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Development of *Deep Learning Learning Tools* to Improve Science Literacy of Junior High School Students on Alternative/Renewable Energy Materials

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Abstract

The purpose of this paper is to discuss Social learning theory (SLT) from the aspects of connectivism and constructivism, together with its pedagogical implications. The discussion intends to provide insight into the development of teaching strategies that adapt to transformation in the way students learn, communicate, and construct new knowledge. The paper, hence, covers the brief overview of both approaches underpinning the Social Learning Theory. The writing is anticipated to be helpful for future research which empirically focus on connectivism and constructivism approaches. As efforts are made in line with the aspirations of increasing engagement, improving quality, and achieving beneficial interpersonal results, collective learning, as propagated by SLT, is believed to be superior to individualistic learning.

Keywords: Social Learning Theory; Connectivism; Constructivism; Education.

INTRODUCTION

The skills that must be possessed by future generations in order to live properly in the world society in the 21st century consist of 16 skills that are categorized into three major categories, namely the category of basic literacies (*foundational literacies*), the category of competencies (*competencies*) better known as the 21st century competence, and the category of

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character qualities (*character qualities*). The basic literacy ability category consists of six literacy skills, namely language and literacy literacy, numerical, science, finance, information and communication technology, and culture and citizenship. The 21st Century competency category consists of four skills (4C/4K), namely critical thinking and problem-solving, creative thinking and innovation, communication, and collaboration. The character quality category consists of six skills, namely curiosity, initiative, never giving up, adaptation, leadership, and socio-culture (*World Economic Forum*, 2016). These 21st Century skills must be developed from an early age in students through education, so that at productive age they can live properly in the world community.

21st century science literacy requires more than just scientific knowledge; Relevant science literacy should equip individuals with the ability to trust science in an informed manner and act as competent outsiders in dealing with complex scientific issues in daily life (Osborne & Allchin, 2024).

Natural Sciences (IPA) as one of the important foundations in education has a crucial role in equipping students with an understanding of nature and the surrounding phenomena. More than just mastering concepts, the main goal of science learning is to develop science literacy, which is the ability to use scientific knowledge, identify questions, and draw conclusions based on scientific evidence in order to understand and make decisions about nature and the changes that occur in it (OECD, 2018).

PISA (*Programe for International Student Assessment*) is an international study coordinated by OECD (*Organisation for Economic Cooperation and Development*) countries, held on a 3-year period with 15-year-old student participants. In 2022 PISA was attended by 81 countries, consisting of 37 OECD countries and 44 partner countries. PISA measures math literacy, science literacy, and language literacy (OECD, 2023). Indonesia has participated in PISA since it was first held in 2000. Participation in PISA allows Indonesia to monitor the quality of education over time, and compare it with other countries. Since 2021, Indonesia has complemented PISA with a National Assessment to comprehensively assess the quality of education in each school and region (Ministry of Education and Culture, 2023).

Based on data from the Ministry of Education and Culture in 2023, the results of PISA 2022 for science literacy ranked 67th out of 81 countries. In 2018, Indonesia's science literacy ability was ranked 73rd out of 81 countries that participated. However, despite the increase in the ranking in PISA 2022, Indonesia recorded a decrease in score compared to the 2018 PISA results.

Low science literacy can hinder students' ability to understand scientific information relevant to their lives, such as health, environmental, and technological issues. As a result, they

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may have difficulty in making informed decisions based on scientific considerations and become vulnerable to misleading information (Osborne & Dillon, 2008).

The independent curriculum emphasizes the importance of essential, differentiated, and student-centered learning. The characteristics of this curriculum include: the preparation of learning outcomes based on the phase of student development, the reduction of excessive material load, and the integration of the values of the Pancasila Student Profile. In an effort to realize the goals of the independent curriculum optimally, a learning approach is needed that not only teaches content, but also builds deep understanding, learning awareness, and emotional involvement of students. The *deep learning* approach is one of the relevant pedagogical approaches to answer these challenges. *Deep learning* does not just refer to technology or artificial neural networks, but in the context of pedagogy, emphasizes the learning process that is *mindful*, meaningful, and joyful (Ministry of Education and Education, 2025).

