Theoretical Analysis of 'Assessment as Learning' (AaL) as a Science Learning Model in the Digital Era. An Effort to Optimize the Assessment Pyramid Configuration in the Merdeka Curriculum in Indonesia

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Abstract
This article aims to theoretically analyze how 'Assessment as Learning' (AaL) can be a learning model in the digital era. This learning model is intended to optimize the configuration of the assessment pyramid in the merdeka curriculum in Indonesia which can be adapted in other countries. The research method used is a literature study with deductive reasoning which is a "top-down" approach. The aspects studied are the characteristics of AaL and the rationality of AaL as a learning model. The results of the analysis indicated that AaL emphasizes the activeness of learners in the form of selft-assessment and peer-assessment in the process of cognitive restructuring to create their own understanding. In addition, learners must learn to be critical assessors who are able to understand information, connect it with prior knowledge, and use it for new learning. Moreover, the results indicated rationally that AaL has the potential to be the basis for developing a learning model, which is indicated by the existence of a learning theory that underlies it as a learning model, syntax, social system, reaction principles, support system, and instructional and accompanying impacts. AaL as a learning model in the digital era can be practically implemented with the following stages: : 1) orienting students regarding the learning objectives to be achieved, 2) organizing students in independent work activities using online assessment system (OAS), 3) guiding students in group discussions guided by automatic feedback media, 4) organizing students in AaL activities, both self-assessment and peer assessment, and 5) reinforcement from educators in the form of reflection or evaluation.
Keywords: Science Learning Model, Assessment as Learning, Assessment Pyramid, online assessment system, and automatic feedback.

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1. INTRODUCTION

The educational process with all forms of activities in it is very identical to the teaching and learning process [1]. The process includes three components that must be synchronized, namely learning outcomes based on the curriculum, learning activities and processes, and assessment. The main focus of the activity or learning process is the learner, so the learning approach used is learner-centered [2]. A science educator is emphasized to make efforts on how to understand the development of students and make them active learners. If these efforts are successful, it will make the first step to actualize the educational goals, namely the development of the character and competence of students. Science educators in the merdeka curriculum play a role in facilitating the process and activities of science learning in the classroom therefore students achieve these goals [3]. The ability of science educators to implement an merdeka curriculum holistically is realized in designing, implementing, and evaluating learning according to the characteristics of their students.

The merdeka curriculum that was implemented nationally in Indonesia 2022/2023 academic year gave rise to a new learning paradigm that contains a learning development framework that is not a linear model but is a continuous cycle. Especially in the new paradigm, assessment is one aspect that has undergone significant changes [3]. Particularly in the new paradigm, assessment is one aspect that has undergone significant changes. [3]. Waugh & Gronlund (2013) emphasize that assessment is a process of collecting data that serves to see the abilities of students [4]. Assessment in the context of an merdeka curriculum refers to all activities carried out by educators and learners where feedback is used and developed in the learning process in the classroom [3]. Therefore, as assessment is an integral part of the learning process, the purpose of assessment can be focused on three main categories: Assessment as Learning (AaL), Assessment for Learning (AfL), dan Assessment of Learning (AoL) [5], [6], [7]. All three are seen as objectives rather than methods to establish the desired outcomes of the learning process. As cited in Torrance (2007) , assessment has three roles that are in line with the merdeka curriculum in Indonesia which raises a new paradigm of both the process and assessment of learning which is realized in the form of AoL, AfL, and AaL with the largest portion on AaL [8], [9].

The author views that one form of innovation for improving or improving the process and learning outcomes of students by optimizing AaL, especially in the digital era, which can be integrated with OAS and automatic feedback. Many innovative learning models are recommended in learning including in science such as discovery learning models, problem-based learning, project-based learning, or other models based on scientific approach [10], [11], [12]. All of these learning models are very good to be applied in science learning in the classroom, but the problem in these

learning models is that there are no AaL activities that provide opportunities for students in the metacognitive process. Meaningful learning occurs when learners are actively involved in their learning [13], [14]. In addition, learners will have the experience to do self-assessment or peer-assessment. Self-assessment is more beneficial to learners than assessment by teachers in terms of improving learning. Moreover, learners will also learn through assessment, when educators implement Assessment as Learning (AaL). As a consequence, they will perform tasks according to what is expected by the educator.

