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Transformative Deep Learning-Based Learning Model for Conceptual Mastery and Critical Attitude Development in Students

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ABSTRACT

Current global dynamics demand educational systems to adopt transformative approaches that empower learners to become critical, adaptive, and socially responsible individuals. This study aims to analyze the effectiveness of a transformative learning model based on deep learning in enhancing conceptual mastery and critical attitudes among senior high school students.

A quasi-experimental design with pretest-posttest control group was employed. The sample comprised 235 eleventh-grade students from seven classes across three private senior high schools in West Bandung Regency, with six experimental classes and one control class. Research instruments included conceptual mastery tests, critical attitude questionnaires, and observation sheets for reflective and collaborative activities. Data analysis utilized descriptive and inferential statistics, including paired t-tests, independent t-tests, gain score analysis, and descriptive qualitative analysis of students' reflective notes.

The Transformative Learning Model based on Deep Learning significantly enhanced students' conceptual mastery, higher-order thinking skills (HOTS), digital literacy, and critical reflection abilities. Specifically, 84.5% of students reported deeper conceptual understanding, 87% demonstrated improved analytical capabilities, and 86% exhibited enhanced productive and ethical digital literacy. The integration of interdisciplinary approaches and project-based learning strengthened learning relevance to real-world contexts, fostering collaboration and active participation.

The transformative learning model effectively bridged the gap between 21st-century competency demands and actual learning practices while developing reflective, creative, and adaptive learners. These findings contribute to 21st-century pedagogy advancement and provide a foundation for innovative learning strategies at the secondary education level.

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1. INTRODUCTION

The 21st century is characterized by rapid and complex social, economic, and technological changes, demanding that the education system adapt to a new learning paradigm. Education is no longer sufficient merely to transfer knowledge from teachers to students; it must focus on developing critical, creative, and reflective thinking skills, as well as the ability to adapt to dynamic global changes. UNESCO (2023) emphasizes that learning in the modern era must be transformative, meaning a process that changes learners' ways of thinking through critical reflection, self-awareness, and the formation of new meaning from their learning experiences. Thus, transformative education not only develops cognitive competence but also cultivates character and critical attitudes rooted in deep conceptual understanding.

However, the actual conditions in many senior high schools (SMA) in Indonesia still show a tendency toward rote memorization and knowledge reproduction. This one-way learning model only produces surface learning, where students memorize material without understanding its deeper conceptual meaning. Marton and Saljo (1976) distinguish between surface learning and deep learning, where surface learning emphasizes short-term memory, while deep learning emphasizes deep understanding, reflection, and the ability to apply concepts meaningfully in various real-life contexts. This indicates that conventional learning models have not yet fully fostered students' conceptual mastery and critical attitudes, as required by 21st-century competencies.

Transformative learning theory, introduced by Mezirow (1978; 1991), emphasizes the importance of critical reflection on assumptions, values, and learning experiences to form new, more open, and autonomous awareness. When combined with the principles of deep learning, this approach can create learning that is not only cognitively meaningful but also builds students' critical attitudes toward social, cultural, and technological issues around them. Thus, the integration of transformative learning and deep learning offers a strong conceptual foundation for developing 21st-century learning models oriented toward deep understanding and reflective character development.

However, there are several fundamental challenges in implementing education at the senior high school level. First, there remains a gap between the demands of 21st-century competencies which include critical, collaborative, communicative, and creative thinking and learning practices that are still predominantly conventional. Many teachers still apply lecture methods and exercises without fostering reflective concept exploration. Second, fragmented curricula make it difficult for students to connect concepts across disciplines with real-world contexts. Third, higher-order thinking skills (HOTS), such as analysis, synthesis, and evaluation, have not been optimally developed due to learning approaches that focus on outcomes rather than thinking processes. Fourth, in the era of educational digitalization, students face new challenges, including low reflective ability and digital literacy in discerning credible information and critically analyzing complex issues.

Based on these problems, a learning model is needed that can bridge the gap between the demands of 21st-century competencies and the actual learning reality in schools. A transformative learning model based on deep learning becomes a strategic alternative as it combines the power of critical reflection (from transformative learning) with the depth of conceptual understanding (from deep learning). Through learning oriented toward reflection, rational dialogue, and deep meaning-making of concepts, students not only

comprehend the lesson content but also build self-awareness, social responsibility, and sustainable critical thinking skills.

This study was conducted to design and analyze the effectiveness of a transformative learning model based on deep learning in improving students' conceptual mastery and critical attitudes in senior high schools. By integrating cognitive, affective, and reflective dimensions, this model is expected to create learning that is more meaningful, relevant, and contextual to the challenges of the times. Based on the introduction above, the researcher formulates several research problems focused on four main questions:

(i) How can the gap between the demands of 21st-century competencies and actual learning practices in educational institutions be bridged through a transformative learning approach?
(ii) How can the integration of interdisciplinary knowledge strengthen contextual and meaningful learning for students?
(iii) How can the implementation of a deep learning approach enhance students' higher-order thinking skills (HOTS)?
(iv) How can a transformative learning model improve digital literacy and critical reflection skills in the information era?

