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Promoting Students' Mental Models and Problem-Solving Skills Through Argumentation-Based on Three Levels of Representation (AB3LR)

Hazrati Ashel[1], Ida Hamidah[1*], Sjaeful Anwar[1], Muslim[1]

Department of Science Education, Faculty of Mathematics and Science Education, Universitas Pendidikan Indonesia, Bandung, Indonesia.

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Corresponding Author:
Ida Hamidah
idahamidah@upi.edu

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Abstract: Mental models and problem solving skills need to be developed in learning. However, previous study show that students' mental model and problem-solving skills are not optimal. The solution is to develop an Argumentation Based on Three Levels of Representation (AB3LR) model. This research aims to determine the components, validity, and practicality of the AB3LR model. The method of this study is Design and Development Research (DDR). The instruments used consisted of validation sheets and student response questionnaires. The model was validated by five experts and applied to 19 students taking Statistical Physics courses. The data obtained was analyzed using the Content Validity Ratio (CVR) and Percentage Calculation Method (PCM). The AB3LR model consists of seven stages, namely identifying problems or phenomena, collecting data or information, assimilation and accommodation, presenting tentative arguments, implementing solutions, analyzing and synthesizing the results of discussions, and evaluation. The validation result is 0.99 with a valid category. The AB3LR model is also practical to use with the average percentage is 86.12%. 78.90% and 63.2% students strongly agree that AB3LR model can promote mental models and problem-solving skills. The conclusion of the study is the AB3LR model is valid and practical for use in learning.

Keywords: Argumentation; Learning model; Mental model; Problem-solving skills; Three levels of representation

Introduction

Mental models are knowledge structures that exist in an individual's mind that are used to explain a phenomenon or problem. Mental models are categorized into three levels, namely scientific, synthetic, and initial. Students who have a scientific mental model mean they have a scientific knowledge or thinking structure. This can be seen from the way they answer questions descriptively and visually or using drawing-writing techniques (Hamdiyati et al., 2022; Kurnaz & Eksi, 2015). This scientific knowledge is used in the problem solving process. Problem solving skills are a person's ability to find a solution to a problem through a process that involves the student's internal knowledge. Problem solving skills consist of five aspects, namely focus the problem, describe the physics, plan a solution, execute the plan, and evaluate the answer. We will go into more detail about mental models and problem solving skills.

Mental models are at the core of meaningful learning. Mental model is a person's internal representation in accessing their knowledge structure, content knowledge and daily experiences, which are used in solving problems. The students' knowledge structure will affect their understanding of a concept because mental models are one way to understand the content and structure of students' knowledge about scientific concepts (Batlolona & Souisa, 2020). Mental

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models in learning, especially in the Physics learning, indicate the existence of proper reasons for compiling good knowledge and can explicitly explain conjectures to a phenomenon. Mental models relate to the way students access knowledge structures so that they can be used to solve problems, understand phenomena, and see actual phenomena (Corpuz & Rebello, 2011; Fratiwi et al., 2020; Sağlam-Arslan et al., 2020). Several studies have been conducted to improve mental models such as the integration of argumentation in learning and applying the model Problem-based Learning (Batlolona et al., 2020; Praisri & Faikhamta, 2020). In addition, research on mental models has also been carried out in several fields in science education such as Physics (Amalia et al., 2017; Sari et al., 2019) and Chemistry (Praisri & Faikhamta, 2020). This means that mental model is one of the important factors that must be developed by students because it is related to the knowledge they have.

How students construct knowledge and use it to solve problems is a study of mental models. The mental model largely determines the initial problem-solving strategy used. Students need to acquire new knowledge and improve mental models before they can solve the problem (Batlolona & Souisa, 2020; Gustina et al., 2024). Problem-solving skills are one of the skills that need to be possessed in the twenty-first century because they are related to a person's cognitive process (Muzana et al., 2021; Sa-ngiemjit et al., 2024). Problem-solving skills are a form of cognitive ability that requires a process in determining solutions to difficult problems (Sa-ngiemjit et al., 2024). This is related to the ability to manage, assess, and find solutions. We can conclude that there is a relationship between mental models and problem-solving skills.