This article aims to examine the characteristics of AaL in learning and analyze the rationality of AaL as a learning model. In addition, this article also introduces practical steps for educators in general and especially science educators in the digital era how AaL as a basis for learning models that can be integrated with OAS and automatic feedaback.

1.1 Research Questions

According to the description of the research background and to simplify the theoretical analysis, the research questions in this article are as follows.

1. What are the characteristics of 'Assessment as Learning' (AaL)?
2. What are the results of the theoretical analysis of 'Assessment as Learning' (AaL) as a science learning model in the digital era from the aspects of learning theory, learning syntax, social systems, reaction principles, support systems, and instructional and accompanying impacts?

2. METHODS

The research method used is a literature study with a qualitative approach. A literature study is the compilation, classification, and evaluation of what other researchers have written about a particular topic. Literature studies are usually part of a research thesis, but can also stand alone as an merdeka review of writings on a subject. Literature studies combine theoretical and conceptual frameworks that guide researchers in completing research and offer a foundation for establishing its credibility [15]. The research method used to answer the objectives of this research is deductive reasoning which is a "top-down" approach with a scheme as in Figure 1 [16].

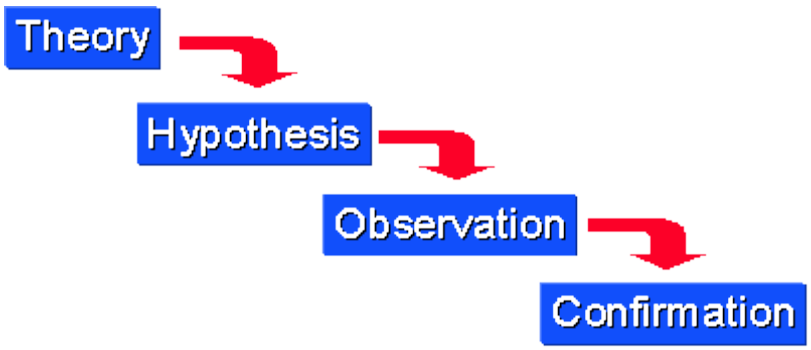

Figure 1. Deductive Reasoning Research Method/a "top-down" approach

3. RESULT AND DISCUSSION

3.1.Characteristics of Assessment as Learning

The term AaL was first introduced at Alverno College in the 1970s [17]. Early in its development the theory was not so clear. AaL at that time was defined as "a process, integral to learning, that involves monitoring and assessing the performance of individual learners against explicit criteria, with resulting feedback to learners". The initial concept of AaL was that feedback from the assessment process could be used to support learning and recognize self-assessment as an important learner experience for learning. AaL is one type of approach to assessment. Before the assessment approach was widely introduced, Scriven (1967) had introduced two widely used terms: formative assessment and summative assessment [18].

AaL and AfL are part of formative assessment designed to improve or enhance quality during the learning process, while AoL is an example of summative assessment that refers to strategies designed to confirm what learners know or to certify learners' proficiency [8], [19], [20], [21]. The concept of formative and summative assessment associated with AaL in science learning is easy to understand if it is also associated with the conceptual AfL and AoL as Figure 2.

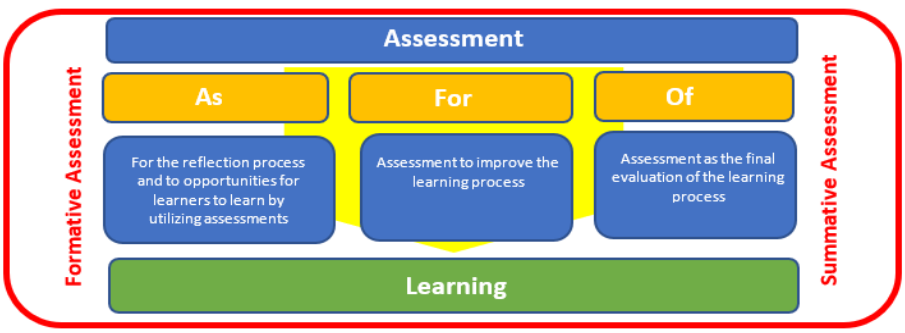

Figure 2. Relationship of AaL, AfL, and AoL with formative and summative assessments

