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GREEN OPTIMA: AN ECOTHEOLOGY-BASED GAMIFICATION OF LINEAR PROGRAMMING TO IMPROVE STUDENTS' CONCEPTUAL UNDERSTANDING

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ABSTRACT
Madrasah implements the Love-Based Curriculum (Kurikulum Berbasis Cinta/KBC), which integrates religious and ecological values into learning to foster environmental responsibility. To support this initiative, an ecotheology-based interactive learning medium, Green Optima, was developed using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model and evaluated for validity, practicality, and effectiveness. The study involved three experts (content, language, and media) for the validity assessment and 32 eleventh-grade Madrasah Aliyah students for the practicality and effectiveness testing. Data were collected using expert validation sheets, practicality and student response questionnaires, and a conceptual understanding test on linear programming. The results showed that Green Optima achieved an average validity score of 90.44% (very valid) and a practicality score of 83.75%. Its effectiveness was demonstrated by an improvement in students' conceptual understanding, with mean test scores increasing from 38.00 on the pretest to 77.81 on the posttest, yielding an N-gain of 0.66 (moderate category). Student responses reached 83.78%, particularly regarding the attractiveness of the learning medium and its integration of ecotheological values. These findings indicate that Green Optima is a valid, practical, and effective learning medium for improving students' conceptual understanding of linear programming while fostering ecological awareness. Furthermore, the findings suggest that Green Optima provides an innovative instructional approach by integrating gamification, mathematical concepts, and ecotheological values to promote contextual learning and advance education for sustainability in madrasas.
Keywords: ADDIE; conceptual understanding in mathematics; ecotheology; green optima; linear programming.

ABSTRAK
Madrasah menerapkan Kurikulum Berbasis Cinta (KBC) yang mengintegrasikan nilai-nilai religius dan ekologis dalam pembelajaran sebagai wujud tanggung jawab terhadap lingkungan. Untuk mendukung tujuan tersebut, dikembangkan media pembelajaran interaktif berbasis ekoteologi bernama Green Optima menggunakan model ADDIE (Analysis, Design, Development, Implementation, and Evaluation) yang selanjutnya dievaluasi berdasarkan aspek validitas, kepraktisan, dan efektivitas. Penelitian ini melibatkan tiga orang ahli, yaitu ahli materi, ahli bahasa, dan ahli media, untuk menguji validitas, serta 32 siswa kelas XI Madrasah Aliyah untuk menguji kepraktisan dan efektivitas media. Data dikumpulkan melalui lembar validasi ahli, angket kepraktisan dan respons siswa, serta tes pemahaman konsep pada materi program linier. Hasil penelitian menunjukkan bahwa Green Optima memperoleh skor validitas rata-rata sebesar 90,44% dengan kategori sangat valid dan skor kepraktisan sebesar 83,75%. Efektivitas media ditunjukkan oleh peningkatan rata-rata nilai siswa dari 38,00 pada pretest menjadi 77,81 pada posttest dengan nilai N-Gain sebesar 0,66 yang termasuk kategori sedang. Respons siswa mencapai 83,78%, terutama pada aspek kemenarikan media dan integrasi nilai-nilai ekoteologi. Temuan ini menunjukkan bahwa Green Optima merupakan media pembelajaran yang valid, praktis, dan efektif untuk meningkatkan pemahaman konsep matematis siswa pada materi program linear sekaligus menumbuhkan kesadaran ekologis. Selain itu, penelitian ini mengimplikasikan bahwa Green

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Optima dapat menjadi alternatif pembelajaran inovatif yang mengintegrasikan gamifikasi, konsep matematika, dan nilai-nilai ekoteologi untuk mendukung pembelajaran kontekstual serta memperkuat implementasi pendidikan berkelanjutan di madrasah.
Kata kunci: *ADDIE; ekoteologi; green optima; program linear; pemahaman konsep matematis.*

Introduction

Developing students' readiness for twenty-first-century competencies requires mathematics education that cultivates logical, critical, and structured ways of thinking (Ningsih et al., 2026). Furthermore, the Industrial Revolution 4.0 has highlighted the importance of integrating mathematics learning with interdisciplinary themes, especially technological advancement and environmental awareness, to support holistic student development (Islami et al., 2025; Pujiastuti et al., 2021). Students must also be able to connect information to solve problems (Ulfah et al., 2017). Unfortunately, mathematics is still viewed as a difficult, abstract, and boring subject, leading to low interest and low learning outcomes (Afiatushalihah et al., 2025; Indriyani & Putra, 2018).

