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A Study of Understanding and Implementing Assessment as Learning in Science Teaching: A Case Study of Science Teachers in Indonesia

Un estudio sobre la comprensión y la aplicación de la evaluación como aprendizaje en la enseñanza de las ciencias: estudio de un caso de profesores de ciencias en Indonesia

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Abstract

This study aims to reveal science teachers' understanding regarding 'assessment as learning' (AaL) and its application in science teaching and to propose some recommendations for optimizing AaL. The research approach used is a mixed-methods. The research respondents are 259 science teachers from several regions in Indonesia. The respondents were established by using the convenience sampling technique. The data were collected by using a questionnaire and through interviews in focus group discussions and document studies of science learning tools. Data analysis was carried out quantitatively and qualitatively. The quantitative analysis was in the form of descriptive statistics, while the qualitative analysis used the Miles & Huberman. The validity of the data was measured using a triangulation technique by comparing data from various sources. The result shows that science teachers in Indonesia still do not have a comprehensive understanding of 'assessment as learning'. In addition, they have not been able to fundamentally distinguish between AaL, assessment of learning (AoL), and assessment for learning (AfL). This condition emphasizes the need for AaL guidelines as a teaching model so that they are able to understand AaL, AoL, and AfL and apply them effectively in science teaching.

Key Words

Assessment as Learning (AaL), Indonesian Science Teachers, Science Teaching

Resumen

Este estudio tiene como objetivo revelar la comprensión de los profesores de ciencias sobre la "evaluación como aprendizaje" y su aplicación en la enseñanza de las ciencias, así como proponer algunas recomendaciones para optimizar la evaluación como aprendizaje. El método de investigación utilizado es mixto. Los participantes en la investigación son 259 profesores de ciencias de varias regiones de Indonesia. Los encuestados se seleccionaron mediante la técnica de muestreo por conveniencia. Los datos se recopilaron mediante un cuestionario, entrevistas en grupos de discusión

y estudios documentales de las herramientas de aprendizaje de las ciencias. Los datos se analizaron cuantitativa y cualitativamente. El análisis cuantitativo fue en forma de estadística descriptiva, mientras que el cualitativo utilizó el Miles & Huberman. La validez de los datos se midió utilizando una técnica de triangulación mediante la comparación de datos procedentes de diversas fuentes. El resultado muestra que los profesores de ciencias de Indonesia todavía no tienen una comprensión global de la "evaluación como aprendizaje". Además, no han sido capaces de distinguir fundamentalmente entre AaL, evaluación del aprendizaje y evaluación para el aprendizaje. Esta situación pone de relieve la necesidad de disponer de directrices sobre la evaluación del aprendizaje como modelo pedagógico para que los profesores puedan comprender la evaluación como aprendizaje, la evaluación del aprendizaje y la evaluación para el aprendizaje y aplicarlas eficazmente en la enseñanza de las ciencias.

Palabras clave

Evaluación como Aprendizaje, Profesores Indonesios de Ciencias, Enseñanza de las Ciencias

1. INTRODUCTION

The Ministry of Education, Culture, Research and Technology of the Republic of Indonesia has begun to implement the Merdeka Curriculum as a substitute for Curriculum 2013 in an effort to improve the quality of education in Indonesia (Indriani & Yumna, 2022). The Merdeka Curriculum proposes the importance of a new paradigm in all teaching including the teaching process and assessments carried out by science teachers. One of the new paradigms in the curriculum is the application of assessments carried out continuously at the beginning, process, and end of intra-curricular and project learning so that it can display the learning process and achievements of students as a whole. Due to the importance of assessment in relation to teaching, the relationship between assessment and learning is studied extensively, resulting in much research on assessment impacting learning (Schellekens et al., 2021). The indirect impact in the new paradigm of the assessment process in Indonesia is that all learning including science in class is carried out continuously and in practice it is hoped that it will emphasize a comprehensive and balanced assessment approach including assessment of learning (AoL), assessment for learning (AfL), and assessment as learning (AaL) (Earl & Katz, 2006; Sufyadi et al., 2021).

The term assessment as learning (AaL) was reintroduced by Dann (2002) in his book entitled Promoting Assessment as Learning: Improving the Learning Process. This term is composed of assessment and learning, so that to get a complete conceptual framework for the definition of assessment as learning, start with a definition of assessment and a definition of learning. The initial conceptual assessment in an educational context can be seen as a process of obtaining information that is used to reveal and make decisions about students (what material has been absorbed well and which has not); curriculum, programs, and schools; and education policy (Arustamyan, 2020; Houtz, 2010; Waugh & Gronlund, 2013). Conceptual Learning can be defined as the process of transforming knowledge from teachers to students so that there is a change brought about in the process by developing a new skill, understanding a scientific law, changing an attitude. It is referred to as a combination of various elements in the process where an educator identifies and sets learning objectives and develops teaching resources and implements teaching and

learning strategies (Munna & Kalam, 2021; Sequeira, 2012). Waugh & Gronlund (2013) explain that there is a close relationship between effective learning and assessment. The closeness of the relationship requires that educators clearly specify the learning outcomes to be achieved by learners and the provision of well-designed assessments closely aligns with the characteristics of effective teaching. The description provides an understanding as stated by Waugh & Gronlund (2013) that assessment as a basic part of the instructional program or assessment as learning assessment as learning.

