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The development of a reading model in physics teaching for argumentation skills and critical thinking skills: a 'Fuzzy Delphi' method

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ABSTRACT

Reading activities are essential to the physics learning process. Physics teaching has mostly been carried out to foster higher order thinking skills such as critical thinking and argumentation skills. This present study aims to develop a reading model that can be enacted in physics education to facilitate critical thinking and argumentation skills. This study employed the Fuzzy Delphi method. In this study, the Fuzzy Delphi method was divided into two phases. In the first phase, the experts (5 experts) were interviewed to determine the relevance of reading activities to the development of argumentation and critical thinking skills in the physics learning process. Then, in the second phase, we employed 27 experts to determine the stages of the reading model. In this phase, a questionnaire was developed consisting of fourteen questions. The research findings indicate that a consensus was reached on the stages of the reading model aimed at developing argumentation and critical thinking skills. These stages include predicting the purpose and content of the passage, explaining phenomena, reading by critical-argumentation activities, and evaluating predictions of the purpose, content, and explanation of the phenomena.

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Introduction

Reading scientific texts is a fundamental activity in the teaching and learning process in science education. It plays a vital role in enhancing students' comprehension (Oliveras, 2013) and can also support laboratory activities by helping students understand scientific information and processes (Rojas, 2019). Reading scientific texts aids in the acquisition of academic and scientific language skills (Anjani, 2022; Duke, 2021). Michalsky (2013) further notes that engaging with scientific texts activates cognitive processes and serves as a bridge to various scientific thinking skills, such as observing, classifying, interpreting, predicting, hypothesising and formulating questions.

Beyond fostering essential skills such as higher-order thinking, reading scientific texts also supports the development of critical thinking and argumentation skills. This is because the activity helps students comprehend scientific information and gather evidence from the text, which can be used to construct well-reasoned arguments. Research has shown that reading activities enhance conceptual understanding (Muhid, 2020; Meneses, 2018; Smith, 2021; Oliveira, 2014; Moats, 2020; Petscher, 2020), providing a foundation for evidence-based argumentation. Processing information from texts often challenges students' preconceived notions about scientific concepts, prompting them to think critically about what they read. Thus, reading activities offer valuable opportunities to develop both critical thinking and argumentation skills (Casado, 2023; Demircioglu, 2023; Anggraeni, 2023; Alsaleh, 2020).

There remains a lack of empirical evidence detailing how a framework or model for such activities can be explicitly designed to achieve these goals. Referring to the general structure of reading activities, which are typically divided into three stages—before, during, and after reading—we aim to integrate critical thinking and argumentation skills into specific activities tailored for physics teaching and learning. To achieve this, we propose using the Fuzzy Delphi method to develop an appropriate reading model. This model will encompass key phases and sub-phases designed to assist students in cultivating their critical thinking and argumentation skills through reading activities in physics learning.

Based on the description above, the research question in this study is how the reading model can be implemented in physics learning to train students' critical thinking and argumentation skills?. In this study, the reading model was developed in stages based on expert consensus.

Methods

We used a fuzzy Delphi Method (FDM) as an analytical method to analyse consensus among experts in developing a reading model for teaching physics.

Fuzzy Delphi Method

FDM combines Fuzzy Theory and the Delphi method (Saido, 2018), a decision-making approach to obtain consensus among experts using a sequence of questionnaires. The use of Delphi method was mainly aimed to attain consensus among experts focused on different opinions of a group decision instead of individual decision (Al-Rikabi, 2024). Practically, using the Delphi method without Fuzzy makes decision-making more difficult, as it requires a longer time to reach a conclusion. In addition, the decision-making process will take even longer.

Blending Fuzzy Theory with the Delphi method can eliminate these difficulties; this was called Fuzzy Delphi Method (FDM). It was an effective tool for obtaining subjective data produced by opinions which engages uncertainty and imprecision and transforms them into quantitative data for a decision making this claim needs a reference. We consider FDM was suitable because it established a decision making of experts' opinions to develop a reading model in physics teaching learning that integrates argumentation and critical thinking activities.