2. METHOD

This study employs a quantitative approach with a quasi-experimental method, as the primary objective is to examine the effectiveness of the Transformative Learning Model based on Deep Learning on students' conceptual mastery and the development of critical attitudes in senior high schools (SMA). An experimental approach was chosen because it allows testing the cause-and-effect relationship between the implementation of the learning model and measurable changes in student learning outcomes. The research design used is a pretest–posttest control group design, in which two groups of students an experimental group and a control group receive different treatments but are assessed using the same instruments before and after the intervention.

The experimental group received treatment through the implementation of the Transformative Learning Model based on Deep Learning, which emphasizes students' reflective, dialogic, and analytical engagement in understanding concepts in depth. In contrast, the control group was taught using a conventional approach that focused on lectures, employing PowerPoint presentations and memorization. With this design, the researcher can compare the extent to which the transformative learning model based on deep learning can enhance concept mastery and develop students' critical attitudes compared to traditional learning methods.

The population of this study consisted of selected eleventh-grade students from three senior high schools in West Bandung Regency during the odd semester of the 2025/2026 academic year, totaling 235 students. The sampling technique employed was purposive sampling, taking into account equality in academic ability, cognitive background, and gender distribution across classes. From this population, seven classes were selected, comprising six experimental classes and one control class. Thus, the total sample involved in this study was 235 students, who participated in four types of tests used to measure learning outcomes and critical attitudes.

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The instruments used in this study consisted of three main components. First, the Conceptual Mastery Test, consisting of 25 multiple-choice items with reasoning and short-answer questions, was designed to measure conceptual understanding and higher-order thinking skills (HOTS). Content validity of this instrument was ensured through expert judgment, and reliability was tested using Cronbach's Alpha coefficient. Second, the Critical Attitude Questionnaire was developed using a Likert scale ranging from 1–5 to assess critical thinking dimensions such as analysis, reflection, openness to new ideas, and the ability to make rational decisions. Third, the Reflective and Collaborative Activity Observation Sheet was used to assess the extent to which students demonstrated reflective, participatory, and communicative behaviors during the learning process.

The research procedure was carried out in three stages: preparation, implementation, and evaluation. During the preparation stage, the researcher developed learning tools, validated instruments, and determined the experimental and control classes. The implementation stage began with a pretest to determine students' initial abilities in both groups, followed by the application of the transformative learning model based on deep learning in the experimental classes over six meetings. Throughout the learning process, students' activities were observed to monitor the development of reflective thinking and critical interactions. After the learning process was completed, both groups were given the same posttest to measure improvements in conceptual mastery and changes in critical attitudes

Data analysis was conducted using a combination of descriptive and inferential statistical approaches. Descriptive analysis was used to describe the profile of students' learning outcomes and critical attitudes based on pretest and posttest mean scores. Next, normality and homogeneity tests were conducted to ensure that the data met the assumptions for parametric tests. Paired-sample t-tests were then used to analyze differences in abilities before and after treatment within each group, while independent-sample t-tests were used to compare improvements between the experimental and control groups. Additionally, gain score analysis was applied to measure the effectiveness of the learning model by considering relative improvements from initial scores.

To complement the quantitative analysis, this study also employed descriptive qualitative analysis of observation data and students' reflection notes during the learning process. This analysis aimed to narratively describe the dynamics of students' critical thinking and reflective engagement, providing a more holistic view of the impact of the learning model on the development of cognitive abilities and critical attitudes.

With this design and procedure, the study is expected to provide empirical evidence regarding the effectiveness of the Transformative Learning Model based on Deep Learning in enhancing conceptual mastery while fostering critical attitudes among senior high school students. The results are expected not only to contribute to the development of reflective and deep learning theories but also to serve as a foundation for pedagogical innovations at the secondary education level that are more relevant to the challenges of the 21st century.

3. RESULT AND DISCUSS

This study was conducted at three private senior high schools in West Bandung Regency, involving 235 eleventh-grade students from seven classes. Six classes, totaling 200 students, were designated as the experimental group and taught using the Transformative Learning Model based on Deep Learning, while the remaining class, consisting of 35 students, served as the control group and was taught using conventional lecture-based methods. The research employed a mixed-methods approach, in which quantitative data were collected through test results, questionnaires, and observations of learning activities, while qualitative data were gathered from students' reflection notes and interviews with teachers.

The results indicate that the implementation of transformative learning significantly reduces the gap between 21st-century competency demands and actual classroom learning practices. Out of 200 students, 169 students (84.5%) reported that reflection-based, discussion-oriented, and meaningful learning helped them understand concepts more deeply, while 31 students (15.5%) still experienced difficulties adapting to this new learning model. Teachers also noted an increase in collaborative activities and reflective communication in the classroom, indicating positive changes in learning dynamics. Overall, the level of achievement for 21st-century competency indicators falls within the "high" category, as shown in the table below.

