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Problematics of HOTS Assessment in Science Learning in Higher Education: Systematic Liteature Review

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Abstract
Higher Order Thinking Skills (HOTS) are skills that are required in 21st century learning. This study aims to describe the problems of HOTS assessment in science learning in universities in terms of technical aspects, forms, and results of learning evaluation through analysis of reputable international journal articles. Data analysis was carried out using Systematic Literature Review (SLR) using the PRISMA (Preferred Reporting Item for Systematic Review and Meta-Analysis) method. The article search tools used are Google Scholar, ERIC, and Science Direct in the 2018-2022 range. The keywords used in the search were "higher education", and "higher order thinking skills". Articles that meet the inclusion and exclusion criteria are articles in reputable international journals Q1 to Q4 in 2018 to June 2022. The results of the SLR analysis describe that: (i) the HOTS assessment technique which is implemented in a formative way in the learning process is not in accordance with the summative assessment; (ii) there are several forms of HOTS assessment in the form of a description test, multiple choice, or non-test in the form of a questionnaire, and the dimensions that are used as references in this measurement are different, namely Bloom's Taxonomy, Marzano's Taxonomy, and factors of educator behavior; (iii) the results of the HOTS assessment at the tertiary level are quite alarming, which are generally in the low category. Suggestions that can be recommended based on these results, namely carrying out learning based on local wisdom oriented 4C (creativity and innovation, critical thinking and problem solving, collaboration, and communication) to improve students' HOTS and carrying out HOTS evaluations in learning in higher education in the form of essay tests.
Keywords: *assessment problems; HOTS; science learning; higher education*

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INTRODUCTION

The educational process at each level leads to the achievement of competence. This competency shows the standards that must be achieved by students after participating in the learning process. Therefore, educators are expected to be able to present a learning process that accommodates the achievement of these competencies to achieve national education goals

with a learning process and evaluation that is oriented towards 21st century skills. The main components in 21st century learning skills are basic literacy, competence, and character quality. Skills that are closely related to the learning process are 21st century learning competencies consisting of four competencies, namely: (i) creativity and innovation, (ii) critical thinking and problem solving, (iii) collaboration, and (iv) communication (WEF, 2015). These four competencies are trained in the learning process so that students are able to achieve Higher Order Thinking Skills (HOTS) both at the cognitive analyze, evaluate, and create levels (Ratna & Retnawati, 2019; Rozi et al., 2021; Widana, 2018).

Nevertheless, the reality of the current learning process is still not able to accommodate the maximum achievement of the four learning competencies, even the learning process and evaluation tends to only reach Lower Order Thinking Skills (LOTS) (Jaenudin et al., 2020; Pratiwi et al., 2019; Saraswati & Agustika, 2020). Concrete evidence of this reality is the PISA survey on the quality of education in Indonesia, namely Indonesia's position in reading ability is ranked 74th, mathematics ability is ranked 73rd, and science ability is ranked 71st out of 79 countries in 2018 (Hewi & Shaleh, 2020). Likewise, the results of the 2015 TIMSS show that Indonesia is ranked 44th out of 49 countries with an average rating of 397. This assessment information also shows that the scientific ability of students in TIMSS is still below the international average of 500 (Adnan et al., 2021; Safari, 2021). This evidence shows that there is a problem, especially the evaluation of learning that must be addressed immediately for process improvement and evaluation of education and achieving maximum learning competence.

In this regard, the evaluation of science learning in universities is currently experiencing several problems. As for some of these problems, namely the minimal implementation of formative HOTS evaluation and metacognitive skills as an effective method (Hamzah et al., 2022), the existence of various forms of HOTS instruments that have been attempted but have not been able to achieve these competencies optimally (Ichsan et al., 2019; Maryani et al., 2022; Mitarlis et al., 2020; Su, 2021; Wijnen et al., 2021; Yusuf et al., 2021), and students always have difficulty in solving HOTS problems properly so that the results are still in progress low category (Ichsan et al., 2019; Mitarlis et al., 2020; Tsaparlis, 2020; Yusuf et al., 2021).

