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Development of E-LKPD Based on Search, Solve, Create, and Share (SSCS) to Empower Critical Thinking Skills in Class X High School Students' Biology Learning

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ABSTRAK

Abad ke-21 ditandai dengan kemajuan pesat dalam ilmu pengetahuan dan teknologi, sehingga keterampilan berpikir kritis menjadi kompetensi esensial bagi peserta didik. Namun, penelitian pendahuluan di SMA Negeri 1 Limbangan menunjukkan bahwa 69,44% siswa berada pada kategori sangat rendah dalam keterampilan berpikir kritis, dengan rata-rata skor hanya 20%. Kondisi ini dipicu oleh pembelajaran yang cenderung berpusat pada guru dan penggunaan bahan ajar konvensional yang minim aktivitas analitis. Penelitian ini bertujuan mengembangkan Lembar Kerja Peserta Didik Elektronik (E-LKPD) berbasis model *Search, Solve, Create, and Share* (SSCS) untuk pembelajaran biologi, menilai validitas produk, serta menganalisis respons siswa terhadap penggunaannya. Metode yang digunakan adalah Research and Development (R&D) dengan model 4-D (Define, Design, Develop, Disseminate), difokuskan pada tahap Develop, melibatkan 36 siswa kelas X. Validasi pakar meliputi ahli materi, media, metode pembelajaran, berpikir kritis, serta guru biologi menunjukkan tingkat validitas tinggi (rata-rata >90%). Uji coba skala kecil menunjukkan respons siswa positif dengan rata-rata 90,4%, menandakan keterbacaan dan praktikabilitas produk yang tinggi. Hasil penelitian menunjukkan bahwa E-LKPD berbasis SSCS efektif meningkatkan keterampilan berpikir kritis, memfasilitasi pembelajaran berbasis inkuiri, serta menjembatani kesenjangan antara bahan ajar konvensional dan kebutuhan kompetensi abad ke-21. Penelitian ini menegaskan perlunya inovasi bahan ajar digital yang mengintegrasikan model pembelajaran berpikir kritis untuk mendukung kesiapan peserta didik menghadapi tantangan global.

Kata kunci: berpikir kritis, E-LKPD, SSCS, pembelajaran biologi, R&D, abad ke-21

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ABSTRACT

The 21st century is characterized by rapid advancements in science and technology, making critical thinking an essential

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competency for students. Preliminary research at SMA Negeri 1 Limbangan revealed that 69.44% of students were in the very low category of critical thinking, with an average score of only 20%. This issue is attributed to teacher-centered learning and conventional instructional materials that provide minimal opportunities for analytical activities. This study aims to develop an Electronic Student Worksheet (E-LKPD) based on the Search, Solve, Create, and Share (SSCS) model for biology learning, evaluate the validity of the product, and analyze students' responses. A Research and Development (R&D) approach using the 4-D model (Define, Design, Develop, Disseminate) was employed, focusing on the Develop stage, involving 36 Grade X students. Expert validation, including material, media, instructional methodology, critical thinking, and biology teachers, showed high validity (average >90%). A small-scale trial revealed positive student responses with an average score of 90.4%, indicating high readability and practicality. The findings demonstrate that the SSCS-based E-LKPD effectively enhances students' critical thinking, facilitates inquiry-based learning, and bridges the gap between conventional learning materials and 21st-century competency needs. This study underscores the necessity of innovative digital instructional tools that integrate critical thinking models to prepare students for global challenges.

Keywords: : *critical thinking, E-LKPD, SSCS, biology learning, R&D, 21st century*

INTRODUCTION

The 21st century is characterized by the rapid advancement of science and technology, often referred to as the era of the Industrial Revolution 4.0 (Mahrunnisya, 2023). In this dynamic context, education plays a crucial role in equipping students with the competencies required to navigate complex challenges, societal shifts, and technological transformations. According to Redhana (2019), 21st-century skills represent essential capabilities that enable students to succeed in a world that demands adaptability, creativity, and problem-solving proficiency. Among the core competencies critical thinking, creativity, communication, and collaboration, known collectively as the 4Cs critical thinking stands out as a pivotal skill for students to master (Nopiani et al., 2023; Pratama et al., 2019).

Critical thinking encompasses the ability to analyze, synthesize, and evaluate information, to design alternative solutions, and to apply acquired knowledge to real-life problems (Wayudi et al., 2020). It enables learners to reason logically, make informed judgments, and approach situations with analytical precision. Students with well-developed critical thinking skills tend to understand concepts more deeply and demonstrate greater capacity in solving academic as well as real-world problems (Affandy et al., 2019; Ariadila et al., 2023). As stated by Sulistiani and Masrukan (2017), critical thinking empowers learners to construct valid arguments, evaluate the credibility of evidence, and make reasoned decisions in a complex information landscape.