The facts in the field of learning tools with the*deep learning* approach still do not exist so that the learning tools to be developed consist of teaching modules, student worksheets and assessment of learning outcomes in science literacy learning on alternative/renewable energy materials. The application of the*deep learning* approach in alternative/renewable energy learning is very appropriate to improve students' science literacy. Through this approach, students not only understand concepts theoretically, but are also able to apply them creatively, collaboratively, and contextually and equip them as an environmentally conscious and innovative generation.

LITERATURE REVIEW

Deep Learning in Science Education

Deep learning in education refers to a learning approach that emphasizes meaningful understanding, critical thinking, reflective inquiry, and the ability to connect knowledge with real-world contexts. In science education, deep learning encourages students not only to memorize scientific concepts but also to interpret, analyze, and apply scientific knowledge to solve contextual problems. This approach is closely aligned with the demands of 21st-century education, which emphasize higher-order thinking skills, problem-solving abilities, and scientific reasoning.

Previous studies indicate that deep learning approaches can improve students' cognitive engagement and conceptual understanding in science learning. Learning activities that involve inquiry, problem-solving, collaborative discussion, and reflective thinking have been found to strengthen students' analytical abilities and knowledge transfer processes (Fullan et al., 2018;

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Hattie & Donoghue, 2020). In junior high school science learning, deep learning also supports meaningful learning experiences because students are encouraged to connect scientific concepts with environmental and societal issues encountered in daily life.

Scientific Literacy in Junior High School Science Learning

Scientific literacy is defined as the ability to understand scientific concepts, use scientific knowledge to make decisions, interpret evidence, and explain natural phenomena scientifically. The Organisation for Economic Co-operation and Development (OECD) identifies scientific literacy as an essential competency needed for students to face global challenges, including environmental sustainability and energy issues.

Results from the Programme for International Student Assessment (PISA) consistently show that Indonesian students' scientific literacy remains below the OECD average. This condition indicates that science learning practices still tend to emphasize memorization rather than scientific reasoning, data interpretation, and contextual problem-solving skills (OECD, 2023). Several studies also report that the low level of scientific literacy is associated with the limited use of learning tools that support inquiry-based and reflective learning activities (Widodo et al., 2021).

The development of learning tools oriented toward scientific literacy has become an important strategy for improving science learning quality. Contextual and problem-based learning tools can help students interpret scientific information, evaluate evidence, and relate scientific concepts to everyday situations (Bybee, 2019). Effective learning tools are expected to facilitate active learning processes that strengthen students' reasoning and scientific understanding.

Alternative and Renewable Energy in Science Learning

Alternative and renewable energy topics have strong contextual and interdisciplinary characteristics, making them highly relevant for developing students' scientific literacy. Energy issues are closely connected to environmental sustainability, technological advancement, and social life. Learning about renewable energy allows students to understand scientific principles while developing awareness of sustainable energy use and environmental responsibility.

Previous research demonstrates that renewable energy learning implemented through project-based learning, inquiry learning, and problem-based learning can improve students' critical thinking and environmental literacy (Fitriyah et al., 2022; Rahmawati & Suprapto, 2023). However, studies specifically focusing on the integration of deep learning principles into learning tools for improving scientific literacy on renewable energy topics at the junior high school level

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remain limited. Most previous studies emphasize instructional models rather than the systematic development of integrated learning tools.

METHODS

The development design used in this study is the ADDIE model. ADDIE development design is one of the systematic learning designs as a procedural aspect of the system approach that has been realized in many methodological practices for text design and development, audiovisual materials, and computer-based learning materials. Based on that, this study uses the ADDIE development design so that the design prepared can be systematic and procedural. The ADDIE model was developed by Dick and Carry (1996) to design a learning system consisting of 5 steps or stages, namely: *analysis, design*, *development*, *implementation*, and *evaluation*.