Based on this description, science learning in universities, especially related to HOTS assessment, has various problems. Therefore, we need a literature review on HOTS in science learning in universities to describe the problems that occur both in terms of technical aspects, forms, and learning evaluation results. The benefits expected in this literature review are (i) adding insight into the problems of HOTS assessment in science learning in universities; (ii) become a reference for research focus on HOTS assessment in science learning in universities; and (iii) obtaining alternative solutions to overcome the problem of evaluating science learning in higher education.

METHOD

The approach used in this study is a qualitative approach through Systematic Literature Review (SLR) with the PRISMA (Preferred Reporting Item for Systematic Review and Meta-Analysis) method according to Figure 01 through the Google Scholar, ERIC, and Science Direct search tools. The articles analyzed are in the range of 2018-2022. The keywords used in the search were "higher education", and "higher order thinking skills". Articles that are included in the inclusion and exclusion criteria according to Table 1 are articles in reputable international journals from 2018 to June 2022 with the topic of HOTS assessment problems in science learning in universities totaling 13 articles. The process of data reduction and presentation is based on the results of inclusion and exclusion by grouping problematic findings in terms of technical aspects, forms, and learning evaluation results. Furthermore,

triangulation is carried out by building understanding so that alternative solutions are obtained to overcome the problems of HOTS assessment in science learning in universities.

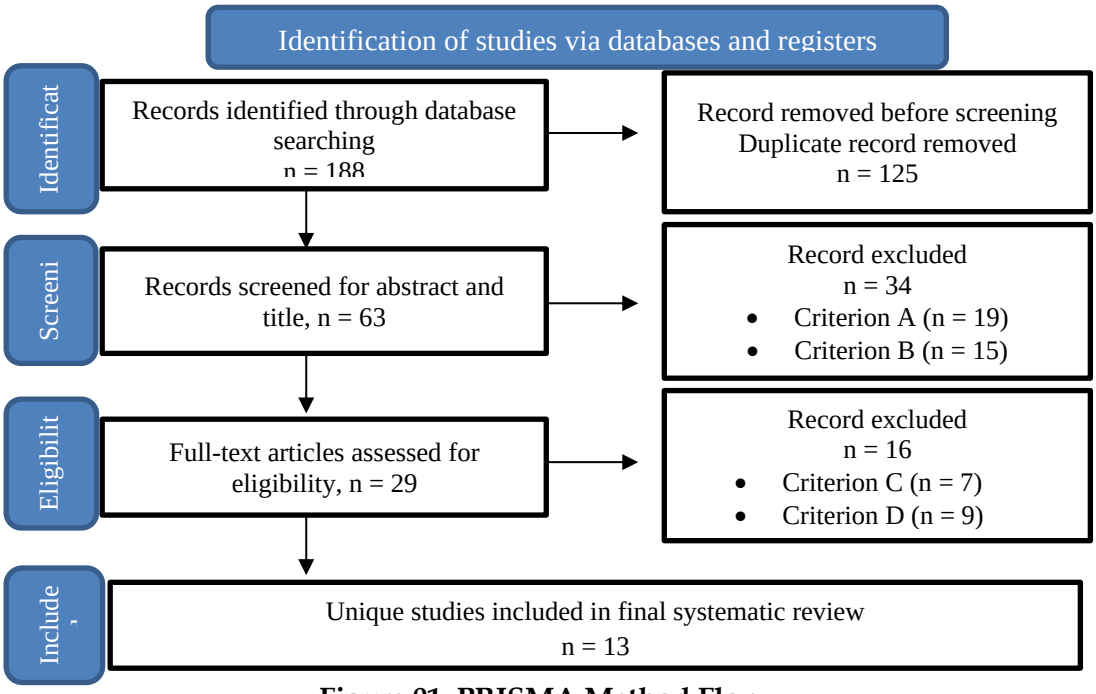

Figure 01. PRISMA Method Flow

Table 1. Inclusion and Execution Criteria

	Inclusion Criteria	Exclusion Criteria
A	Empirical studies or research in English published in reputable international peer-reviewed journals	Other publications (documents that content is theoretical or related to non-educational aspects or books).
B	Free access via internet	No free access via internet
C	Category is restricted to "science education or learning" related to the proposed objective	Papers related to other aspects are not included in the purpose of this study.
D	Documents at the higher education level	Studies or other levels in the education stage.

