Review of Assessment Instruments to Measure Students' System Thinking Skills

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Abstract
System thinking is one of the most important skills of the 21st century. System thinking helps students organize their thoughts in a meaningful way and make connections between seemingly unrelated problems. This study aims to determine the application of assessment instruments on system thinking skills based on literature review. This research uses the Systematic Literature Review (SLR) method. The SLR method is used to identify, review, evaluate, and interpret all available research with the topic area of phenomena of interest, with certain relevant research questions totaling 11 articles. The results of the literature review study that researchers analyzed and concluded that a good and relevant assessment instrument can help evaluate system thinking skills objectively and comprehensively, the application of the assessment instrument has an impact on students, especially on the ability to think systemically and critically.
Keywords: Assessment Instruments, Student Ability, Systems Thinking

INTRODUCTION

In the current era of the Industrial Revolution 4.0, one of them demands human resources that have quality and can be competitive in global competition which requires changes in competencies or skills characterized by the use of information and communication technology in all aspects of life. Qualified and qualified human resources come from quality education as well, where in the learning process students are equipped with skills to solve problems, find ways to solve problems and think reflectively and evaluatively. One of the skills in question is thinking skills. Thinking skills are the most frequently discussed topic in education. Thinking skills are one of the student abilities that must be developed through learning (Retnawati et al., 2019). Thinking skills are one of the life abilities that need to be developed, one of which is through the education process which can ultimately equip students to be able to compete globally which is needed to answer all the challenges and demands faced by individuals including students, one of the thinking skills is the ability to think systems.

System thinking helps students organize their thoughts in a meaningful way and make connections between seemingly unrelated problems to be interrelated (Clark et al., 2017). Systems thinking skills are needed by students in science learning (Assaraf et al., 2013). This is because in science learning students are always emphasized to understand concepts in science material that is very complex. According to Liu & Cindy, many concepts in science material are related to each other, especially in the material of cycles and organ systems (Nuraeni et al., 2020). Hrin et al., (2017) in their research stated that the process of understanding carried out by students will run faster if students are able to relate a concept to other concepts. Systems thinking skills are needed because when students have this ability the process of linking one material with another will be easier. Systems thinking can contribute to the development of students' understanding of dynamic living systems (Schuler

et al., 2017). This ability is needed in education given that the provision of knowledge in schools still focuses on isolated facts rather than on systemic relationships and processes over time. Although noted as important, the integration of systems thinking in education is still limited, which is in line with research conducted by Gilissen et al. (2017).

The ability to think systems requires understanding the multilevel structure of several concepts and the relationship between these concepts (Gilberta, 2018). In addition, systems thinking is the ability to solve problems by looking at other aspects of various overall sources and the relationship of concepts with other sciences Zoller & Nahum (2012) mention systems thinking with its indicators classified as part of high other-thinking skills (HOTS) or high-level thinking skills. Systems thinking skills are closely related to content-specific domain knowledge, but knowledge of content-specific domains characterized by systems. Good systems thinking skills will help students in making decisions so as to avoid a mistake, because systems thinking can help make comprehensive decisions by looking at the impact of decisions or problems in other fields (Clark et al. 2017). Systems thinking is one type of complex thinking. Thirty teachers from various countries participated in developing students' systems thinking skills (Connell & Kozar, 2014). The results showed that students need more support to develop the concept of systems thinking.

Learning with any model is inseparable from the assessment of learning outcomes. Because learning and assessment are inseparable. Learner assessment activities are an important and integral component in teaching and learning activities in schools. To obtain information about the achievement of the results of the learning process of students in accordance with the predetermined objectives, an assessment of learning outcomes is needed. According to Arifin, assessment is a systematic and continuous process or activity to collect information about the process and learning outcomes of students in order to make decisions based on certain criteria and considerations (Destiana et al., 2020). An important function for educators in evaluating student learning is to provide feedback to students in considering the effectiveness and efficiency of the learning process carried out (An et al., 2019). Based on this, educators are expected to be able to conduct good assessments and use appropriate assessment instruments in accordance with the competencies to be measured.