Table 1. Achievement of 21st-Century Competencies through Transformative Learning

21st-Century Competency Indicators	Number of Students	Percentage (%)	Category
Independence and learning responsibility	164	82	High
Reflective collaboration and communication	172	86	Very High
Creativity and problem-solving	158	79	High
Reflective awareness and perspective shift	168	84	Very High
Overall average achievement	166	82.75	High

These results demonstrate that transformative learning effectively bridges the gap in 21st-century competencies by encouraging students to think reflectively, work collaboratively, and take responsibility for their own learning. Furthermore, the study revealed that interdisciplinary integration within the curriculum plays a crucial role in creating contextual and meaningful learning. Through a thematic project with the theme "Technology and Humanity," 162 students (81%) successfully connected concepts across fields such as science, social studies, and technology in their assignments. This project-based and reflective dialogue approach enables students to understand the relevance of theory to practice in real-life contexts.

Table 2. Achievement of Interdisciplinary Integration

Interdisciplinary Integration Indicators	Number of Students	Percentage (%)	Category
Ability to connect cross-field concepts	162	81	High
Contextual analysis of socio-scientific phenomena	156	78	High
Application of cross-disciplinary concepts in projects	166	83	Very High
Holistic understanding of global issues	150	75	Fairly High
Overall average achievement	158	79.25	High

This interdisciplinary integration enriches the learning experience and promotes meaningful learning, where students not only memorize concepts but also understand the relevance and interconnections of knowledge holistically. The results also indicate that the implementation of deep learning positively impacts the development of higher-order thinking skills (HOTS). Based on the post-test results, 174 students (87%) demonstrated excellent analytical skills, while 160 students (80%) were able to develop innovative solutions to contextual problems. This confirms that the deep learning approach encourages students to interpret, evaluate, and apply knowledge critically rather than merely memorizing it.

Table 3. Achievement of Higher-Order Thinking Skills (HOTS)

HOTS Indicators	Number of Students	Percentage (%)	Category
Analytical thinking	174	87	Very High
Synthesis and idea innovation	164	82	High
Evaluation and rational argumentation	168	84	Very High
Knowledge transfer to new contexts	158	79	High
Overall average achievement	166	83	Very High

Additionally, aspects of digital literacy and critical reflection also improved significantly. Through digital projects, online peer reviews, and reflective journaling, students were trained to use technology productively and reflectively. A total of 172 students (86%) demonstrated high ability in verifying digital information sources, while 163 students (81.5%) were able to write critical reflections on information ethics and media bias. These activities strengthen students' critical thinking skills and digital awareness amid the massive flow of information.

Table 4. Achievement of Digital Literacy and Critical Reflection

Digital Literacy & Critical Reflection Indicators	Number of Students	Percentage (%)	Category
Verification of sources and credibility of digital info	172	86	Very High
Ethical and productive use of technology	166	83	High
Ability to write critical reflections	162	81	High
Awareness of information bias	156	78	Fairly High
Overall average achievement	164	82	High

Overall, the data indicate that the Transformative Learning Model based on Deep Learning not only enhances cognitive competencies but also strengthens reflective awareness, collaboration, and students' digital literacy. The model's overall average achievement reached 81.75%, classified as "high," as shown in the table below.

Table 5. Overall Research Findings

Measured Aspect	Average Number of Students	Average Achievement (%)	Category
21st-Century Competencies	166	82.75	High
Interdisciplinary Integration	158	79.25	High
Higher-Order Thinking Skills (HOTS)	166	83	Very High
Digital Literacy & Critical Reflection	164	82	High
Overall Average Achievement of the Model	164	81.75	High

The implementation of the Transformative Learning Model based on Deep Learning has been proven to bridge the gap between 21st-century competency demands and actual learning practices, integrate interdisciplinary knowledge to produce contextual learning, develop higher-order thinking skills (HOTS), and enhance students' digital literacy and critical reflection skills in the modern information era.

4. CONCLUTION

Based on the findings above, it can be concluded that the Transformative Learning Model based on Deep Learning has a significant impact on enhancing students' conceptual understanding, critical reflection abilities, and higher-order thinking skills (HOTS). This model effectively bridges the gap between 21st-century competency demands and actual learning practices by strengthening active participation,

interdisciplinary integration, and digital literacy mastery. The approach encourages students to shift from passive learning to reflective, contextual, and meaningful learning, thereby fostering a generation of independent, analytical, and adaptive learners ready to face the challenges of modern life.

Given the importance of this model in preparing students for the future, it is recommended that:

(i) The government and educational policymakers integrate the principles of transformative learning and deep learning into the national curriculum to strengthen reflective and interdisciplinary learning practices in schools.
(ii) Teachers receive ongoing professional development to effectively implement learning strategies that cultivate critical thinking, ethical digital literacy, and student-centered approaches.
(iii) Schools establish a collaborative learning ecosystem through thematic projects, student mini-research activities, and joint reflection forums that connect theory with real-life practice, in order to comprehensively develop 21st-century competencies.

5. AUTHORS' NOTE

The author declares that there are no conflicts of interest in the preparation and publication of this article. The author also ensures that this manuscript is free from plagiarism and has been prepared based on a review of credible scientific literature relevant to the research topic.

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