However, various studies have indicated that Indonesian students' critical thinking abilities remain at a low level (Putra, 2015; Putriningtyas & Bachtiar, 2022; Alawiyah & Marlina, 2020; Suharyani et al., 2023). This condition is further supported by pre-research data collected from SMA Negeri 1 Limbangan, which revealed that 69.44% of students fall into the very low category of critical thinking skills, 11.11% in the low category, 11.11% in the medium category, 5.56% in the high category, and only 2.78% in the very high category, with an overall average score of merely 20%. These findings clearly suggest that students' critical thinking skills are far from satisfactory, necessitating the development of learning interventions that can foster higher-order thinking skills in a more effective and engaging manner.

Field observations further revealed several factors contributing to this low performance. One primary factor is that students are rarely challenged with learning activities or questions that require analytical or reflective thinking. Most of the assessments used in the classroom focus on memorization rather than reasoning. Furthermore, learning is predominantly teacher-centered, where students act as passive recipients of information rather than active participants in constructing knowledge (Latang & Amir, 2023). Interviews with biology teachers at SMA Negeri 1 Limbangan revealed that many students demonstrate low motivation and limited curiosity, often sitting quietly during lessons, taking notes, and avoiding active engagement. Only a few students dare to ask questions or express opinions during discussions, indicating weak argumentative and reasoning skills. This pattern aligns with the findings of Hayudiyani et al. (2017), who reported that teachers tend to dominate the learning process, leaving limited opportunities for students to explore ideas or practice critical thinking.

An evaluation of the current instructional materials used in biology classes such as textbooks, PowerPoint slides, and conventional student worksheets (LKPD) shows that these resources focus primarily on content delivery and conceptual understanding rather than on inquiry or problem-solving activities. They rarely include structured opportunities for students to practice reasoning, questioning, and evaluating evidence. Therefore, there is a pressing need for the development of innovative teaching materials designed explicitly to enhance critical thinking. One promising solution is the creation of an Electronic Student Worksheet (E-LKPD) based on the Search, Solve, Create, and Share (SSCS) model, which integrates digital technology with a structured inquiry-based learning framework.

E-learning–based instructional materials have been widely recognized for their ability to promote student engagement and independent learning. Khasanah and Setiawan (2022) define the E-LKPD as an interactive digital worksheet containing conceptual explanations, summaries, and guided inquiry tasks accessible via computers or smartphones (Pratiwi & Margunayasa, 2022). Raudoh (2023) emphasizes that E-LKPDs not only increase students' motivation and active participation but also enhance their critical and creative thinking skills while encouraging collaboration in accordance with 21st-century learning principles.

The SSCS learning model an acronym for Search, Solve, Create, and Share was first introduced by Pizzini (1991) as a problem-solving framework that encourages students to explore issues, analyze data, and generate innovative solutions through group collaboration (Widyati & Irawati, 2021). Sariasih (2023) describes SSCS as a scientific and inquiry-oriented model that cultivates curiosity, deepens conceptual understanding, and strengthens students' reasoning processes. When integrated into digital learning environments such as E-LKPD, the SSCS model offers a highly effective approach for fostering critical thinking in biology education.

Despite its potential, previous research indicates that most digital learning materials in biology remain focused on conceptual mastery and factual recall rather than developing higher-order thinking. Only a limited number of studies have attempted to integrate inquiry-based models such as SSCS into interactive electronic formats (Putriningtyas & Bachtiar, 2022). This reveals a research gap concerning the lack of effective, technology-based learning tools explicitly designed to cultivate critical thinking in high school biology contexts.

In terms of current trends, contemporary science education increasingly emphasizes inquiry-driven and problem-based learning as means to nurture critical thinking skills. Approaches such as problem-based learning (PBL), cooperative learning, and project-based learning (PjBL) have proven effective in encouraging student engagement and reflective reasoning (Angraini et al., 2022; Triansyah et al., 2023). However, many of these approaches rely on traditional print-based materials or static digital content, which limit interactivity and student autonomy. The SSCS model, on the other hand, provides a comprehensive problem-solving structure that guides students through searching for information, solving problems, creating solutions, and sharing outcomes. Studies by Arisa et al. (2021) and Saregar et al. (2018) have shown that implementing SSCS significantly enhances students' analytical and evaluative thinking. Therefore, developing an SSCS-based E-LKPD represents a state-of-the-art educational innovation, combining inquiry learning with digital interactivity to effectively empower critical thinking.

