Profile of The First Year Student's Argumentation Skills on General Chemistry Courses at a Public University in West Sumatera: A Preliminary Study

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Abstract. Scientific argumentation is one of the key components of habits of mind, while habits of mind are one dimension of scientific literacy that should be developed in Indonesia. However, the student's scientific argumentation ability in learning, which has been weak lately, has become a common problem that needs to be solved immediately. The solution can be related to how to evaluate the learning process, construct the problems found in learning, and design learning that can motivate students to argue. This is a descriptive study. It aimed to find out the profile of the early scientific argumentation skills of first-year students who took general chemistry courses at one of the public colleges in West Sumatra. Research instruments consist of four open and semi-closed essay questions. Those were given to 125 chemical education students involved in this study. Data was analyzed by evaluating the students' written argumentation, which became the research samples by following the Toulmin Argumentation Pattern (TAP), consisting of claim, data, warrant, backing, and rebuttal. The study results show that most students (97.25%) have level 0–3 argumentations skills. While only 2.25% of students have level 4 argumentation skills and 0.5% are at level 5. This means that the early argumentation skills of chemistry students are still low, and only a few students are able to emerge with a rebuttal in the scientific arguments they build. These findings are further used as the basis for designing learning strategies that can improve students' argumentation skills during the learning process, especially in general chemistry courses, so that their habits of mind and scientific literacy will also increase.

1 Introduction

The demands for quality human resources align with the development of information and communication technology today. In education, the government and related stakeholders have made various efforts to improve the quality of graduates produced. One focuses on education, especially science education, to develop students' competence to become science-literate citizens. [1,2,3]

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Scientific literacy can be defined as the ability of learners to understand science, communicate science both orally and in writing, and apply scientific knowledge to explain phenomena and solve natural problems in the learning environment or society [4–7]. Through scientific literacy, students are expected to understand the scientific process, apply scientific knowledge rationally and creatively, and make decisions based on scientific reasoning [8,9]. In addition, they must have the skills to conduct scientific investigations and a critical attitude to become informed and participatory citizens. Therefore, scientific literacy is considered a critical competency that is very important to improving the quality of human capabilities and welfare in the present and future.

Scientific argumentation is one of the critical components of habits of mind, and habit of mind is one of the dimensions of scientific literacy that must be promoted in order to produce science-literate learners [10,11]. Argumentation skills are very important to develop in science learning, especially in chemistry learning, because students who study chemistry must know scientific explanations related to chemical phenomena that occur and can use them to solve their daily life problems. Several reasons reported in the literature related to the importance of developing students' argumentation skills in learning include: the use of arguments in learning can develop students' understanding of the nature of science [10,12]; the use of arguments can improve the conceptual understanding of the scientific ideas presented [13]; it can develop critical thinking and communication skills [14]; and it can train students' skills in making evidence-based decisions in the given problem context [15].

Based on the above description, it can be concluded that the practice of argumentation is very important for developing students' critical thinking, which is the core of the ability to make the right decisions in the complexity of real-world problems in social life to find the truth. In addition, argumentation plays a very important role in science because it is used to present, support, refine, and evaluate science [16]. Using strong evidence to support claims and build arguments is a hallmark of science. The ability to make claims based on evidence (argumentation) is important for scientists to do their work because this skill helps them to meet the challenges of discoveries and scientific methods, improve their scientific literacy, solve problems, and ultimately support the progress of science development in the future [17].

Chemistry learning that involves this argumentation process cannot occur naturally but must be carefully prepared and planned. Teachers should be able to teach students how to build and support knowledge through arguments and evaluate or respond to other people's claims or arguments using appropriate learning models. In addition, teachers are also required to be able to prepare issues or problems that can provoke students to argue and express their opinions in solving these problems. The classroom learning environment is designed to encourage students to communicate with each other by arguing to justify or refute scientifically based statements. However, the fact is that not all teachers can create such a learning process in practice. Based on the results of previous research, it is known that the main obstacle teachers face in creating a learning environment that supports the argumentation learning process is difficulty organizing learning due to limited time and resources [18]. In addition, teachers still struggle to find issues and problems that can make students argue during the learning process. As a result, the culture of argumentation has yet to develop among students, so they are not accustomed to defending their opinions by providing appropriate evidence.