RESULTS AND DISCUSSION

Based on the inclusion and exclusion criteria that have been implemented, the following is a profile of the literature review of reputable international journals that will be analyzed in Table 2. The number of articles analyzed in 2018 and 2019 is 1 article each, in 2020 is 4 articles, in 2021 is 5 articles, and 2022 is 2 articles. All of these articles are analyzed in relation to technical aspects, forms, and evaluation results of Higher Order Thinking Skills (HOTS).

Table 2. Literature Review Profile of Reputable International Journals

No	Author	Title	Journal	Profile
1	(Yusuf et al., 2018)	Implementation of E-learning based-STEM osn Quantum Physics Subject to Student HOTS Ability	Journal of Turkish Science Education	Scopus Q2 SJR 0,5 Impact Factor 1,91

No	Author	Title	Journal	Profile
2	(Ichsan et al., 2019)	HOTS-AEP: Higher Order Thinking Skills from Elementary to Master Students in Environmental Learning	European Journal of Educational Research	Scopus Q3 SJR 0,31 Impact Factor 1,714
3	(Jarvis & Baloyi, 2020)	Scaffolding in reflective journaling: A means to develop higher order thinking skills in undergraduate learners	International Journal of Africa Nursing Sciences	Scopus Q2 SJR 0,396 Impact Factor 1,62
4	(Mitarlis et al., 2020)	The Effectiveness of New Inquiry-Based Learning (NIBL) for Improving Multiple Higher-Order Thinking Skills (M-HOTS) of Prospective Chemistry Teachers	European Journal of Educational Research	Scopus Q3 SJR 0,31 Impact Factor 1,714
5	(Tsaparlis, 2020)	Higher And Lower-Order Thinking Skills: The Case Of Chemistry Revisited	Journal of Baltic Science Education	Scopus Q2 SJR 0,478 Impact Factor 1,48
6	(Yusuf et al., 2020)	Higher order thinking skills (HOTS)-oriented e-module in electric circuit	Journal of Physics: Conference Series	Scopus Q4 SJR 0,21 Impact Factor 0,48
7	(Su, 2021)	Hocs-Oriented Learning for Students ' Higher- Order Thinking Abilities By Marzano ' S Taxonomy	Journal of Baltic Science Education	Scopus Q2 SJR 0,478 Impact Factor 1,48
8	(Widyaningsih et al., 2021)	The Development of the HOTS Test of Physics Based on Modern Test Theory: Question Modeling through E-learning of Moodle LMS	International Journal of Instruction	Scopus Q2 SJR 0,5 Impact Factor 2,332
9	(Prakash & Litoriya, 2021)	Pedagogical Transformation of Bloom Taxonomy's LOTs into HOTs: An Investigation in Context with IT Education	Wireless Personal Communications	Scopus Q2 SJR 0,481 Impact Factor 2,64
10	(Wijnen et al., 2021)	Measuring primary school teachers' attitudes towards stimulating higher-order thinking (SHOT) in students: Development and validation of the SHOT questionnaire	Thinking Skills and Creativity	Scopus Q1 SJR 1,16 Impact Factor 3,652
11	(Yusuf et al., 2021)	Blended learning: its effect towards Higher Order Thinking Skills (HOTS)	Journal of Physics: Conference Series	Scopus Q4 SJR 0,21 Impact Factor 0,48
12	(Hamzah et al., 2022)	Systematic Literature Review on the Elements of Metacognition-Based Higher	Sustainability	Scopus Q1 SJR 0,66