The challenge for students in solving problems is when connecting or integrating ideas and showing how these ideas are related to each other in solving the problem (Zhafransyah et al., 2024). Based on this problems, we can conclude that the student's mental models have not been well developed. They still find it difficult to assimilate and accommodate the knowledge they have with the new knowledge and problem. Assimilation and accommodation are one of the characteristics of mental models, namely involving hidden knowledge. To overcome this problem, students need to be facilitated to connect their knowledge with the information obtained and the solutions that will be provided.

Students need to continue to improve, modify, and reorganize the mental models they have in each new experience after going through the learning process. In addition, students can solve problems well if the mental model is also good. Problem-solving skills are important to have in Physics learning because they are related to science process skills (Kurniawan et al., 2019). However, based on the results of preliminary research conducted by researchers, it was found that students' mental models were not optimal. They still have difficulty connecting related concepts, building concept maps, providing appropriate explanations, and solving problems given (Ashel et al., 2024). Another finding is the low level of problem solving skills in static fluid material so that students are categorized as novice solvers. They have difficulty interpreting mathematical concepts and equations, resulting in incorrect solutions (Almujaddid et al., 2025). The research linking mental models and problem-solving skills, especially in the Physics learning, is still rarely studied (Batlolona & Souisa, 2020). Research on mental models in Physics concepts, especially Statistical Physics, is also still rare. Therefore, it is necessary to develop a learning model that is developed from the characteristics of the mental model and the problem-solving skills themselves.

One solution that can be done to encourage mental models and problem-solving skills is to develop an Argumentation-Based on Three Levels of Representations (AB3LR) learning model. The development of this model is based on Toulmin's argumentative model and Johstone's three levels of representation (Inch, 2006; Pande & Chandrasekharan, 2017). Argumentation is a process of producing statements or arguments that are supported by evidence and relevant scientific concepts (Hani'ah & Aznam, 2022; Rahma et al., 2024). A person can produce arguments that are acceptable to others if he has a sufficient understanding of the concept or problem given. This is related to the structure of knowledge they have. The argumentation process is a very important effort in developing students' cognitive abilities because it facilitates students in reasoning, interacting, and sharing learning motivation. As a result, there is a conceptual change in the cognitive structure so that it can be used in the problem solving process (Hakim et al., 2023).

Argumentation can improve competencies in the 21st century, including mental models and problem-solving skills (Praisri & Faikhamta, 2020; Songsil, 2019). In addition, argumentation practice can also increase students' knowledge and competence (Hani'ah & Aznam, 2022). This means that students can build their knowledge so that the resulting mental model becomes more scientific. Students will make a mental effort to understand complex systems and build appropriate mental representations to model and explain those systems. Students who have a good mental model can find constructions and provide reasonable explanations about the phenomena they are facing (Praisri & Faikhamta, 2020). Argumentation is also a rational way of solving problems. Argumentation instruction can be used to assist students in improving their reasoning and the way of thinking used to solve problems involving scientific phenomena (Iwuanyanwu, 2020). Argumentation plays a role at the evaluation stage in problem solving because students can evaluate the extent to which they understand the material. They can determine whether the findings they produce are logical and can be accepted as true (Hasnunidah et al., 2024).

In the development of this learning model, the argument is based on three levels of representation. The use of representation in learning can help students achieve a deeper understanding so that it can improve argumentation performance and reduce cognitive load (Hochberg et al., 2020; Wu & Liu, 2021). Several previous studies have discussed a lot about representation, but only focused on the study of multiple representations (Denny et al., 2023). There has not been much research on the three levels of representation in Physics learning and looking at their influence on mental models (Batlolona & Souisa, 2020). Three levels of representation help students understand the same concepts, but in different perspectives (Praisri & Faikhamta, 2020). The explanations of these three levels are interconnected because they explain the same thing at different levels. Students can build their knowledge through three levels of representation because they gain an understanding of how a phenomenon is explained from the macroscopic, microscopic, and symbolic sides.

