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Development of Chemistry Lecture Sets for Reducing Logical Fallacy in Arguing

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ABSTRACT
Objective: This study aims to develop a lecture set designed to reduce the occurrence of logical fallacies by training students' argumentation skills. **Method:** The lecture sets were developed to refer to the stages of the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation). Validity was validated by three validators on student activity sheets and argumentative ability assessment sheets. The validity of the test results was obtained based on the mode of calculation and the percentage of agreement between validators. **Results:** The lecture sets are structured by containing six types of logical fallacies, namely relative privation, blind authority fallacy, hasty generalization, questionable cause fallacy, reification fallacy, and non sequitur, and includes general chemistry lecture material, namely stoichiometry, atomic structure, periodicity of elements, chemical bonds, the concentration of the solution, the equilibrium of ions in the solution, and the colligative properties of the solution. The chemistry lecture sets for reducing logical fallacies in arguing has been declared valid by the validator. **Novelty:** The results of this study can be used as a reference by teachers, lecturers, or other researchers who wish to study more about logical fallacies.

INTRODUCTION

The development of information today is so fast. The flow of information is enormous in terms of quality and quantity. The quality of the information spread in cyberspace is very diverse; some are even misleading and disturbing. Hoaxes contain false news or non-sourced news. Today, hoaxes are very widely spread through internet media. The development of information technology that has quickly triggered the spread of hoax information through the internet has become uncontrolled (Mustofa & Mahfudh, 2019). For example, information on creamer powder, packaged in the video format, is visualized that creamer powder is highly flammable if sprinkled over a fire. The visualization is not wrong, and it is a fact. Problems will arise when the visualization is narrated with misleading information; for example, the creamer contains explosives. The narrative of a fact or news of this kind is a form of statement called a "claim."

The claim states, "If the creamer powder is flammable like an explosive, it can be interpreted that the creamer contains explosives or other materials that resemble explosives." This statement can be categorized as a false claim. This false claim occurs because of a logical error or so-called logical fallacy. A logical fallacy is an error in reasoning that describes irrelevant arguments. The general public still believes in this false claim. This shows that the community still needs to have adequate argumentation skills. In everyday discussions, logical fallacies often occur in society; even scientists are not immune to logical errors. Whether this logical fallacy is innate since the individual is at school or college, answering this question requires an assessment process that can be accounted for through research. If, according to the definition above, then a person's logical fallacy can be detected using a question of argumentation skills. Submission of arguments by someone can be done in written form to facilitate decision-making on the arguments presented (Iordanou & Rapanta, 2021; Kabataş et al., 2020; Rubinelli et al., 2021; Saribas & Çetinkaya, 2021). There are at least three benefits if students understand logical fallacies. First, students can make correct logic; second, they will avoid faulty logic; and third, arguments that contain logical fallacies will not affect them. In the long term, someone who can understand argumentation well can identify logical errors (Neylan et al., 2021).

Chemical knowledge is obtained through inductive and deductive logic, which must be free from logical errors. Research conducted by Suyono et al. (2021) shows the distribution of data on the types of logical fallacies experienced by chemistry students, namely six types of logical fallacies that occur when students are undergoing the argumentation process on internalized argumentation skill questions at a manageable level, namely non sequitur, ad populum, black-and-white, rash generalizations, distraction, and card-stacking.

Data about student errors in reasoning can be used to find weak points in arguments. An argument is declared convincing when it fulfills the "pillars" through solid evidence and logic. If a logical error occurs in a student, the method of argumentation may be wrong, so the conclusions made are wrong. The results of student error description data in arguing can be used to test the robustness of logic. Argumentation skills are a form of thinking skills possessed by a person in compiling knowledge claims that are supported by evidence and strengthened by reasons when assessing a phenomenon. Argumentation skills are an integral part of the thinking skills demanded by the 21st Century (Akhdinirwanto et al., 2020; Almerich et al., 2020; Hasnunidah et al., 2019; Tight, 2021; van Laar et al., 2020). Argumentation skills are needed by someone in responding to issues related to all aspects of people's lives to avoid falling into wrong conclusions (Bronkhorst et al., 2020; Chinn et al., 2020; Ozden, 2020).