No	Author	Title	Journal	Profile
		Order Thinking Skills (HOTS) Teaching and Learning Modules		Impact Factor 3,889
13	(Maryani et al., 2022)	Higher-order Thinking Test of Science for College Students Using Multidimensional Item Response Theory Analysis	Pegem Journal of Education and Instruction	Scopus Q4 SJR 0,17 Impact Factor 0,2

HOTS Assessment Problems on Evaluation Technique Aspects

Based on the literature review that has been carried out, the HOTS (Higher Order Thinking Skills) assessment is generally used for class evaluation, not only for final or summative assessments but also for formative evaluations in learning (Tsaparlis, 2020). One of the minimal evidences of the implementation of formative HOTS evaluation is that teachers do not use metacognitive skills as an effective method in HOTS-based learning (Hamzah et al., 2022). Therefore, learning that focuses on science is needed as a process or implementing a HOTS-based learning process for students (Tsaparlis, 2020). Some of the efforts that students can practice in this learning are: developing STEM-based e-learning (Yusuf et al., 2018), developing media, materials, models, and learning strategies that are oriented towards increasing HOTS (Ichsan et al., 2019), HOTS-oriented e-module (Yusuf et al., 2020), provides HOTS-based learning resources (Widyaningsih et al., 2021), carries out brain-based learning to promote elements of thinking in HOCS (Higher-Order Cognitive Skills) (Su, 2021), or the development of metacognition-based HOTS learning modules (Hamzah et al., 2022), or the application of blended learning facilitated by animation, simulation, interactive multimedia, and virtual laboratories (Yusuf et al., 2021). In addition, scaffolding that develops ZPD towards critical thinking can also be trained to provide more professional and independent HOTS achievements (Jarvis & Baloyi, 2020). Another way that can be done is to link learning materials with relevant examples or applications in everyday life that are carried out continuously (Tsaparlis, 2020).

The above efforts emphasize that the HOTS evaluation technique must be implemented comprehensively. This can be trained in the learning process and then measured at each learning phase, such as during UTS and UAS. One of the efforts that can be implemented in the process and evaluation of HOTS-based learning is 4C-oriented learning. This is because HOTS is part of the 21st century (4C) learning skills, namely creativity and innovation, critical thinking and problem solving, collaboration, and communication. After the learning process is running, in a certain phase, namely UTS or UAS, a HOTS evaluation is carried out to measure the qualifications of student learning achievement. This effort is similar to the development of metacognition-based HOTS learning that is able to measure the mastery of thinking skills, attitude formation, and student behavior in learning (Hamzah et al., 2022). In addition, there are also other efforts in implementing the HOTS evaluation technique, namely applying local wisdom-based learning and HOTS-based assessment (Abidinsyah et al., 2019).

The analysis provides a conception of the 4C-oriented local wisdom-based learning process effort to improve students' HOTS. Local wisdom, 4C orientation, and HOTS can be implemented by: (i) designing learning in the context of local wisdom; (ii) training 21st century skills, namely creativity and innovation, critical thinking and problem solving, collaboration, and communication that characterize learning activities; and (iii) measuring student learning achievement with the HOTS instrument. This HOTS evaluation technique is able to minimize or even eliminate the direct focus of learning that does not require students to plan actions, including collecting evidence, and to answer questions that develop students' HOTS (Tanak, 2020).

The Problems of HOTS Assessment on Aspects of Evaluation Forms

In addition to observing the technical implementation of the HOTS evaluation in a formative, summative, or learning process-based manner, the HOTS evaluation can also be measured with several forms of instruments. Wijnen et al. (2021) developed a HOTS evaluation in the form of a questionnaire called SHOT (Stimulating Higher-Order Thinking). Likewise, there are multiple choice questions and descriptions that measure the HOTS ability totaling 77 questions (Maryani et al., 2022). Another form is HOCS (Higher-Order Cognitive Skill) which emphasizes the cognitive aspect in evaluating learning (Su, 2021). In addition, there are also Multiple Higher-Order Thinking Skills (MHOTS) instruments which include critical, analytical, creative, and practical thinking skills (Mitarlis et al., 2020). There is also a form of HOTS evaluation that can be measured through cognitive levels C4, C5, and C6 (Ichsan et al., 2019; Prakash & Litoriya, 2021; Yusuf et al., 2021).