One way to develop students' argumentation skills is to introduce a culture of scientific argumentation into the learning process, where students are guided to seek evidence and make decisions collaboratively to solve a given problem. This inquiry-based learning approach, emphasizing argumentation, has been identified as a possible mechanism for conceptual growth and change, complex reasoning development, and improving students' scientific and critical thinking skills and epistemic understanding. Therefore, a culture of scientific argumentation should be emphasized in all quality science education in schools and universities to increase students' interest in science learning. Thus, it can enhance their learning and develop their scientific literacy [19,20, 21,22].

In order to assess the quality of the student's written argumentation, it can be conducted by referring to the Toulmin Argumentation Pattern (TAP). TAP is considered to improve the quality of argumentation in the classroom through searching, responding to differences, and taking a stand. It is thought to improve scientific communication in the classroom and reduce student misconceptions [23]. TAP can also train and develop students' critical thinking skills. According to Toulmin (2003), an argument consists of a set of interconnected sentences and is based on a statement that is considered true, namely a claim (C). This statement is supported by proven data (D), which is connected by warrants (W) and reinforced by backing (B). Qualifiers (Q) must exist for the claim to be accurate and represent its limitations. Qualifiers can also be considered weak rebuttals. Rebuttals (R), or counterarguments, present facts that contradict the data, warrants, and backings, thus proving that the statement is untrue. This rebuttal is the highest element of the TAP level. It must have a sufficient basis in the previous element.

Theoretically, a good and high-quality argument includes all the components of TAP. However, many students struggle to construct arguments by including all TAP components such as claim, data, warrant, backing, qualifier, and rebuttal. Handayani et al., found that when constructing arguments, some students are only able to make statements in the form of claims, but they still have difficulty in providing evidence and other components that support their claims [24]. Similarly, Wahdan et al. (2017) found that students could make claims and provide evidence or data in their research, but other scientific explanations did not accompany the data they presented. These research results indicate that students still need help constructing quality arguments according to Toulmin's argumentation pattern.

One factor determining students' success in argument construction is the teacher's ability to create an argumentative learning process in science, especially chemistry learning. In order to successfully promote students' argumentation skills, teachers must have a broad and deep knowledge of argumentation [10,25]. Teachers should be able to construct appropriate and high-quality arguments when solving a problem. In addition, teachers should be able to evaluate students' arguments and provide constructive feedback during the learning process [11].

On the other hand, students need to be familiarized with chemistry learning involving the argumentation process to develop their ability to construct quality arguments. Therefore, as future teachers, chemistry education students need to be prepared with knowledge about constructing quality arguments before they enter the field as teachers. They must be proficient in both oral and written scientific argumentation so that they can later guide their future students in argumentative learning. For this reason, it is necessary to know the profile of the initial argumentation skills of education students as a basis or reference for researchers in developing learning models and strategies to train and improve students' argumentation skills.

This research is a preliminary study of a learning model development research to train students' argumentation skills. This research aims to determine the initial argumentation skills of first-year students taking general chemistry courses in one of the public universities in West Sumatra. The research results in the form of students' initial argumentation profiles are used to determine appropriate strategies to improve students' argumentation skills in line with their increasing understanding of concepts and their cognitive achievements. As a result, their thinking skills and scientific literacy will also increase.

2 Methodology

This type of research is descriptive research, which aims to describe the profile of initial argumentation skills of first-year chemistry students taking general chemistry courses in the odd semester of 2022/2023 at one of the public universities in West Sumatra. *Descriptive research* can be defined as a type of scientific research that aims to describe and explain phenomena or circumstances that are systematically observed [25]. The main purpose of descriptive research is to provide a clear and comprehensive description of certain situations, events, or characteristics without changing variables or drawing causal conclusions.

This research was conducted by giving four open and semi-private type argumentative questions to 125 chemistry education students involved in this study. The questions were given in the form of argumentative essays on acid-base and reaction-rate materials. Furthermore, analyzing students' written argumentation is carried out using the Toulmin Argumentation Pattern (TAP), where the argumentation consists of a claim, data, warrant, backing, qualifier, and rebuttal. In order to determine the quality of the students' argumentation, an evaluation, and scoring of the argumentation were carried out by referring to Osborn's (2004) evaluation rubric, where the level of argumentation is divided into five levels [13] , as can be seen in Table 1 below.