Based on the background and problems, this research focused on the development of instructional model based on Toulmin argumentative pattern and three levels of representation. The name of this model is Argumentation Based On Three Levels of Representation (AB3LR). The use of AB3LR will improve students' mental model and problem-solving skills. The purpose of this research are determine the components of AB3LR learning model, the result of validity test, and the result of practicality test of using the AB3LR model. The research questions are what are the components of the AB3LR learning model?; how is the validity of the AB3LR learning model and its supporting components?; and how practical is the AB3LR learning model in encouraging mental models and problem-solving skills?. This article is expected to contribute to the literature due to several things, namely the AB3LR model contributes as one of the alternative learning models that emphasizes the delivery of arguments based on three levels of representation; the AB3LR model facilitates students to generate arguments based on data and supporting evidence; and the AB3LR model can encourage students to develop students' mental models and problem-solving skills. The novelty of this research lies in the model components and the relationship between mental models and problem solving skills. The argumentation process in this model is based on three levels of representation so that the arguments produced are more scientific and complete. This model can be applied to materials that are difficult to carry out experiments on.

Method

This research aims to produce a learning model that is able to promote mental models and problem-solving skills. To achieve this goal, the research design used is DDR. DDR is a systematic study of the design, development, and evaluation process with the aim of building procedures, techniques, and tools based on the needs analysis (Lah et al., 2024; Richey & Klein, 2007). This study uses a DDR type 2 research design because it is related to the research on the development, validation, and use of the developed design and model. This type of research focuses on the model and development process itself rather than its implementation. Type 2 DDR research discusses the validity or effectiveness of existing or newly built development models, processes, or techniques.

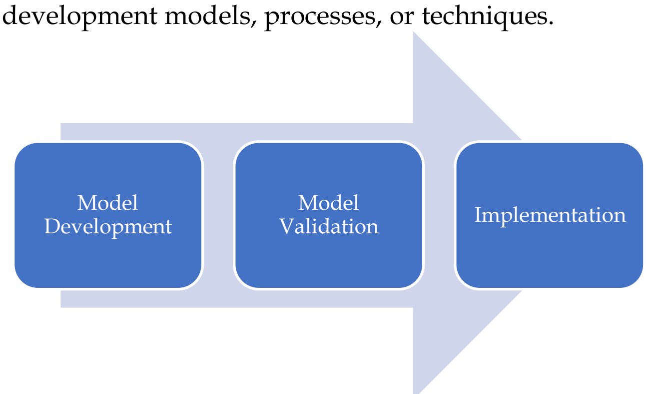

Figure 1. Research procedure

DDR type 2 consists of three stages, namely model development, model validation, and implementation. The first stage is model development which consists of literature study and model development. In the early stages, a literature study was carried out on argument-based learning models, argumentation, three levels of representation, mental models, and problem-solving skills. The development of the AB3LR model is carried out by integrating the Toulmin's argument component (Inch, 2006) and three levels of representation (Pande & Chandrasekharan, 2017). This model was developed to promote mental models and problem-solving skills. To achieve this goal, it is necessary to consider the characteristics of the mental model (Franco & Colinvaux, 2000) and problem-solving skills indicators (Heller & Heller, 2010) in the development of AB3LR leaning model syntax. In addition to the AB3LR model, the researchers also developed model supporting components, namely teaching materials, semester learning plans, and mental model (Kurnaz & Eksi, 2015) and problem-solving skills measurement instruments (Heller & Heller, 2010).