The SHOT (Stimulating Higher-Order Thinking) questionnaire consists of four factors, namely relevance scale, self-efficacy, dependency context, and teaching behavior (Wijnen et al., 2021). The relevance scale refers to educators' beliefs about the importance of stimulating higher order thinking. Self-efficacy refers to the educator's perceived ability to stimulate higher-order thinking. Context dependence refers to educators' perception that external factors, such as available time, or support are prerequisites for them to be able to stimulate higher order thinking. Teaching behavior to determine the attitude of educators towards thought stimulation. This section can also measure teachers' self-reported teaching behaviors related to stimulating higher order thinking.

The HOTS test is divided into six indicators, namely logic and reasoning, analysis, evaluation, creation, problem solving, and assessment (Maryani et al., 2022). Each indicator was developed into 77 questions, 73 items in the form of multiple choice and 4 items in the form of descriptions. Furthermore, HOCS (Higher-Order Cognitive Skill) which emphasizes the cognitive aspect is based on four cognitive levels in Marzano's Taxonomy, namely: (i) retrieval (L1) which can be demonstrated by the ability of students to list characteristics to recognize, remember , and implement as feedback their learning object; (ii) comprehension (L2) which is demonstrated by students' ability to explain reasoning questions, conclude which symbolizes conclusions, and make the right sense to connect scientific knowledge; (iii) analysis (L3) which can be shown by the ability of students to determine the reasons for their expectations to generalize, analyze, classify, and find out conceptual knowledge with alternative relationships and applications, and (iv) knowledge utilization (L4) which is indicated by the ability of students to conduct experiments, solve problems, and make knowledge decisions in encouraging their learning goals (Su, 2021).

The Multiple Higher-Order Thinking Skills (MHOTS) instrument includes four types of abilities, namely critical thinking, analytical, creative, and practical (Mitarlis et al., 2020). These four types of ability indicators are called CACP skills which are measured using tests. The development of the critical thinking ability test follows the indicators proposed by (Ennis, 2011), the analytical thinking test was developed according to Bloom's taxonomy (Anderson et al., 2001), the creative thinking test was developed according to (Torrance, 1980), and the practical thinking test was developed with the concept (Sternberg et al., 2012). Another HOTS instrument can be a multiple choice test based on Bloom's Taxonomy, namely at levels C4, C5, and C6 (Rahmi et al., 2021; Yusuf et al., 2021). Analyzing (C4) is measured through the sub-aspects of differentiating, organizing, and attributing. Evaluating (C5) is measured through the sub-aspects of checking and critiquing. Creating (C6) is measured through the sub-aspects of generating, planning, and producing (Rahmi et al., 2021; Yusuf et al., 2021).

Based on several forms of HOTS instruments that have been developed, the evaluation of students' higher order thinking skills, especially students in science learning can be carried out in the form of description questions at cognitive levels C4, C5, and C6 (Anderson et al.,

2001). Analyze (C4) is in measuring related parts into a structure. Categories in level C4 consist of differentiating, organizing, and attributing. Evaluate (C5) is an indicator in making an assessment based on criteria and standards. Categories in level C5, consisting of, checking and critiquing. Create (C6) is an indicator in arranging and placing elements into a new pattern or structure. Categories in this level consist of generating, planning, and producing. The three cognitive levels in the HOTS assessment refer to three dimensions of knowledge, namely conceptual, procedural, and metacognitive. One of the contexts of learning science in higher education which is process capable of supporting the achievement of cognitive levels C4, C5, and C6 as well as the dimensions of conceptual, procedural, and metacognitive knowledge is local wisdom. Some examples of local wisdom are in the form of learning resources (Abidinsyah et al., 2019), pocket books (Zukmadini et al., 2020), science comics media (Widiyastuti et al., 2021), or the Trikaya Parisudha learning model (Astawan et al., 2021).