This research was carried out at Surabaya State Junior High School, in the even semester of the 2025/2026 school year with the implementation time in March 2026. The research subjects of class IX-G students were 34 students, IX H as many as 33 students and IX I as many as 33 students, while the focus of the research was the development of *deep learning learning device modules* to improve the science literacy of junior high school students on alternative/renewable energy materials.

The learning tools in this study are tools used in the learning process at the time of data collection, which consists of teaching modules, LKPD, and teaching materials whose stages are adjusted to the *Deep learning* model. The learning tools that have been developed will be validated using the validity instrument sheet of the learning tool. The validity instrument of the learning tool is a measurement tool used to determine the level of validity or feasibility of the developed learning tool. This instrument is in the form of a questionnaire or assessment sheet given to experts or validators. What is assessed is the validity of the construct and the validity of the content (Budiaji, 2018).

OVERVIEW OF CONSTRUCTIVISM

This research uses ADDIE's development design so that the design prepared can be systematic and procedural. The ADDIE model was developed by Dick and Carry (1996) to design a learning system consisting of 5 steps or stages, namely: *analysis, design*, *development*, *implementation*, and *evaluation*.

The main activity in this first stage is to analyze the need for the development of new learning models/methods and analyze the feasibility and conditions for the development of new

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learning models/methods. Content analysis is carried out with the aim of identifying the main parts of the research, such as models, approaches, materials, and so on. Construct analysis was carried out to determine the need for new learning tools in improving students' science literacy.

The design stage includes several planning for the development of learning tools, including several activities , namely the preparation of learning tools based on curriculum studies, learning outcomes, learning objectives, to determine learning materials based on facts, concepts, principles and procedures, learning time allocation, indicators, and student assessment instruments. The next stage is to design learning scenarios and learning tools in the form of teaching modules/lesson plans, teaching materials, LKPD, and learning media based on learning materials in accordance with the learning model used in the development.

In carrying out this development step, there is an important goal that must be achieved, namely producing or revising learning tools that will be used to achieve the learning objectives that have been formulated. The researcher validated the trial of the resulting device and revised it.

Evaluation is a process carried out to provide value to the development of media in learning. Evaluation is carried out during the development process starting from the *analysis, design, development*, and *implementation* stages (Syahid et al., 2024).

RESEARCH RESULT

The results of validation by three expert validators show a high level of agreement. Based on Cronbach's Alpha calculations, the reliability value of the content validity reached 0.783 and the construct validity was 0.724. This shows that the assessment instruments and tools developed are consistent and reliable.

Learning Tool Validation Results

Device Components	Deal Percentage (%)	Category
Teaching Module	93,0%	Highly Valid
Student Worksheet (LKPD)	88,0%	Highly Valid
Textbooks	95,0%	Highly Valid
Science Literacy Test Instrument	94,0%	Highly Valid

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The practicality of the device is assessed from two aspects: the implementation of learning by the teacher and the response of the students. In the extensive trial, the average implementation reached 89.0%, which means that all steps in the teaching module can be implemented very well. Student response to the learning process reached an average of 93.2%.

Students stated that the use of Deep Learning-based LKPD made them more concerned about environmental issues (score 97%). In addition, the illustrations in the textbook were considered very helpful in understanding abstract concepts about energy conversion (score 94%)

The effectiveness analysis is based on improving science literacy scores. The results of the t-test showed a p< value of 0.05, which means that there was a significant difference between before and after use of the device. The average *N-Gain* values in the broad trial class were as follows:

Science Literacy N-Gain Results

Classes	Rerata N-Gain	Category
IX G	0,44	Medium
IX H	0,48	Medium
IX I	0,45	Medium

This improvement is supported by the application of *the joyful learning* pillar where students feel happy when doing a project to create a simple alternative energy model. A non-stressful learning atmosphere triggers students' creativity and critical thinking skills in solving problems related to alternative/renewable energy.