AaL is student-centered and emphasizes assessment as a metacognitive process (knowledge of thinking processes) in learners (Earl & Katz, 2006; Gutiérrez et al., 2018; Latafat, 2021; Lam, 2018; Schellekens et al., 2021). AaL in its application in science learning strongly utilizes learners' thoughts, feelings, actions, and motivations to organize the learning process. Consequently, AaL emphasizes learners' active participation in evaluating and reconstructing specific knowledge with or without teacher guidance. AaL rarely involves grades, but encourages the dynamic application of metacognitive awareness, knowledge and strategies in reviewing work before and/or after submission (Abejehu, 2016; Yan & Yang, 2021). AaL in science learning in the classroom can be implemented in the form of self-assessment or peer-assessment by optimizing the role of feedback from educators (Domun & Bahadur, 2014; Leach, 2012; Panadero, 2016; Radinsky, 2016). Furthermore, Earl & Katz (2006) dimensions of AaL in learning include using assessment to identify what students believe to be true, using assessment to motivate learning, using assessment to make connections, using assessment to extend learning, and using assessment for reflection and self-monitoring. These dimensions become the main focus of how educators in general are able to develop and implement AaL effectively in learning. This research focuses on how well science teachers understand AaL and how to implement AaL in science learning.

Assessment in its various forms has always been a central part of educational practice including in science education at elementary, secondary, and tertiary education levels (Amua-Sekyi, 2016; Lora et al., 2020; Tosuncuoglu, 2018). Examples of implementing AoL in Indonesia are national exams, school exams, and various forms of summative assessment. Problems that are still found in the implementation of AoL in learning include the quality of the tests used to assess students, which are still low, not fully oriented to higher-order thinking, and without or not yet having validity and reliability tests (Mustafidah et al., 2018; Santhosh, 2021). Examples of the application of AfL in Indonesia are assignments, presentations, projects, quizzes, and various forms of formative assessment (Earl & Katz, 2006; Setiawati, et al., 2019). Problems that are still found in the implementation of AfL in learning in Indonesia include the quality of the assignments given to students that are not fully in accordance with the achievement of indicators of achieving competence in accordance with the nature and standards of science (Mulyana et al., 2021; Wulandari et al., 2020). Examples of the application of AfL in Indonesia are self-assessments and assessments between friends (Earl & Katz, 2006; Setiawati, et al., 2019). Problems that are still found in the implementation of AaL in learning in Indonesia include being oriented towards attitude/affective aspects and not optimizing cognitive aspects (Asmarawati & Sujadi, 2016; Tiara & Sari, 2019).

This explanation shows that it is very important for science teachers to understand AaL, AfL, and AoL so that they are able to apply them in a balanced way in science teaching which has an impact on improving the quality of teaching processes and outcomes (Sudiyanto et al., 2015; Widodo et al., 2022). Furthermore, the assessment

approach consisting of AoL, AfL, and AaL has explicitly become a national policy in Indonesia in the Merdeka Curriculum so that each subject applies a comprehensive assessment approach starting from curriculum analysis, the learning process, and the assessment process in one complete cycle. The indirect implication is that all teachers, including science teachers, need to understand the three approaches conceptually and practically in integrating teaching and assessment processes effectively. Some of the principles of assessment in the Merdeka Curriculum are that assessment is carried out integrated with learning and involves students in conducting assessments, through self-assessment, peer assessment, self-reflection, and peer feedback. Waugh & Gronlund explain that there is a close relationship between the learning process and effective assessment (Waugh & Gronlund, 2013). The closeness of this relationship requires that teachers clearly specify the learning outcomes to be achieved by students and that well-designed assessment provisions closely align with the characteristics of effective teaching. These provisions refer to the relationship assessment approach consisting of AoL, AfL, and AaL which are applied in a balanced manner so as to obtain maximum results.

The relationship between the learning process and the effective assessment embodied in AoL, AfL, and AaL underscores the importance of science teachers expanding lesson planning to include comprehensive assessment planning with the AoL, AfL, and AaL approaches. This research article is part of efforts to support the implementation of the new Merdeka Curriculum paradigm in the learning process and effective assessment in Indonesia. This article aims (1) to examine how AaL is understood by science teachers in Indonesia and (2) to reveal how AaL is implemented in the teaching and assessment process and AaL's position when compared to AoL and AfL.

2. METHODOLOGY

2.1. Research design

The research has been conducted by mixed methods with a convergent parallel design model (Creswell, 2017). This approach combines qualitative and quantitative approaches to obtain more complete research data so that the data collected include qualitative and quantitative data, as authors shown in Figure 1.

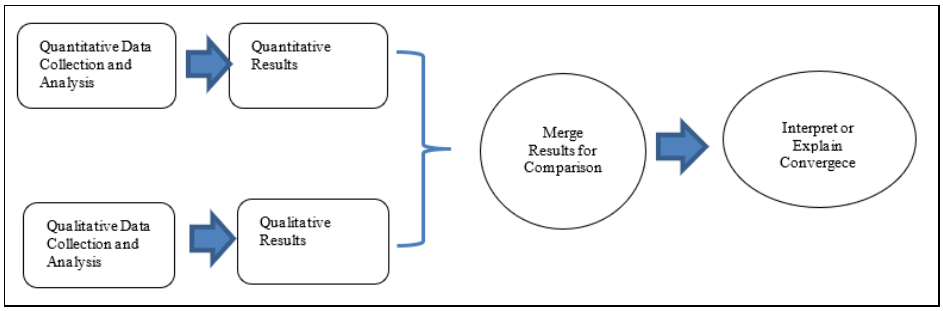


Figure 1. Convergent Parallel Mixed Methods Diagram

The aim of the convergent parallel design model is to provide a comprehensive analysis of the research problem by converging or combining quantitative and qualitative data. Authors in this design usually collect both forms of data at the same time, prioritize

methods equally, maintain the independence of data analysis, mix results during overall interpretation, and try to look for convergence, divergence, contradiction, or relationship between the two data sources (Creswell, 2017; Razali et al., 2019).