Based on the Regulation of the Minister of Education and Culture Number 66 of 2013 concerning Educational Assessment Criteria as a technical guideline for developing assessment methods, there are several methods that can be used to assess these three aspects. Learner or peer assessment and observation journal notes, self-assessment, interpersonal assessment. Assessment of learners' knowledge (cognitive) can be done through written tests, oral tests, assignments, and assessment of learners' skills (psychomotor) can be done through practical tests, projects, portfolios. Referring to the Permendikbud, an educator should be able to create an instrument that can be used in terms of assessing student learning outcomes. Moreover, in terms of assessing the ability to think systems that use the project-based learning model. Proper and thorough assessment of each aspect will affect the quality of student learning outcomes. Educators must be able to meet the demands of the Permendikbud by conducting a comprehensive assessment not limited to the affective, cognitive and psychomotor aspects of students also need to be considered.

The results of preliminary research on 52 science teachers in Lampung Province show that almost most (70%) already know what is meant by system thinking ability and only a small proportion (20%) have understood how to conduct system thinking assessment. All teachers (100%) feel the need to train students' systems thinking skills and need examples of instruments to measure systems thinking skills in students. The results of the analysis of the test instruments used in the final semester exams for the last 3 (three) school years in Central

Lampung district showed that none of the test instruments measured the ability to think systems.

Other problems related to systems thinking skills experienced by learners include 1) difficulty in analyzing complex problems, learners often face difficulties in identifying the important elements of a problem and devising effective solution strategies; 2) limitations in seeing long-term impacts, systems thinking requires the ability to consider the long-term impact of a decision on an action. Learners often tend to focus on immediate gratification or visible results, without considering the long-term implications of their actions; 3) inability to understand the complexity of the real world, learners can have difficulty in understanding and coping with complexity, as well as making connections between the various aspects involved in a situation; 4) lack of analysis and synthesis skills, systems thinking involves strong analytical skills to break a problem down into its interrelated components that form a whole; 5) lack of awareness of indirect consequences, in system thinking, actions or decisions taken can have significant indirect consequences; 6) inability to adapt to change, system thinking involves the ability to identify changes in a system and adjust the strategy or approach used; 7) lack of collaboration skills, system thinking skills often involve cooperation and collaboration between individuals who have different understandings. Based on the background explanation, this study aims to examine the results of the assessment instrument on aspects of students' system thinking skills on environmental pollution material.

Literature Review

Assessment or evaluation is the process of gathering information to determine the extent to which predetermined learning objectives have been achieved. The information can be in the form of opinions of educators, parents, book quality, evaluation results, and students' attitudes, where evaluation can not only evaluate learning outcomes, but also the learning process (Nuriyah, 2014). Educational assessment is the process of collecting and processing information to measure the achievement of student learning outcomes including: authentic assessment, self-assessment, portfolio-based assessment, tests, daily tests, mid-semester tests, semester-end tests, competency level exams, competency level quality exams, national exams, and school/madrasah exams (Salamah, 2018). The aspect of assessment according to Bloom divides the "learning domain" as a goal formulated into three classifications or aspects, namely: (1) cognitive aspects; (2) affective aspects; and (3) psychomotor aspects. Bloom's Taxonomy is a classification of learning objectives within education that educators set for students, (Nurtanto & Sofyan, 2015).

System thinking helps students organize their thoughts in a meaningful way and make connections between seemingly unrelated problems to be interrelated (Clark et al., 2017). Systems thinking is one of the approaches needed so that humans can view the problems of this world more thoroughly and thus decision making and action choices can be made more directed to the sources of problems that will effectively change the system (Hidayatno, 2016). According to Ackoff, in principle systemic thinking combines two thinking skills, namely the ability to think analytically and synthesize thinking. Meanwhile, according to Hurliman, Systemic thinking emphasizes awareness of everything related in a series of systems. Patterns in thinking such as opposite to fragmented-linear-cartesian thinking (Bungsu & Rosadi, 2021). Systems thinking skills are closely related to content-specific domain knowledge, but knowledge of content-specific domains that are characterized by systems. So this ability is needed in education considering that the provision of knowledge in schools still focuses on isolated facts rather than on systemic relationships and processes over time (Haniyah & Hamdu, 2022). There are 10 indicators of systems thinking that are classified into 6 domains of systems thinking.

