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Analysis of Argument-Driven Inquiry Activity in Chemistry Textbooks

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Abstract

Argument-Driven Inquiry (ADI) in science learning can improve students' argumentation skills and understanding of concepts. In the textbooks, it is important to have ADI activities inside. This research aims to analyze ADI activities in the high school chemistry textbook Revised Curriculum 2013. This research used nine indicators of ADI activities: questions, evidence, student explanation, scientific theories, argumentation, communication and justification, analysis, connection, investigation report, and reflection. The research method used a descriptive instrument as an analysis sheet prepared based on ADI activities. Data was collected using documentation techniques and data analysis using content analysis of ADI activities. The results showed that the reliability test of the data obtained was 0.94 in the very good category. The ADI activity most found in textbooks is evidence activity, with a percentage of 31.25 Meanwhile, the textbook needs to explain question and answer and reflection activities. The textbook needs to increase ADI activities that support student-centered learning and teaching.

Keywords: argumentation skills, ADI activities, chemistry textbook, understanding of concepts

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1. Introduction

Teaching and learning activities are essential in learning and basic needs that students must meet to achieve learning outcomes (Aliwanto, 2017). This condition can help students learn effectively and provide opportunities for students to increase their knowledge individually (Bosch et al., 2021). One form of student activity that can make students active in the classroom is improving students' argumentation skills. Argumentation skills are crucial for students to be able to defend data, claims, and ideas that deviate from their thinking to be able to argue (Songsil et al., 2019), as well as be involved in discussions so that students can make decisions in solving scientific problems (Fakhriyah et al., 2021). This situation can be achieved by implementing Argument-Driven Inquiry (ADI) in learning because ADI is a laboratory-based learning model that can encourage students to be involved in experimental activities and scientific argumentation (Demircioglu & Ucar, 2015). ADI is relevant in learning because it can train students' science process skills and argumentation abilities and build student activities (Admoko et al., 2021; Walker et al., 2016).

Moreover, textbooks are always connected to the learning process. The textbooks contain valuable scientific concepts and are the primary learning source for teachers and students to gain new knowledge and achieve learning goals through content or subject matter (Sothayapetch, 2013). Also, almost all textbooks and workbooks provide great opportunities to explore student activities in the teaching and learning process because textbooks are prepared for students, so the presentation of textbooks is oriented toward student activities or learning activities (Muslich, 2016; Penney et al., 2003).

On the other hand, Aldahmash and Omar (2021) state that there are several aspects in conducting the ADI activities: a) question (involving students in scientifically oriented questions), b) evidence (asking students to prioritize evidence), c) student explanation (asking students to provide explanations based on data or evidence), d) scientific theories (asking students to connect explanations with scientific knowledge), e) argumentation, communication, and justification (asking students to express opinions), f) analysis (asking students to analyze the evidence), g) connection (involving students to connect explanations with scientific knowledge), h) investigation reports (asking students to make reports based on the results of investigations or learning), and i) reflection (asking students to reflect on the investigation and learning process).

Based on the explanation above, analyzing ADI activities in chemistry textbooks is necessary. Regarding this condition, ADI activities are essential to improve students' argumentation and critical thinking skills. Apart from that, analysis of student activities in textbooks has yet to be carried out in the last ten years, especially in Indonesia.

Furthermore, there are several studies focused on: analyzing students' activities in physical textbooks, but the activities studied were laboratory activities (Gumilar & Ismail, 2021); analyzing students' activities in English textbooks, which focused on the cognitive level, as viewed from Bloom's taxonomy (Putri & Komariah, 2018), and students' activities in chemistry textbooks (Aldahmash & Omar, 2021).

Unlike the previous research, this study analyzes students' activities in terms of ADI based on the textbook. This instrument was chosen because ADI activities are crucial to improve students' argumentation and critical thinking skills. The book analyzed is a revised 2013 curriculum of an 11th-grade high school chemistry textbook published by Erlangga and written by Unggul Sudarmo. Meanwhile, based on observation, some schools in Samarinda City have chosen chemistry textbooks for 11th-grade high school because the books present complex lessons. Hence, this study aims to explore students' activities depicted in 11th-grade high school chemistry textbooks as reviewed by ADI. Thus, this research involves a benefit for teachers in developing the chemistry material, and for the textbook's writers can develop textbooks that can improve students' argumentation and critical thinking skills.