2.2. Data collection technique

The data were collected by using a questionnaire and through interviews in focus group discussions (FGD) and the study of learning tools documents. The quantitative data were collected using a questionnaire technique, while qualitative data were collected by interviewing in focus group discussions (FGD) activities and studying document learning materials compiled by science teachers. Meanwhile, respondents were established by using a convenience sampling technique which is a sampling technique based on ease of access to respondents and not based on randomness (Bhattacherjee, 2012; Creswell, 2017; Fraenkel et al., 2023). In this case, the respondents are 259 science teachers who are students of the teacher professional education program, spread across several regions of Indonesia, including Java, Sumatra, Sulawesi, Kalimantan, Papua, and East Nusa Tenggara. The research was conducted from July 2022 to February 2023.

2.3. Research Instruments

The instruments used to collect research data are a questionnaire, an open interview guide in focus group discussions (FGD) activities regarding AaL understanding and its implementation in the learning process and science assessment, and document study sheets for science learning tools. The quality of the quantitative data collection instruments was analyzed using Aiken's V involving five science education experts. Aiken's V validity coefficient is determined by assessing a rating scale from 1 to 5 with information 1 = very irrelevant, 2 = less relevant, 3 = quite relevant, 4 = relevant, and 5 = very relevant. Aiken's validity coefficient is obtained by calculating the raw score from experts with the following equation.

$$V = \frac{\sum(r_i - l_o)}{\lceil n(c-1) \rceil}$$

Description:
r = score given by the assessor
lo = low validity score
c = highest validity score
n = number of experts and practicians who do the assessment
i = month from 1, 2, 3 up to n
n = number of assessors

The determination of being valid or invalid is based on the Aiken table for 5% or a p-value < 0,05 for five expert assessors, which is a minimum of 0,80 (Aiken, 1985). In addition, qualitative data from open interviews in focus group discussion (FGD) activities regarding AaL understanding and its implementation in the learning process and science assessment, and document study sheets of science learning tools in research were analyzed directly by the researchers. The researchers as instruments provide themselves opportunities to enter a world that individuals do not know about the phenomenon in

question and sometimes face many challenges in achieving this goal. Theories and insights that must be mastered by the researchers are AaL, AoL, and AfL in learning science.

2.4. Data analysis technique

The quantitative data were analyzed by using the descriptive statistical method with the help of the Jamovi application, while the qualitative data were analyzed using the Miles & Huberman model including data reduction, data presentation, and conclusion/verification as authors shown in Figure 2 (Miles & Huberman, 1994).

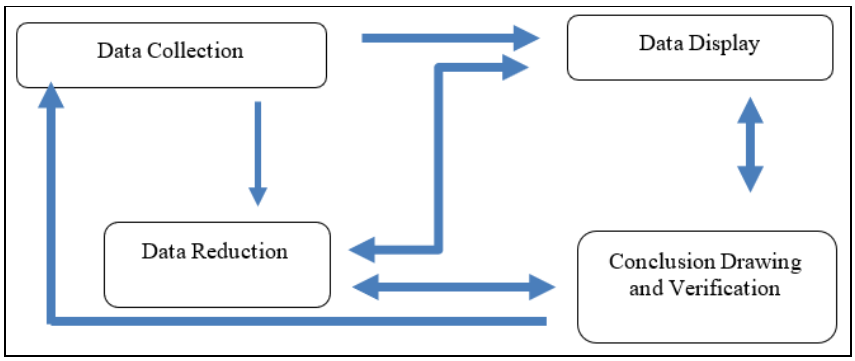


Figure 2. Interactive Model of Qualitative Data Analysis

In addition, a qualitative analysis was carried out with the help of the QDA Miner Lite application. By looking at the presentation of this data, we can understand what is happening and what should be done. The conclusion of the data analysis allows for new findings which can be in the form of descriptions, images, or patterns that were previously unclear so that after the research is carried out these findings become clear. In addition, the validity of the data were also analyzed applying alternate triangulation by comparing data from various sources, as authors shown in Figure 3.

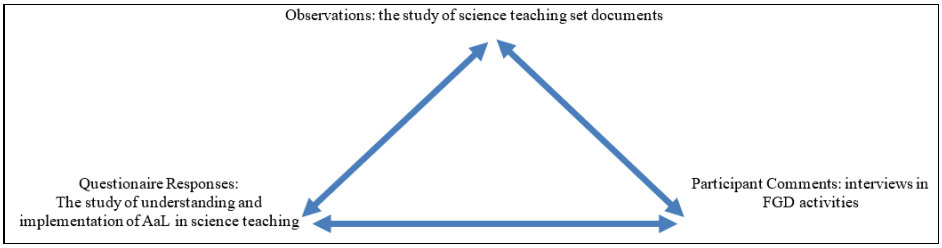


Figure 3. Interactive Model of Qualitative Data Analysis

3. RESULT

3.1. Analysis of the quality of quantitative data collection instruments

The data collection instrument in the form of an AaL understanding questionnaire was analyzed using Aiken's V to maintain the quality of the instrument before it was used in data collection (Aiken, 1985). The analysis of the quality of this data collection

instrument was carried out to ensure validity was fulfilled so that the data collected had valid quality and the conclusions that were precise and accurate. The result of the analysis of the data collection instrument, i.e. a questionnaire, using Aiken's V is presented in Table 1.

