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STEL (System Thinking and ESD Learning) Model : Developing Elementary School Students' Systems Thinking Skills

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Abstract: This study aims to improve elementary school students' systems thinking skills through sustainable development-oriented learning. This research method uses an experiment with a quantitative approach to test the effectiveness of developing elementary school students' systems thinking skills. The learning prepare expressly employments the STEL (System Thinking & ESD Learning) learning show which is taken after by 19 basic school understudies in Tasikmalaya City, West Java. The instrument used is an essay test consisting of 8 questions with an assessment rubric made on a scale of 1-3, then the value processing is converted into a maximum score of 100 so that it is easier to analyze the value of elementary school students' systems thinking skills. Information collection was carried out some time recently and after the execution of learning utilizing the STEL model. Generally, the comes about of the pretest-posttest think about of students' systems thinking abilities experienced an insignificant increment. These results provide an overview that elementary school students' systems thinking skills can be developed, only the pretest results of 37.47 and posttest of 49.89 certainly show the results of an increase in students' systems thinking. An important note from the results of this study provides information that systems thinking skills can be developed gradually and sustainably. The learning process through the STEL learning model will prepare understudies to discover the center of environmental issues efficiently and empower understudies to pay more consideration to the affect of each of their exercises and take more mindful activities as it were for environmental, social and economic sustainability.

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Introduction

Education for Sustainable Development (ESD) is an inseparable part in supporting the Sustainable Development Goals (SDGs) program, where ESD is a global issue that has 17 sustainable development goals (SDGs). To realize these sustainable development goals, one way is through education, where instruction may be a implies to present the concept of SDGs as an exertion to alter people's points of view and demeanors towards the environment. Most natural issues are established in a need of instruction approximately the environment and around ways to lead a economical life. In relation to these problems, UNESCO has an approach to learning known as Education for Sustainable Development (ESD) which can provide solutions. ESD for the most part centers on creating and reinforcing person abilities, empowering people to contribute and take part within the sustainable development handle of different sorts and measurements (Hoffmann & Siege, 2018). ESD has 3 columns that receive the concept of sustainable development, specifically the environment, economy and society (UNESCO, 2017). ESD is one of the ideas and principles of sustainable development to individuals through education (Nikolic et al., 2020).

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ESD emphasizes more on the Activity Abilities approach, to be specific in terms of creating students' abilities, inspiration, and want to play an dynamic part in finding equitable arrangements to sustainable development issues (Mogensen & Schnack 2010). ESD underpins five essential sorts of learning to supply quality instruction, to be specific learning to know, learning to be, learning to live together, learning to do, and learning to convert oneself and society (UNESCO, 2009). Where schools are an important place to develop the knowledge and awareness needed among future youth towards sustainable development, which ultimately helps pave the way for achieving sustainable development goals. Where through the concept of sustainable development, there's an generally objective to adjust the welfare and change of people's lives all inclusive in space and time, whereas at the same time protecting characteristic assets and environments (Pauw et al., 2015).