Table 1. Osborn Argumentation Assessment Rubric

Category	Argument Component
Level 0	There is no response or argument.
Level 1	An argument consists of a simple, correct claim.
Level 2	An argument consists of a correct claim, backed up with relevant data, and a clear justification or backing.
Level 3	An argument consists of a correct claim supplemented by relevant data, clear justification, strong support, and an unclear rebuttal.
Level 4	An argument consists of a correct claim, supported by relevant data, a clear warrant, strong backing, and a clear and correct rebuttal..
Level 5	An argument consists of a correct claim with relevant data, clear justification, strong support, and more than one correct rebuttal.

Source: Osborn:2004

The argument score data from the assessment based on Osborn's rubric was analyzed qualitatively and quantitatively. The quantitative data collected was then processed and tabulated, and the percentage of claims, data, warrants, backings, and rebuttals produced by students on the given test was calculated. At the same time, qualitative data is described in such a way as to illustrate the phenomena that arise based on the results of the analysis by calculating the argumentative assessment by setting a standard score. Students' arguments to answer each question are processed into scores according to the TAP components resulting from the answers given. Based on the score, it is possible to see the profile of the argumentation ability of the participants in this study.

Two raters assessed this student's argument because the assessment of essay questions allows for high subjectivity. To reduce this subjectivity, interrater reliability or interrater agreement can be calculated [26]. Interrater reliability data can affect the validity and trustworthiness of the research findings, which is very important. In addition, interrater reliability can also reduce the bias of research results. Interrater agreement tends to make studies more objective by involving several different raters, thus reducing the biases of individual raters.

3 Results and Discussion

In this study, the researchers evaluated and analyzed only the written argumentation of the student's answers to the four types of problems given. Open and semi-closed question types—as many as four questions—are given in the form of argumentative essays to see how the initial ability of chemistry students in constructing arguments is used to answer the given problems. The results obtained are expected to provide an overview of the profile of students' argumentation skills as a consideration or basis for researchers in developing models or learning strategies that can train students' argumentation skills during the learning process.
The assessment of the student's written arguments is based on Osborn's assessment rubric, which classifies the arguments into five levels according to the TAP components that appear in the argument. Based on the student's answer sheets, the quality of the argument was analyzed by two raters, doctoral students in chemistry education experienced in argument construction and evaluation, who independently scored 20% of the test samples. In addition, inter-rater agreement was determined by calculating kappa agreement (k) using SPSS 27. The kappa agreement value for the test in this study was 0.739, which means that the strength of agreement between the two raters in evaluating students' arguments could be classified as "good"[29]. Meanwhile, disagreements between the two raters were resolved after discussion. For more details, the interpretation of the kappa value according to Altman (1991) is presented in Table 2. From the results of the analysis performed, several data points were obtained, namely the percentage of student argument quality for each question, the percentage of student argument quality in terms of question type, the percentage of student argumentation based on Toulmin's Argumentation Component (TAP), and the overall profile of student argumentation skills.

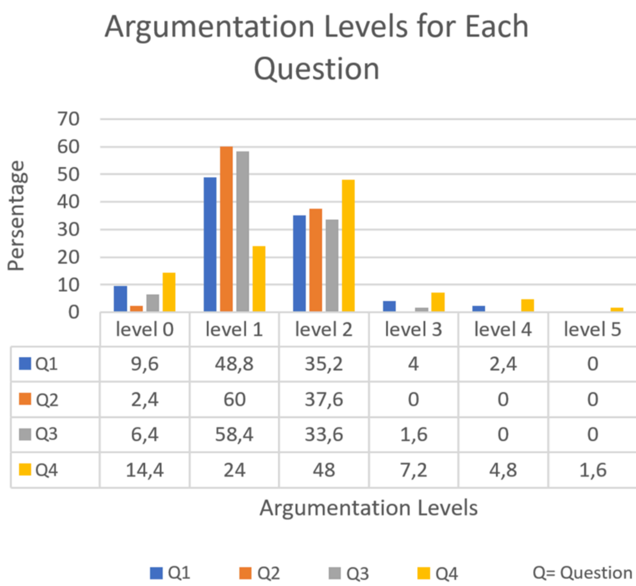
Table 2. Kappa Value Interpretation

K value	strength of agreement
≤ 0,20	poor
0,21 – 0,40	Less than medium
0,41 – 0,60	medium
0,61 – 0,80	Good
0,81 – 1,00	Very Good