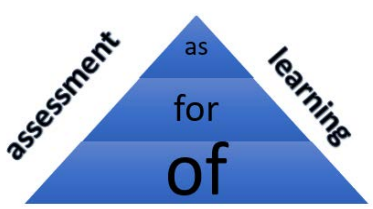
Indicator	Expert Evaluation					V Aiken Average
	(1)	(2)	(3)	(4)	(5)	
Familiar with the term AaL	5	4	5	4	5	0,90
Conceptual understanding of AaL	5	4	5	5	5	0,95
AaL minimum standards in class implementation	5	4	5	4	5	0,90
Automatic feedback in the online assessment system	5	5	4	5	5	0,95

Table 1. Result of the Analysis of Questionnaire Validity using Aiken's V

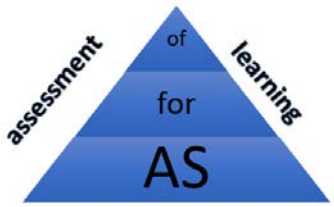
The determination of validity is based on Aiken's filter for 5% or $p < 0,05$ is 0,80. Table 1 shows that the developed quantitative data collection instrument has fulfilled its validity.

3.2. Analysis of the quality of quantitative data collection instruments

Theories and insights that form the basis for collecting qualitative data are AaL, AoL, and AfL in science teaching. The researchers have studied conceptually in depth the three types of assessment approaches applied in science teaching, which are associated with the Merdeka Curriculum paradigm in Indonesia. In an effort to facilitate data collection, the researchers compiled a matrix of the main concepts in AaL, AoL, and AfL in science teaching as authors shown in Figure 4 (Anisah, 2022; Dann, 2002; Earl & Katz, 2006; Sufyadi et al., 2021).



Traditional Assessment Pyramid



Configuration of The Merdeka Curriculum Assessment Pyramid

Figure 4. AoL, AfL, and AaL in the new Paradigm of the Merdeka Curriculum in Indonesia

Researcher used theories and insights about comparison of assessment pyramid. Teachers are expected to focus more on formative rather than summative assessments and use the results of formative assessments for sustainable improvement of the learning process as the Merdeka Curriculum applies in Indonesia. AaL functions as a reflection of the learning process and functions as a formative assessment. AfL serves to improve the teaching process and formative assessment. AoL serves as an evaluation at the end of the teaching and learning process and a summative assessment. In practice, the portion of AaL is larger than that of AoL and AfL.

3.3. Science Teachers' Understanding of Conceptual AaL

Science teachers' understanding of conceptual AaL is very important before they implement AaL in classroom teaching. The information extracted from the science teachers who come from several regions in Indonesia includes familiarity with the term AaL and the understanding they have so far mastered and how to apply it conceptually. Instruments for obtaining information are a closed questionnaire, an open questionnaire, and a guide for interviews in group discussion forums. The familiarity of the term AaL is known from a closed questionnaire and authors shown it in Figure 5.

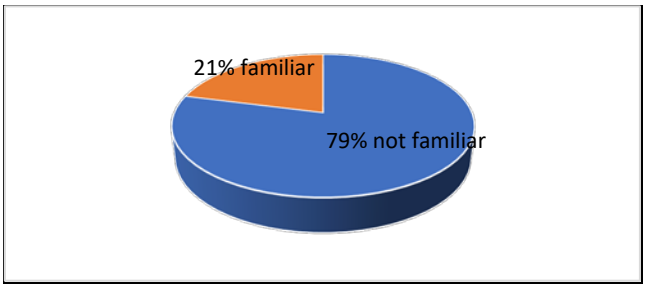


Figure 5. Number of Science Teachers Familiar with AaL

Information related to understanding AaL and the teacher's role in implementing AaL was conceptually gleaned from science teachers who were familiar with the term AaL using an open questionnaire and through interviews in the form of group discussion forums. The answers from the science teachers were analyzed using a scoring rubric to obtain a score of understanding AaL and the conceptual role of the teacher in implementing AaL in teaching science. The result of the quantitative analysis is presented in Table 2.

Island	N	Mean	Standard deviation	Minimum	Maximum
Sumatra	17	0,88	0,93	0	2
Jawa	21	1,90	1,37	0	4
Kalimantan	14	0,071	0,27	0	1
52 of 259 science teachers in Indonesia					

Table 2. Scores of Science Teachers' Descriptive Understanding of AaL

Science teachers in Sulawesi, Papua, and East Nusa Tenggara are not familiar with the term AaL, so there is no need to evaluate their understanding of conceptual AaL. The graph of the average AaL understanding score of science teachers in Java, Sumatra, and Kalimantan regions by authors is shown in Figure 6.

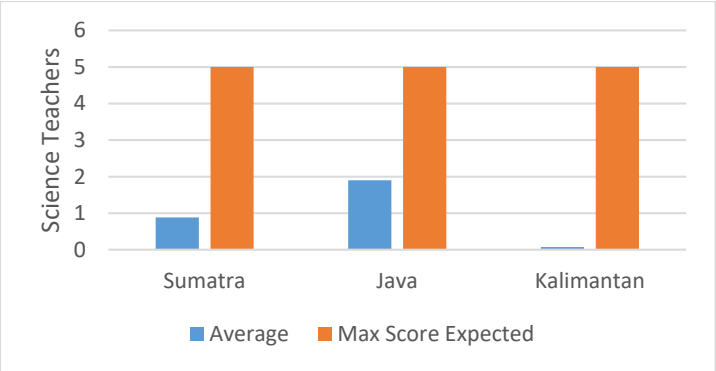


Figure 6. Science teachers' understanding of AaL

With the QDA Miner Lite application from respondents who stated that they were familiar with the term AaL (21%), a figure was obtained about their understanding of AaL, namely, some had led to AaL, some led to AfL, and some others led to AoL, as well as answers that were not related to assessment as shown in Table 3.