Participants

We employed 32 participants to develop a reading model integrating argumentation and critical thinking activities for physics teaching and learning. The choice of the number of participants aligned with Damigos (2011) who recommended from 10 to 50 experts based on their competency. Because we divided the developments of the reading model into two phases, we employed five experts in the first phase (science education and language experts) to achieve a consensus of relevancy and substance of aspects of reading model to argumentation and critical thinking skills. The experts were associate professors and a professor of science education with 5 years to 20 years of experience. Then, in the second phase, we employed 27 experts to determine the stages of the reading model. The experts were practitioners and a lecturer teaching physics and education in college and they were ever involved in several trainings of professional lecturers by Indonesian Ministry of Education and Culture.

Instruments

We used two sorts of instruments in this present study, namely an interview protocol for a semi-structured interview for the first phase and an FDM questionnaire that referred to themes emerging from analysis of interview data for the second phase.

The first instrument asked respondents to outline their views about a reading model that was suitable for developing argumentation and critical thinking skills. The second instrument involved four phases: predicting the purpose and content of the passage; explaining phenomena; reading by critical-argumentation discussion; and evaluating prediction of purpose, content, and explanation of the phenomena. Finally, the experts were asked to comment on the sub-phases of each phase; it consisted of 14 sub-phases. In the context of the reliability of the questionnaire, we counted Cronbach coefficient by piloting it among 10 experts in science education and we found 0.821 for Cronbach coefficient and this value was categorized as high reliability (Saido, 2018).

Data Analysis

We conducted two data analyses. First analysis was dealing with the interview data and second analysis was related to questionnaire data. In the context of the interview data, we conducted a thematic analysis by transcribing the analysis of the FDM questionnaire was conducted by following some steps:

- Step 1: we determine the linguistic scale. Then, fuzzy numbers were added to the constructed Likert scale (Hsieh, 2004). We then formed a triangular Fuzzy number in order to address the fuzziness among experts by establishing three fuzzy numbers that were m1 (the minimum value), m2 (medium value), and m3 (maximum value). All these numbers are in range 0 and 1. Nevertheless, there will be three values for each response in the Likert scale.
- Step 2: we compute the average fuzzy number and this is conducted by identifying the average responses for every fuzzy number (Benitez, 2007)
- Step 3: we identify threshold value (d) using the formula 1 to determine the consensus level among experts. The specific value of the threshold value that is less than 0.2 shows a consensus achieved by experts and another analysis can be seen from overall group consensus that should be more than 75%. When the condition is not achieved, the FDM should be repeated until a consensus is attained.

$$d(\bar{\boldsymbol{M}}, \bar{\boldsymbol{m}}) = \sqrt{1/3 \times (M_1 - \boldsymbol{m}_1)^2 + (\boldsymbol{M}_2 - \boldsymbol{m}_2)^2 + (\boldsymbol{M}_3 - \boldsymbol{m}_3)^2} \qquad (1)$$

Table 1

Linguistic Scale with Fuzzy number

Linguistic scale	Fuzzy number		
	m_1	m_2	m_3
Strongly agree	0.6	0.8	1
agree	0.4	0.6	0.8
Moderately agree	0.2	0.4	0.6
disagree	0	0.2	0.4
Strongly disagree	0	0	0.2

- Step 4: we identify alpha-cut level. In this value, we take 0.5 for alpha-cut level to select elements (sub-phases) for the reading model to train argumentation and critical thinking skills. Nevertheless, the score above and under 0.5 will be omitted; the choice of this score is based on several studies (e.g. Saido, 2018).
- Step 5: we make the defuzzification process in order to justify expert consensus on the element for phase and sub-phases in the reading model. In this process we convert fuzzy number into crips real number (Hsieh, 2004). We can defuzzification value (DV) from this process by using the following equation:

$$DV = 1/3 \times (\boldsymbol{m}_1 + \boldsymbol{m}_2 + \boldsymbol{m}_3) \qquad (2)$$

The values of m_1, m_2, m_3 are the mean value of fuzzy number for each expert.