The educational framework in Madrasah Aliyah (MA) is designed not only to enhance students' cognitive abilities but also to nurture their spiritual values and character development through the Love-Based Curriculum (Arham, 2025; Nurvayanti et al., 2025; Syah et al., 2025). This love-based curriculum emphasizes the values of divinity, humanity, and concern for the environment, with learning based on compassion and love for nature (Islami et al., 2025; Nadlir, 2025; Nurvayanti et al., 2025), and places compassion (mahabbah) as the center of the learning process to create a child-friendly and psychologically safe environment (Syah et al., 2025). Islamic ecotheology provides a theological foundation for integrating environmental values into mathematics learning by emphasizing that humans are entrusted with the responsibility of protecting and sustaining God's creation. The Qur'an describes humans as *khalifah* (stewards) on Earth, entrusted with the ethical responsibility to manage natural resources wisely and sustainably (Qur'an 2:30). It also commands humans not to cause corruption on Earth (*fasad fi al-ard*) after it has been set in order (Qur'an 7:56) and to preserve the balance (*mizan*) established by God (Qur'an 55:7–9). Building upon these principles, Islamic ecotheology conceptualizes environmental stewardship as a religious obligation, encouraging humans to maintain ecological balance and prevent environmental degradation (Sriyono et al., 2025; Widiastuty & Anwar, 2025; Yudi, 2025). This integration is crucial for providing more meaningful and humanistic mathematics learning (Islami et al., 2025; Ulfiani et al., 2026).

Among various mathematics topics, linear programming is particularly suitable for integrating ecotheological values because it requires students to make optimal decisions under limited-resource constraints. Real-world linear programming problems frequently involve optimizing resource allocation, minimizing waste, maximizing production efficiency, and balancing economic, social, and environmental considerations. These characteristics closely align with ecotheological principles, which emphasize responsible stewardship of natural resources and sustainable decision-making. Furthermore, meaningful learning of

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linear programming requires the use of authentic contexts that reflect real-life situations (Simamora & Ramadhanta, 2024). Contexts that are closely related to students' daily lives enable them to recognize the relevance of mathematics to real-world problems and facilitate deeper conceptual understanding (Pujiastuti et al., 2021). Therefore, integrating environmental issues and ecotheological values into linear programming provides an authentic learning context in which students not only develop conceptual understanding of mathematical optimization but also cultivate ecological awareness and ethical responsibility toward environmental sustainability.

The low understanding of students' mathematical concepts in linear programming material and the need for integration of religious-ecological values in MA are the basis of this research (Nurani et al., 2021). Conceptual understanding represents one of the most essential competencies in mathematics because it enables learners to connect ideas, interpret mathematical relationships, and apply concepts meaningfully rather than relying on rote memorization (Sudarman & Vahlia, 2016). Empirical evidence indicates that many students rely on memorizing mathematical formulas without fully comprehending the underlying concepts, which often leads to difficulties when solving complex word problems (Maure et al., 2020; Shofiah et al., 2021). Conceptual understanding is very important for students to be able to solve problems systematically and apply mathematical ideas in various situations, while avoiding misconceptions (Hermaya et al., 2025; Pujiastuti et al., 2021). According to the National Research Council (2001, as cited in Verina & Darhim, 2023), conceptual understanding is one of the components of mathematical proficiency. In linear programming material, students often have difficulty visualizing the solution region graph and determining the optimum value manually (Meslita, 2022; Mutrofin et al., 2020). Learning that is still dominated by lectures and textbooks makes students less motivated to explore (Indriyani & Putra, 2018; Pujiastuti et al., 2020). In addition, the current global environmental crisis is considered a spiritual crisis that requires an educational response to change human behavior towards nature (Ulfiani et al., 2026; Widiastuty & Anwar, 2025). Students' conceptual understanding varies according to their metacognitive abilities. Learners with stronger metacognitive skills tend to demonstrate a better capacity to interpret concepts, determine appropriate procedures, and apply mathematical ideas accurately during problem solving (Khoiruddin et al., 2024).