The professionalism of educators in general in carrying out pedagogical tasks in both the learning process and assessment has been a concern of academics, parents, and other interested parties that continues to this day [22], [23], [24]. So far, the use of assessment in classroom learning is still unbalanced [25], [26]. Educators who develop assessments in a balanced manner will provide corrective instructions to improve the learning process and provide a second chance for students to demonstrate success in learning. The level of understanding of science teachers about the assessment approach in learning is the main variable for the successful implementation of balanced assessment. Curriculum changes that are enforced nationally in Indonesia have consequences in the implementation of assessment, namely placing AaL in a larger portion than AfL and AoL as proposed by Dann (2002) and Earl (2003) as shown in Figure 3 [27], [28].

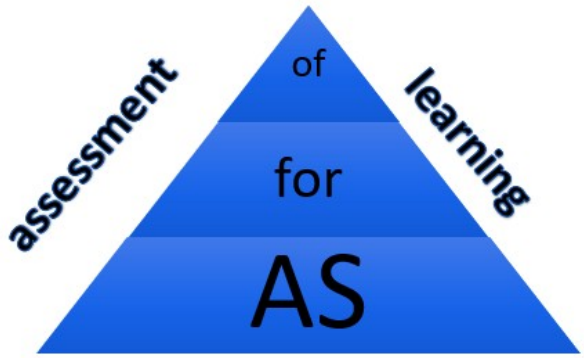

Figure 3. Assessment Pyramid Configuration

The term AaL was first introduced by Dann (2002) in his book entitled Promoting Assessment as Learning: Improving the Learning Process. The term is composed of assessment and learning, so to get a complete understanding of the definition of AaL begins with the definition of assessment and the definition of learning [27]. AaL as part of science learning focuses on learners and emphasizes assessment as a process of metacognition (knowledge of the thinking process) in learners. The statement emphasizes that AaL arises from the idea that learning is not just a transfer of ideas from someone who is knowledgeable to someone who is not, but an active process of cognitive restructuring that occurs when individuals interact with new ideas. For learners to be actively involved in creating their own understanding, they must learn to be critical appraisers who make sense of information, relate it to prior knowledge, and use it for new learning. The author underlines that learners in the AaL-based learning perspective are an important link between assessment and learning.

The process of metacognitive regulation in AaL is that learners become adept at personally monitoring what they are learning, and using what they discover from these monitoring activities to make adjustments, adaptations, and even major changes in their thinking [28]. AaL is based on research on how learning takes place, and is characterized by learners reflecting on their own learning and making adjustments in order to achieve more understanding [8]. Only reading assessment done with learners and ultimately by learners can foster true reading independence and success. Although Afflerbach's (2002) research was specifically on reading, the comments can also be applied to many other areas of learning [29]. Learners become productive learners when they see their work as part of critical and constructive decision-making. AaL focuses on explicitly developing learners' capacity over time to be their own best judges. However, what needs to be considered is that educators should start by presenting and modeling external and structured opportunities for learners to assess themselves in AaL activities.

Assessment is used to understand the state or condition of learning organized by educators in the classroom. An educator assesses learning through observation and measurement in an effort to better understand student learning. Furthermore, Waugh & Gronlund (2013) stated in their book entitled Assessment of Student Achievement that assessment of learning achievement basically includes a broad category of various methods to determine the extent to which students achieve the learning outcomes desired by educators [4]. Furthermore, it is explained that there is a close relationship between the learning process and effective assessment to produce optimal learner achievement. 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. Effective learning requires educators to extend attention to the teaching-learning-assessment process, with assessment as a fundamental part of the learning program. As with all learning activities, the primary function of assessment is to improve learning and can contribute to this goal in several ways.