- Step 6: we rank phases and sub-phases (elements) of the reading model and use this rank to prioritise the elements based on the DV in the model form implementation in the physic teaching class. The placed on the highest priority ranking that adjust to the highest DV value.

Findings

The result of the thematic analysis of experts' interview data in the first phase can be seen in the Table 2 and Table 3. According to thematic analysis as shown in Table 2 dan Table 3 categorises the two aspects, namely, the relevance and substance of the content. From the interview data, we know that reading activities are relevant to train or bridge aspects of higher-order thinking skills such as critical thinking and argumentation skills. Experts considered that not all reading activities could train argumentation and critical thinking skills; the reading activity that refers to training these skills is advanced reading activities, a reading activity driven by using SQ4R techniques or maximising critical reading techniques.

Table 2

Sample of the thematic analysis about the relevance of reading for argumentation and critical thinking skills

Themes	Coding category	Open coding	Sample of answer by Expert
Reading activity is relevant to train argumentation and critical thinking	Relevance of reading activity for HOTs in science learning process	Reading can build higher order thinking skills (HOTs) and critical thinking	"…*Reading is not only conducted passively; active reading can train students to build their own knowledge. For example, there is the SQ4R technique to train aspects of Higher Thinking Orders Skills (HOTs)...*" (Expert-1) "…*the reading process can be conducted by critical reading. If students are able to read critically, I*

Themes	Coding category	Open coding	Sample of answer by Expert
activities.			*think it can help students construct their knowledge…"* (Expert-2).
		Reading activities are relevant for HOTs	*"…One of the achievements of learning science is facilitating student HOTs, reading activities are relevant to that as long as it is adjusted to the achievements to be achieved…"* (Expert-3).

Table 3

Sample of the thematic analysis about substance of reading activities in science learning

Themes	Coding category	Open coding	Sample of answer by Expert
The substance of reading model in science learning	Predicting purpose of the passage	Critical reading leads to predict the purpose of the texts	*"…Critical reading is usually characterized by the reader being able to predict what the purpose of the text he is reading… a critical reader must be able to find the purpose of his reading…"* (Expert-2)
	Explaining phenomena	Reading content can depict contextual phenomena.	*"…In reading, students are still given some reading content related to contextual phenomena. Students can be asked questions related to these phenomena, then look for explanations by reading…"* (Expert-3)
	Supporting critical thinking	Reading activity can be engaged to critical questions	*"…Presenting critical questions, can use the framework proposed by Tiruneh. Students answer these questions by reading…"* (Expert-3)
	Training argumentation activities	Reading activities can train argumentation activities and patterns	*"…To practice argumentation, students can answer questions by asking argumentation patterns, using Toulmin's formulation as a reference…"* (Expert-4)
	Understanding science concepts/phenomena	Reading activities can be a way for understanding science concepts	*"…but most importantly, students can understand the science content that the text wants to convey…For critical reading, students must understand the message the reading wants to convey…"* (Expert-5)

In addition, based on the Table 2 and Table 3, the experts also viewed that advanced reading activities could be created by innovating the stages of reading activities that are in accordance with the content of the reading material (text) used and the expected learning objectives. Further, we found that reading activities that were suitable for science/physics teaching and learning should contain existence of several elements such as bridging to predict purpose of the passage, explain phenomena, provide critical-argumentation thinking activities, and understand science concepts/phenomena. To follow up what we found in the thematic analysis, we constructed a framework of a reading model that consisted of three main parts: before, during, and after reading. Each part of reading activities leads to several elements obtained from thematic analysis of the interview data. Specifically, the elements emerged in the stages of a reading activity developed aim to support argumentation and critical thinking skills (Figure 1). These elements consisted of four phases: predicting the purpose and content of the reading, explaining the phenomenon, reading by critical-argumentation activities, and evaluating the prediction of the purpose, content, and explanation of the phenomenon. Each phase was elaborated to sub-phases that aims to operationalize the phases in science/physics learning activities. There were 14 sub-phases as presented in the Table 4.