As a solution, the developer of the interactive learning media "Green Optima" based on ecotheology with the Genially platform is designed to present abstract concepts visually and interactively through innovative features such as dynamic visual representations, nonlinear navigation, and interactive quizzes with direct feedback (Afiatushalihah et al., 2025; Ningsih et al., 2026). Pastás Hernández et al. (2024) reported that such characteristics enhance students' interest, engagement, and conceptual understanding. Therefore, Genially provides an appropriate technological foundation for developing interactive learning media on linear programming that not only facilitates conceptual learning but also supports reflection on environmental issues through ecotheological contexts. The ecotheology approach is integrated through optimization problems related to environmental conservation, including waste management and the use of green land (Sriyono et al., 2025; Yudi, 2025). Through this approach, students are expected to

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develop mathematical understanding in a meaningful manner by connecting learning experiences with their role as *caliphs* responsible for environmental stewardship (Sriyono et al., 2025; Yudi, 2025).

Numerous studies on innovations in mathematics learning media have been conducted over the past decade. Findings reported by Islami et al. (2025) indicated that the use of a Genially-based educational game was effective in strengthening junior high school students' conceptual understanding in mathematics. Gamification-supported learning materials integrated with Android technology can create more engaging and enjoyable learning environments, encourage students to actively participate in learning activities, and improve their motivation to explore mathematical concepts independently (Winarto et al., 2023). Ningsih et al. (2026) also used Genially interactive media to explain the concept of decimal numbers in elementary schools. Regarding values, Marom (2018) found that integrating mathematical models with Quranic verses significantly improved students' understanding of prophetic values. In linear programming, Indriyani & Putra (2018) developed Sparkol Videoscribe-based media to visualize the simplex method. In addition, Arham (2025) explored the Love Curriculum at the elementary madrasah level with an emphasis on ecotheology and nationalist values.

Although interactive learning media have been widely developed, they primarily emphasize visualization and cognitive achievement. Likewise, studies integrating religious values generally focus on moral education without connecting them to mathematical optimization. Moreover, research on linear programming has concentrated on procedural understanding rather than contextualizing optimization through authentic environmental problems. Consequently, no previous study has integrated gamification, linear programming, Islamic ecotheology, and the Love-Based Curriculum within a single interactive learning medium for Madrasah Aliyah students.

Beyond addressing these gaps, Green Optima contributes a pedagogical framework that combines authentic environmental optimization problems, gamified learning, and Islamic ecotheological narratives within a single digital platform. This integration enables mathematics learning to simultaneously strengthen conceptual understanding and cultivate ecological responsibility, thereby extending the implementation of the Love-Based Curriculum into mathematics instruction.

Accordingly, this study aims to develop Green Optima, an ecotheology-based interactive learning medium for linear programming, using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model. The ADDIE model was selected because it provides a systematic and flexible framework that supports continuous revision throughout the development process, making it well-suited for classroom-scale instructional media integrating mathematical content, gamification, and ecotheological values. The study further evaluates the developed media in terms of validity, practicality, and effectiveness in improving Madrasah Aliyah students' conceptual understanding of linear programming, while also examining students' responses to the integration of ecotheological values in mathematics learning.

Research Methods

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This study adopted a Research and Development (R&D) methodology to design and develop an educational product in the form of Green Optima learning media (Sugiyono, 2016). Development research generally comprises three key components: the development model, development procedures, and product evaluation (Puslitjaknov, 2008). In this study, the ADDIE model, consisting of Analysis, Design, Development, Implementation, and Evaluation, served as the instructional design framework. It was selected due to its systematic and flexible structure, which allows for continuous improvement through iterative revisions at each stage of development. Accordingly, the ADDIE model offers a comprehensive framework for producing high-quality learning media that satisfy the criteria of validity, practicality, and effectiveness.

The participants in this study were 32 eleventh-grade students of Madrasah Aliyah (MA). The research instruments comprised expert validation sheets, student practicality and response questionnaires, and a pretest–posttest test measuring students' conceptual understanding of linear programming. Before implementation, all research instruments were validated by a mathematics education lecturer and a Madrasah Aliyah mathematics teacher to ensure the validity of the content, clarity of the items, and consistency with the research objectives. Feedback provided by the validators was used to revise and refine the instruments before being used in this study.

