's Cognitive Theory of Multimedia Learning, which emphasizes that reducing extraneous cognitive load enables students to focus more effectively on processing the learning content.

From the language perspective, the communicative style and adherence to linguistic conventions demonstrate the feasibility of EcoLearn in supporting students' independent learning. The use of simple, structured sentences reduces ambiguity and makes complex economic concepts more approachable. This aligns with Vygotsky's sociocultural theory, particularly the principle of scaffolding, where appropriately leveled language can mediate learning and support students as they progress to more advanced concepts.

Compared with previous studies, EcoLearn offers several unique contributions. Prior research on digital feasibility analyses often focused on single aspects, such as media attractiveness (Anshori & Novianingsih, 2021), without integrating curriculum alignment and language appropriateness simultaneously. EcoLearn, by contrast, undergoes a holistic feasibility assessment that integrates pedagogical, technological, and linguistic perspectives. Moreover, while earlier works (Putra & Nugroho, 2016); (Choirun et al., 2022) found that m-learning applications are feasible in improving motivation and concept mastery, they did not explicitly examine their role in supporting differentiated learning. This study fills that gap by showing that feasibility is not only about usability and attractiveness but also about adaptability to different learner needs an essential aspect of personalized education in the Merdeka Curriculum era.

Thus, the feasibility analysis of EcoLearn does not merely confirm its appropriateness for classroom use but also contributes a novel framework for feasibility validation that integrates curriculum relevance, multimedia learning principles, and differentiated instruction. This provides both a practical guideline for future developers and a theoretical advancement in the evaluation of educational technologies, especially in the Indonesian context of curriculum transformation.

**3. Analysis of the Effectiveness of Using the EcoLearn M-Learning Application for Differentiated Learning**

The effectiveness of EcoLearn is evident from the increase in pre-test to post-test scores in the experimental classes: from 57.28 to 90.57 at SMAN 4 and from 60.37 to 91.00 at SMAN 2. In contrast, the control classes only increased from 57.14 to 79.86 at SMAN 4 and from 61.12 to 78.37 at SMAN 2. These results indicate that EcoLearn is more effective in enhancing understanding of Phase E Economics. The improvement in learning outcomes was more significant in the experimental classes using the EcoLearn m-learning application for Phase E Economics at SMAN 4 and SMAN 2 Sidoarjo. Based on the learning analysis, several key factors contributed to the improved conceptual understanding:

a. First, the Phase E Economics material in EcoLearn was designed to be visually interactive, with supporting illustrations and emphasis on key points, accompanied by example questions tailored to students' learning styles.
b. Second, each chapter includes animated videos that illustrate economic concepts in everyday life, supporting students with auditory and visual learning preferences.
c. Third, the application provides a group discussion menu to encourage collaboration through case studies and analytical questions, in line with project-based and case-based learning approaches that foster critical thinking.
d. Fourth, at the end of each chapter, interactive quizzes including multiple choice, matching images, and true/false questions are provided with explanations and scores, while light background music enriches the learning atmosphere and enhances focus.
e. Fifth, pre-test and post-test features are provided as assessments to measure learning effectiveness and offer objective feedback on students' learning progress.

The results of the study indicate that the use of the EcoLearn m-learning application significantly enhances understanding of Phase E economics material and contributes positively to students' learning outcomes. This conclusion is supported by the Wilcoxon Signed Rank Test analysis presented in Tables 15 and 16, which show a significant difference between pre-test and post-test scores. The improvement serves as an indicator of the effectiveness of technology based learning interventions, particularly through interactive media designed according to differentiation principles.

The researcher also observed that students' learning achievements were driven by conceptual understanding, skills in using information technology, and a positive attitude toward independently operating the media (Bernacki, 2020). which emphasize that successful learning is strongly influenced by students' positive attitudes and the attainment of learning objectives. Additionally, research by (Rizal et al., 2021) demonstrates that the use of e-learning media can enhance students' interest, enthusiasm, and academic performance. In line with this, Romero-Rodriguez, (Romero-Rodriguez, 2020), (Sitar-Tăut, 2021), (Shakarami, 2021), (Kusdiyanti, 2022), (Gao, 2020), and (Shortt, 2023) conclude that the implementation of interactive digital media has a significant impact on students' competency and skill development. The integration of interactive quiz elements in the EcoLearn application also creates a more enjoyable, flexible, and motivating learning experience, thereby overall increasing the effectiveness of economics learning in Grade X at SMAN 4 Sidoarjo and SMAN 2 Sidoarjo.

**4. Analysis of Student Responses to the Use of the EcoLearn M-Learning Application for Differentiated Learning**

Student responses to EcoLearn were highly positive. At SMAN 4 Sidoarjo, the feasibility scores reached 94% for software, 92% for learning aspects, and 89% for visual communication, while at SMAN 2 Sidoarjo the scores were 97%, 93%, and 90%, respectively. Students considered the application easy to use, engaging, and capable of enhancing learning motivation through interactive features such as videos, audio, and quizzes. These results indicate that EcoLearn is not only effective as an m-learning medium but also succeeds in creating a meaningful and enjoyable learning experience. This finding aligns with (Efstathiou, 2018), which emphasizes that effective instructional media development should adhere to the VISUAL principles (Visible, Interesting, Simple, Useful, Accurate, Legitimate, Structured). These principles are strongly reflected in the application's design and features, thereby supporting the optimal achievement of learning objectives. Overall student responses to EcoLearn were collected through a rating-scale questionnaire administered to 35 students at SMAN 4 and 40 students at SMAN 2 Sidoarjo. Data analysis showed response scores of 92.14% at SMAN 4 and 93.13% at SMAN 2, which, according to the (Riduwan, 2016) scale, fall into the "very good" category.

Based on this analysis, it can be concluded that the EcoLearn m-learning application is rated as "very good" and is highly feasible to be used as a learning medium for Phase E Economics in Grade X. The positive evaluation reflects the application's success in meeting students' learning needs in the digital era, both in terms of content, ease of use, and the

visual and interactive appeal it provides. These findings also reinforce previous studies, such as those by (Umami et al., 2021), (Maulana et al., 2024), (Krouska, 2022), (El-Sofany, 2020), which concluded that m-learning-based instructional media are consistently considered effective, adaptive, and feasible for improving the quality of learning.

## Conclusion

This study demonstrates that the EcoLearn m-learning application is an effective digital medium for improving students' motivation and conceptual understanding in Phase E economics. The integration of differentiated learning principles with mobile technology offers a concrete example of how the Merdeka Curriculum can be operationalized to create more adaptive and student-centered learning experiences. Theoretically, this study contributes to the development of educational technology research by providing a model that bridges differentiated instruction, motivation theory, and 21st-century learning skills. EcoLearn illustrates how gamification, adaptive pathways, and cross-platform accessibility can be combined to support diverse learner needs while fostering autonomy, engagement, and deeper learning.

In terms of educational policy, the findings highlight the importance of supporting schools and teachers in adopting inclusive, technology-driven pedagogies. EcoLearn's design aligns with the government's agenda for digital transformation in education, suggesting that scalable and curriculum-relevant applications can serve as a sustainable alternative to traditional print-based resources. At the same time, challenges such as infrastructure readiness, internet stability, and inclusivity for a broader spectrum of special needs students indicate areas where policy intervention is necessary, particularly in expanding access and equity.

In conclusion, the EcoLearn application is not only a practical product but also a scientific contribution that advances discourse on adaptive and inclusive digital learning. By combining pedagogical innovation with technological feasibility, this study provides a reference point for future efforts in developing interactive, flexible, and equitable learning technologies that can strengthen the quality of education in Indonesia.

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