THEORETICAL INSIGHT

The *Deep Learning approach* in this study is constructed through three pillars that are integrated with each other to overcome students' psychological and cognitive barriers, namely *mindful learning* which will encourage students' full awareness and attention to scientific details, which allows students to become active agents where students directly participate in the investigation process, not just passive recipients of information. *Meaningful Learning*: that is learning that connects abstract concepts of science (such as alternative energy) with authentic real-world phenomena. This ensures that scientific knowledge has a "useful value" in the frame of

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mind of students. The next is *Joyful Learning*: where learning creates a positive and challenging learning environment, which theoretically lowers the *affective filter* of learners, so that they are more courageous in asking scientific questions and critically evaluating data.

Theoretically, the development of this tool maps the learning phases precisely to the science literacy competency indicators:

- **Problem Orientation Phase (Meaningful):** Practicing the Competence **of Explaining Phenomena Scientifically**. Learners are encouraged to identify real problems in their environment (e.g. energy crises), which builds an early awareness of the importance of scientific evidence.
- **Investigation Guidance Phase (Mindful):** Train the competence of **Compiling and Evaluating Scientific Investigation Designs**. In this stage, students conduct independent research and critical data interpretation, which is the core of high-level science literacy.
- **Developing & Presenting Results (Joyful) Phase:** Practicing the ability **to communicate solutions**. The transformation of data into products (such as infographics or posters) reflects a deep understanding that has been internalized.

SOCIAL LEARNING THEORY - ACADEMIC PERSPECTIVE

In the context of research on the development of learning tools to improve science literacy, *Social Learning Theory* (SLT) pioneered by Albert Bandura, as well as its development within the framework of socioconstructivism, serves as a theoretical foundation that explains how social interaction accelerates the acquisition of scientific competence.

From an academic perspective, *the Deep Learning* tools developed in the research in the form of Teaching Modules, LKPD, Textbooks and Science Literacy Tests do not stand alone, but interact in a triadic relationship, namely the personnel factor (Cognitive) which is the expectations and self-confidence (*self-efficacy*) of students towards science literacy. The environment, which is an alternative energy-based learning tool that provides contextual and behavioral stimulus, namely research and discussion activities structured in the LKPD.

The *Social Learning Theory* perspective emphasizes that the success of learning is highly dependent on an individual's belief in his or her abilities which is closely related to *deep learning*, namely the Joyful Learning Element, by creating a joyful atmosphere, your learning device reduces anxiety and increases *self-efficacy*. Relation to Literacy with Students who have high social *self-efficacy* (dare to discuss and debate scientifically) tend to be better in the competence of "Explaining Phenomena Scientifically" because they feel supported by their learning community.

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And Insight, namely *Deep learning*, occurs when a device is able to create an environment that stimulates behavior change through mindful cognitive processes.

CONNECTIVISM'S IMPLICATIONS FOR TEACHING AND LEARNING

Connectivity is a learning theory for the digital era that views learning as the process of forming a *network* and connecting *nodes* of information. In the context of research on *Deep Learning devices* at SMPN 1 Surabaya, the following are the academic implications:

1. The Role of the Teacher as a "Node-Facilitator" (Network Guide)

   In connectivity, teachers are no longer the only source of knowledge (*sage on the stage*).

   - Implications: In the *Deep Learning* tools you developed, teachers serve as a link between learners and external sources of information (textbooks, global issues of alternative energy, and environmentalists).
   - Relevance to Data: A high value of practicality (89%) indicates that your teaching module successfully facilitates teachers to not only teach, but direct students to navigate science information independently**.**

2. Learning as a Connecting Node Process

   Connectivityism emphasizes that knowledge lies within networks, both human networks and technological networks.

   - Implications: Science literacy is no longer about how many formulas are memorized, but rather students' ability to connect alternative energy concepts in schools with real-time data of the global energy crisis.
   - Deep Learning Integration: The Meaningful Learning pillar in your thesis is a manifestation of connectivityism, in which students connect the "science theory" node with the "real problem around" node (the student's response score is 90% on this point).