The variables measured in this study comprised validity, practicality, and effectiveness. Validity refers to the degree to which the Green Optima media met the required content, language, and media design standards, as evaluated by expert validators. Practicality is defined as the ease of use, usability, and overall attractiveness of the media as perceived through teacher and student evaluations. Student responses reflect interest and motivation towards the ecotheological content in the media. Effectiveness refers to the extent to which the Green Optima media improved students' conceptual understanding of linear programming. Students' conceptual understanding was assessed using a test developed based on the indicators proposed by Verina and Darhim (2023). The test consisted of five indicators: (1) restating a concept verbally, (2) classifying objects based on whether they meet the criteria for forming a concept, (3) applying a concept, (4) presenting a concept through various mathematical representations, and (5) linking various mathematical concepts. The effectiveness of the media was determined by comparing students' pretest and posttest scores and was quantified using (Hake, 1998) Normalized Gain (N-Gain) index, which measures the magnitude of learning improvement following the implementation of the instructional media. The N-Gain score was computed using Equation (1).

$$g = \frac{(posttest\ score - pretest\ score)}{(highest\ score - pretest\ score)} \quad (1)$$

According to Hake (1998), the N-Gain values are categorized into three levels: high ($g > 0.7$), moderate ($0.3 \leq g \leq 0.7$), and low ($g < 0.3$).

The non-test instruments were distributed in the form of closed-ended questionnaires using a five-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). The student response questionnaire was designed to capture students' perceptions of the media's appeal and the integration of ecotheological

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content. Meanwhile, the media validation instrument was evaluated by three experts, namely a media specialist, a subject-matter expert, and a language expert, to determine the quality and appropriateness of the developed Green Optima media. Data analysis was conducted using descriptive percentage techniques to evaluate the validity, practicality, and students' responses to the developed media. The obtained scores were then converted into percentage values and analyzed using Equation (2).

$$Achievement\ Score = \frac{Total\ Score}{Ideal\ Score} \times 100\% \quad (2)$$

The percentage scores obtained from expert validation, practicality questionnaires, and student response questionnaires were interpreted using the criteria presented in Table 1, adapted from (Sugiyono, 2016).

Table 1. Criteria for Interpreting Percentage Scores

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

The feasibility of Green Optima was evaluated based on expert judgments using a five-point Likert scale. The resulting percentage scores were interpreted according to the criteria presented in Table 1. A product was considered feasible if it achieved at least the good category (≥61%), indicating that the media met the minimum quality requirements for classroom implementation.

Results and Discussion

The development of Green Optima includes five main stages: (1) Analysis: analyzing students' needs for interactive media, an analysis of the love-based curriculum in Madrasah Aliyah, and an analysis of linear program materials, ; (2) Design: compiling materials into an ecotheological narrative, designing a storyboard, and determining the media navigation structure on the Genially platform; (3) Development: producing a draft of the Green Optima media and conducting expert validation to ensure product feasibility; (4) Implementation: testing the media in real learning to measure practicality and effectiveness; and (5) Evaluation: conducting an analysis of implementation data and final product revisions based on user input.

The initial stage involved a needs analysis conducted through classroom observations, interviews with students and teachers, and a review of the Madrasah curriculum. The results indicated that students experience difficulties in translating contextual problems into mathematical models and in visualizing graphs within linear programming topics. Based on these findings, Green Optima was designed on the Genially platform by incorporating gamification elements inspired by the principle of *khalifah fil-ardh*, which emphasizes students' responsibility to protect and preserve the environment. At this stage, storylines, learning objectives, navigation structures, visual layouts, animations, interactive graph activities, and game-based learning scenarios were systematically developed. Ecotheological

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values were embedded into learning materials, narratives, missions, and problem-solving activities to encourage students to connect mathematical concepts with environmental issues and ethical responsibilities toward nature.

The developed media can be accessed on personal computers, laptops, and mobile devices through a web browser and internet connection, making it suitable for both classroom and independent learning. Green Optima includes several features, namely navigation menus, learning materials, interactive graph visualizations, and a five-level educational game designed to reinforce students' conceptual understanding of linear programming. Its accessibility and interactive design support teachers' roles as facilitators in technology-enhanced learning environments while promoting meaningful learning experiences. As shown in Figure 1, Green Optima begins with an opening screen that functions as the main gateway to the learning medium.