Table 1. System Thinking Indicators

Aspects of System Thinking	System Thinking Indicators
Realted	Ability to identify system components nd processes within the system.
Synthesis	1. Ability to identify relationships among system components 2. Ability to identify dynamic relationships within the system
The Emergence of	Ability to organize system components and processes in framework of relationships.
Feedback Loop	1. Ability to understand the cyclical nature of the system 2. Ability to use

RESEARCH METHODS

This scientific article was prepared using the Systematic Literature Review (SLR) method. The SLR method is used to identify, review, evaluate and interpret all available research with the topic area of the phenomenon of interest, with specific relevant research questions. In using the SLR method, a systematic review and identification of journals can be carried out. To complete this research, researchers collected journal articles from Google Schoolar, SINTA, DOI. The keywords are Assessment Instrument, learners' ability, thinking system. The articles collected were only articles published from 2012 to 2023. Researchers selected 11 articles that were closely related to the keywords used.

RESEARCH RESULTS AND DISCUSSION
Research Results

The application of system thinking in students refers to their ability to understand, analyze, and integrate various components in an interrelated system. as for the results of the literature review that the researchers conducted, namely, as follows:

Table 2. Results of Previous Research

Author Name & Year	Title Research	Review Results
Purwanti, Indah Rahadian, Putri Kusumawati, Dyah (2021)	System Dynamics: Implementation of Systems Thinking in STEAM-based Education Paradigm provides an opportunity if it can be utilized properly, forming humans who have only cognitive intelligence.	The research results can be concluded in implementing systems thinking to analyze everyday phenomena. Systems thinking can invite students to find elements contained in a phenomenon and see the relationship between these elements. By using the system dynamics technique, students are trained to be able to simulate their thinking model into a mathematical computational model. The learning stages and assessment system that the author has described above is one example of learning that can be done by teachers in using the system dynamics technique, but the author has not conducted trials on students, so that the real application of this study can be done (Purwanti et al., 2021).
Sujayanti, et. Al, (2012)	Determinants of educational success: systems thinking, external potential, and learning processes	The results of the analysis showed that the ability to think systems of prospective Biology teachers after attending lectures using MLI combined with concept maps on air pollution material averaged 70.33 categorized as sufficient, the percentage of achievement of system thinking ability indicators averaged 74.33% categorized as good, mastery of student concepts on air pollution material averaged 66.10 categorized as good, the correlation between concept mastery and system thinking ability (r) 0.9753 showed a high correlation (Sujayanti, 2012).
Habe, M Junaidi Us, Kasful Anwar (2022)	Determinants of educational success: systems thinking, external potential, and learning processes	The results of this literature review article are: 1) Thinking system affects the success of education; 2) The external potential of education affects the success of education; 3) The learning process affects the success of education (Habe & Us, 2022).