In this setting, instruction for sustainable development particularly includes the securing of a number of aptitudes (de Haan, 2006). Where in shaping competence implies the particular capacity to act and unravel issues, those who have these competences can offer assistance, through their dynamic support in society, to alter and shape long run of society, and to direct social, economic, innovative and environmental changes along the lines of sustainable development (de Haan, 1999). Or it implies having the abilities, competences and information to form changes in economic, ecological and social behavior without such changes continuously being as it were a response to pre-existing issues (de Haan & Seintz, 2001). Education for sustainable development has taken an important role in the discussion on the acquisition of competences that are appropriate to the future (de Haan, 2006). Therefore, within the instructive handle it is essential to apply ESD abilities such as systems thinking abilities, expectant aptitudes, regulating aptitudes, key aptitudes, collaboration aptitudes, basic considering aptitudes, self-awareness abilities, and issue integration abilities (UNESCO, 2017). Students learn to adapt to complex evolving situations, develop better systems thinking skills, problem-solving skills (Laurie et al., 2016). In addition, systems thinking goes past fundamental real review and incorporates aptitudes such as assessment and revelation, so it ought to be considered a higher-order considering ability (Frank, 2000). Instructors ought to energize understudies at all scholastic levels to lock in in errands that include higher-order thinking abilities (Zohar & Dori, 2003). Systems thinking is characterized as a set of explanatory abilities that are key and arranged towards progressing the capacity to distinguish and get it a system, foresee human behavior, plan and adjust something to assist human work (Arnold & Wade, 2015). In line with that, systems thinking is the ability to reason systematically related to biological characteristics (Gilissen et al., 2020). Another opinion is explained by Godfrey, (2010) that "system thinking may be a way to fathom complex issues and plans, which can be connected in any teach or hone, system thinking permits understudies to get it and oversee circumstances of complexity and vulnerability where there are no straightforward answers. So based on the two definitions, system thinking allows people to look at problems in new ways and it leads to new solutions. By using system thinking, students can organize and understand their experiences better. System thinking has three characteristics, namely: (1) parts, wholeness and layers; (2) connections; and (3) processes (Godfrey, 2010). In addition, system thinking consists of four domains, namely: (1) mindset, (2) content, (3) structure, and (4) behavior (Arnold & Wade, 2017).

The significance of learning that creates systems thinking abilities within the setting of science instruction lies within the reality that numerous wonders around us are illustrations of complex systems, and understanding their capacities requires systemic thinking (Evagorou et al., 2009). Subsequently, understudies who have systems thinking skills are anticipated to

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way better get it how changes in one portion of the system can influence other parts and each component is interconnected. Systems thinking skills are included in one of the ESD criteria. ESD grasps a all encompassing approach and addresses the change of the instruction system to alter the introduction of society for sustainable development. The application of ESD values (social, economic, and environmental) in Elementary Schools will be able to bring out systems thinking competencies in students. Systems thinking is a framework that allows us to see events that are interconnected, not single, and to see forms that change gradually (Lin & Chien, 2019). The application of systems thinking abilities contributes to an coordinates decision-making system, so that students are stimulated to conduct a thorough examination when making decisions (Davidson & Venning, 2011). The capacity of students to get it the flow of life systems will create through systems considering competencies (Schuler et al., 2018). In addition, systems thinking competencies can help improve standard operating procedures in disaster management and similar events in the future (Lin & Chien, 2019). Systems thinking competencies include: (1) the capacity to know and get it connections, (2) to analyze something complex, (3) to think around how systems are implanted totally different spaces and distinctive scales, and (4) to bargain with instability (UNESCO, 2017) Therefore, systems thinking is very appropriate to be developed in elementary schools as a competency that can help students.

Several studies have been conducted in the implementation of systems thinking competencies, including research conducted by (Evagorou et al., 2009), which stated that sixth grade elementary school students have the potential to develop systems thinking skills. In addition, an investigation of systems thinking concept mapping conducted by (Brandstädter et al., 2012) on 150 fourth grade students in Germany positively influenced student performance in concept mapping. The effectiveness of developing an interactive learning environment through contextual topics was able to promote systems thinking to students in six Italian elementary schools and the results showed a positive impact (Ceresia, 2017). Furthermore, (Forrester, 2007) argued that creating a systems point of view takes less time when beginning with youthful (primary school) children who are inquisitive and open-minded compared to minds that have been conditioned to see the world in terms of unidirectional cause and impact. However, systems thinking skills in learning at the primary school present some additional challenges, which are caused by the relatively basic language competencies and abstract thinking skills of children (Forrester, 2007).