2. Research Method

This research used qualitative with a descriptive technique collected from words or images in textbooks to provide an overview of the research presentation. The research object was ADI activities in the 11th-grade high school chemistry textbook revised 2013 curriculum published by Erlangga and written by Unggul Sudarmo. These textbooks were selected based on observation of the chemistry textbooks that were most widely and frequently used in ten high schools in Samarinda City. Meanwhile, this study used nine indicators of ADI activities: questions, evidence, student explanation, scientific theories, argumentation, communication and justification, analysis, connection, investigation report, and reflection. Data was collected using document analysis. Each indicator unit contained in the textbook was read and understood in depth. Then, activities that fulfilled ADI activities were grouped according to the research instruments prepared based on Table 1. For each indicator activity, marked scores were calculated and divided by the total number of student activities indicators reviewed from the ADI to calculate the percentage of statements in the textbook. The formula for calculating the percentage of activity is as follows.

Percentage of student activities indicators =

$$\frac{n}{\Sigma N} \times 100\%$$

Description:

n = Number of indicators per category

ΣN = Total number of indicators per category

Table 1. Student Activities Scoring Instrument in Textbooks viewed from the ADI

ADI Activities Indicators	Scoring Variations			
	4	3	2	1
Questions	In the textbook, some activities asked students to formulate problems, identify problems, and create questions based on stimulus in the form of events/phenomena/illustrations/discourses/problems presented.	In the textbook, some activities asked students to formulate a problem and create a question based on stimulus in the form of events/phenomena/illustrations/discourse/problems presented.	In the textbook, some activities asked students to make questions based on stimulus in the form of illustrations or problems and questions that had been presented.	In the textbook, there were no activities that asked students to formulate problems, identify problems, and ask questions, but directly asked to carry out an experimental or practical activity.
Evidence	In the textbook, some activities required students to respond to the questions, collect data, and analyses data using appropriate techniques based on accurate data, information and evidence from the results of investigations and investigation procedures that had been presented.	In the textbook, some activities required students to respond to the questions and collect data based on data, information and evidence from the results of investigations and investigation procedures that had been presented.	In the textbook, some activities asked students to respond to questions based on observations tables and/or the results of data analysis that had been presented from the investigation results.	In the textbook, there were no activities that asked students to respond to questions, collect data, and analyze data using appropriate methods; but directly ask to collect data based on the information found or the results of investigations.
Student Explanations	In the textbook, some activities asked students to respond to questions by providing explanations based on data or evidence that supports the results of an investigation (based on experiments/practicum/experiments/activities and the results of further investigations)	In the textbook, some activities asked students to respond to questions by providing explanations based on valid data or evidence (based on searching or searching for information or observing pictures/tables)	In the textbook, some activities asked students to respond to questions by providing explanations based on invalid data or evidence.	In the textbook, some activities asked students to provide supporting evidence from the investigation results without explaining.
Scientific Theories	In the textbook, some activities asked students to respond to questions by providing explanations based on data or evidence that supports the results of an investigation by connecting them to scientific theories, principles and concepts.	In the textbook, some activities asked students to respond to questions by providing explanations based on data or evidence that supports the results of an investigation by connecting them to scientific theories and concepts.	In the textbook, some activities asked students to respond to questions by providing explanations based on data or evidence that supports the results of an investigation by connecting them to scientific concepts.	In the textbook, some activities asked students to respond to the questions without providing explanations based on data or evidence supporting an investigation's results.