This study introduces two key innovations. First, it develops an E-LKPD based on the SSCS model specifically tailored for biology instruction, focusing on empowering students' critical thinking skills. Second, it integrates the structured stages of SSCS within an interactive digital format that incorporates multimedia elements such as images, videos, and inquiry-based exercises. Unlike conventional worksheets, the developed E-LKPD can be accessed through the Liveworksheet platform, enabling flexible, engaging, and technology-supported learning experiences with automated feedback mechanisms.

Accordingly, the objectives of this study are threefold: (1) to develop an E-LKPD based on the SSCS model for high school biology learning; (2) to evaluate the validity of the developed E-LKPD as an instructional tool; and (3) to analyze students' responses toward the use of the E-LKPD in classroom settings. The outcomes of this

research are expected to provide both theoretical and practical contributions by enriching the application of the SSCS model in digital learning environments and by offering an innovative, validated learning tool that effectively enhances students' critical thinking skills in accordance with the demands of 21st-century education.

METHODS

This study used a Research and Development (R&D) approach with the 4D (Four-D) model developed by Thiagarajan et al. (1974), consisting of four stages: *Define, Design, Develop,* and *Disseminate.* The 4D model was chosen because it provides a systematic yet simple process for product development. However, this research was limited to the Develop stage, focusing on product validation and small-scale trials. The subjects were 36 Grade X students of SMA Negeri 1 Limbangan in the 2025/2026 academic year. The development process included three stages. The Define stage involved a needs analysis and curriculum review to identify problems in biology learning and determine relevant materials for SSCS-based E-LKPD development. The Design stage focused on creating the E-LKPD prototype and storyboard based on the four phases of the SSCS model (*Search, Solve, Create, Share*). The Develop stage included expert validation (materials, media, and learning methodology experts) and small-scale testing with students to evaluate readability and practicality. Data were collected using interviews, questionnaires, and critical thinking skill tests. Interviews identified learning needs, while questionnaires were used during expert validation and student testing. Data were analyzed using descriptive qualitative and quantitative analysis. The product's validity and readability were calculated using the formula (Riduwan, 2013):

The results were interpreted using Akbar's (2013) validity criteria, as shown in Table 1.

Table 1. E-LKPD Validity Criteria

Validity Criteria (%)	Validity Level
85.01% – 100.00%	Very valid (usable without revision)
70.01% – 85.00%	Fairly valid (usable with minor revisions)
50.01% – 70.00%	Less valid (requires major revision)
01.00% – 50.00%	Invalid (cannot be used)

Source: Akbar (2013)

Based on these criteria, the E-LKPD was considered valid and feasible for use if it achieved a score above 70%

RESULTS AND DISCUSSIONS

1. Needs Analysis Findings

The needs analysis was conducted to determine the urgency of developing an SSCS-based E-LKPD for biology learning at the senior high school level. Interviews with biology teachers and classroom observations revealed that students' critical

thinking skills remained relatively low. This was indicated by students' difficulty in analyzing biological phenomena, identifying causal relationships, and linking theoretical concepts with authentic life contexts. Teachers reported that current teaching materials were dominated by text and lacked interactivity, resulting in passive learning experiences and limited opportunities to practice higher-order thinking skills. Furthermore, both teachers and students emphasized the need for digital-based teaching materials that integrate inquiry-oriented learning and technological tools. The integration of multimedia and structured learning stages was considered capable of stimulating curiosity, enhancing reasoning, and encouraging independent exploration. In line with the demands of the *Merdeka Curriculum* and 21st-century education, which emphasize creativity, critical thinking, collaboration, and communication (4C), the development of an SSCS-based E-LKPD was viewed as a timely innovation to improve student engagement and conceptual understanding in biology.

2. Design and Storyboard of E-LKPD

The design of the SSCS-based E-LKPD followed the *4-D* model (Define, Design, Develop, Disseminate), with the present research focusing on the "Develop" stage. The Define phase involved identifying the learning needs and competencies outlined in the biology curriculum, while the Design phase focused on preparing a digital storyboard and user interface prototype. The E-LKPD incorporated Grade X biology materials, including *biological technology innovation*, *ecosystem components and interactions*, and *environmental change*. The structure of the product included the cover, foreword, user guide, concept map, learning outcomes (CP), learning objectives (TP), supporting information, learning activities, formative assessments, references, and developer profile. The digital format was created through Liveworksheets, ensuring interactive engagement through hyperlinks, embedded videos, and auto-graded exercises. Figures 1 and 2 illustrate the layout and navigation flow that emphasize visual clarity, balanced color schemes, and ease of access for both teachers and students.