Source : Altman 1991

3.1 Quality of Students Argumentation for Each Question

In this study, first-year students who took general chemistry courses as participants were given four argumentative essay questions to be completed individually and were not allowed to cooperate with other students in answering the questions. Based on the assessment of student answers, the analysis and calculation of percentages according to the level of argumentation as illustrated in the bar chart in Figure 1.



	level 0	level 1	level 2	level 3	level 4	level 5
Q1	9,6	48,8	35,2	4	2,4	0
Q2	2,4	60	37,6	0	0	0
Q3	6,4	58,4	33,6	1,6	0	0
Q4	14,4	24	48	7,2	4,8	1,6

Fig 1. Argumentation Level for Each Question

Based on Figure 1, it can be seen that for questions no. 1, 2, and 3, the majority of students' argument quality is at level 1 with 48.8%, 60%, and 58.4%, respectively. As for question no. 4, most students (48%) have level 2 argumentation skills. Meanwhile, the lowest percentage for the argumentation level of the four questions is level 5. It means the student's answers have yet to find rebuttals or qualifiers to explain the facts and data from the questions. Students can only make correct claims and collect accurate data to support the claims. Meanwhile, warrant and backing just appeared in the answers of several students for each question.

3.2 Quality of Student Argumentation Based on Question Type

As previously explained, this research instrument uses two types of questions: open essay questions with as many as two questions (questions no. 2 and 3) and semi-closed essay questions with as many as two (questions no. 1 and 4). Open essay questions give students the freedom to express thoughts, analyze, and build arguments to answer questions according to their knowledge of the topic being asked. Therefore, open essay questions provide a more comprehensive picture of students' understanding of the subject matter. Whereas semi-closed essay-type questions still give students the opportunity to express their thoughts broadly and deeply, they are given several guidelines or options to be chosen to answer the question. Although students can choose a topic, they are still expected to compose answers in the form of essays that contain in-depth analysis, arguments, and explanations. The analysis and processing of student argumentation data based on this type of question are shown in Figure 2.

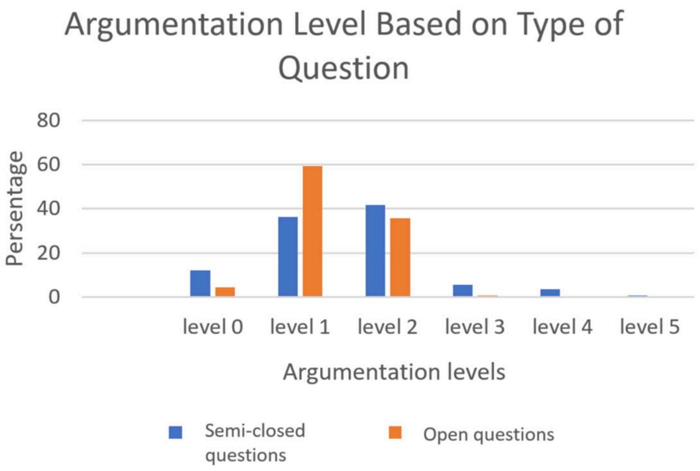


Fig 2. Students Argumentation Level based on Type of Questions

Based on Figure 2, it is known that 41.6% of students answer semi-closed questions by building arguments that can be categorized as level 2. In comparison, 36.4% of students are classified as level 1, and 12% of students are categorized as level 0. The remaining 10% of other students are grouped as having argumentation skills at levels 3, 4, and 5. Most students can make claims in semi-closed questions based on relevant data, warrants, or backing. The guidelines and choices given in the question help students compile arguments to answer the semi-closed questions. However, from the analysis of students' answers, it can be seen that most students write all the data provided in the problem one by one in their answers without considering which data is more appropriate to support the claims they make. In addition, they could not construct a quality argument because most students are not used to this type of argumentation-based learning. This is in line with previous research, which suggests that one of the reasons for students' low ability to argue is that previous learning does not facilitate students to argue orally or in writing, so students are not experienced in doing this[27]. As for open-type essay questions, the argumentation skills of most students in answering questions are at level 1. As many as 59.2% of the test participants have level 1 argumentation skills, 35.6% have level 2, and 4.4% have level 3 argumentation skills. The arguments students use to answer this open-ended question depend heavily on their knowledge of a concept. In support of this, Handayani (2015) reported that the students' opinions expressed in their arguments were based only on the known information. Thus, the level of argumentation students produced was classified as low [24].