Figure 1

Stages of a reading model for argumentation and critical thinking activities

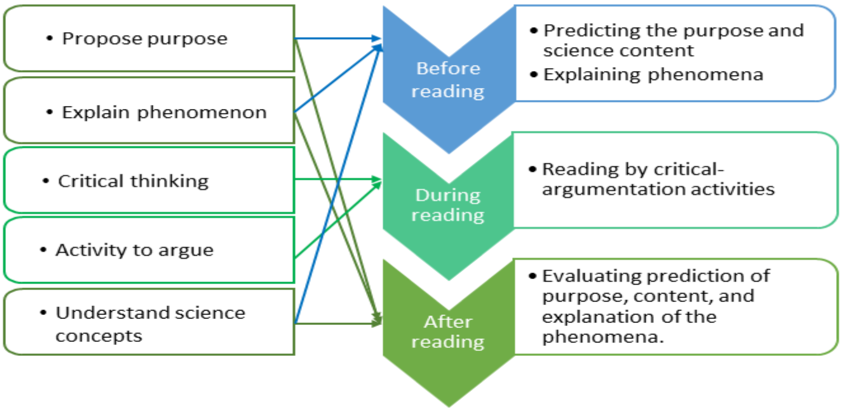


Table 4

Stages of a reading model for argumentation skills and critical thinking skills

Parts of reading activities	Phases	Sub-phases
Before reading	A. Predicting purpose and content of the passage B. Explaining phenomena	• A_1: Predict purpose of the texts • A_2: Predict short description of the content • B_1: Provide an explanation with prior knowledge of a phenomenon related to the texts
During reading	C. Reading by critical-argumentation activities	• C_1: Evaluate validity of the data • C_2: Detect ambiguous concepts and abuse definition • C_3: Explain relationship among variables • C_4: Identify whether a causal relationship claim can/cannot be made • C_5: Predict a possible event • C_6: Evaluate incomplete information in an argument • C_7: Provide a solution to a problem • C_8: Provide a comprehensive scientific argument including to proses claims, evidence/data, explanations, and support
After reading	D. Evaluating prediction of the purpose, purpose, content, and explanation of the phenomena	• D_1: Evaluate purpose of the text predicted in before reading • D_2: Evaluate short descriptions predicted in before reading • D_3: Evaluate the explanation of the phenomena predicted in before reading

After we established stages of a reading model including phases and sub-phases, we tested this reading model by using fuzzy approach. Here, we counted average score of fuzzy number each stage, threshold score, percentage of consensus, alpha cut, and ranking. All scores can be seen in Table 5 and Table 6. Based on data on the Table 6, we found that the threshold value is less than 0.2 and the percentage of agreement is more than 75%. We concluded that sub-phases in the reading model developed have been agreed by all experts. Thus, there is no need for the Delphi test for the next step. Meanwhile, all identified alpha cut values are more than 0.5 that shows an agreement among experts about sub-phases and phases formulated in our reading model. In addition, this value also indicates that the sub-phases created are able to train critical thinking skills, argumentation skills, reading comprehension skills, and motivate students as science teacher candidates.

The Alpha-Cut value shows the ranking in the sub-phases carried out in each main phase. The ranking here refers to an element of priority. A higher ranking indicates that the sub-phase is of higher priority to be carried out than the sub-phase with a lower ranking (Figure 2). In the before-reading stage, the sub-phase explaining the phenomenon becomes the most essential activity. The second order is the activity of predicting the content of the text, and the last order is the activity of predicting the purpose. At the reading stage, the activity that becomes the most important priority is detecting ambiguous concepts and abusive definitions, which are activities in critical thinking. The second place is the activity of providing solutions to a problem. The scientific argumentation activity is also the second priority. The third priority is explaining the relationship between variables and predicting phenomena. The last priority in the stages of reading is the activity of identifying causal claims and evaluating arguments. In the context of the stage of after reading, the priority is assessing the explanation of the phenomenon. The second priority is to evaluate the predictive content of the text, and the third priority is to assess the purpose of the text.