Understanding of AaL	Count	% Codes	% Cases
In line with AaL	26	37,7	100
Leading to AfL	13	24,5	100
Leading to AoL	10	18,9	100
Not related to the assessment	10	18,9	100

Table 3. Result of analysis of understanding of AaL against AaL, AfL, and AoL

Table 3 shows the percentage of 59 science teachers who stated they were familiar with AaL with varying responses to understanding. Responses varied, where 37.7% were in accordance with AaL, 24.5% understood AaL which led to AfL, 18.9% understood AaL which led to AoL, and 18.9% understood AaL which was not related to the assessment. This is shown by authors more clearly in Figure 7.

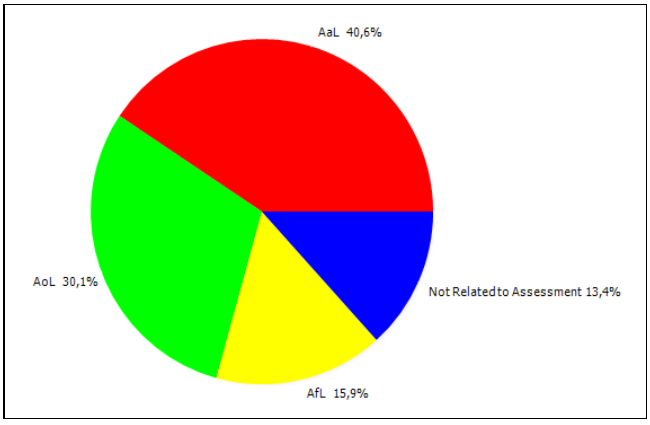


Figure 7. Percentage of Science Teachers' Understanding of AaL against Assessment Approach Type

Further, the results of the interviews in the form of focus group discussions in several meetings with science teachers in different classes from the science teacher during the Teacher Professional Education program are as follows.

1. Some of the science teachers who are familiar with AaL said that they have only heard the terms assessment of learning, assessment for learning, and assessment as learning, but they have not deepened them to actual application in class.
2. Most science teachers are not familiar with AaL, especially when juxtaposed with AoL and AfL.
3. Some teachers stated that AaL was only for attitude assessment.
4. Some teachers stated that AaL was in the form of self-assessment or peer assessment

3.4. Implementation of Assessment in Science Teaching and Aal Position against AoL and AfL

Researchers as data collection instruments use the understanding of AaL, AfL, and AoL about existence of assessment tools are shown in Table 4.

Island	AaL	AfL	AoL
Sumatra	7	9	89
Jawa	16	49	112
Kalimantan	5	8	17
Sulawesi	0	3	21
Papua	0	0	2
Nusa Tenggara	0	0	13
Total	28	69	259

Table 4. Result of Analysis of Science Teachers' Assessment Instrument

Furthermore, the application of the assessment approach to the cognitive, affective, and psychomotor domains in science teaching is shown in Table 5.

Assessment Approaches	Total		Category		
	In Number	In %	Cognitive	Affective	Psychomotor
AaL	28	11%	X	√	X
AfL	69	27%	√	X	√
AoL	259	100%	√	X	X

Notes:
X= not yet implemented
√= already implemented

Table 5. Number of Science Teachers that Implement AaL, AfL, and AoL

Tables 7 and 8 show that most of the AaL have not been implemented by science teachers in classroom teaching. In addition, it can be seen that the portion of AaL is smaller than that of AfL and AoL, and, sequentially, the number of science teachers who apply AaL is 28 teachers, AfL is 69 teachers, and AoL is 259 teachers as authors shown Figure 8.

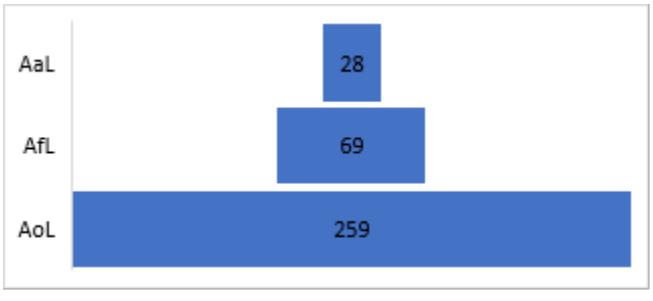


Figure 8. Implementation of AaL, AfL, and AaL in Science Teaching

In addition to the study of the assessment tool document for learning science, feedback is an important part of implementing AaL in teaching science. In addition, the results of interviews in the form of focus group discussions in several meetings with science teachers in different classes during the Teacher Professional Education program are as follows.

1. Most science teachers are not familiar with AaL, especially when juxtaposed with AoL and AfL
2. Cognitive assessment in summative form (daily tests) is always held. While formative assessments in various forms of assignments, quizzes, and laboratory performance evaluations are sometimes not carried out.
3. Skills assessment focuses on reports of practicum results, while practical work is not used to being done on the grounds that it is difficult to assess more or less 25 students with only one teacher.
4. Attitude/affective assessment is carried out by peer-to-peer and self-assessment as in the assessment guide and is carried out once or twice in one semester.
5. During professional education assistance, science teachers focus more on the assessment of and for learning that will be used in field learning practices.

4. DISCUSSION

4.1. Science Teachers' Understanding of Conceptual AaL

The research is a case study of science teachers in different regions in Indonesia, including Java, Sumatra, Sulawesi, Kalimantan, Papua, and East Nusa Tenggara. Figure 5 shows a graph of the number of science teachers who are familiar with the term AaL, amounting to 21% or 52 teachers and those who are not familiar with it amounting to 79% or 207 teachers. The number of science teachers who are not familiar with the term AaL is more, so the term AaL needs to be socialized to science teachers in various types of teacher professional development training. Moreover, the paradigm in the Merdeka Curriculum emphasizes AaL in learning activities. Apart from that, the Merdeka Curriculum which has been applied nationally since 2022 emphasizes AaL getting a larger portion than AoL and AfL (Sufyadi et al., 2021).