3.3 The quality of Students Argumentation based on Toulmin's argumentation Pattern (TAP)

Looking at the components of Toulmin's argument, the majority of the students who participated in the study were able to make claims. However, the claims made by the students were still naive or incorrect. The ability of the students to make such a claim shows their knowledge of the concept that was asked in the problem. An example of an incorrect claim made by a student is shown in Figure 3.

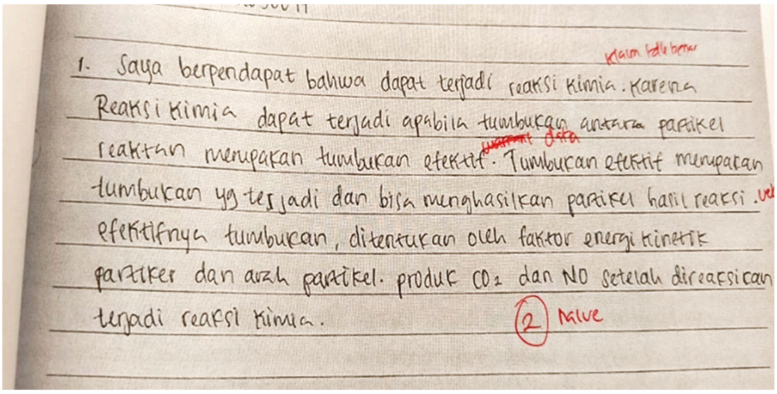


Fig 3. Example of incorrect claim made by a students

The correct claim for Figure 3 should be "Chemical reactions cannot occur" (claim). The reason is that the reaction occurs at room temperature, so the kinetic energy is smaller than the activation energy (data). Incorrect claims, such as those in Figure 3, arise due to students' limited understanding of the topic in question. In addition, students are not familiar with oral and written argumentation. Therefore, students must learn how to construct a quality arguments to solve a problem. The quality of students' initial argumentation regarding the TAP component is presented in the bar chart in Figure 4.

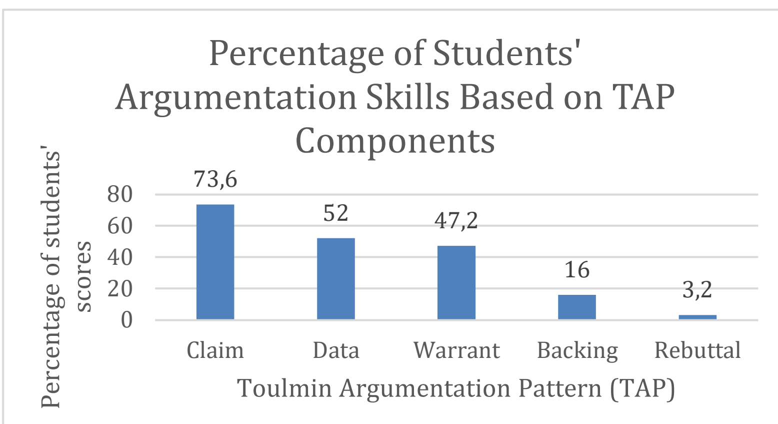


Fig 4. Student's Argumentation Skills Based on TAP Component

According to the data on students' argumentation skills seen from the argumentation component, the claim has the highest percentage, which is 73.6%; the data component is 52%; the warrant component is 47.2%; the backing component is 16%, and the lowest percentage is the rebuttal component, only 3.2%. Claims have the highest percentage in this study because each level of argument always includes claims in its argument structure [29]. Meanwhile, the data and warrant components are found in levels 2 to 5 argumentation. The backing component appears only in level 3 argumentation and above, while rebuttal has the smallest percentage of students' performance. Weak rebuttals appear in level 4 argumentation, and strong rebuttals are found in the highest level of argumentation, level 5. Students who have level 5 argumentation quality can write more than one rebuttal (counterclaim) in their argument. However, from the results of the study, it was found that only a few students could include rebuttals in the arguments they compiled. Students are too focused on presenting facts that support their claims[29]. They did not think that certain circumstances might contradict the original claim. Therefore, the level of argument shows the complexity of the components that build the argument. The higher the level of one's argumentation, the more complex the argumentation components used in constructing the argument.