Argumentation skills need to be trained in every student as a scientific person for four reasons. First, argumentation skills are moderating skills for critical thinking skills. Second, argumentation, critical thinking, and problem-solving skills are one unit. Third, problem-solving skills are one of the 21-st century demand thinking skills (Arzak & Prahani, 2023; Neswary & Prahani, 2022; Nouri et al., 2020; Saphira & Prahani, 2022; Sholihah & Lastariwati, 2020). Fourth, argumentation skills are not abilities that can develop by themselves along with human physical development (Lytzerinou & Iordanou, 2020; Majidi et al., 2021; Mtawa et al., 2021; Spöttl & Windelband, 2021). In lectures in the chemistry department, students are often faced with data and facts that must be analyzed. At this analysis stage, an emphasis on argumentation skills can be carried out to avoid logical fallacies.

Previous research on argumentation skills was carried out by Suyono et al. (2020), who produced questions to measure students' argumentation skills. This package of questions aims to describe argumentation skills that have been internalized in students' cognitive structures. The specification formulation of argumentation skills is divided into four components, namely (1) compiling claims, (2) showing evidence, (3) compiling reasons, and (4) compiling counterarguments.

One's logical fallacies can lead to unreasonable arguments. Therefore, they are essential to teaching (Gallant et al., 2020). Lecturers/teachers must provide learning on how to construct logical arguments and avoid logical errors (Hasibuan et al., 2020). In addition, sources of logical errors and misinformation must also be found immediately

(Bonial et al., 2022). Research by Christoforides et al. (2016) has shown that students who are taught to master logical errors impact the learning process's effectiveness. Based on the description, it is necessary to develop a lecture tool designed to reduce the occurrence of logical fallacies by practicing argumentation skills. Therefore, it is essential to develop lecture tools to train argumentation skills that help students avoid logical fallacies.

RESEARCH METHOD

Research Instruments

This research is a type of research development or Research and Development (R&D). The products developed in this study are described in Table 1.

Table 1. Developed products.

Developed Products	Information
Learning media	BC-SAS_RLF 01 (Basic Chemistry Student Activity Sheet Reducing Logical Fallacy 01)
	BC-SAS_RLF 02 (Basic Chemistry Student Activity Sheet Reducing Logical Fallacy 02)
Assessment tool	BC-AAS_RLF (Basic Chemistry Argumentation Assessment Sheet Reducing Logical Fallacy)

To produce a quality product, it is necessary to have a careful development plan. In developing lecture tools, this research refers to the ADDIE development model (Branch, 2009). The ADDIE model consists of five stages: analysis, design, development, implementation, and evaluation. The components carried out in the ADDIE development model can be described in Table 2.

Table 2. Stages of research device development.

Stages	Description of Research Device Development
Analysis	Conducting a needs analysis for efforts to achieve the thinking skills demanded by the 21st century that must be possessed by graduates of the Faculty of Mathematics and Natural Sciences through Basic Chemistry learning. The need is the availability of time and supporting devices to practice thinking skills. One of the skills used to understand concepts is thinking skills, and one of the thinking skills is argumentation skills. So that students' arguments are not wrong, a tool called "Logical Fallacy Reduction" is needed. Lecture tools as a reference in implementing learning are currently being developed, namely two student activity sheets (BC-SAS_RLF) and one assessment sheet for argumentation skills (BC-AAS_RLF).
Design	Develop lecture tools to facilitate student involvement in thinking activities with the ultimate goal being that students have adequate thinking skills, namely argumentation skills that are free from logical errors. The design of learning tools developed includes descriptions of logical fallacies, logical forms, examples of general cases, and examples of chemical cases. The assessment device design developed includes claims, approval of claims, and arguments against claims.