AaL is based on the belief that learners are adaptable, flexible, and independent in their learning and decision-making [8]. When educators engage learners and encourage their independence, they give them the tools to do their own learning wisely and well. To become independent learners, learners must develop a good combination of skills, attitudes, and behaviors. Self-monitoring and evaluation are complex and difficult skills that do not develop quickly or spontaneously. As with other complex skills, becoming metacognitively aware requires modeling and teaching from educators, and practice on the part of learners. Earl & Katz (2006) state that the role of educators in encouraging the development of learner independence through assessment as learning is as follows [8].

1. Modeling and teaching self-assessment skills.
2. Guiding learners in setting goals, and monitoring their progress towards them.
3. Provide examples and models of good practice and quality work that reflect

curriculum output.

4. Working with students to develop clear criteria for good practice
5. Guiding students in developing feedback
6. Providing regular and challenging opportunities to practice, so that students can become confident and competent self-assessors
7. Monitoring students' metacognitive processes and their learning, and provide descriptive feedback
8. Creating a safe environment for students to take advantage of the opportunities and supports available.

Some of the roles of educators in implementing AaL show that feedback is very important in AaL. Appropriate feedback can improve understanding and provide a model for learners to learn independently, learners will tend to be diligent, and more engaged in active learning. Although AaL is designed to foster independently learning, learners cannot complete it without the guidance and direction that comes from detailed and relevant feedback. Thus, learners need feedback to help them develop independence and competence.

Furthermore, M. Earl (2003) dimensions of AaL in learning include the main focus of AaL in learning, using AaL to identify what learners believe to be true, using AaL to motivate learners, using AaL to make connections, using AaL to extend learning, and using AaL for reflection and self-monitoring [28]. These dimensions become the main focus of how professional educators in general are able to develop and implement AaL effectively in learning. These stages of AaL-based science learning will force learners to learn through how they will be assessed. Some stages of how educators implement AaL in classroom learning are suggested by Heritage (2007, Leahy et al. (2005), and McMillan & Hearn (2008) as Table 1 [30], [31], [32].

Table 1. Stages of AaL Implementation in Learning

Leahy et. al (2005)	**Haritage (2007)**	**McMillan & Hearn (2008)**
The model consists of five stages: 1. Explaining and sharing learning objectives and success criteria. 2. Designing effective class discussions, questions and learning tasks. 3. Providing feedback that moves students forward 4. Activating students	The model consists of seven stages: 1. Defining learning objectives and success criteria 2. Obtaining evidence of learning 3. Interpreting evidence of learning 4. Identifying gaps 5. Providing feedback 6. Adapting and responding to learning needs 7. Supporting new	The model consists of three stages: 1. Determining appropriate learning and learning objectives 2. Self-monitoring which includes awareness of thinking or actions to be performed 3. Self-assessment which includes activities to determine the

as owners of their own learning 5. Activating students as resources for each other	learning and closing gaps	progress of achieving learning goals.

AaL focuses on learners and emphasizes assessment as a metacognitive process (knowledge of the thinking process) in learners [8], [33], [34], [35], [36]. AaL dalam pembelajaran IPA sangat memanfaatkan pemikiran, perasaan, tindakan, dan AaL 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. 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 [37], [38], [39], [40].

According to the description above, it can be concluded that assessment as learning emphasizes learners' activeness in the form of selft-assessment and peer-assessment in the process of cognitive restructuring to create their own understanding. In addition, learners must learn to be critical assessors who are able to understand information, connect it with prior knowledge, and use it for new learning. The dimensions of AaL that become the main focus of how educators develop and implement AaL effectively in learning in this study include the main focus of AaL in learning, the role of educators in AaL, AaL to identify what learners believe to be true, AaL to motivate learning, AaL to make connections, AaL to extend learning, AaL for reflection and self-monitoring, and stages of implementing AaL.