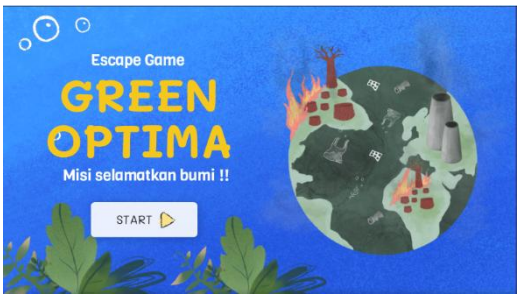

Figure 1. Opening Screen of Green Optima

Figure 1 presents the initial gamification interface of Green Optima, featuring the game title, learning mission, and a "Start" button to begin accessing the media. After selecting the "Start" button, users are directed to the main menu, as shown in Figure 2.

Figure 2. Main Menu of Green Optima

Figure 2 presents the main menu interface of Green Optima. The menu bar provides navigation options to select the desired menu or start the learning game. The narrative is aligned with ecotheological principles, emphasizing environmental protection and humans as stewards of the Earth. As illustrated in Figure 3, the Learning Materials menu displays a selection of learning topics that allow students to study the concepts of linear programming systematically before engaging in the interactive game.

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Figure 3. Learning Options Menu

Figure 3 presents the menu of learning options available in Green Optima, consisting of instructional videos and interactive materials on linear programming to support students' conceptual understanding. After completing the learning materials, students proceed to the gamified activities. Figure 4 illustrates one of the game missions, in which students solve a contextual linear programming problem embedded within an ecotheological narrative to apply the concepts they have learned.

Figure 4. Mission Display

Figure 4 presents the mission interface of Green Optima, in which learning tasks are contextualized within environmental protection themes to promote meaningful problem-solving activities. Figure 5 illustrates the gameplay interface, where students apply their understanding of linear programming to complete interactive challenges, reinforcing conceptual understanding through immediate feedback and game-based progression.

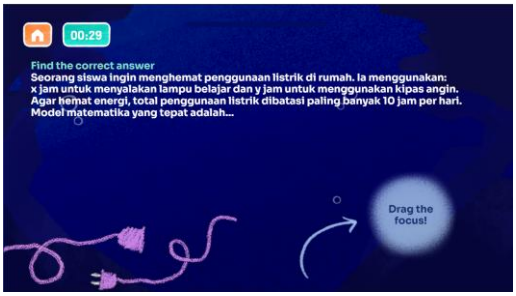

Figure 5. Game Display

Figure 5 shows the display of questions in one of the environmental protection missions, namely, saving energy. This game has five missions, each containing four questions related to ecotheology. Correct answers allow users to proceed to the next question, while incorrect answers require them to retry until they successfully progress to the next level. After completing the product

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development, the experts validated the developed media to assess its usability, design quality, content validity, and language appropriateness. The validation results are presented in Table 2.

Table 2. Expert Validation Results

No	Validator	Percentage	Criteria
1	Material expert	85,33%	Very Good
2	Media expert	88,00%	Very Good
3	Language expert	98,00%	Very Good
Average		**90,44%**	**Very Good**

Table 2 concludes that the overall expert validation results, involving material, media, and language experts, achieved a score of 90.44%, categorized as very feasible (Ernawati & Sukardiyono, 2017). The practicality, as measured through a student response questionnaire after the implementation of Green Optima, is presented in Table 3.

Table 3. Media Practicality Results

Aspect	Answer					Score	Percentage (%)	Criteria
	SD	D	N	A	SA			
Ease	0	4	23	36	33	386	80.45	Very Good
Clarity	0	2	8	52	34	406	84.58	Very Good
Navigation	0	1	15	42	38	405	84.38	Very Good
Efficiency	0	2	19	38	37	398	82.92	Very Good
Implementation	0	1	10	42	43	415	86.46	Very Good
Average							**83.75**	**Very Good**

As shown in Table 3, Green Optima obtained an overall practicality score of 83.75%, indicating that students perceived the learning media as practical. The web-based Green Optima platform provides flexible access on smartphones and personal computers without requiring complex installation, thereby supporting students' independent learning anytime and anywhere. Furthermore, the pretest and posttest results demonstrated that Green Optima significantly improved students' conceptual understanding of mathematics. The mean scores of the pretest, posttest, and N-gain are presented in Table 4.