Table 5

Average scores of fuzzy numbers

Reading activity	phase	Sub-phases	Average score of a fuzzy number		
			M_1	M_2	M_3
Before reading	A	A_1	0.46	0.66	0.86
		A_2	0.47	0.67	0.87
	B	B_1	0.49	0.69	0.89
During reading	C	C_1	0.50	0.70	0.90
		C_2	0.53	0.73	0.93
		C_3	0.50	0.70	0.90
		C_4	0.47	0.67	0.87
		C_5	0.50	0.70	0.90
		C_6	0.47	0.67	0.87
		C_7	0.51	0.71	0.91
		C_8	0.51	0.71	0.91
After reading	D	D_1	0.45	0.65	0.85
		D_2	0.48	0.68	0.88
		D_3	0.50	0.70	0.90

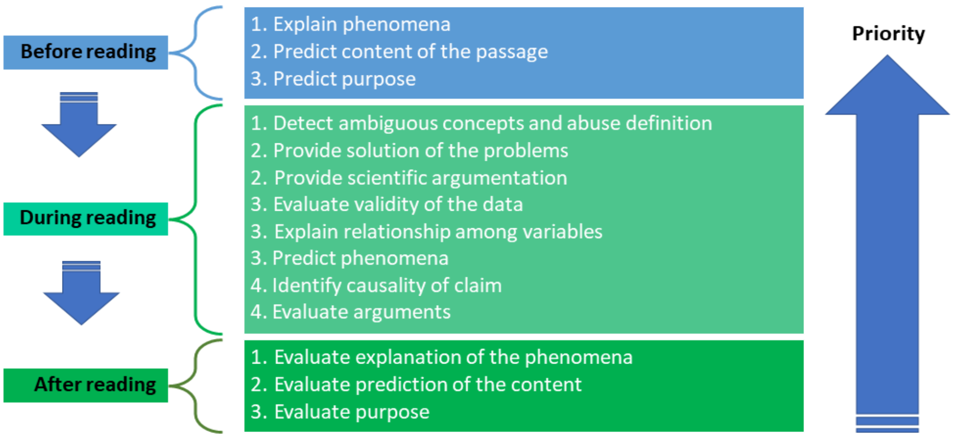
Table 6

Threshold value, percentage of consensus, alpha cut, and ranking of sub-phase

Reading activity	Sub-phase	d	%	Alpha cut	Ranking
Before reading	A_1	0.14	85.90	0.66	3
	A_2	0.13	87.41	0.67	2
	B_1	0.11	88.89	0.69	1
During reading	C_1	0.10	89.63	0.70	3
	C_2	0.07	90.37	0.73	1
	C_3	0.10	89.63	0.70	3
	C_4	0.13	86.67	0.67	4
	C_5	0.10	89.63	0.70	3
	C_6	0.13	86.67	0.67	4
	C_7	0.09	91.11	0.71	2
	C_8	0.09	91.11	0.71	2
After reading	D_1	0.15	85.19	0.65	3
	D_2	0.12	88.15	0.68	2
	D_3	0.10	89.63	0.70	1

Figure 2

Stages of a reading model and its elements for argumentation skills and critical thinking skills



Discussion

The reading model developed in this study emphasises argumentation and critical thinking activities. Critical thinking and scientific argumentation indicators are integrated into the three reading stages: before, during, and after reading. In the interview, science education experts agreed that practising higher-order thinking skills in the science learning process, such as critical thinking skills and scientific argumentation, could be carried out by using reading activities. This is because reading activities involve various kinds of complex cognitive processes, including scientific processes as trained through experimental activities in the laboratory (Siswanto, 2022; Michalsky, 2013). Thus, students can be facilitated to learn how scientific knowledge is developed, formed, and understood in various models of scientific reasoning (Fang, 2010). Based on the study's findings, we discuss what we found in the first and second stages of the development of the reading model.