The second stage is the validation of the model and supporting components with five validators who are experts in the field of education and Statistical Physics content. In this study, content validation was carried out for all products developed. Content validation requires rational analysis from experts in the field related to the product being developed. The instrument used is a validation sheet consisting of two assessment criteria, namely "Yes" and "No" or "Appropriate" and "Not Appropriate" or "Feasible" and "Not Feasible". Positive answers are given a value of 1 and negative answers are given a value of zero. The validation data was analyzed quantitatively using the Content Validity Ratio (CVR) and Percentage Calculation Method (PCM). CVR developed is a content validation approach to determine the conformity of items with the dominant one measured based on the assessment of experts. CVR is calculated using the Formula 1.

$$CVR = \frac{n_e - \left(\frac{N}{2}\right)}{\frac{N}{2}} \quad (1)$$

One is the number of responses stating yes and *N* is the number of experts. The critical value of CVR for five experts with a level of significance of 0.1 is 0.736 (Wilson et al., 2012). If the CVR value is higher than the critical value, then the product developed is said to be valid and worthy of use in improving mental models and improving problem-solving skills. To support the results of this calculation, an analysis was also carried out using the PCM method with the following formula (Ping, 2020):

$$PCM = \frac{Total\ experts'score}{Total\ maximum\ score} \times 100\% \quad (2)$$

Meanwhile, qualitative data is obtained from expert suggestions and inputs on the product. This data is collected and encoded.

The last stage is the implementation of the learning model. The AB3LR model that has been declared valid was tested in a Statistical Physics lecture at a university in Padang City. The test was carried out on the concept of the distribution function of speed, rate, and molecular energy. The number of students involved was 19 people. To find out the practicality of the product developed, data was collected through a practicality questionnaire and filled out by students. In this instrument, the Likert scale is used with the criteria of Strongly Agree (score 4), Agree (score 3), Moderate (score 2), and Disagree (score 1). The aspects assessed include usable, easy to use, appealing, and cost effective. The data obtained were analyzed using the PCM method with the following criteria: very weak (0-20), weak (21-40), moderate (41-60), strong (61-80), and very strong (81-100) (Mufit et al., 2022). Qualitative analysis is carried out by summarizing the responses given by students.

Result and Discussion

In this study, several results were obtained, namely the AB3LR model components, the results of the validation of the AB3LR model and its supporting components, and the results of limited trials on the AB3LR model and its supporting components.

Components of AB3LR Learning Model

The AB3LR model was developed based on Toulmin's argumentation pattern and Johnstone's three levels of representation. Arguments based on the Toulmin pattern have six main components. Claims is the submission of opinions or conclusions that will be accepted by others. Data is facts or a condition that can be objectively observed, trusted, and clearly accepted. Warrants is explanations of the relationship between data and claims. Backing is the basic assumption that supports warrants. Qualifiers is providing specific evidence stating that the claimed claims are true. Reservation is a statement that refutes or contradicts an argument. Toulmin recommends that there are at least three components that must be present in the argument, namely claim, warrant, and data. Meanwhile, the three levels of representation consist of macroscopic, symbolic, and microscopic levels as shown in Figure 2.

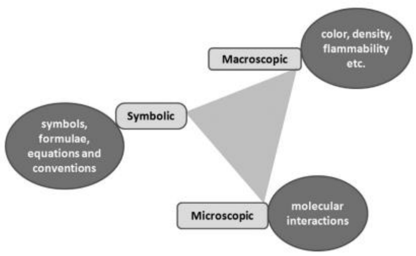

Figure 2. Johnstone's three-level representation model (Pande & Chandrasekharan, 2017)

Argumentation is used in constructing explanations and producing a decision in scientific debates. Scientists use argumentation to produce a statement or claim and connect it with data and supporting evidence. The three levels of representation can help students in understanding the same concepts, but in different perspectives so that the resulting arguments can be accepted for truth (Praisri & Faikhamta, 2020). Arguments based on three levels of representation will produce claims that are precise, in-depth, and interrelated with each other. Arguments based on phenomena or macroscopic levels can encourage students to have new knowledge (Syarqiy et al., 2023). When students have understood the concept in its entirety, the resulting arguments will be easier to understand and accept the truth by others.

The AB3LR model is a learning model design that emphasizes argumentation activities based on the relationship between the three levels of representation. The resulting arguments will be more complete, in accordance with the facts, and have scientific and logical reasons. This model is different from the argument-based learning models that have been developed previously. There are several adjustments made in the development of this model, namely paying attention to the characteristics of abstract materials and involving perspectives from three levels of representation, problem identification is carried out by considering three levels of representation, facilitating students in building knowledge through the process of assimilation and accommodation, integrate the characteristics of the mental model and integrate problem-solving measures.