Among teacher who are familiar with AaL asked to make essay shortly about what AaL especially when it is compared with AfL and AoL. The ideal scores for understanding AaL are 4 (good) and 5 (very good), but the analysis of the answers from the science teachers shows a score below the expected standard. Regarding to Table 2, the highest average score for understanding AaL from science teachers/respondents in the Indonesian region who stated they were familiar with the term AaL was a science teacher in the Java region with an average of 1,90. In contrast, the lowest average score of AaL understanding of science teachers who stated they were familiar with AaL was science teachers in the Kalimantan region with an average of 0,071.

Moreover, the graph in Figure 6 shows the average score against the ideal score expected from a maximum score of 5. Science teachers in Java, Sumatra, and Kalimantan are still far from having a good understanding of AaL. The distribution of comprehension per score includes 0 (misunderstanding of AaL), 1 (very poor), 2 (poor), 3 (fairly good), 4 (good), and 5 (very good) of science teachers per region. It can be seen that science

teachers' average understanding of AaL still varies and tends to be lacking in each. This graph has major implications for the implementation of AaL in the Merdeka Curriculum paradigm in Indonesia, which places a larger portion of AaL than AoL and AfL. Assessment as learning emphasizes students' progress in learning based on an active process of cognitive restructuring by students in the form of self-assessment or peer assessment. The following is the expected minimum understanding (Dann, 2002; Earl & Katz, 2006; Hickey et al., 2012; Mutch, 2012).

1. Assessment as learning focuses on students.
2. Forms of peer assessment and self-assessment
3. The emphasis is on assessment as a process of metacognition (knowledge of one's own thinking processes) for students.
4. The teacher begins by presenting and exemplifying a structured and grading rubric for students to assess themselves and/or to assess their peers.
5. AaL aims to monitor and self-correct students independently by students so that it indirectly increases student learning independence.

Table 3 and Figures 5 and 6 show that among the science teachers who are familiar with the term AaL, there are still many who do not have the comprehensive understanding that is expected as a provision for implementing AaL. Earl & Katz state that the role of teachers in encouraging the development of student independence through assessment as learning is as follows.

1. Model and teach self-assessment skills.
2. Guide students in setting goals, and monitor their progress towards those goals.
3. Provide examples and models of good practice and quality work that reflect curriculum outputs.
4. Work with students to develop clear criteria for good practice.
5. Guide students in developing feedback.
6. Provide regular and challenging opportunities to practice, so students can become confident and competent self-assessors.
7. Monitor students' metacognitive processes and their learning, and provide descriptive feedback.
8. Create a safe environment for students to take advantage of available opportunities and support.

In addition, the understanding of AaL of some science teachers was still varied, and some of the answers were not correct and there were responses that led to AoL and AfL. The graph in Figure 7 shows the low understanding of AaL and conceptual misconceptions about AaL. These results are consistent with research conducted by Nurcahyono & Putra and Ulumudin et al., which states that teachers' understanding of Merdeka Curriculum learning (differentiated learning) and the three assessment functions is still low, especially in the assessment as learning function. Furthermore, the results of interviews in focus group discussions (FGD) with science teachers showed that their understanding of AaL was still varied and relatively low (Nurcahyono & Putra, 2022; Ulumudin et al., 2020). In addition, there are still misunderstandings. As an example, some of the responses to these answers are presented in Table 6.

Response to Answers to Understanding of AaL by Science Teachers	Answer Analysis
Student learning outcomes become a reference for further learning improvement.	AfL
Students are involved in formulating assessment procedures, criteria, as well as rubrics/guidelines for assessment so that they know exactly what must be done in order to obtain maximum learning outcomes.	AaL
Assessment for learning processes is related to student assessment results	AoL
The application of 'assessment as learning' in science teaching is by using innovative learning models.	Not related to the assessment

Table 6. Responses to Science Teachers' Answers to Varied AaL

Table 6 indirectly shows the readiness of science teachers to implement the Merdeka Curriculum, especially AaL which is still not fully ready. Science teachers' understanding of AaL is still diverse and misunderstandings are found to be the main factor or obstacle that must be overcome first. This is in line with the findings of Ihsan's research which show that in implementing the Merdeka Curriculum there are many readiness components for teachers to be said to be ready to implement the Merdeka Curriculum (Ihsan, 2022). Furthermore, Ihsan states that currently there are still many teachers who are confused about implementing the Merdeka Curriculum, and teachers always need to know what readiness is needed when implementing the independent learning curriculum in the teaching process at school, to the form of assessment.

The results of the discussions and interviews with science teachers, both those who stated they were familiar with AaL and those who were not familiar, showed that the majority of science teachers did not understand AaL well, especially when compared to AoL and AfL. The results of the interpretation and validity of the data using the triangulation technique from various data sources are mutually reinforcing synchronizations briefly as shown in Table 7.

Data Sources	Result of Analysis Using Triangulation Technique
Questionnaire, Answer Analysis, Interviews in FGD activities	1. Science teachers' understanding of AaL, AoL, and AfL is not yet comprehensive. 2. Science teachers still have difficulty conceptually distinguishing bAaL, AoL, and AfL and further applying it, especially AaL 3. Science teachers have not studied in depth AaL and how to apply it effectively and efficiently in science teaching in class

Table 7. Interpretation and Validity of Data on AaL Understanding in Indonesia

4.2. Implementation of Assessment in Science Teaching and Aal Position against AoL and AfL

Ideally, the application of assessments that have been carried out by science teachers based on the new paradigm of the Merdeka Curriculum in Indonesia is carried out in a balanced and sustainable manner from planning, implementing, and not continuing with the AaL, AfL, and AoL approaches (Prihantoro, 2021; Sufyadi et al., 2021). This information was extracted from science teachers who came from several regions in Indonesia, both those who stated that they were familiar with the term AaL and those who had not been or were not familiar with AaL. The instrument for obtaining information was the researchers themselves by examining the science learning tools documents and interviews in group discussion forum activities. AaL emphasizes the integration of teaching and assessment at the same time (Dann, 2003; Earl & Katz, 2006; Sadeghi &

Rahmati, 2017). If it is associated with the new paradigm of Indonesian education, then aspects of teaching and assessment principles are integrated by placing AaL in a larger portion than AoL and AfL.