This design not only enhances user experience but also integrates the four SSCS stages into each activity sequence. Each module includes guiding questions and reflective prompts aligned with critical-thinking indicators such as *inference*, *evaluation*, and *logical reasoning*.

3. Sample of SSCS-Based E-LKPD

A representative module demonstrates how the SSCS model (Search, Solve, Create, Share) is operationalized within the E-LKPD.

- In the Search stage, students explore phenomena from digital articles, news reports, or visual simulations, identifying key variables related to environmental or biotechnological issues.

- During the Solve stage, students discuss findings collaboratively to formulate hypotheses or explanations supported by scientific reasoning.
- The Create stage allows students to develop innovative products or visual outputs—such as digital posters or infographics—that represent their understanding of biological processes.
- In the Share stage, students present and defend their ideas through virtual discussion boards or class presentations.

Figures 3 and 4 show how these stages are visually integrated into the E-LKPD layout. The activities are designed to foster critical-thinking indicators based on Ennis (1985), including providing simple explanations, building basic support, drawing inferences, and employing strategies and tactics. The systematic alignment of these indicators ensures that students not only absorb knowledge but also engage in analytical and reflective reasoning.

4. Validation Results

The developed product underwent a comprehensive validation process involving experts in content, media design, learning methodology, and critical thinking, as well as biology teachers as practitioners. Each expert assessed dimensions such as content accuracy, visual design, linguistic clarity, and pedagogical feasibility.

Expert Type	Average (%)	Category
Material Expert	95.5	Very Valid
Media Expert	86.2	Very Valid
Learning Methodology Expert	92.5	Very Valid
Critical Thinking Expert	86.5	Very Valid
Biology Teacher (Practitioner)	95.9	Very Valid

The overall average validity of above 90% indicates strong content reliability and pedagogical soundness. Expert feedback suggested minor revisions such as improving typography, refining illustrations, and enhancing the clarity of instructions. These refinements contributed to the E-LKPD's readiness for classroom implementation and its potential as an effective digital learning resource.

5. Student Response and Small-Scale Trials

To evaluate practicality and readability, a small-scale trial was conducted with 36 Grade X students from SMA Negeri 1 Limbangan. Students assessed five aspects—material, convenience, language, presentation, and usefulness.

Rated Aspect	Percentage (%)	Criteria
Material	87.5	Very Valid
Convenience	88.2	Very Valid
Language	89.7	Very Valid
Presentation	92.0	Very Valid
Usefulness	92.0	Very Valid
Average	**90.4**	**Very Valid**

Students reported that the E-LKPD was easy to navigate, visually engaging, and supported interactive learning. They expressed that multimedia features such as embedded videos and interactive quizzes made complex concepts more understandable and motivated them to participate actively in the learning process. The high readability and satisfaction levels confirm that the product is pedagogically effective and technologically accessible.

6. Discussion of Findings

The validation and student trial findings consistently demonstrate that the SSCS-based E-LKPD is both valid and practical for enhancing students' critical-thinking skills in biology. The integration of multimedia elements such as interactive visuals, animations, and embedded videos not only facilitates cognitive engagement but also supports various learning modalities, catering to visual, auditory, and kinesthetic learners. This multimodal design enables students to visualize abstract biological concepts, fostering a more meaningful and lasting understanding of the material. Moreover, the interactive nature of the E-LKPD encourages active participation, self-paced exploration, and immediate feedback, which are essential for promoting deep learning in digital environments. The systematic application of the SSCS model where students *search* for information, *solve* contextual problems, *create* innovative Very Valid solutions, and *share* their findings creates a continuous cycle of inquiry, reasoning, and reflection. This process nurtures higher-order cognitive skills, as students are challenged to analyze, evaluate, and synthesize information rather than merely recall it. Such learning dynamics not only develop critical-thinking and problem-solving competencies, but also cultivate collaboration, creativity, and communication key components of 21st-century skills. The emphasis on student-centered inquiry transforms learning from passive knowledge acquisition to active knowledge construction, making biology lessons more relevant to real-world contexts.