ADI Activities Indicators	Scoring Variations			
	4	3	2	1
Argumentation, Communication, and Justification	In the textbook, some activities asked students to form and create a logical and reasonable argument to communicate and justify explanations.	In the textbook, some activities asked students to communicate an argument based on the results of the investigation that had been carried out.	In the textbook, some activities asked students to perfect an argument based on the argument that had been presented in an illustration.	In the textbook, some activities asked students to criticize arguments based on the arguments that had been presented in an illustration.
Analysis	In textbooks, some activities asked students to analyze evidence from the results of an investigation by choosing to use an appropriate method.	In the textbook, some activities asked students to analyze evidence from the results of an investigation with steps for analyzing the evidence given.	In the textbook, some activities asked students to analyze evidence from the results of an investigation where data and steps for analyzing the evidence had been given.	In the textbook, some activities asked students to carry out an activity based on the steps given to analyze evidence so that data could be obtained.
Connection	In the textbook, some activities asked students to respond to questions by connecting explanations and scientific knowledge based on the questions that had been presented.	In the textbook, some activities asked students to respond to questions by connecting explanations and scientific knowledge.	In the textbook, some activities asked students to respond to questions without connecting explanations and scientific knowledge.	In the textbook, there were no activities that asked students to respond to questions by connecting explanations and scientific knowledge based on the questions that had been presented. However, explanations and scientific knowledge based on the questions that had been presented had been presented.
Investigation Report	In the textbook, some activities asked to discuss the results of an investigation and make a report based on the results and further investigation.	In the textbook, some activities asked to discuss the results of the investigation and make a report based on data from the results of the investigation/search/literature study.	In the textbook, some activities asked to make a report based on data from investigations/searches/literature studies without conducting discussions.	In the textbook, there were no activities that asked to discuss the results of investigations and make reports based on the results of further investigations and investigations.
Reflection	In textbooks, some activities asked students to provide reflections or complete conclusions based on the results of investigations and learning and convey lesson concepts that were not yet understood.	In the textbook, some activities asked students to provide reflections or convey conclusions based on the results of investigations and learning.	In the textbook, some activities asked students to reflect by responding to reflection questions regarding the learning process.	In the textbook, there were no activities that asked students to reflect or conclude, but reflections and conclusions from the results of investigations and learning were presented in the reading.

The next step was to carry out a reliability test to measure and assess the reliability of the data and avoid observer subjectivity. This reliability was conducted by three observers: one chemistry lecturer and two high school chemistry teachers. In checking the data, the observer gave a checklist mark in the students' activities analysis sheet column. Then, the agreement results between the researcher and observer were calculated using the following Kappa Coefficient formula.

$$KK = \frac{P_A - P_C}{1 - P_C}$$

Description:
P_A = The probability of the same statement between two observers
P_c = Marginal distribution of the number of categories in a contingency table

The results of the Kappa Coefficient were interpreted for reliability to obtain conclusions based on the following interpretation as shown in Table 2 (Kusumawati et al., 2022).

Table 2. The Interpretation of Kappa Coefficient

Kappa Coefficient	Interpretation
< 0.00	Very Poor
$0.00 < x \leq 0.20$	Poor
$0.20 < x \leq 0.41$	Less
$0.41 < x \leq 0.61$	Medium
$0.61 < x \leq 0.80$	Good
$0.80 < x \leq 1.00$	Very Good

3. Result and Discussion

The research results show that the ADI activity best described in the 11th-grade high school chemistry textbook published by Erlangga was the evidence activity. This activity had an occurrence percentage of 31.25%. This value arose because the book asked students to refer more to data collection and respond to experimental questions that had been carried out. After that, the second was the investigation report indicator, with an appearance percentage of 27.08%. In this book, students were asked to make reports individually and in a group after conducting experiments and answering several questions. Meanwhile, the third position was argumentation, communication, and justification, with an appearance percentage of 18.75%. This activity referred to presenting the results of experiments or reports that students have made. Besides, the fourth position was the students' explanation indicator of 14.58%. This activity had a lower percentage than evidence because the presentation of this activity in textbooks was not explored enough for students, even though it was enough to support students in honing their abilities in critical thinking. The fifth was the scientific theories or models indicator, with a percentage of 4.17%. This position was similar to the student explanation activity and had quite a similar activity indicator: explaining the results of investigations that had been carried out. The sixth was analysis and connection indicators, with a percentage of 2.08%. The seventh was question and reflection, which had a percentage of 0%; it means that these indicators were not described in the book. Hence, the percentage of student activity indicators appearing in the book can be seen in Table 3.