The main goal of developing the AB3LR model is to facilitate students in building scientific arguments that are in accordance with strong data and evidence. Meanwhile, the specific objectives of the development of this model are assisting students in constructing knowledge and improving the structure of knowledge or mental models, producing a meaningful learning process, encouraging students to be able to solve problems, and increasing student engagement in learning. When students are able to produce quality arguments, they are already able to understand the material so that they are also able to solve the given problem.

The development of the AB3LR model is based on three learning theories, namely the learning theory of constructivism, Piaget's theory of cognitive development, and Vygotsky's theory of social constructivism. In addition, the development of this model is also based on Toulmin's argumentation theory, the three levels of Johnstone representation, the characteristics of the mental model, and indicators of problem-solving skills. These theories are integrated in the basic components of the model namely syntax, social systems, principles of reactions, support systems, instructional and nurturant effects (Joyce et al., 2015).

Syntax is the sequence or operational steps of learning. Different syntax will achieve different goals so the syntax cannot be reversed. The researchers synthesized the Argument-Driven Inquiry (ADI) model and the argument-generating instructional model in developing the syntax of the AB3LR model. ADI's instructional model provides students with the opportunity to learn how to develop methods for generating data, conducting investigations, using data to answer research questions, writing, and reflecting on their work. Students also participate in generating scientific arguments, understanding how to write arguments, and learning important content as part of the process. The steps of the ADI model are identification of task, generation data, production of a tentative argumet, argument session, creation of a written investigation report, double-blind peer review, and revision of the report (Alfarraj et al., 2023; Sampson et al., 2011). Next is the argument generation model. This model is designed to involve students in scientific arguments without requiring them to collect data in the laboratory or the field. Students can collect data from the latest scientific knowledge, build scientific arguments, and respond appropriately and critically to comments. The steps of this argument generation model are identification of the problem, question, and task; generation of a tentaive argument, the argumentation session, dan group sense-making and individual arguments (Sampson & Gerbino, 2010). Meanwhile, the AB3LR model has a different purpose from the previous two models. The AB3LR model is designed to produce scientific arguments by analyzing problems based on three levels of representation. The data obtained does not have to be through practicum activities, but can be through articles, simulations, and other sources of information. Based on the objectives and characteristics of the AB3LR model, seven learning steps were developed as shown in Table 1.

Table 1. Syntax of the AB3LR Learning Model

Syntax	Description	Characteristics of mental models (Franco & Colinvaux, 2000)	Indicators of problem-solving skills (Heller & Heller, 2010)
Identifying problems or phenomena	Students are given the opportunity in the group to identify a problem or phenomenon through three levels of representation and re-explain by connecting the three levels of representation. The results obtained are data to support the claims that will be generated.	Involves simple representations	Focus on the problem; describe in Physics terms
Collecting data	Students identify problem-related concepts and	Influenced by prior	Focus on the problem

Syntax	Description	Characteristics of mental models (Franco & Colinvaux, 2000)	Indicators of problem-solving skills (Heller & Heller, 2010)
or information	look for new information to support them. In this phase, there are argumentation components, namely data, warrant, and backing.	knowledge	
Assimilation and accommodation	Students are given the opportunity to relate their knowledge and new information to a given problem or phenomenon. In this phase, there is a process of knowledge construction so that it will affect the development of mental models.	Engaging hidden knowledge	Focus on the problem
Presenting a tentative argument	Students present tentative arguments, which can be in the form of predictions or solution plans, based on data and information that has been collected. Students also explain the basic theories or evidence that supports the claim.	Using new information to predict and generate explanations	Plan a solution
Implementing solutions	Students implement solutions based on the plan that has been submitted. Students make reports as a result of discussion activities	Using new information to predict and generate explanations	Executing the plan
Analyzing and synthesizing the results of the discussion	Each group presented the results obtained. The other group observes and provides consideration, support, criticism, and suggestions. Lecturers also provide reinforcement and direction. Presenters need to record criticisms and suggestions to be analyzed and synthesized as a basis for making improvements.	Using new information to predict and generate explanations	Evaluation
Evaluation	Students make improvements based on the criticism and suggestions given. Students need to answer the question "Is the solution made correct and complete?". Through this answer, lecturers can see whether the student's knowledge structure has been formed or not and whether they are confident in the answers given.	Using new information to come up with the right solutions	Evaluation