In the first phase of developing a reading model, we found several activities that should exist in the reading model. These activities include expressing goals, explaining phenomena, critical thinking activities, presenting arguments, and understanding the contents of the reading. These activities aligned with other researchers' arguments about patterns of reading activities (Oliveras, 2013) and elements of critical thinking that should exist in reading activities (Mozaffari, 2021). Further, we used these activities to analyse the stages of the main activity in a reading model developed. The analysis results show that the activities of stating goals, understanding the contents of the reading, and explaining phenomena are in the activity stages before and after reading, whilst critical thinking and argumentation activities are in the activity stages during reading. This aligns with Rojas (2019), who stated that reading has three main stages: before, during, and after reading. Activities before reading are beneficial to activate the initial knowledge possessed by students. Activities during reading then construct new knowledge obtained from a text and relate it to initial knowledge; this can usually be done by proposing some questions. Finally, activities after reading aim to organise the knowledge obtained to become meaningful knowledge.

In the second phase of development of the reading model, the experts agreed that phases and sub-phases in reading activities can develop critical thinking skills, argumentation, reading comprehension skills, and reading motivation for science teacher candidates. Specifically, the experts agreed on all activities in the reading stages. For activities before reading, the experts agreed on the two proposed phases, namely predicting the purpose and content of the reading and explaining the phenomenon. These align with other researchers arguing that activities before reading are related to activities to predict what the text will explain before students start reading (e.g. Patterson, 2018). These activities activate prior knowledge and link it with existing contextual phenomena (Oliveras, 2013; Alshehri, 2024).

We here elaborate and discuss what students do in the context of before reading. In the phase of predicting the purpose and content of the text, students are given a sentence containing the text's title. They can explore their prior knowledge to indicate the purpose and description of the content of the text. This phase is used as the initial stage in practising critical thinking skills, as we know that predicting the text's purpose and content is part of the elements of critical science reading (Archila, 2024). When a reader aims to pass the literal reading stage to the critical reading stage, the reader must be able to interpret the purpose and content of the text presented (Tsai, 2022). In addition, this phase is used to stimulate the initial knowledge stored in the students' memory. Then, in explaining the phenomenon, students are asked questions related to the phenomenon presented in the text. By presenting these questions, students become more motivated to read texts because they aim to restructure the initial knowledge and have built a skill in explaining phenomena (Tseng, 2010). In addition, the phenomena presented have the characteristics of contextual concepts so that students are aware that the concepts studied are closely related to everyday life. This motivates students to learn (Armario, 2022; Mufit, 2024).

Practically, we divided the activities before reading into three sub-phases, namely predicting the purpose of the text, predicting the content of the text, and explaining phenomena. Based on the results of expert consensus, the sub-phase of explaining the phenomenon is the priority; the sub-phase of predicting the content of the text is the second priority; and the sub-phase of predicting the goal is the third priority (Figure 2). This makes a lot of sense because the disclosure of phenomena is very important to be presented in the context of science learning (Lee, 2020). Presenting phenomena at the beginning can lead to cognitive conflicts that create curiosity to learn (Doran, 2021; Tseng, 2010). More importantly, the most important thing in starting learning is to encourage students to have curiosity and activate the knowledge they have (Bybee, 2006). Then, predicting the description of the content and the purpose of the text has a function to complete the sub-phase of explaining the phenomenon. These two sub-phases are beneficial in activating the knowledge possessed by students. This does not mean that the sub-phase of predicting content and purpose should be carried out after the sub-phase of explaining the phenomenon, because we consider that students' prior knowledge in their memory needs to be activated as initial capital to explain phenomena.

In the context of the activities during reading, we found that experts agreed on the proposed phase of a reading model for argumentation skills and critical thinking skills. This phase aims to help students focus on understanding the content of the texts. Here, we integrated several statements/questions to be answered or found in the texts. The importance of providing questions is to focus on the key concepts that must be understood (Siswanto, 2022; Macceca, 2013). The statements/questions in the activities emphasise critical thinking indicators (Anggraeni, 2023) and scientific arguments (Lazarou, 2021). These indicators are then used to develop sub-phases or elements during reading (see Table 4). In this context, reading activities can be designed complexly by involving high-level thinking to process the meaning so that readers are able to connect the content of reading with contextual problems. These activities drove students to understand, assess, and reflect critically on the content of the text (Oliveras, 2013; Macceca, 2013). In addition, we designed this stage to connect students' initial knowledge to what they found in the texts through textual investigations (Saido, 2018). In other words, it involved a variety of complex cognitive processes, including scientific processes and scientific reasoning (Siswanto, 2022; Fang, 2010). For example, the element of evaluating the validity of the data was conducted through textual investigation, in which students will present valid data in the statement. They look for relevant concepts in the texts, and then they will apply them to test the validity of the data presented.