Table 3. The Results of Activities Analysis in Textbooks

Students Activity Indicators	Score (%)				Σ	$\overline{X}$	%	Level
	1	2	3	4				
Questions	0	0	0	0	0	0.00	0.00	-
	0%	0%	0%	0%				
Evidence	4	2	9	0	15	2.33	31.25	2
	26.67%	13.33%	60.00%	0%				
Student Explanations	0	0	0	7	7	4.00	14.58	4
	0%	0%	0%	100%				
Scientific Theories/Models	2	0	0	0	2	1.00	4.17	1
	100%	0%	0%	0%				
Argumentation, Communication, and Justification	0	0	9	0	9	3.00	18.75	3
	0%	0%	100%	0%				
Analysis	0	1	0	0	1	2.00	2.08	2
	0%	100%	0%	0%				

Students Activity Indicators	**Score (%)**				**Σ**	**X̄**	**%**	**Level**
	1	**2**	**3**	**4**				
Connection	0	0	1	0	1	3.00	2.08	3
	0%	0%	100%	0%				
Investigation Report	0	3	8	2	13	2.92	27.08	3
	0%	23.08%	61.54%	15.38%				
Reflection	0	0	0	0	0	0.00	0.00	-
	0%	0%	0%	0%				

Level 1: the skill is included but is strongly directed toward teacher-centered learning and teaching
Level 2: the skill is included but is directed toward teacher-centered learning and teaching
Level 3: the skill is included but is moderately directed toward student-centered learning and teaching
Level 4: the skill is included but is strongly directed toward student-centered learning and teaching

The results of the analysis carried out by the researcher were then subjected to reliability testing by three observers. The reliability test results show that the kappa coefficient value is more than 0.81 which is included in the very good category, which can be seen in Table 4.

Table 4. Observer Coefficient of Agreement

No.	Observer	Kappa Coefficient	Interpretation
1.	I	0,95	Very Good
2.	II	0,95	Very Good
3.	III	0,93	Very Good
	Mean	0,94	Very Good

Based on Table 3, seven ADI activities are described in the chemistry textbook. ADI activities not described in the book are questions and reflection, even though these two activities are essential in the learning process. Question activity is designed to attract student's attention and interest so that they are interested in the learning process. Apart from that, this activity can be done by providing a stimulus or short illustration of the material to be studied so students can answer several questions or ask new questions, solve problems, and complete assignments (Sampson et al., 2011). Besides, question activities can increase students' curiosity and critical thinking; students must possess critical thinking in the learning process (Nurfazri, 2022). Added by Lestari (2015) states that asking questions can arouse students' interest and curiosity. On the other hand, reflection can be used to assess student learning outcomes (Marinda et al., 2023). Consequently, reflection activities explore students' knowledge and self-evaluate the extent of the material or knowledge they have mastered.

Furthermore, Sandoval and Reiser (2004) stated that reflection is vital in learning and scientific investigation. It can be used as a self-evaluation to understand specific problems experienced or obtained and to build scientific explanations.

On the other side, evidence was an ADI activity that asked students to prioritize data and evidence in responding to questions. This activity was the most dominant in the book. One example of this activity is as shown in Figure 1.