The social system describes the roles of educators and learners, hierarchical relationships, and rules based on those roles. The role of educators varies greatly depending on the model used. When using the AB3LR model, educators play the role of motivators, informants, facilitators, directors, mediators, supervisors, and evaluators. The hierarchical relationship between educators and students is that educators become a source of input, as a regulator of activity distribution, and concentrate learning on students. By applying the AB3LR model, there is interaction between students and educators, between students and students, and between one group and another.

The principle of reaction is to provide educators with principles to guide their reactions to student activities or an overview of how educators should view, treat, and respond to students. For example, rewarding conceptual development activities and encouraging learners to compare their concepts. In the AB3LR model, educators view that students have understood most of the material so that they are able to construct knowledge and solve problems.

A support system is needed to create an environment that fits the model. This component is necessary because many failed models are caused by failures in considering support systems. The supporting systems needed in the implementation of the AB3LR model are semester learning plans, teaching materials, and assessment instruments. The teaching materials developed must contain three levels of representation and stages of the AB3LR model. The AB3LR stage is integrated in teaching materials as a learning activity.

Instructional and nurturant effects are learning outcomes that are obtained directly based on the targeted learning objectives. The main objectives to be achieved from the application of the AB3LR model are improving mental model and enhancing problem-solving skills. This model was developed by paying attention to constructivist learning theory and Piaget's cognitive learning theory where this learning theory emphasizes the construction of knowledge or mental models. Argumentation based on the Toulmin pattern describes students' flow of thinking through good and correct answers so that educators can find out the mental models that students have (Hakim et al., 2023).

This mental model is used to reason, explain a given phenomenon or problem, and communicate ideas to other people or in solving problems (Gustina et al., 2024). Mental models influence a person's ability to solve problems so that there is a relationship between mental models and problem solving skills. The development of this model also facilitates students to solve problems because learning begins with giving problems. In addition, the application of this model can also produce achievements beyond the targeted goals such as improving understanding of concepts and argumentation skills.

AB3LR Model Validation

The AB3LR model that has been developed is further validated by five experts. Experts evaluate the eligibility of the model based on five components of the model. Each component of the model is developed into 30 items of assessment indicators. The CVR value of each item is analyzed and then determined by its average (the mean of the CVR). Table 2 shows the results of validation using CVR and PCM.

Table 2. AB3LR Model Validation Results

Assessment indicator	Mean of CVR	PCM (%)
Supporting theories	1	100
Model syntax	0.98	98
Social system	1	100
Reaction principle	1	100
Support system	1	100
Instructional and nurturant effects	1	100
Average	0.99	99.80

The critical value of CVR for five experts with a significance value of 0.1 is 0.736 (Wilson et al., 2012). Based on Table 2, it can be seen that each AB3LR model assessment indicator has the Mean of the CVR value above the critical value and a PCM value of 100%. This value shows that the AB3LR model is feasible and can be used in learning. The AB3LR model has relevant and complete supporting theory so that it can be a guide in implementing the model. The syntax component has not reached its maximum value. One of the experts gave advice for the stage of analyzing and synthesizing the results of the discussion. At this stage, students are facilitated to disseminate the results obtained and consider the criticisms and suggestions given by other groups. Experts argue that, at this stage, students not only gain criticism and advice, but also additional insights and knowledge from other groups. However, in general, the AB3LR model syntax is valid and suitable for use in learning. The AB3LR model facilitates students to interact in social systems. Educators have various roles not only as sources of knowledge. The AB3LR model application guide contains practical rules that can be used to measure students. The AB3LR model is also supported by several components as shown in Table 3. The AB3LR model has an instructional effects on mental models and problem solving skills and nurturant effects on conceptual understanding and argumentation abilities.