Regarding to Figure 8, these results show a triangle where the portion of AoL implementation dominates compared to AfL and AaL. Figure 8 shows that the application of assessment in Indonesia is still in the category of traditional assessment pyramid conditions (Earl & Katz, 2006; Sufyadi et al., 2021). This condition basically becomes a special challenge for all science teachers, i.e. how they are able to apply the Reconfigured Assessment Pyramid with more AaL portions than AfL and AoL. These results are in sync with the research conducted by Sudiyanto et al., and Ulumudin et al., which state that the use of assessment in classroom teaching is still not balanced and the use of assessment is still dominated by 'assessment of learning' without being balanced by 'assessment for learning' and 'assessment as learning' (Sudiyanto et al., 2015; Ulumudin et al., 2020). The ideal condition that is expected in the implementation of the new Merdeka Curriculum paradigm is that AaL gets a bigger portion than AfL and AoL. The pattern of applying AaL, AfL, and AoL in science teaching in Indonesia is based on Table 8 if arranged into a graph as authors shown in Figure 9.

Figure 9. Implementation of AaL, AfL, and AaL in Science Teaching

According to Figure 9, the results is in line with traditional assessment pyramid (Earl & Katz, 2006; Sufyadi et al., 2021). Based on the description above, using the triangulation technique by comparing the results of analysis from various data sources, there is a synchronization as follows.

Data Sources	Result of Analysis using triangulation technique related to the implementation of AaL in science teaching
Questionnaire Interviews (FGD) Document Analysis	1. Science teachers are still confused about implementing effective AaL in teaching science. 2. The implementation of AaL is still oriented toward the affective domain. 3. Science teachers tend to develop more AoL for science teaching, followed by AfL, and at least AaL in the form of the Traditional Assessment Pyramid. 4. Science teachers are not used to giving feedback on the results of assignments or students' work.

Table 8. Result of Interpretation and Validation of Data on AaL Implementation in Indonesia

4.3. Recommendations

The results of the interpretation and validity of the data using the triangulation technique show the pattern of applying the assessment in the form of a traditional assessment pyramid which places AoL greater than AfL and AaL. This condition

emphasizes the efforts that must be made by the Indonesian government by involving universities to reform from the traditional assessment pyramid to the reconfigured assessment pyramid as authors shown in Figure 10.

Assessment	Domains		
	Cognitive	Affective	Psychomotor
AoL	√	√	√
AfL	√	√	√
AaL	√	√	√

Figure 10. Reconfigured Assessment Pyramid

Figure 11 is a reconfigured assessment pyramid that is expected in implementing the new paradigm of the Merdeka Curriculum in Indonesia. The implementation of balanced AaL, AfL, and AoL assessments covers the cognitive, affective, and psychomotor domains. This aspect of the assessment refers to learning outcomes based on the applicable curriculum and the Indonesian Qualifications Framework (IQF) which includes affective domain (attitude), psychomorphic domain (general skills and specific skills), and cognitive domain (knowledge) (Directorate General of Higher Education, 2010; Setyawarno & Prasetyo, 2016). A comprehensive reconfiguration design for the implementation of AaL, AfL, and AoL is shown by authors in Figure 11.

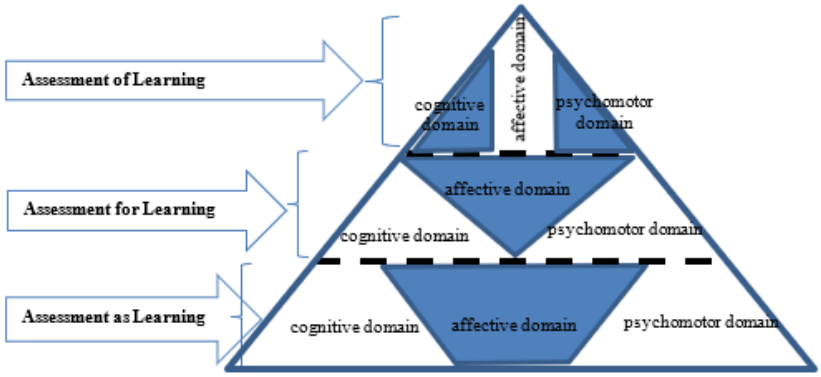


Figure 11. Comprehensive Reconfigured Assessment Pyramid Based on IQF

Students at all levels of education are required to have balanced learning outcomes including science, knowledge, expertise, and skills according to the levels of the Indonesian Qualifications Framework (IQF). These competencies need to be optimized in teaching activities and assessments including in science subjects at the secondary school level. Indonesia is the largest archipelagic country in the world as well as one of the most spatially diverse countries in terms of resource wealth, human settlements, location of economic activities, ecology, and ethnicity (Faisal & Martin, 2019; Hill et al., 2008). This condition has a very large impact, one of which is on the quality of science education in Indonesia, especially the ability to adapt to implementing AaL, AfL, and AoL in a comprehensive and sustainable manner. This research shows that science teachers in Indonesia need training or outreach about implementing the Merdeka Learning Curriculum so that the goals of the curriculum can be implemented properly (Utari et al., 2023). Practical guidance on implementing AaL that differentiates it from AfL and AoL is considered very important for science teachers in Indonesia, as shown in Table 9.