Table 4. Average Test Score and N Gain Values

Test	Average
Pretest	38,00
Posttest	78,81
N-Gain	**0,66 (Moderate)**

As presented in Table 4, students' mean score increased from the pretest to the posttest, resulting in an N-gain value of 0.66, which falls into the moderate category. This finding indicates that Green Optima was moderately effective in improving students' conceptual understanding of linear programming. Interestingly, the integration of ecotheological values into story problems, such as calculating carbon-emission limits or green-space utilization, makes mathematics learning more contextual and meaningful and increases awareness of the responsibility for preserving nature. The use of digital media also supports students' independent observation, analysis, and conclusion-making, with the teacher acting

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as a strategic facilitator (Pujiastuti & Haryadi, 2023). Students' feedback on Green Optima after the use of the media in classroom instruction is presented in Table 5.

Table 5. Student Response Questionnaire Result

Aspect	Answer					Score	Percentage (%)	Criteria
	SD	D	N	A	SA			
Interest	0	1	17	48	62	555	86.72	Very Good
Conceptual Understanding	0	1	22	67	38	526	82.19	Very Good
Learning Motivation	0	1	31	54	42	521	81.41	Very Good
Echoteologi	0	1	23	52	52	539	84.23	Very Good
Usability	0	0	24	52	52	540	84.38	Very Good
Average							**83.78**	**Very Good**

As shown in Table 5, Green Optima received a positive response from students, with an overall score of 83.78%. The high level of interest and motivation reflects students' acceptance of the media and indicates that integrating mathematical learning with ecotheological and environmental contexts created a more meaningful learning experience. Observations and interviews also revealed that Green Optima improved conceptual understanding and motivation to learn, while reminding us that preserving nature is a shared mandate and responsibility. These findings are consistent with Marom (2018), who argues that incorporating Qur'anic verses can enhance both spiritual and cognitive understanding. Students demonstrated increased interest as the learning materials were linked to real environmental issues and religious responsibilities, thereby fostering a humanistic learning environment that aligns with the principles of the Love-Based Curriculum. The main innovation of this media is its ability to bridge the spiritual aspects of MA with logical thinking skills in linear programming.

The findings demonstrate that Green Optima is a valid, practical, and effective learning medium for teaching linear programming in Madrasah Aliyah. The high validity score indicates that the mathematical content, media design, language, and ecotheological narratives were well integrated and aligned with the objectives of the Love-Based Curriculum. This result suggests that combining mathematical concepts with Islamic ecotheological values can be achieved without reducing the scientific accuracy of the subject matter. Instead, the integration enriches the learning experience by connecting mathematical knowledge with students' moral responsibility toward environmental sustainability. This finding supports the view of Arham (2025) that the implementation of the Love-Based Curriculum should integrate cognitive, spiritual, and ecological dimensions within the learning process.

The practicality results indicate that Green Optima was easily accepted and used by students during classroom implementation. This finding can be attributed to the intuitive interface, systematic learning sequence, and gamification features that enabled students to navigate the learning activities independently. The availability of instructional videos, concept explanations, interactive quizzes, and game missions reduced the abstract nature of linear programming and encouraged students to participate actively throughout the lesson. These findings are consistent with those of Islami et al. (2025), who reported that Genially-based interactive

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media improved students' engagement and conceptual understanding through attractive visualizations and interactive learning experiences. Similarly, Ningsih et al. (2026) found that interactive digital media facilitated students' understanding of mathematical concepts by presenting learning materials in a more accessible and engaging manner. Unlike these previous studies, however, Green Optima not only utilizes interactive digital technology but also embeds ecotheological narratives that connect mathematical learning with authentic environmental issues.