3.2 Rationality Analysis of AaL as a Learning Model

Science learning model has been defined operationally as a systematic framework and procedure in organizing science learning experiences for students. The learning model allows the process of interaction of students with educators and learning resources in an organized learning environment structured from syntax, social systems, reaction principles, support systems, and instructional and accompanying impacts [41], [42], [43], [44], [45]. In addition, there are learning theories that underlie learning models including AaL-based science learning models with OAS and automatic feedback.

The first analysis of AaL as the basis of the science learning model is that AaL in learning practices emphasizes how assessment trains students in the process of metacognition (knowledge of the thinking process) [8]. AaL arises from the idea that learning is not just a transfer of ideas from someone who is knowledgeable to someone who is not / not yet knowledgeable, but is an active process of cognitive

restructuring that occurs when individuals interact with new ideas. The statement shows that there are keywords that indicate the learning theory on which AaL is based as a learning model, namely constructivism learning theory proposed by Jean Piaget & Lev Vygotsky and Gagne's information processing [46].

Constructivism learning theory integrates the concepts of schemata, cognitive conflict, assimilation, accommodation, and balance in metacognitive learning syntax as a representation of the character of learners according to Piaget [47], [48]. Learners who learn using the AaL base will apply the theory of constructivism in which they will be guided to plan, monitor, and evaluate the achievement of learning goals and strategies that are metacognitive in nature as a representation of the character of learners. In addition to the constructivism learning theory that underlies AaL, the practice of AaL in the learning process in the classroom really requires activeness from students in the process of obtaining information, processing information, storing information and recalling information controlled by the brain [49], [50].

Gagne divides the learning process of students in information processing theory into four main phases, namely: (1) receiving the stimulus situation (apprehending)/recognition phase, (2) stage of acquisition/acquisition phase, (3) storage/retention phase, (4) retrieval/recall phase. Gagne also categorizes forms of learning into eight types, namely: (1) signal learning, (2) stimulus-response learning, (3) chaining, (4) verbal association, (5) discrimination learning, (6) concept learning, (7) rule learning, (8) problem solving [46].

The second analysis of AaL as the basis of the science learning model is that in practice there are structured stages or have syntax. Joyce et al. (2015) state that syntax is steps, or phases as a form of sequence of learning activities [42]. There are several different stages from several different education experts. Some stages of how educators apply AaL in classroom learning are stated by Heritage (2007), Leahy et al. (2005), and McMillan & Hearn (2008) as listed earlier in Table 1 [30], [31], [32]. The syntax of the AaL-based science learning model was adapted from the problem-based learning model as shown in Figure 4. [12], [51].

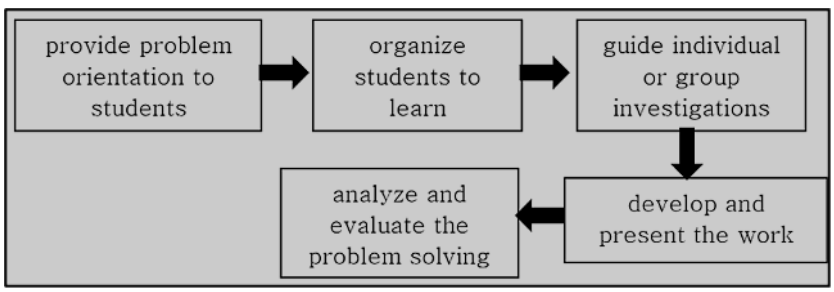

Figure 4. Learning Syntax of Problem-Based Learning Model

The digital era emphasizes how learning can be integrated with digital technology in this case the author proposes an online assessment system and automatic feedback. Online assessment system (OAS) or internet-based assessment

system is an ongoing effort to improve and increase the use of computers in education Another statement related to OAS was also stated by Weleschuk et al. (2019) which states that OAS is a means to evaluate learner achievement, provide feedback, or advance learners in the learning process online [53]. The automatic feedback feature is a digital technology that is very efficient in learning today [54]. Feedback has become part of the teaching and learning process that can serve as a catalyst to improve learner achievement through motivation and effort before, during, and after learning [55], [56], [57]. When associated with science, OAS and automatic feedback function as learning media that contain four dimensions of science, namely science as a way of thinking, science as a way to investigate, science as a science, and science and its relationship with technology and society [10], [58].