3.4 Profile of Students Initial Argumentation

In general, the profile of the initial argumentation ability of chemistry education students in one of the public universities in West Sumatera is represented by a bar chart, as shown in Figure 5.

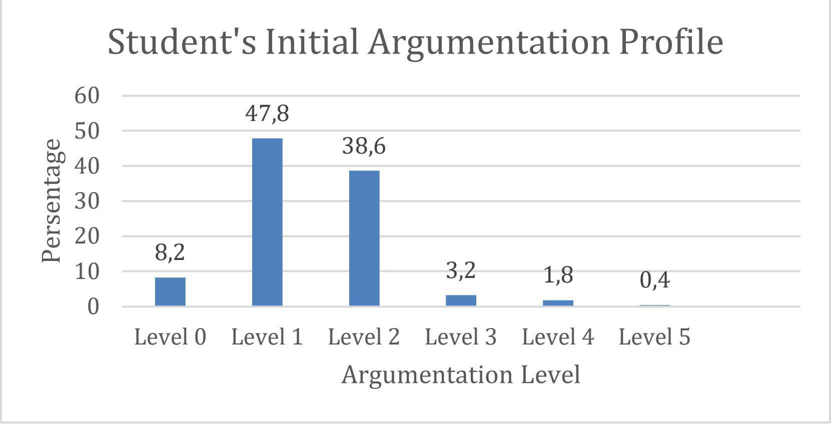


Fig 5. Profile of Students Initial Argumentation ability

Based on the figure, it can be seen that most of the participants have level 0, 1, and 2 argumentation skills, whereas 8.2% of the students have level 0 argumentation skills. This results mean that students at this level were unable to make claims because some of them did not understand or remember the concepts of reaction rate and acid-base that were asked in the question [28]. Most students have initial level 1 argumentation skills (47.8%), meaning they could make correct claims and provide data or strong evidence to support their claims. Meanwhile, 38.6% of students have level 2 argumentation skills, meaning they were able to provide warrants that connect data and claims. At this level, there is also backing that justifies their warrant. Argumentation levels 0, 1, and 2 are categorized as low-quality arguments [29]. Such arguments should not be called arguments at all but rather reasoning, because reasoning is actually high-quality argumentation. If we calculate it, 94.6% of the participating students have low argumentation skills, while the remaining 5% have middle argumentation skills and 0.4% at high level. These results show that students still need to be trained in argumentation during learning. Furthermore, this finding is used as a basis for researchers to develop learning strategies to train students' argumentation skills explicitly during the learning process.

4 Conclusion

Based on the research conducted by giving argumentation tests to the first-year students of the Chemistry Education program at one of the public universities in West Sumatra, it can be concluded that the argumentation skills of most of the test participants (96.7%) are still relatively low, namely at levels 0, 1, and 2. Students are unfamiliar with argumentation learning, so they still need guidance in developing a quality argument to answer the problems given. Regarding the Toulmin Argumentation Pattern (TAP) components, claims have the highest percentage in this study. This is because each level of argumentation always includes claims in its argument structure. Meanwhile, the component with the lowest performance percentage is rebuttal (3.2%). These results show that most test participants could make claims based on their prior knowledge, collect data from the facts in the problem, and provide warrants that connect the data and the claims made. However, only a few students could include backing and rebuttal in their arguments. Students like this are grouped as having the highest level of argumentation, Level 5. Students' argumentation skills, which are still low, need to be improved through learning that actively involves students in practicing argumentation skills. These findings are then used as a basis for designing learning strategies that can improve the argumentation skills of chemistry students during the learning process, especially in general chemistry courses.

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