Stages	Description of Research Device Development
Development	Producing two student activity sheets (BC-SAS_RLF) and one assessment sheet (BC-AAS_RLF) according to the design that has been made. Three experts then assessed the draft tool to determine whether it fulfills the theoretical validity requirements from the construct dimension (consistency) and the content dimension (relevance). Drafts declared valid are still being improved regarding ease of understanding according to written input from experts before implementation.
Implementation	Carry out activities for implementing student activity sheets (BC-SAS_RLF) and assessment sheets (BC-AAS_RLF) to targets or users, which in this case are students of the 2022 Physics Education Study Program taking Basic Chemistry/General Chemistry courses. There are two target student classes, namely Physics Class E and Physics Class F.
Evaluation	Evaluating BC-SAS_RLF and BC-AAS_RLF in terms of practicality and effectiveness. The practicality of BC-SAS_RLF and BC-AAS_RLF was evaluated based on student assessments submitted in writing through an open questionnaire. The effectiveness of BC-SAS_RLF and BC-AAS_RLF was evaluated based on three data sources from student users. The first data is in the student's assessment of the device's function in guiding the occurrence of thinking exercises for them, which are captured through a closed questionnaire. The second data is in the student's assessment of the device's function in guiding the occurrence of thinking exercises for them, which are captured through an open questionnaire. The third data is learning outcomes in the form of argumentation ability scores.

Data Collection and Analysis Techniques

Validity data collection was obtained from the validator's assessment (expert judgment) of BC-SAS_RLF and BC-AAS_RLF to determine compliance with theoretical validity requirements, both from the construct dimension (consistency) and the content dimension (relevance). The validation criteria for BC-SAS_RLF and BC-AAS_RLF differ according to the construct and content of each tool. Tables 3 and 4 contain validation criteria for BC-SAS_RLF and BC-AAS_RLF.

Table 3. BC-SAS_RLF validation criteria.

Number	Validation Criteria
1	The description "Description" provides a clear definition according to the type of logical fallacy
2	Description "Logic Form" provides a precise, logical formulation according to the type of logical fallacy
3	Examples of "Claim" and "Argument" provide a clear picture of the types of logical fallacy cases
4	Claims in the “General Case” provide appropriate training according to the type of logical fallacy
5	Claims "Chemical Case" provides suitable training in chemistry according to the type of logical fallacy.

Table 4. BC-AAS_RLF validation criteria.

Number	Validation Criteria
1	Claim each question according to the type of logical fallacy being tested
2	Claim each question according to the material in the General Chemistry Course

Number	Validation Criteria
3	Availability of space that students can use to write statements of accepting (agreeing) or rejecting (disagreeing) claims.
4	The availability of expandable space that students can use to present arguments explaining the decision to accept or reject a claim.

Each validator assesses BC-SAS_RLF and BC-AAS_RLF according to the validation criteria in Tables 3 and 4 based on the score criteria in Table 5.

Table 5. Criteria score validity.

Score	Evaluation
1	Invalid
2	Less valid
3	Pretty valid
4	Valid
5	Very valid

To be able to conclude the construct validity of the developed BC-SAS_RLF and BC-AAS_RLF, it can be done by calculating the mode (the score that appears the most) and the percentage of agreement as reinforcement, which states that between validators, it is stated that they have an understanding in giving judgments (Borich, 1994). Thus, the use of mode (Mo) in decision-making is unquestionable. The percentage of agreement (R) formula in question is as follows.

$$Percentage\ of\ agreement\ (R) = \left[1 - \frac{A - B}{A + B}\right] \times 100\%$$

Information:
R: Coefficient of percentage of agreement (R)
A: The highest score from the validator
B: The lowest score of the validator

The conclusion criterion for the R-value is that the validators mutually agree on the assessment given if the R-value is ≥ 75% (Borich, 1994).

RESULTS AND DISCUSSIONS

Results

BC-SAS_RLF Structure and Design

The design of the student activity sheet refers to the logical fallacy teaching arrangement by Bennett (2020). It integrates it with the argumentation skill component from Chin & Osborne (2010) to produce a student activity sheet design, as shown in Figure 1.