Based on Table 1 and Figure 4, if AaL is combined with OAS and automatic feedback which functions as a medium that will contain the four dimensions of science, then AaL-based science learning by modifying the syntax of the problem-based learning (PBL) model stages as follows.

1.Orienting students regarding the learning objectives to be achieved.

2.Organizing students in merdeka work activities using OAS media.

3.Guiding students in group discussions guided by automatic feedback media.

4.Organizing students in AaL activities, for example self-assessment or peer-assessment, to train students to be the best and critical assessors, so that students are able to produce score products and know whether a task is right or wrong.

5.Strengthening from educators in the form of reflection or evaluation of the learning that has been passed is related to important concepts, metacognitive processes, and reconstruction processes in solving questions/problems.

The five stages in the AaL-based science learning model are similar to the problem-based learning (PBL) model with slight modifications made by the author based on several references. The activities of educators and students in AaL-based science learning with OAS and automatic feedback are as shown in Table 2.

Table 2. Syntax of the AaL-based learning model with OAS and automatic feedback

No	Syntax	Educator Activities	Learners Activities
1.	Orienting students regarding the learning objectives to be achieved	In the first phase, educators inform the learning objectives to be achieved using assignments/assessment questions that have been prepared in a structured manner that covers all the important points. The purpose of the task	In the first phase, students listen to information from educators regarding the learning objectives to be achieved using the assignment method/work on assessment questions. Apart from that, this phase also provides an opportunity for students to ask if there are any technical

No	Syntax	Educator Activities	Learners Activities
		is to confirm that students understand what they have to do. Apart from that, this phase is also to avoid confusing students in carrying out assignments.	aspects of completing the assignment that are considered confusing.
2.	Organizing students in merdeka work activities using OAS media	In the second phase, educators assign students to work on assignments/assessment questions for a certain duration of time. The tasks given by educators are in sync with the learning objectives or competencies that must be mastered. Assignments are prepared by educators with the help of OAS media	In the second phase, students work on tasks assigned by the educator for a certain duration of time. OAS is a medium that students can use to see questions and work on questions directly.
3.	Guiding students in group discussions guided by automatic feedback media	In the third phase, educators guide students in group discussions to pay attention to feedback. This feedback will be obtained after students send/submit their work results to OAS, so it is automatic feedback.	In the third phase, students receive feedback from OAS in the form of writing or video from educators which gives students the opportunity to process information and gain correct understanding. This phase equips students in the next phase to be able to become critical assessors.
4.	Organizing students in AaL activities	This fourth phase can implement self-assessment or peer-assessment. However, if there is enough time, educators can use both, so that students have experience assessing the work of their peers in class.	
	Self Assessment	In this phase, the educator directs students to assess their work results from the assignments/questions	In this phase, students assess the results of their work from assignments/questions given by the teacher using the teacher's assessment criteria

No	Syntax	Educator Activities	Learners Activities
		given by the educator with the assessment criteria from the educator which have been determined previously from the automatic feedback media.	which have been determined previously from the automatic feedback media.
	Peer Assessment	In this phase, the educator directs students to assess the work of their colleagues from the assignments given by the educator using previously determined criteria from the educator.	In this phase, students evaluate the work of their peers based on assignments given by the educator using predetermined criteria from the educator
5.	Reinforcement from educators in the form of reflection or evaluation	In the fifth phase, educators provide reinforcement and feedback in the form of reflection or evaluation of the assignments given to students. In this phase, educators also provide strategies for successfully carrying out other similar tasks and other new models. Apart from that, educators reassign students to rework assignments/assessment questions so that they are collected at the next meeting/time determined by the educator.	In the fifth phase, students receive reinforcement and feedback in the form of reflection or evaluation of the assignments given to students from the assignments given by the teacher. In this phase, students get strategies for successfully working on other similar tasks or other new models. Apart from that, students rework assignments/assessment questions so that they are collected at the next meeting/time determined by the teacher.