3. Currency Information Update

   A key tenet of connectivity is *currency*—that knowledge is constantly changing and evolving rapidly.

   - Implication: Renewable Energy Materials are highly dynamic. Your learning tools (LKPD and Teaching Materials) train students to find the latest information. Science literacy in the perspective of connectivity is the ability to distinguish between up-to-date and outdated science information.
   - Research Results: Improved "Data Interpretation" competency (Chapter 4) shows students are beginning to be able to process this dynamic flow of information.

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4. Distributed Cognition

Learning in connectivity is collective. Knowledge is spread among the students.

- Implications: Through *Social Learning* driven by LKPD, there is a process of sharing knowledge.
- Relation to Data: The highest score in student responses (97%) was in the aspects of discussion and collaboration. Theoretically, this means that your device has successfully built a "learning network" in the classroom, where the success of the individual depends on his or her ability to absorb and contribute to the group's network.

Sec. 5. Decision Making as a Learning Process

Connectivity views choosing what to learn and interpreting the incoming information as the core of the learning process.

- Implications: Learners are trained to decide which alternative energy solutions are most feasible to implement based on scientific evidence.
- Deep Learning Connection: The Pillars *of Mindful Learning* (mindfulness) support this principle by requiring students to be critical of every "node" of information they find before accepting it as scientific truth.

CONCLUSION

Based on the results of research and development of Deep Learning-based learning tools to improve the science literacy of junior high school students in Alternative Energy materials, several main conclusions can be drawn as follows:

1. Successful Device Development (ADDIE Model)

   This research has succeeded in developing a complete learning tool through the ADDIE (*Analysis, Design, Development, Implementation, Evaluation)* development model. These tools include Teaching Modules, Student Worksheets (LKPD), Textbooks, and Science Literacy Test Instruments. All components are systematically designed by integrating the three main pillars *of Deep Learning*, namely *Mindful Learning* (cognitive awareness), *Meaningful Learning* (contextual meaning), and *Joyful Learning* (emotional comfort).
2. High Quality Validity and Reliability

   The learning tool was declared Very Valid based on the assessment of experts. The consistency of validator assessments tested using *Cronbach's Alpha* coefficient showed reliable numbers, namely 0.783 for content validity and 0.724 for construct validity. This

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proves that the developed device has a strong theoretical foundation, logical interconnectedness, and language and graphic display that are in accordance with the level of cognitive development of junior high school students.

3. Level of Practicality in Implementation
   Learning tools have proven to be very practical to use in classroom learning. This is supported by two key findings:
   - Syntax Implementation: The percentage of learning implementation by teachers reached an average of 89%, indicating that the teaching modules prepared are easy to understand and can be implemented according to planning.
   - Student Response: Students responded very positively with an average score of 93.2%. Students feel most helped by the team collaboration aspect and the device's ability to connect alternative energy materials with real environmental issues around them.
4. Effectiveness on Science Literacy
   The application of *Deep Learning tools* has proven to be effective in significantly improving students' science literacy. The results of the paired t-test showed a real difference between the initial ability (*pre-test*) and the final ability (*post-test*). The average increase value (*N-Gain*) is in the range of 0.44 to 0.52 (Medium Category). This effectiveness is especially seen in the students' ability to interpret data and evidence scientifically and explain scientific phenomena related to renewable energy.
5. Learning Culture Transformation
   Substantively, this study concludes that the transition from *Surface Learning* to *Deep Learning* through this device is able to build a network-based learning ecosystem (*Connectivism*). Students not only become consumers of information, but become subjects who actively construct knowledge through social interaction and critical reflection on global energy issues.

The development of this learning tool is expected not only to stop as an administrative document, but also to become an instrument of pedagogical change that is able to equip future generations with resilient science literacy to face the global energy and environmental crises in a *mindful*, meaningful, and *joyful* manner.

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