Student Activity Sheet

Types of Logical Fallacy

1. **Explanation**
   a. Description
   ....
   b. Logic Form
   ....
   c. General Example
   - Claim
   ....
   - Argument
   ....
2. **General Case**
   a. Claim
   ....
   b. Approval/Rejection of Claims
   ....
   c. Argument
   ....
3. **Chemical Case**
   a. Claim
   ....
   b. Approval/Rejection of Claims
   ....
   c. Argument
   ....

Figure 1. Logical fallacy reduction student activity sheet design.

BC-AAS_RLF Structure and Design

The assessment tool used to find the results of logical fallacy reduction in student argumentation is the Argumentation Ability Assessment Sheet (BC-AAS_RLF). The design of the assessment sheet refers to the component of argumentation skills from Chin & Osborne (2010), namely (1) compiling claims, (2) showing evidence, (3) compiling reasons, and (4) compiling counterarguments, as shown in Figure 2. The BC-AAS_RLF consists of 11 questions arranged containing six types of logical fallacies and the scope of the chemistry material that has been taught.

Argumentation Ability Assessment Sheet

Name :
Class :
Number :
Instructions for filling out the test:
...

Question

a. Claim
....
b. Approval/Rejection of Claims
....
c. Argument
....

Figure 2. Arguing ability assessment sheet design

Results of BC-SAS_RLF and BC-AAS_RLF Validity

Validation was carried out on three validators, each of which validated two BC-SAS_RLF and one BC-AAS_RLF. To be able to conclude the validity of the developed BC-SAS_RLF and BC-AAS_RLF, it can be done by calculating the mode (the score that appears the most) and the percentage of agreement as reinforcement which states that the validators have an agreement in giving the assessment (Borich, 1994).

Tables 6, 7, and 8 describe the validity results for BC-SAS_RLF 01, BC-SAS_RLF 02, and BC-AAS_RLF.

Table 6. BC-SAS_RLF 01 validity results.

No.	Validator Score			Mode	Percentage of agreement (%)		
	1	2	3		V1 & V2	V1 & V3	V2 & V3
1.	5	5	4	5	100	89	89
2.	4	5	5	5	89	89	100
3.	5	4	5	5	89	100	89
4.	5	4	5	5	89	100	89
5.	4	5	4	4	89	100	89

Table 7. BC-SAS_RLF 02 validity results.

No.	Validator Score			Mode	Percentage of agreement (%)		
	1	2	3		V1 & V2	V1 & V3	V2 & V3
1.	5	5	4	5	100	89	89
2.	5	5	5	5	100	100	100
3.	5	4	5	5	89	100	89
4.	4	4	5	4	100	89	89
5.	5	5	5	5	100	100	100

Table 8. BC-AAS_RLF validity results.

No.	Validator Score			Mode	*Percentage of agreement* (%)		
	1	2	3		V1 & V2	V1 & V3	V2 & V3
1.	5	5	4	5	100	89	89
2.	5	5	5	5	100	100	100
3.	4	5	5	5	89	89	100
4.	5	5	5	5	100	100	100

Discussions

Discussion of BC-SAS_RLF and BC-AAS_RLF Validity

Based on Table 6, the developed BC-SAS_RLF 01 is very valid based on the mode obtained with four criteria obtaining a score of 5 and one criterion obtaining a score of 4. Then, calculate the percentage of agreement used to see the agreement between validators (validator one and validator 2), validator 1 with validator 3, and validator 2 with validator 3) in giving an assessment, it also showed results ≥ 75%, which means that the validators have mutually agreed on the assessment given. According to Suyono et al. (2019), learning tools are declared to meet the content validity criteria if each component receives a validator assessment with a mode (Mo) of at least four from a score range of 1-5. With these results, the developed BC-SAS_RLF 01 can be said to be valid.