The third analysis of AaL as a basis for the science learning model is the existence of a social system in the learning process in the classroom. The social system has been defined previously to describe the process of interaction between educators and students in the learning process. Apart from that, the social system also

emphasizes the various roles of educators and students; presenting a description of the hierarchical relationship between educators and students; and relates to various things and rules that encourage or motivate students in the learning process. Adapting the social system from the problem-based learning model which emphasizes cooperation, the AaL-based learning model also emphasizes cooperation which is realized in the form of self-assessment and peer-assessment [39], [40], [59], [60]. Delisle (1997) states that the principle behind problem-based learning (PBL) is a teaching technique that educates by presenting students with situations that lead to problems to be solved in the form of tasks or questions Traditional AaL-based learning practices involve educators together with students developing clear criteria or rubrics about good practice or task completion [8]. Moreover, with OAS and automatic feedback, learning becomes more efficient where this media becomes a means in group discussions to gain understanding of concepts and complete assignments/questions correctly.

The fourth analysis of AaL as a basis for the science learning model is the principle of reaction in the learning process in the classroom. The principle of reaction, as defined in the previous section, is to describe the reaction shown by educators to the activities shown by students in the learning process in class [42]. Regarding to Table 2, the activities of educators and students are in line with the AaL learning syntax. The principle of reaction in AaL learning is that educators carry out 1) orientation to students regarding the learning objectives to be achieved, 2) organizing students in independent work activities using OAS media, 3) guiding students in group discussions guided by automatic feedback media, 4) organizing students in AaL activities and providing opportunities for self-assessment and peer-assessment activities, and 5) providing reinforcement to students in the form of reflection or evaluation. The reaction principle in the AaL-based learning model is generally as follows [8].

1. The role of educators in implementing AaL is to provide examples or models of good practice in completing assignments based on criteria or rubrics that have been developed which can be used by students as feedback for learning.
2. The role of educators in implementing AaL is to develop feedback so that students can improve students' understanding so that they are able to validate and control learning progress independently.
3. The implementation of AaL in science learning provides students with opportunities for self-reflection, self-monitoring and self-adjustment from the results of the work they have done.
4. The implementation of AaL in science learning allows participants to control which parts of the material have been mastered and which have not been mastered.
5. The implementation of AaL in science learning evaluates students whether the learning objectives have been achieved or not achieved.

The fifth analysis of AaL as a basis for the science learning model is the existence of a support system. The support system, as defined in the previous section, refers to the conditions required by the learning model so that it can be used optimally in learning, which includes technical facilities, skills or abilities of teachers or educators, as well as the demands that students wish to achieve [42]. Educators in the AaL-based learning process must prepare complete teaching materials and materials in the form of assignments/assessment questions and feedback that cover all competencies that must be mastered by students in a systematic and structured manner so that they can be understood correctly and clearly. Assignments/assessment questions and feedback are prepared before learning takes place to stimulate students to be active in the learning process. When AaL learning is combined with digital technology, assignments/assessment questions and feedback are included on the OAS platform/media and automatic feedback makes it more efficient [61], [62]. Apart from that, AaL-based learning in science learning makes students connect the material they have studied with a structured solution strategy combined with the OAS platform/media and automatic feedback. The application of AaL-based learning in learning stimulates students to review the material they have studied.

he analysis of the six AaL as the basis of the science learning model is the existence of instructional and accompanying impacts. Instructional and accompanying impacts, as previously defined, are learning outcomes achieved directly by directing students to the expected goals, while accompanying impacts are other learning outcomes produced by a learning process as a result of creating a learning atmosphere experienced by students themselves without direction. directly from educators [42]. As stated by L. Earl & Katz (2006) AaL has a very large role for students in achieving the following learning outcomes [8].

1. AaL focuses on student independence.
2. AaL fosters confidence that students' answers when working on a written problem are correct.
3. The implementation of AaL in science learning ensures that students are able to simplify complex problems (creative thinking skills).
4. The implementation of AaL in science learning makes students more active in studying material and solving problems that hone general cognitive skills.
5. The implementation of AaL in science learning is able to develop solutions to new problems that have not been taught.
6. AaL-based science learning provides students with regular and challenging opportunities to practice, so that students can become self-assessers who are confident and competent in analytical thinking (analytical thinking skills).