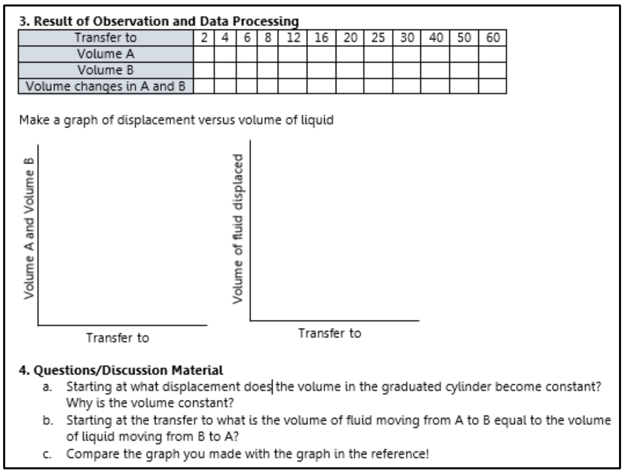

Figure 1. The Example of Evidence Activity Statement

Figure 1 shows an example of an evidence activity that asks students to collect data and respond to several questions based on experiments that have been carried out. This is an example of a level 3 activity that focuses on student-centered teaching and learning. This activity will increase students' ability to collect data and respond to questions based on the results of their investigations and experiments. According to Toulmin in Kulatunga et al. (2013), there are several things to support scientific arguments: data, claims, support, and refutation. Thus, data is used as evidence to strengthen a claim, warrant (to explain the relationship between data and the claim), support (a basic assumption that underlies a justification), and refutation (it can occur when the claim cannot be accepted) (Kulatunga et al., 2013). Therefore, it can be concluded that evidence activities can encourage students to find evidence and look for data and theories to support their claims about problems (Siregar & Pakpahan, 2020). Added by Walker et al. (2016), evidence is an activity that asks students to answer questions based on data or claims; this can train students' investigative skills.

The next activity was student explanation, an ADI activity that asked students to provide explanations based on data or evidence. One example of this activity is as shown in Figure 2.

3. Discussion questions
   a. Are the estimated calculations in accordance with the facts of the experimental results? Explain.
   b. To precipitate and remove Pb^{2+} ions from water, what ions are most effective to use? Explain.

Figure 2. The Example of a Student Explanation Activity Statement

Figure 2 shows an example of students' explanation activities that ask students to explain and hone their abilities in providing explanations based on the result of observation. This activity is primarily focused on student-centered teaching and learning and is at level 4. Explanation is a form of understanding something based on what is obtained. This activity can help students develop their understanding of science; it can also help students design ideas, evidence, and reason in explaining observational data (Grooms et al., 2016). Added by Ginanjar et al. (2015), the explanation of observation results in scientific arguments falling into the warrant category: explaining the relationship between data and others. In other words, explanations can help students convince themselves of the truth and prove the predicted results of investigations or observations (Nuraini et al., 2014).

c. Write down the reactions that occur in steps 2 (b) and 2 (d).
d. Try combining the two reactions you wrote down.

Figure 3. An Example of a Scientific Theory or Model

The next activity is the scientific theories or models activity, an ADI activity that asks students to connect explanations with scientific knowledge. One example of this activity is as shown in Figure 3.

Figure 3 shows an example of a scientific theory or model statement that asked students to write down reactions and combine reactions from an experiment that had been carried out. This example focuses more on teacher-centered teaching and learning, therefore students have not been trained in scientific theories or model activities. This reaction equation is a scientific concept, and has not trained students to provide explanations related to scientific theories, principles and concepts that can strengthen their cognitive abilities. Sampson and Gleim (2009) stated that providing explanations could help students answer the questions that guide investigations and solve problems. Also, this activity could increase students' knowledge and strengthen students' understanding (Admoko et al., 2021). Meanwhile, Suningsih and Istiani (2021) suggest that this explanation could aid students in building comprehension skills and provide an overview of the extent to which students understand the concept of a material.

The next activity is argumentation, communication, and justification, which asks students to express their arguments. Examples of these activities are shown in Figure 4.

b. Design an experiment to identify the acidic and alkaline properties of substances around you (waste water, springs, well water, drinking water, etc.). Present the results of your design in front of the class.