Based on Table 7, the developed BC-SAS_RLF 02 is very valid based on the mode obtained with four criteria obtaining a score of 5 and one criterion obtaining a score of

4. Then, calculate the percentage of agreement used to see the agreement between validators (validator one and validator 2), validator 1 with validator 3, and validator 2 with validator 3) in giving an assessment, it also showed results ≥ 75%, which means that the validators have mutually agreed on the assessment given. With these results, the developed BC-SAS_RLF 02 can be said to be valid.

Based on Table 8, the developed BC-AAS_RLF is very valid based on the mode obtained with four criteria, obtaining a score of 5. Then, the percentage of agreement calculation is used to see the agreement between validators (validator one and validator 2, validator one and validator 3, and validator two and validator 3) in giving an assessment also showed results ≥ 75%, which means that the validators mutually agree on the assessment given. With these results, the developed BC-AAS_RLF can be said to be valid.

The scope of the chemistry material

Chemistry lectures to reduce logical fallacies in arguing are conducted for students of the Unesa physics study program class 2022 through general chemistry courses. Students' argumentation skills are trained by teaching the correct argumentation in assessing a claim according to the argumentation skills component of Chin & Osborne (2010). General chemistry lectures taught the chemistry material during the research. This is done with the aim that students can learn how to argue and avoid logical fallacies through their chemistry lectures.

The learning tools used in chemistry lectures to reduce logical fallacies in arguing consist of two student activity sheets with two different scopes of material.

Table 9. Material coverage on student activity sheets (Chang & Overby, 2019).

Number	Student Activity Sheets	Material Scope
1.	BC-SAS_RLF 01 (Basic Chemistry Student Activity Sheet Reducing Logical Fallacy 01)	- Stoichiometry - Atomic structure - The periodicity of the elements - Chemical bonds
2.	BC-SAS_RLF 02 (Basic Chemistry Student Activity Sheet Reducing Logical Fallacy 02)	- Solution concentration - Equilibrium of ions in solution (acid-base, pH, hydrolysis of salts, buffer solutions) - Colligative properties of solutions

Types of Logical Fallacy Being Taught

Chemistry lectures to reduce logical fallacies in argumentation are carried out by practicing argumentation skills and understanding the types of logical fallacies. Lecturers need to teach, and students need to understand the types of logical fallacies that exist because this is in line with how to construct logical arguments to avoid logical errors, as presented by Hasibuan et al. (2020) and Gallant et al. (2021).

The types of logical fallacies used originate from the types written by Bennett (2020). The types of logical fallacies are selected by analyzing the types of logical fallacies (Bennett, 2020), which are by the chemistry material taught in general chemistry courses. Six types of logical fallacies are used, described in Table 10.

Table 10. Type of logical fallacy used (Bennett, 2020).

Number	Types of Logical Fallacy	Description
1.	Relative Privation	Trying to make scenarios seem better or worse by comparing them to best or worst-case scenarios.
2.	Blind Authority Fallacy	Asserting that a proposition is valid only on the authority making the claim.
3.	Hasty Generalization	Draw conclusions based on small sample sizes rather than looking at statistics that align with typical or average situations.
4.	Questionable Cause Fallacy	Concluding that one thing causes the other simply because they are regularly related.
5.	Reification Fallacy	When an abstraction (an abstract belief or a hypothetical construct) is treated as a concrete event.
6.	Non-Sequitur	When the conclusion does not follow from the premise, in more informal reasoning, it can be when what is presented as evidence or reason is irrelevant or adds little support to a conclusion.

CONCLUSION

Fundamental finding: The results of this research are student activity sheets and valid argumentation ability assessment sheets that are compiled by containing six types of logical fallacies, namely relative privation, blind authority fallacy, hasty generalization, questionable cause fallacy, reification fallacy, and non-sequitur which includes general chemical materials, namely stoichiometry, atomic structure, periodicity of elements, chemical bonds, solution concentration, ion balance in solution, and colligative properties of solutions. **Implication:** This research is expected to be used as a reference for other researchers who wish to investigate further about logical fallacies. **Limitation:** This research only discusses more than just types of logical fallacies and general chemistry lecture material. **Future Research:** Therefore, it is hoped that further research will examine other types of logical fallacies in courses in other fields.

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