On the other hand, Assaraf & Orion, (2005) moreover examined junior tall school students' recognitions of the soil system, and have appeared that they tend to see the system as disconnected parts or pieces of data, which they need a energetic and systemic recognition of the system. This recommends that with appropriate learning students can create their systems thinking abilities, the ponder gives a positive reply to the address of whether such systems thinking aptitudes can be created at the primary schoo. In addition, other research results show that project-based learning with ESD content can train students to develop systems thinking skills and sustainable awareness (Ekselsa, 2023) and ESD learning within the environmental setting has an immaterial impact on students' systems thinking abilities on the subject of natural alter (Mufidah, 2023). This certainly underlies the possibility of developing students' systems thinking competencies in elementary schools. With the clarification that each approach can advance frameworks thinking in schools with the presumption that students can as it were effectively take part in sustainable development in the event that they are able to distinguish and get it complex worldwide connections (Schuler et al., 2018). The novelty of this study is that there are stages of learning through ESD to

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measure primary school students systems thinking skills. Thus, this study aims to create primary school students systems thinking skills through ESD learning.

Research Method

The research method utilized in this consider is an experiment with a quantitative approach. The reason analysts chose exploratory inquire about is since an test within the field of instruction is expecting to evaluate the impact of an activity on behavior or to test whether or not there's an impact of that activity (Creswell, 2014). Actions in an experiment are called treatments, which means providing conditions whose influence will be assessed. The learning topics were developed based on the science material in the independent curriculum which includes Topic A: The Impact of Human Activities on the Environment, Topic B: Various Environmental Problems Due to Human Actions, and Topic C: We Can Be Saviors of the Earth. The learning implementation was carried out for 14 lesson hours with the development of ESD-oriented lesson topics. The implementation of learning carried out in this study used a learning model that was specifically to develop systems thinking skills oriented towards education for sustainable development (ESD). The development of this model is named the STEL (System Thinking and ESD Learning) learning model which adopts systems thinking indicators by Arnold & Wade (2017) and ESD Learning by Hoffmann & Siege (2018). The STEL learning model was developed to facilitate the student learning process in understanding problems systematically and comprehensively. By viewing problems as a system, it does not only focus on fixing what is broken, but will develop a focus on the relationship between what is broken and other components. This relationship can create a relationship, and the relationship can lead to dependency. Thus, students can see a new and better opportunity in solving problems. The stages of implementing the STEL learning model are as follows.

Table 2. STEL (System Thinking and ESD Learning) Learning Stages

Student External Structure	Structure Within Students	Stages	Structure Within Teacher	Teacher's External Structure
Explaining a phenomenon	Thinking about a phenomenon that occurs.	**Identification of Phenomena**	Encourage students to think about a phenomenon	Asking students' views on a phenomenon
Determining the various components present in a phenomenon	Identify the components involved in a phenomenon that occurs	**Component Identification**	Digging students determine various components	Guide students to identify the various components present in a phenomenon
Describes the relationship pattern of components in a phenomenon	Thinking about the relationship patterns between components in a phenomenon that occurs.	**Relationship Patterns Between Components**	Helping students build patterns of relationships between components	Directing students to relate the relationship patterns of components to a phenomenon
Explains the impact of the absence of one component in a phenomenon	Detecting the impact of the absence of one component in a phenomenon that occurs	**Describing the Impact of Components**	Guide students to explain the impact of the absence of one of the components	Provides an understanding of the impact of the absence of one component
Describe past systems or predict future systems.	Analyzing past systems or predicting future systems.	**Describing Past/Future Systems**	Exploring students to respond to past systems/predicting the future	Guide students to recognize systems that occurred in the past or predict systems that will occur in the future

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In expansion, the instrument utilized in this study was a expressive test question comprising of 4 questions, the evaluation rubric was made on a scale of 1-3, at that point the esteem processing was changed over into a most extreme score of 100 so that it was less demanding to analyze the esteem of basic school students' systems thinking skills. The questions were developed based on the systems thinking indicators adopted from Arnold & Wade (2017). The system thinking question grid can be seen in Table 3 below.