In-depth rational analysis of AaL fulfills the basis as a learning model which is shown by the learning theory that underlies it as a learning model, syntax, social system, reaction principle, support system, and instructional impact and accompaniment. The analysis results are confirmed as in Table 3.

Table 3. Analysis Results of AaL as a Learning Model

Learning Model Requirements	Description/ Indicator
Learning Theory	● AaL focuses on students how to use metacognition skills to solve problems in the form of information processing. ● The implementation of AaL in learning is a form of expanding learning in the classroom ● The implementation of AaL expands the role of educators to optimize learning and assessment design so that students are accustomed to reflective thinking and monitoring learning independently
Syntax	● Implementation of AaL-based science learning requires structured stages. ● Adaptation of problem-based learning syntax to AaL: (1) learning goal orientation, (2) independent work activities in the form of structured assignments, (3) delivery and discussion of assessment criteria or rubrics for assigned task activities, (4) assessment activities as learning in the form of self-assessment and peer assessment, and (5) feedback and concept reinforcement
Social Systems	● AaL focuses on how students become the best assessors of themselves (self-assessment) and their peers (peer-assessment). ● The role of educators in implementing AaL is to develop criteria or rubrics together with students that function as clear feedback about good practice or task completion
Reaction Principles	● The role of educators in implementing AaL is to provide examples or models of good practice in completing assignments based on criteria or rubrics that have been developed which can be used by students as feedback for learning ● The role of educators in implementing AaL is to develop feedback so that students can improve

Learning Model Requirements	Description/ Indicator
	students' understanding so that they are able to validate and control learning progress independently ● The application of AaL in science learning provides students with opportunities for self-reflection, self-monitoring and self-adjustment from the results of the work they have done ● The implementation of AaL in science learning allows participants to control which parts of the material have been mastered and which have not been mastered ● The implementation of AaL in science learning evaluates students whether the learning objectives have been achieved or not achieved
Support System	● The implementation of AaL in science learning makes students connect the material they have studied with structured solution strategies ● The implementation of AaL in learning stimulates students to review the material they have studied ● AaL-based learning in the digital era is more optimal by combining online assessment systems and automatic feedback.
Instructional and Accompanying Impact	● AaL focuses on student independence. ● AaL fosters confidence that students' answers when working on a written problem are correct ● The implementation of AaL in science learning ensures that students are able to simplify complex problems (creative thinking) ● The implementation of AaL in science learning makes students more active in studying material and solving problems ● The implementation of AaL in science learning is able to develop solutions to new problems that

Learning Model Requirements	Description/ Indicator
	have not been taught (creative thinking) ● AaL-based science learning provides students with regular and challenging opportunities to practice, so that students can become confident and competent self-assessors (analytical thinking)

4. CONCLUSION

Assessment as learning in practice emphasizes student activity in the form of self-assessment and peer-assessment in the process of cognitive restructuring to create their own understanding. In addition, students must learn to become critical assessors who are able to understand information, relate it to previous knowledge, and use it for new learning. Apart from that, the results of the analysis show that rationally AaL has the potential to become a basis for developing learning models which is indicated by the existence of learning theories that underlie it as learning models, syntax, social systems, reaction principles, support systems, and instructional impacts and accompaniments. AaL as a learning model in the digital era can be practically applied in stages: 1) orienting students regarding the learning objectives to be achieved, 2) organizing students in independent work activities using online assessment system (OAS), 3) guiding students in group discussions guided by automatic feedback media, 4) organizing students in AaL activities, both self-assessment and peer assessment, and 5) reinforcement from educators in the form of reflection or evaluation.

AUTHORS' CONTRIBUTIONS

All authors contributed in arrange research articles. Didik Setyawarno as the main author studied the conceptual Assessment as Learning which has the potential to be part of the development of learning models. Prof. Dr. Dadan Rosana, M.Si and Prof. Dr. Heru Kuswanto, M.Si reviewed the results of the study and validated the validity of the concepts written by the main author.

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