The Problems of HOTS Assessment on the Aspects of Evaluation Results

The literature review that has been carried out has also obtained information about the evaluation results, especially those related to Higher Order Thinking Skills (HOTS). Ichsan et al. (2019) stated that overall the students in their research had a very low HOTS category. Other studies also show that students' scores on all HOTS indicators are categorized as low or moderate in conventional learning (Mitarlis et al., 2020; Yusuf et al., 2021). Tsaparlis (2020) also found that the lowest scores obtained by students were questions about HOTS. This is because students do not understand the context used.

The results of the HOTS evaluation on learning in undergraduate tertiary institutions for level C4 (analyze) obtained a score of 1.99, level C5 (evaluate) received a score of 1.91, and level C6 (create) obtained a score of 2.06. These three cognitive levels are in the very low category (Ichsan et al., 2019). Likewise for the master program, level C4 (analyze) gets a score of 2.20, level C5 (evaluate) gets a score of 1.98, and level C6 (create) gets a score of 2.23. These three cognitive levels are also in the very low category (Ichsan et al., 2019). These results also reveal that the lowest scores of undergraduate and master's students are on items that have indicators on evaluating community behavior in preventing air pollution, namely 1.65 and 1.69, respectively.

Low HOTS evaluation results in conventional learning were also found in other research results. Tsaparlis (2020) found the N-Gain value from the HOTS evaluation was in the low and medium categories. The aspect of critical thinking skills got a score of 0.613, creative thinking skills got a score of 0.240, analytical thinking skills got a score of 0.415, practical thinking skills got a score of 0.352, and mastery of organic chemistry concepts got a score of 0.497. The average N-Gain on all aspects of this HOTS is 0.370. Likewise, (Yusuf et al., 2021) found the results that most of the HOTS sub-aspects were in the low category, namely differentiating (70.83), organizing (61.11), attributing (65.28), checking (31.94) , critiquing (37.50), generating (33.33), planning (25.00), and producing (11.11) with the average value of all sub-aspects of 42.01. Furthermore, Tsaparlis (2020) also shows that the HOTS questions in the learning evaluation get worrisome results. There are 22 HOTS questions, only 3 questions can be answered well by students.

Based on the results of the analysis above, the key so that the results of the HOTS evaluation can show maximum results is to carry out learning that is oriented towards improving HOTS through various developments of learning media, learning materials, learning models, and strategies as well as carrying out HOTS-based formative assessments carried out in learning must be in accordance with with subsequent summative assessments (Ichsan et al., 2019; Tsaparlis, 2020). One of the concrete forms of this effort is implementing a 4C skill-oriented learning process and implementing a HOTS-based learning assessment. This 4C learning skill has a connection with HOTS through learning activities that demand

creativity and innovation, critical thinking and problem solving, collaboration, and communication.

CONCLUSION

Based on the results of the literature review that has been carried out, information is obtained about the problems of HOTS assessment in the evaluation of science learning in universities which includes three parts. (i) The HOTS assessment technique which is implemented in a formative way in the learning process is not in accordance with the summative assessment. (ii) There are several forms of HOTS assessment that can be in the form of a description test, multiple choice, or non-test in the form of a questionnaire, and the dimensions that are used as references in this measurement are different, namely Bloom's Taxonomy, Marzano's Taxonomy, and factors of educator behavior. (iii) The results of the HOTS assessment at the tertiary level are quite alarming which are generally in the low category.

In accordance with these findings, there are several recommendations that can be implemented to improve students' HOTS achievement, especially in science learning in universities. (i) A HOTS-based learning process is needed so that students are accustomed to solving problems. One form of this learning process is carrying out 4C-oriented learning that is related to HOTS. (ii) The form of the HOTS assessment carried out in science learning in universities should be in the form of descriptive questions related to contextual problems, one of which is related to the context of local wisdom. (iii) Further research is needed related to the proposed concept, namely about learning based on local wisdom with an orientation of 4C (creativity and innovation, critical thinking and problem solving, collaboration, and communication) to improve students' HOTS.

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