The effectiveness of Green Optima is reflected in the improvement of students' conceptual understanding, as indicated by the moderate N-gain score. This finding suggests that the integration of interactive learning activities, authentic contexts, and gamification facilitated students in constructing a deeper understanding of linear programming concepts. The improvement can be explained by several interrelated factors. First, authentic environmental contexts enabled students to recognize the relevance of mathematical optimization to real-world situations, thereby reducing the abstract nature of linear programming and making learning more meaningful. This finding is consistent with Pujiastuti et al. (2021), who argued that authentic contexts help students connect mathematics with everyday life, and with Simamora and Ramadhanta (2024), who emphasized that contextual learning facilitates students' understanding of linear programming because optimization problems become easier to comprehend when presented through realistic situations. Second, the gamified learning environment maintained students' motivation and active engagement throughout the learning process, while instructional videos, visual representations, and interactive quizzes supported conceptual construction through multiple forms of representation. Immediate feedback provided during quizzes and game missions also enabled students to identify misconceptions and improve their problem-solving strategies. These findings are consistent with Pastás Hernández et al. (2024), who reported that Genially-based learning environments enhance students' participation, engagement, and meaningful learning by integrating multimedia, interactive features, and formative assessment within a single platform. In the present study, these technological affordances were further enriched with authentic environmental problems and Islamic ecotheological narratives. Consequently, Green Optima not only improved students' conceptual understanding of linear programming but also encouraged them to reflect on responsible decision-making and environmental stewardship, demonstrating that mathematics learning can simultaneously support cognitive achievement and the development of sustainability-oriented values.

An additional contribution of this study lies in the integration of Islamic ecotheological values into mathematics learning. Previous studies have investigated the incorporation of religious values into mathematics education. For example, Marom (2018) demonstrated that integrating Quranic values into mathematics learning enhanced students' understanding of prophetic values. However, such studies primarily emphasized moral and spiritual development without explicitly connecting these values to environmental sustainability or mathematical optimization. Green Optima extends this line of research by embedding ecotheological narratives into linear programming tasks, allowing students to learn mathematical optimization while simultaneously reflecting on responsible

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environmental stewardship. This approach is also consistent with the ecotheological principles described by Islami et al. (2025), which position humans as responsible stewards of nature within educational practice.

Compared with previous studies, Green Optima offers several distinctive contributions. Earlier interactive mathematics media primarily focused on visualization (Indriyani & Putra, 2018), conceptual explanation through digital technology (Islami et al., 2025; Ningsih et al., 2026), or the integration of religious values separately (Arham, 2025; Marom, 2018). In contrast, Green Optima integrates gamification, authentic environmental contexts, linear programming, and Islamic ecotheological values within a single instructional medium. This integration enables students not only to improve conceptual understanding but also to develop ecological awareness and ethical responsibility toward environmental sustainability. Therefore, the contribution of this study extends beyond technological innovation by demonstrating that mathematics learning can simultaneously support cognitive development, character education, and education for sustainability within the context of Madrasah Aliyah.

Despite these positive findings, this study has several limitations. The implementation involved only one Madrasah Aliyah and focused exclusively on linear programming, limiting the generalizability of the findings to other educational contexts and mathematical topics. Furthermore, the study evaluated students' conceptual understanding immediately after implementation and did not investigate long-term retention or changes in environmental attitudes. Future research is therefore recommended to involve larger and more diverse samples, examine other mathematics topics, and explore the long-term impact of ecotheology-based interactive learning media on both cognitive and affective learning outcomes.

Overall, the findings have important theoretical and practical implications. Theoretically, this study enriches the literature by demonstrating that the integration of gamification, authentic learning contexts, and Islamic ecotheological values provides a coherent framework for improving conceptual understanding in mathematics learning. Practically, Green Optima offers mathematics teachers an innovative instructional medium that supports the implementation of the Love-Based Curriculum while fostering meaningful learning and ecological awareness. The findings also provide a foundation for future development of digital mathematics learning media that integrate sustainability education into classroom practice.

Conclusion and Suggestion

The developed media, called Green Optima, is a gamified linear programming model with an ecotheological context, supporting a love-based curriculum in Islamic schools. Green Optima is equipped with text materials, interactive graphics, and learning videos to support understanding. The entire development process systematically and flexibly followed the five ADDIE steps, with evaluation at each stage. Expert validation showed a validity rate of 90.44% and a practicality rate of 83.75%. Overall, Green Optima was found to be effective in enhancing students' conceptual understanding, as indicated by an N-Gain score of 0.66. Field testing results showed a positive student response of 83.78%, especially regarding its

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appeal, usability, and integration of ecotheological values. Accordingly, Green Optima is deemed appropriate for use in the learning process.

Mathematics teachers at Islamic high schools are advised to use ecotheology-based interactive media to strengthen students' character. Schools need to support the provision of digital literacy facilities. Future research is encouraged to apply this media to a wider range of subjects or to focus specifically on students' higher-order thinking skills in mathematics.

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