In the following analysis, we view agreement consensus on the priority order of the sub-phases or elements during reading (Figure 2). We found four priorities. The first priority is detecting ambiguous concepts and abuse definitions; the second priority is providing solutions to problems and submitting scientific arguments; the third priority is evaluating the validity of the data, explaining relationships among variables, and predicting phenomena; the fourth priority is identifying causal claims and evaluating arguments. The element of detecting ambiguous concepts and abuse definitions has a position of first priority because they are closely related to the formation of conceptions to strengthen the construction of key concepts in the text. Implementation of these elements aims to drive students to restructure their knowledge by investigating textual evidence in the texts (She, 2004). In the context of providing solutions to problems and making arguments, this phase has a second priority because it naturally trains students to become problem solvers and perform scientific reasoning (Rojas, 2019). These conditions aligned with some examples of science practice that involve students carrying out argumentation and critical thinking activities (Siswanto, 2022; Osborne, 2019; Fathonah, 2023). The other sub-phases or elements have a position on the third and fourth priority because they function as complementary elements for practising science.

Finally, we will discuss the activities after reading. We found that the experts agreed on the proposed phases: evaluate the prediction of the purpose, content, and explanation of the phenomenon. This phase aims to examine accurately students' understanding of the contents of the text and to review the explanations of phenomena presented before reading. The activities after reading are similar to the learning stages based on HOTs at the conclusion and reflection stage (Saido, 2018). They were also similar to the 5E model at the elaboration and evaluation stages (Bybee, 2006). These activities are also an essential part of the learning process to train critical thinking skills (García-Carmona, 2023). Further, we examined sub-phases or elements agreed upon through consensus in the form of the priority order (Figure 2). Evaluating the explanation of the phenomenon is the first priority, while evaluating the description of the content and purpose is the second and third priority, respectively. This consensus result aligned with the consensus result on the before-reading activity. It has been explained previously that the disclosure of phenomena is very prominent in the science learning process because it generates cognitive conflicts that support curiosity to learn (Lee, 2020; Tseng, 2010; Evi, 2024).

Conclusion and Implications

In this study, the phase of a reading model in physics learning has been produced to train critical thinking skills and scientific argumentation based on the consensus among experts. This model was developed based on reading activity as a process, namely before, during, and after reading. The identified stages include predicting the purpose and content of the passage, explaining phenomena, reading by critical-argumentation activities, and evaluating predictions of the purpose, content, and explanation of the phenomena.

The reading model developed in this study has significant implications for physics teaching and learning. Firstly, incorporating scientific reading activities into physics education offers a promising alternative to enhance students' critical thinking and argumentation skills. Since these activities rely on scientific texts, it is essential to ensure that high school physics textbooks are accurate and free from misconceptions that could lead to misunderstandings in students' acquisition of scientific concepts. Secondly, this study has the potential to shift the teaching approach of physics educators. Teachers must actively engage students in both the key phases and sub-phases of the proposed reading model. To do so, they need a thorough understanding of the model and the ability to design worksheets that effectively foster critical thinking and argumentation skills through reading activities. This shift underscores the importance of teacher training programs to equip physics teachers with the necessary competencies. Specifically, teachers must learn how to create statements provided in the worksheet that highlight key concepts, address challenging topics, and identify areas prone to student misconceptions. These skills will enable teachers to guide students effectively in using reading activities to build a deeper understanding that can be a foundation for critical thinking and argumentation skills.

On the other hand, implementing the reading model may face challenges due to the prevalence of mathematical equations in physics textbooks or other scientific texts. To address this issue, the texts should include detailed explanations of the equations, covering their origins and providing examples of their application in real-world physics phenomena. This approach allows students to connect the mathematical models with the contextual phenomena they represent, making it easier for them to grasp the meaning and significance of the equations.

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