The AB3LR model has supporting components, namely teaching materials, Semester Learning Plan, and mental model test instruments and problem-solving skills instruments. Each component is also validated by five experts. Table 3 shows the results of validation of the supporting components of the AB3LR model.

Table 3. Results of Validation of Supporting Components of the AB3LR Model

Assessment indicator	Mean of CVR
Teaching material	0.94
Semester learning plan	1
Mental model test instruments	0.95
Problem-solving skills test instrument	0.95

Based on Table 2, it can be seen that the Mean CVR value of each component is above the critical value. This value indicates that each component is feasible to use in learning and can support the application of the AB3LR model. The teaching materials developed contain three levels of representation and seven syntax of the AB3LR model. The semester learning plan is also prepared by applying the AB3LR model. The instructional impact of this model is to improve mental models and problem-solving skills, so it is necessary to develop a valid mental model and problem-solving skills test instrument.

AB3LR Model Practicality

The AB3LR model that has been validated is tested to find out its practicality in the field. This model is applied to a Statistical Physics lecture at a university in the city of Padang. The model test was carried out on the material of the distribution function of speed, velocity, and molecular energy. Statistical Physics was chosen to apply the AB3LR model because this course is considered difficult by most students. 14.5% of students can understand all the material presented by the lecturer (Ashel et al., 2024). In addition, the material characteristics of Statistical Physics have a perspective from three levels of representation. However, in the learning process only microscopic and symbolic representations (equations and formulas) are often used so that students have difficulty learning them. Therefore, this course was chosen to apply the AB3LR model.

The practicality aspect of the model consists of several components, namely usable, easy to use, appealing, and cost effective. The results of the practicality of 19 students are shown in Table 4. Based on Table 4, it can be seen that the average of each indicator is in the range of 81 – 100%. This means that the AB3LR model is practically used in lectures. Students stated that this model is very useful to achieve the goals of the Statistical Physics lecture. In addition, the AB3LR model is useful for building knowledge structures and can improve problem-solving skills as shown in Figure 3. This model is easy to use and makes it easier for students to learn independently. AB3LR model makes the learning process more interesting. Students become more motivated in learning. This model is effective for improving mental models and problem solving skills in Statistical Physics course. Students said that the application of the AB3LR model can facilitate students in presenting arguments based on three levels of representation. AB3LR model is useful in guiding lecture activities.

Table 4. Results of the Practicality of the AB3LR Model Application

Assessment indicator	Average (%)	Description
Usable	88.16	Very strong
Easy to use	89.47	Very strong
Appealing	83.42	Very strong
Cost effective	83.42	Very strong
Average	86.12	Very strong