Hamdu, Ghullam Suryani, Lilis Mulyadiprana, Ahmad, (2021)	Difficulty Level of System Thinking Test Questions on the Implementation of Education For Sustainable Learning	The results show that the level of difficulty of the questions that have been developed is divided into 4 levels, including: Very Difficult (21.43%), Difficult (35.71%), Easy (14.29), Very Easy (28.57%) (Hamdu et al., 2021).
Nuraeni, Resti Aliyah, Himatul (2020)	Analysis of System Thinking Ability of Class XI High School Students on Human Respiratory System Material	The results showed that the profile of thinking skills of students in grade XI of Sukabumi City State Senior High School in the 2019/2020 academic year was still lacking in the level 1 and level 2 categories. These results can still be improved by using learning models, strategies and approaches that are able to empower students' system thinking skills. One of the recommended learning models is the discovery learning model assisted by concept maps (Nuraeni & Aliyah, 2020).
Susanti, Ade, Yulianis, (2019)	Analysis of ability to think higher levels in the body defense system topics the grade xi high school students analysis of ability to think higher levels in the body defense system topics the grade xi high school students	Based on the results of data analysis, it can be concluded that the high-level thinking ability of SMAN 2 Lubuk Basung on the material of the body's defense system is categorized as poor. This research can be continued by further researchers because higher order thinking skills need to be applied in the learning process to face future challenges (Susanti, Ade, 2019).
Fakhrurrazi, (2021)	Systemic Thinking Concepts in Developing Strategic Plans	The strategic planning process can provide useful results, including providing a framework for annual budget development, planning management development tools, mechanisms to force management to think about the long term and tools to align managers with long-term strategies (Fakhrurrazi, 2021).
Haniyah, Ami Hamdu, Ghullam, (2022)	Analysis of Systems Thinking Skills Based on Education for Sustainable Development in Education for Sustainable Development Primary Schools	Research results on measurement definition, type of statistical analysis. Rasch Model jointly uses score data based on per person (person) and score data per item (item). The grouping of student abilities into 7 groups, namely students with very low abilities, quite low, low, medium, quite high, high and very high. Meanwhile, the grouping of the difficulty level of the question is divided into 4 groups, namely, the difficulty level of the question is very easy, easy, difficult, and very difficult (Haniyah & Hamdu, 2022).
Haryanti, Yuyun Dwi, (2017)	Problem Based Learning Model Builds Critical Thinking Ability of Elementary School Students	Based on the results of the studies that have been presented, the problem-based learning model has a very large share in developing students' critical thinking skills. Students' critical thinking skills can be developed in the learning process through the learning steps of the Problem Based Learning model. One of the characteristics of the model is the presentation of the problem as the focus of learning. (Haryanti, 2017)
Meilinda, Rustaman Y N, 2021	The Role and Process of Systems Thinking in Science Education	The results of system thinking research are a necessity in learning science because science is a system, however, different systems have different characters. For this reason, the character of learning should pay attention to four characters, namely 1) orienting students to the system used in learning, 2) emphasizing leveling, 3) introducing the interaction of components / subcomponents in the system, 4) linking the structure, function and behavior of components / subcomponents in the system (Meilinda, 2021).
Kordova, Sigal Koral, (2018)	Systems Thinking Education — Seeing the Forest through the Trees	Research results Systems thinking enables understanding of the whole system beyond its components, and clarifies the importance of isolated components as part of the overall system. Systems thinking helps to understand how sub-systems connect to one overall system,

		and provides solutions to client specifications and requirements. In addition, systems thinking makes it possible to understand the reciprocal and mutually influencing relationships among system components and the rest of the system. (Kordova, 2018)

Discussion

In the context of education, the application of systems thinking to learners involves high-level understanding, understanding the interrelationships between concepts gives an impact on learners to be able to see and understand how different concepts are interrelated and form a complete system, then analyze and design problem-solving strategies, consider long-term impacts, identify patterns and changes in the system, use systems thinking tools and methods, and collaboration in problem solving.

The results of the study that researchers found that assessment instruments can play an important role in evaluating students' system thinking skills. There are several relationships between assessment instruments and students' systems thinking skills, including: 1) comprehensive assessment tasks, meaning that assessment instruments designed to measure students' systems thinking skills must include tasks that allow students to apply the principles of systems thinking; 2) open and complex questions, meaning that assessment instruments can include open and complex questions that encourage students to think systematically; 3) project or project-based tasks, assessment instruments can be projects that involve students in system modeling, simulation or data analysis related to the system being studied; 4) the use of system analysis tools, assessment instruments can ask students to use system analysis tools; 5) formative assessment, normative assessment instruments can be used to provide feedback to students about their system thinking skills periodically during the learning process; 6) performance-based evaluation, performance-based assessment instruments can be used to evaluate students' ability to solve problems or practical system thinking tasks.

In line with Schuler's opinion, system thinking skills are needed because when students have this ability the process of linking one material with another will be easier. Systems thinking can contribute to the development of students' understanding of dynamic life systems. This ability is needed in education considering that the provision of knowledge in schools still focuses on isolated facts rather than systematic relationships and processes over time (Schuler et al. 2017).

CONCLUSION

Good and relevant assessment instruments can help evaluate the ability to think objectively and comprehensively, the application of these assessment instruments has an impact on students, especially on the ability to think systemically and critically.

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