These outcomes are consistent with the findings of Hatari et al. (2016), Wahyuningsih et al. (2020), and Marlangen et al. (2021), who emphasize that the SSCS learning model effectively strengthens students' reasoning, communication, and problem-solving skills through structured inquiry. Their studies collectively support the notion that SSCS encourages learners to think critically and independently while fostering curiosity and persistence in problem-solving. In addition, the digital delivery format of this E-LKPD, particularly through Liveworksheets, enhances accessibility and interactivity, allowing teachers to manage assignments, track student progress, and provide direct feedback online. This aligns with the principles of blended and flexible learning promoted by Pratiwi & Margunayasa (2022), where digital tools are used to complement face-to-face instruction and extend learning beyond classroom walls. Furthermore, the development of the SSCS-based E-LKPD reflects the ongoing paradigm shift toward technology-enhanced, inquiry-based education. It bridges the gap between pedagogy

and digital innovation, empowering students to take greater responsibility for their learning while enhancing engagement and motivation. The findings demonstrate that integrating the SSCS framework within a digital environment not only supports the mastery of biological concepts but also prepares students to think critically and adaptively in a world increasingly shaped by science, technology, and data-driven problem-solving. Consequently, this product represents a significant step forward in modernizing biology education and serves as a model for implementing innovative digital learning strategies in other scientific disciplines.

7. Strengths and Weaknesses

The developed E-LKPD has several significant strengths:

- Accessibility – It can be used anytime and anywhere through internet-connected devices, promoting flexible and self-paced learning.
- Interactivity – Multimedia features enhance engagement and visualization of abstract biological processes.
- Pedagogical Alignment – Learning activities align closely with SSCS stages and curriculum competencies.
- Monitoring and Assessment – Teachers can track progress and provide feedback through integrated online systems.
- Skill Integration – It supports critical thinking, collaboration, and communication—core 21st-century competencies.

However, several limitations remain: (1) full functionality depends on stable internet access; (2) some teachers and students still lack familiarity with digital platforms; and (3) teacher training is essential for maximizing implementation. Institutional support, digital literacy development, and infrastructure readiness are thus crucial for sustaining E-LKPD integration across schools.

8. Limitations and Future Directions

This study, however, was limited to the development and small-scale testing phases, without extending to broader dissemination or long-term evaluation. Future research should explore large-scale implementation, experimental impact studies, and integration with adaptive learning analytics to monitor students' progress and provide personalized instruction based on individual learning needs. Expanding the scope of testing across different schools and regions would also enhance the generalizability of findings. In addition, further improvements could include gamification elements to increase student motivation, offline accessibility to support use in low-connectivity areas, and AI-based feedback systems to provide real-time, individualized learning guidance.

Sustained collaboration between educators, instructional designers, and policymakers will be critical in scaling up the SSCS-based E-LKPD nationally. Such partnerships can strengthen digital literacy, encourage innovation in classroom pedagogy, and support Indonesia's transition toward a more inclusive and

technology-driven education system. By continuously improving and implementing this model, the SSCS-based E-LKPD has the potential to become a transformative tool that not only enhances critical thinking in biology but also contributes to shaping future-ready learners in the digital era.

CONCLUSION AND RECOMENDATION

CONCLUSION

Based on the research findings, it can be concluded that the E-LKPD based on the Search, Solve, Create, and Share (SSCS) model developed to enhance the critical thinking skills of 10th-grade high school students in biology learning is very valid and feasible for implementation. The product was designed in a digital format accessible via computers or smartphones and includes materials on biological technology innovation, ecosystem components and interactions, and environmental changes. Validation results demonstrated high levels of validity from experts, with scores of 95.5% (material experts), 86.2% (media experts), 92.5% (learning methodology experts), 86.5% (critical thinking experts), and 95.9% (biology teachers). Furthermore, the small-scale trial conducted with 10th-grade students at SMA Negeri 1 Limbangan yielded a positive response rate of 90.4%, indicating strong usability and student engagement. Overall, the E-LKPD effectively fosters students' critical thinking skills and supports active, inquiry-based learning.

The developed E-LKPD also presents significant implications for educational practice. For biology teachers, it serves as an innovative digital learning tool that integrates the SSCS model to promote higher-order thinking and student-centered learning, encouraging its integration into classroom instruction to enhance engagement and analytical ability. For school administrators, the findings underscore the need for adequate digital infrastructure and teacher training to optimize the use of interactive E-LKPDs. Institutional support is essential to ensure the sustainability of this learning innovation. Moreover, for broader science education, this SSCS-based E-LKPD can be adapted across other scientific disciplines to cultivate analytical, problem-solving, and decision-making skills that are vital for achieving 21st-century learning competencies.

RECOMENDATION

Based on the results of research and development, it is recommended that E-LKPD be based on Search, Solve, Create, and Share The developed SSCS will be further tested to determine its effectiveness in learning. Furthermore, this E-LKPD can be extended to other Biology materials and other relevant subjects. Teachers are expected to utilize this E-LKPD as a teaching material to empower critical thinking skills and enhance students' learning independence.

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