Table 3. Grid of Systems Thinking Test Questions

No	Indicator	Description	No. Question
1	Mindset	Exploring various student perspectives on a phenomenon or problem.	1,5
2	Content	Recognizing a phenomenon or problem systematically.	2,6
3	Structure	Able to identify relevant problem relationships accurately.	3,7
4	Behavior	Predicting behavior in future systems.	4,8

Meanwhile, data processing and analysis uses SPSS assistance for normality tests (Shapiro-Wilk), homogeneity tests (Levene's Test) and pretest and posttest result difference tests (Paired Sample T-Test).

Results and Discussion

The development of systems thinking skills in primary schools can help build a foundation of understanding that is important for intellectual development and problem solving by elementary school students. Furthermore, in this study, the data on students' critical thinking skills in this study will be analyzed statistically assisted by the SPSS version 29 application to carry out normality tests, homogeneity tests and hypothesis tests.

Table 4. Results of Statistical Tests of Elementary School Students' Systems Thinking Skills

Data Types		STEL Model	
Groups		Pretest	Posttest
N		19	19
Average		37,47	49,89
Standard Deviation		4,66	7,25
Normality Test (Shapiro-Wilk)	Sig.	0,062	0,096
	Int.	Normal	Normal
Homogeneity Test (Levene's Test)	Sig.	0,127	
	Int.	Homogen	
Difference Test (Paired Sampel T-Test)	Sig.	0,097	
	Int.	Not Significant	

Based on Table 4 after conducting a normality test using Shapiro-Wilk between the results of the pretest and posttest of students' systems thinking skills, the data results were normally distributed. Furthermore, a homogeneity test was conducted using the Levene Test between the results of the pretest and posttest of students, the data results obtained had homogeneous data variance. After that, a hypothesis test was conducted using the Paired T-test where the hypothesis test showed a significance figure of 0.097 which can be interpreted that there was no significant increase in the average between the results of the pretest and posttest of students' systems thinking skills. This shows that the effect of implementing the STEL (System Thinking and ESD Learning) learning model has not had an effect on students'

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systems thinking skills. These results provide an overview that improving students' systems thinking skills still needs to be developed, in addition, the process of implementing the STEL learning model also needs to be developed in order to provide a better impact in the context of students' ability to respond to a number of environmental problems systemically as an integral part of the success of the sustainable development program. Overall, the results of the pretest-posttest study of students' systems thinking skills have an increase of 12.5%. These results provide an illustration that elementary school students' systems thinking skills can be developed, however, the pretest results of 37.47 and posttests of 49.89 certainly show very poor results.

Systems thinking skills are the ability of students to observe a problem in a complex way in a system, so that they can decide a problem by considering the relationship between one and the other as a whole (Andriani & Hamdu, 2021). Based on the indicators used to measure elementary school systems thinking skills, there are several difficulties for students in developing systems thinking. First, in the mindset indicator, students have difficulty exploring various student perspectives on a phenomenon or problem. Students find it easier to define a problem when viewing a problem than to understand the system as a whole (Assaraf & Orion, 2005). In addition, students have difficulty identifying the problem's point of view, both micro and macro, especially in a new system (Penner, 2000). Arnold & Wade, (2015) explained that in systems thinking there is a shift from a reductionist mindset to a holistic mindset that is still difficult for students to adopt, the lack of awareness and understanding of students about systems thinking also makes it difficult for students to overcome complex problems. Second, in the content indicator, students have difficulty in recognizing a phenomenon or problem systematically. Lack of conceptual understanding of students makes it difficult for students to develop systems thinking skills because they have a weak foundation of principles. Without a strong understanding of the components and relationships of a system, this becomes a challenge for students. Third, in the structure indicator, students have difficulty in identifying relevant problem relationships accurately. Trouble understanding the different levels within the system and making associations between them (Keynan et al., 2014). Students moreover have trouble organizing components and forms inside a system framework. This happens due to the confinements of past educational encounters, where the things learned to students are displayed as isolated components instead of as a system (Shepardson et al., 2014). According to Raved & Yarden, (2014), in creating learning, a more noteworthy and unequivocal accentuation is required on the connections between the different levels of organization within the system. Fourth, in the behavior indicator, students have difficulty predicting future behavior in the system. The ability to predict future system behavior can reflect on the implications of their actions and the actions of society on system sustainability, and be able to identify more sustainable alternatives (Watson et al., 2010).