Type of Assessment	Approach to Assessment	Objectives	Technique of Implementation	Time
Formative	AaL	Increase students' metacognitive knowledge and learning independence	Self-assessment Peer assessment	In learning in each material includes: • Daily assessment • Midterm assessment • End-of-semester assessment
	AfL	Evaluate and improve the quality of the learning process	Assignment Presentation Projects Quizzes	In learning in each material includes: • Daily assessment • Midterm assessment • End-of-semester assessment
Summative	AoL	Knowing the achievement of student learning outcomes	Daily tests National exam School exams	The end of learning in each material includes: • Daily assessment • Midterm assessment • End-of-semester assessment

Table 9. Practical Guide to Implementation of Assessment Approaches in Merdeka Curriculum

Table 9 explains the distribution of types and functions of assessment which aims to assist science teachers in implementing assessments in an effective and balanced manner so that they are in accordance with the objectives of the assessment they are carrying out. The most important thing is that AaL can increase metacognitive knowledge which leads to problem-solving skills. Based on theories about assessment as learning and providing feedback on assessments, the steps that can be applied by science teachers in conducting AaL with automatic feedback are as follows.

1. Identify learning outcomes based on the applicable curriculum and write them down in a matrix table that will be included in the AaL.
2. Prepare stimulus questions (figures, graphs, tables, charts, etc.) as the basis for compiling questions.
3. Make questions in various forms (multiple choices, true-false, short answers, descriptions, etc.) accompanied by answer keys and feedback in the form of explanations in written and video form.
4. Enter the questions and feedback in the online assessment system so that feedback can be automatic after students submit their work.
5. Correct and discuss student work results based on automatic feedback in the form of self-assessment or peer assessment.

Furthermore, the application of AaL in the digital era can be integrated with an online platform that allows science teachers to arrange in a systematic manner with automatic feedback (Setyawarno et al., 2023; Widodo et al., 2022). Web-based AaL is carried out in an online assessment system, with various modes and resources to optimize content and interaction between students and learning resources (Liang & Creasy, 2004). An example of AaL with automatic feedback is shown by authors in Table 10.

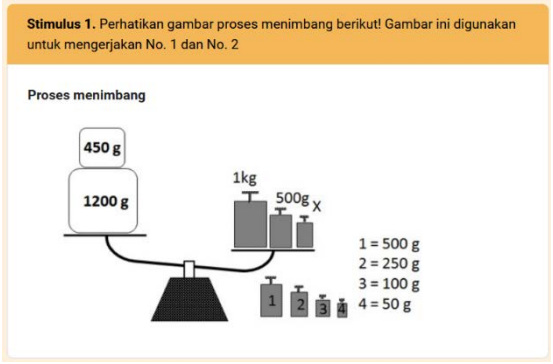
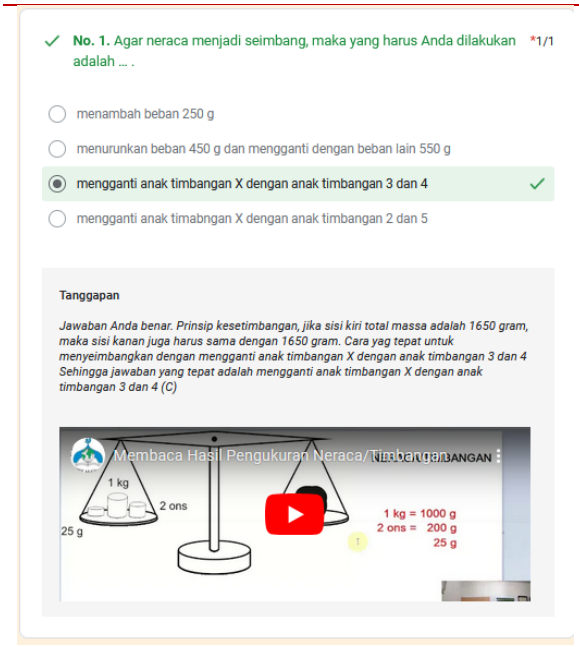
Display	Description
	The stimulus of item about weighing process
	Automatic feedback from weighing questions in the form of writing and video. Allows students to learn from the assessment process

Table 10. Example of AaL in Online Platform and Automatic Feedback

According to Table 10, authors shows a picture of how AaL can be easily integrated with digital platforms. The teacher arranges questions or exercises to improve students' understanding of science concepts, then students work on these questions or exercises for a certain time. After submitting, students automatically get correct or incorrect automatic feedback in the form of explanations presented in writing and reinforced with videos. This process with automatic feedback makes students better understand the concept of science in the form of problem-solving, metacognitive, and independent learning.

5. CONCLUSION

The findings of this study show that science teachers in Indonesia still do not have a conceptual and comprehensive understanding of assessment as learning. The main problem faced by science teachers in Indonesia is that they are not able to fundamentally distinguish between AaL and AoL and AfL both conceptually and practically. The findings also show that the form of the assessment approach in Indonesia is still the traditional assessment pyramid, dominated by AoL rather than AfL and AaL. Furthermore, science teachers also experience difficulties integrating online assessment

systems and automatic feedback to optimize assessment as learning. The implementation of the Merdeka Curriculum is a strategic effort to reform the reconfigured assessment pyramid by positioning AaL to be bigger than AfL and AoL in science learning. This condition emphasizes the need for AaL guidance in practice for science teachers so that they are able to distinguish AaL from AfL and AoL comprehensively to optimize learning outcomes based on the curriculum and the Indonesian Qualification Framework.

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