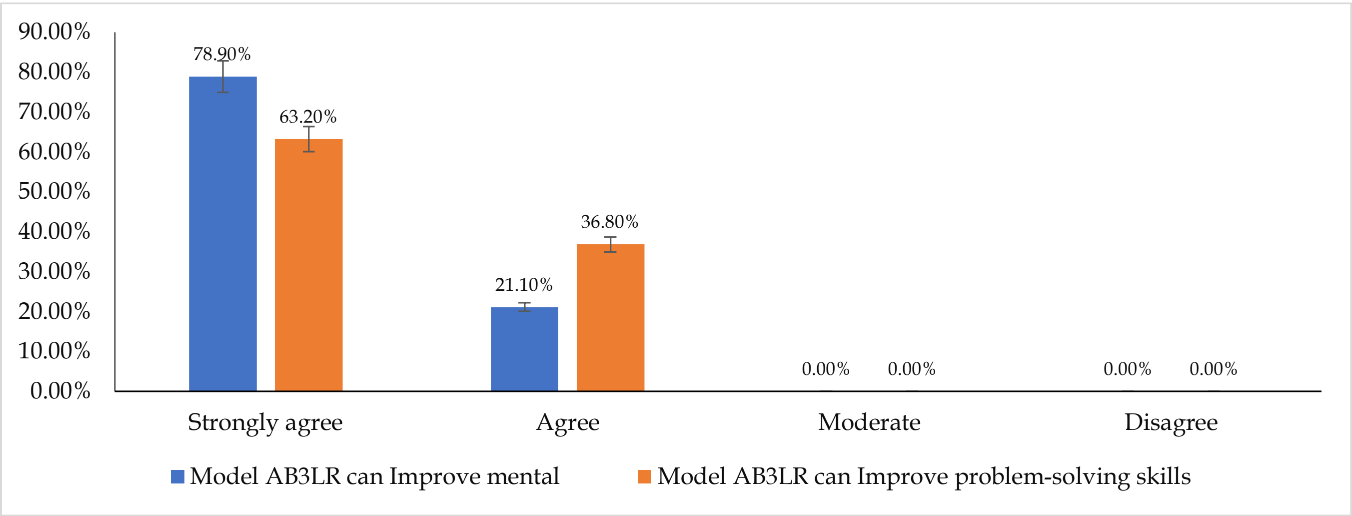

Figure 3. Student perception of the application of the AB3LR model

Figure 3 shows that 78.9% of students strongly agree that the AB3LR model can improve the knowledge structure. Meanwhile, 63.2% of students strongly agree that the AB3LR model can improve problem-solving skills. These two values indicate that the application of the AB3LR model has a positive impact for the majority of students on mental models and problem solving skills. Students stated that learning became more fun and easy to understand. This is because understanding of concepts is related to students' mental models. Mental models are also defined as understanding concepts contained in an individual's mind (Hamdiyati et al., 2022). Activities in learning can add insight and knowledge. The stages of the AB3LR model are very systematic and focus on understanding the concepts. The phase of collecting data and searching for information encourages students to discover new knowledge and concepts. This model can train students' independence and activeness in class. With the AB3LR model, students are able to solve problems or identify Physics problems, find solutions, provide arguments, and observe data microscopicly. The process of building arguments is a structure and strategy used to solve problems. Argumentation can help someone solve problems through activities of creating ideas, assessing various points of view, finding scientific evidence to find solutions to the problems faced, and communicating them (Setiawan & Jumadi, 2023). However, there are several weaknesses felt by students, namely the implementation is less effective because it takes a long time, the interaction between students and lecturers is not optimal, and the material is a little complicated. Students hope that this model will be applied more often in Statistical Physics lectures.

This research has limitations in the development process to trials. In the trial stage, the implementation was carried out on a small scale with a limited number of students. Further research is expected to be carried out more widely. The number of meetings to apply this model is also limited so that it is possible to conduct long-term research by applying the AB3LR model. This has an impact on research because the results obtained are not optimal and students have not felt its full influence. Mental model profiles and problem-solving skills have also not been obtained so that test instruments can be developed for further research. The researchers recommend the use of the AB3LR model in the learning process. This model has been valid and practical so that it can be used to encourage mental models and problem-solving skills. This model can not only be applied to Statistical Physics lectures, but is expected to be applied to various other materials and fields.

Conclusion

The purpose of this study is to determine the components of the AB3LR model, the validity result, and the practicality result of the AB3LR model. The AB3LR learning model consists of seven stages, namely identifying problems or phenomena, collecting data or information, assimilation and accommodation, presenting tentative arguments, implementing solutions, analyzing and synthesizing the results of discussions, and evaluation. The validity results of the AB3LR model are 0.99 in the valid category. The average practicality value of the AB3LR model is 86.12% in the very practical category. Most students strongly agree that the AB3LR model can improve mental models (78.9%) and problem solving skills (63.2%). The conclusion of this research is that the development of the AB3LR model is valid and practical for use in learning to improve mental models and problem solving skills.

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Author Contributions
Collecting data, analyzing data, and writing original draft, H.A; guiding in data analysis, review, and editing article, I.H; data curation and review article, S.A; methodology and review article, M.

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Conflicts of Interest
The authors declare no conflict of interest.

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