The suboptimal development of systems thinking skills is because most students still view their relationship with nature separately or not holistically. This paradigm sees the relationship between people and the common environment independently (Spano et al., 2020). An case of a student's see that still sees the relationship between people and the environment independently is when students have not been able to connect their relationship with motorized vehicles that have an impact on life, such as producing pollution which in the long term if left unchecked will have an impact on air quality which is getting worse. This shows that students are not yet aware of themselves as components of the system in nature. This paradigm is one of the main reasons why sustainable and environmentally friendly development is difficult to achieve, this paradigm has given rise to exploitative attitudes and

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behaviors towards nature (Dunlap, 2008). Through systems thinking and increasing awareness of sustainability, students' paradigms can change to see a issue from different viewpoints. Thus, preparing students to discover sustainable arrangements energizes them to pay more consideration to the affect of each of their exercises and take more capable activities not as it were for environmental sustainability, but too socially and economically. Furthermore, the less than optimal implementation of the STEL model in developing systems thinking skills will be the next focus in this study, where variations in learning have an impact on students actively involved in activities or projects that apply systems thinking concepts to solve real problems or support sustainability initiatives. Where the results of research conducted by Assaraf & Orion, (2005) stated that children are able to think abstractly at a certain level, especially when involved in investigations conducted in real contexts. Students can use a systems thinking approach to find solutions to sustainability challenges. They can design and implement solutions that consider the relationships between system elements. Students can reflect on the implications of their actions and the actions of society on the sustainability system, and are able to identify more sustainable alternatives. Students can explain the concept of systems thinking clearly and can communicate their ideas and analysis to others, either verbally or in writing. Students have an awareness of ethics and responsibility related to their activities within the setting of sustainability., and are able to identify the moral and ethical impacts of decisions.

This study shows the positive implications of the implementation of the STEL learning model on students' systems thinking skills, namely equipping students with the skills to identify systems and encouraging students to think holistically in a complex system. The application of this learning makes a difference students to be more dynamic within the learning process additionally gives students with the opportunity to make conditions for systems thinking and considering arrangements when confronting the required issue. In addition, through the implementation of learning with the education for sustainable development (ESD) program, it provides individual competency strengthening that allows individuals to contribute and participate in the process of sustainable developmentA transformative and intelligent handle that looks for to coordinated sustainability values and recognitions not as it were into the education system but too students' every day individual lives and supports students to develop a system of thinking about a problem and make the right decisions regarding solutions to address environmental problems individually or collectively in the present or in the future.

Conclusion

Overall, the results of the pretest-posttest study of students' systems thinking skills experienced an insignificant increase. These results provide an overview that elementary school students' systems thinking skills can be developed, only the pretest results of 37.47 and posttest of 49.89 certainly show the results of an increase in students' systems thinking. An important note from the results of this study provides information that systems thinking skills can be developed gradually and sustainably. The learning process through the STEL learning model will train students to find the core of environmental problems systematically and encourage students to pay more attention to the impact of each of their activities and take more responsible actions only for environmental, social and economic sustainability.

Recommendation

Recommendations for elementary school teachers to optimize the implementation of the STEL model require a relatively longer and more in-depth project implementation to

strengthen elementary school students' systems thinking skills. In this study, learning is still limited to several sub-chapters of material, therefore in the future researchers suggest more sustainable learning to optimize the development of elementary school students' systems thinking skills. In addition, it is recommended that teachers need to add variations to STEL learning through learning projects or field-based activities, this is expected to provide a concrete picture in developing systems thinking skills based on problems in the student's environment. This study shows the positive implications of the application of the STEL learning model on students' systems thinking skills, namely equipping students with the skills to identify systems and encouraging students to think holistically in a complex system.

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