Figure 4. The Example of Argumentation, Communication, and Justification Activity Statement

Figure 4 shows a statement that asks students to present the results of the activities they have carried out. This is an example of activity that focuses on student-centered teaching and learning and is at level 3. This activity can train students to speak in public and improve their communication and thinking skills. Communication skills are a competency that students require to be able to face future challenges; this can be developed through scientific argumentation activities (Siregar and Pakpahan, 2020). This is also confirmed by Ginanjar et al. (2015) who state that argumentation and communication skills are very important to be trained to develop logical reasoning, clear perspectives, and rational explanations. Explanations can be expressed orally or in writing. Farida and Gusniarti (2014) suggested that students' capacity for oral argumentation might enhance their sociocognitive abilities and improve their capacity for concept expression. According to Sampson and Gleim (2009), learning that emphasizes argumentation will provide opportunities for students to speak by speculating, arguing, and challenging, because in speaking students will articulate their reasons and attempt to defend their conceptual understanding.

Analysis activity is an ADI activity that asks students to analyze evidence. This activity is the activity that is least described in the book. Examples of analysis activities are shown in Figure 5.

Discussion Questions.

a. According to stoichiometric calculations, the reaction between 10 mL of 0.1 M Fe^{3+} solution and 10 mL of 0.1 M SCN^- solution; both of them will react appropriately. Is this statement correct? Prove it with calculations.

Figure 5. The Example of an Analysis Activity Statement

Figure 5 shows an example of an analysis activity that asks students to prove a stated statement using calculation. This activity is classified as level 2, because it provides data (in the form of solution volume) and analysis methods. Analysis activities can train students' reasoning abilities. Reasoning is a foundation that students must have to construct their understanding by thinking logically and critically, as well as understanding cause and effect relationships; hence, it can train students to draw correct and appropriate conclusions regarding the problems given (Maisuhetni, 2022). The next activity is a connection. It is the same as the analysis activity described in the book. An example of connection activity is shown in Figure 6.

a. Is there a relationship between acids and bases that form salt and the properties of salt solutions in water? Explain.

Figure 6. The Example of a Connection Activity Statement

Figure 6 shows an example of a connection activity that asks students to explain the relationship between acids and bases that form salt and the properties of salt solutions found in water. This is an example of a level 3 activity that focuses on student-centered teaching and learning. Connection activities can increase and strengthen students' understanding of scientific knowledge because of the relationship between explanations and scientific knowledge. Admoko et al. (2021) confirmed that connection activities must be applied in learning to develop and improve scientific knowledge and strengthen student understanding. This activity can also maximize students' understanding of interpreting concepts, theories, and functions during investigations (Kusumawardhana & Dintarini, 2021).

On the other hand, the investigation report activity is an activity that asks students to make a report. The investigation report activity is an activity that can train students in writing reports; apart from that, this activity can also help student’s express ideas or things they have obtained from the experiments they have carried out. One example of this activity is as follows.

Make a report on the results of the experiment, including graphs and discussion, as well as explanations. Present the results in front of the class.

Figure 7. The Example of Investigation Report Activity Statement

Figure 7 shows an example of an investigation report activity that asks students to make a report based on experimental results. This is an example of a level 3 activity that focuses on student-centered teaching and learning. The report writing process must comply with the rules of the scientific method because it can allow students to express the results of investigations or experiments that have been carried out in written form by sharing the purpose of the experiment, the methods used, and their overall arguments (Walker et al., 2016). Writing reports can help students understand topics and articulate their thoughts clearly and concisely; it can also increase student integration in writing (Sampson et al., 2011; Sampson & Gleim, 2009).

The reliability test analysis of student activities in textbooks carried out by three observers showed an excellent agreement coefficient of 0.94. This result indicated that the researcher and observers' analysis results did not differ significantly. Hence, the analysis results of chemistry textbooks showed a requirement to develop the textbooks. Also, the developed textbook must accommodate students' argumentation skills so that pupils can master university-level science education and prepare for future scientific life to train their investigation and argumentation skills.

4. Conclusion

Based on the analysis of the 11th-grade high school chemistry textbooks 2013 revised curriculum published by Erlangga, the activity best described in the book is evidence activity with an appearance percentage of 31.25%. Meanwhile, question and reflection activities should be described in the book. Based on these findings, the development of current chemistry textbooks in circulation still needs to improve students' argumentation skills. As a result, these books still need development with qualities that can improve students' arguments so that students can understand and master the process of scientific investigation, critical thinking skills, and argumentation in inquiry learning.

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