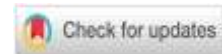




Student's scientific argumentation skills in biology: A gender-based analysis



Hoirun Nisak, Linda Tri Antika *

Department of Biology Education, Faculty of Science Education, Universitas Islam Madura, Indonesia,

* Corresponding author: lindatriantika@gmail.com

Article Info

Article History:

Received 12 July 2024

Revised 29 September 2024

Accepted 22 October 2024

Published 30 November 2024

Keywords:

Scientific argumentation

Gender

Biology



ABSTRACT

Scientific argumentation skill is important to develop in learning because it empowers students' way of thinking in forming new knowledge, stimulates activity, learns to solve problems, build socio-cultural activities through presentations and criticism, encourages students to express their thoughts, understand concepts more easily and get used to critical thinking and logical. This research aimed to determine the significance of differences between scientific argumentation skills based on gender. Research data was obtained from sample class data, namely class XI Science at Bustanul Mubtadiin Proppo Pamekasan High School with 22 students. Measurement of scientific argumentation skills based on gender using an essay writing test with a scientific argumentation rubric using the Osborne Argument Model. Aspects measured were based on the quality of rebuttal, data, collateral, support, refutation, or presence of conflicting claims. The hypothesis test used was an independent sample T-Test using the Jamovi Statistics program. This study reported that the scientific argumentation skills of male and female students were significantly different, which scientific argumentation skills of female students were higher than males. This research provided implications for students to be skilled in scientific argumentation, especially in biology.

Copyright © 2024, Nisak & Antika

This is an open access article under the [CC-BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license



Citation: Nisak, H., & Antika, L.T. (2024). Student's scientific argumentation skills in biology: A gender-based analysis. *JPBIO (Jurnal Pendidikan Biologi)*, 9(2), 171-178. DOI: <https://doi.org/10.31932/jpbio.v9i2.3684>

INTRODUCTION

Education is an effort to improve students' aspirations, skills, talents, and potential. Education can improve the skills of human resources in the 21st century by facilitating the need to respond to global demands. Education is carried out to create an active learning environment to

develop one's potential such as personality, intelligence, noble morals, and skills in society, nation, and state. BNSP overcomes this by changing learning from teacher-centered to student-centered (Sutopo, 2016). In addition to learning in the 21st century requires students to be able to think critically, collaboratively, and communicatively, scientific argumentation skills are skills that are also needed by students to be able to convey their thoughts through observation results that are analyzed both verbally and non-verbally (Widhi et al., 2021).

Scientific argumentation is the ability to formulate and evaluate arguments, which is widely recognized as the foundation of good thinking and is one of the goals of science education. Argumentation includes the process of developing, evaluating, and validating scientific knowledge as well as the process of collecting knowledge. The essence of scientific argument is the construction of a claim or assumption based on scientific evidence (Faize et al., 2018). Scientific argumentation skills are important to develop in learning because they can train students' way of thinking to form new knowledge, stimulate students' activeness, help students learn to solve problems, build socio-cultural activities through presentations and criticism, encourage students to express their thoughts, understand concepts more easily and train students to think critically and logically (Fatmawati et al., 2018). In order for students to have good argumentation skills, it is necessary to be supported by teachers who have good learning management skills (Ekanara et al., 2018), by determining learning strategies or models that aim to realize the development of students' scientific argumentation skills in biology learning to the maximum. Students can be said to have good scientific argumentation skills if they can present arguments that include argumentative components, namely: demands, data, guarantees, support, objections, and explanations. The more complete these components, the higher or better the student's argument (Ekanara et al., 2018). Using the argumentation patterns of claim, evidence, reasoning, and rebuttal can improve high argumentation skills in students (Indrawati et al., 2019).

The results of a survey conducted on December 5, 2023, for the 2023-2024 school year at SMA Bustanul Muhtadiin in grade XI students of SMA Bustanul Muhtadiin showed that biology learning still depended on the teacher using the lecture method, so that 88% of students were still passive in discussing, arguing, and describe conclusions independently from the material presented by the teacher during biology learning. Students tended to present their ideas without sufficient depth or critical analysis. Instead of engaging with evidence and drawing logical conclusions, their responses often relied on general statements or unsupported claims. This lack of rigor not only undermined the quality of their arguments but also reflected a limited understanding of the scientific method, where evidence had to support claims to be considered valid. So, they need to be directed by the teacher to conclude. The second observation on December 16, 2023, showed that there were 3 students and 10 female students who were active in asking and answering questions, but students still had difficulties in delivering arguments and answers scientifically. This fact showed that the scientific argumentation skills of grade XI students of Bustanul Muhtadiin High School still need to be developed. This was in line with the researcher's opinion who explained that the level of student argumentation, both verbally and in writing, is still weak and students have not been able to convey their analysis well (Anwar et al., 2019).

Gender is one of the influential aspects of students' argumentation skills. Research shows that there is a significant difference in scientific argumentation skills between male and female students, where female students' scientific argumentation skills are better than male students, both in terms of claims, evidence, and reasoning (Atqiya et al., 2020). Gender in Latin is called "Genus" which means type. Epistemologically, gender is the traits and behaviors associated with men and women due to social and cultural influences. In terminology, gender refers to the division of roles, functions, statuses and responsibilities given to men and women as an embedded form of culture. Gender is formed due to social and cultural influences, it is not permanent so it can change

according to time and place. Lippa stated that one of the differences between men and women lies in the sex chromosomes that cause differences in brain structure (Suendang, 2017). This difference in brain structure then determines the abilities of men and women which shows that in class discussions men often dominate the conversation while women do not. However, when there is a discussion in a smaller group, students who are not actively speaking will actively speak (Fitriyyah, 2021).

In the results of another study, it was found that scientific argumentation skills in female students were more active or tended to be meticulous in answering, and their symbolic ability was higher in answering questions or arguing than male students who relied more on verbal skills in arguing to answer questions or arguments (Sholihah, 2019). Based on the results of other studies, it was shown that the achievement of argumentation skills before and after learning there was an increase in students' argumentation skills. In the study, it was found that scientific arguments differ based on gender in students (Afgani et al., 2021).

The above statements show that scientific argumentation skills are an important aspect of 21st-century education, where there are aspects of communication, collaboration, and using information to solve complex problems (Suprpto et al., 2018). However, research reports that the quality of students' written arguments is still in the low category because classroom learning has not facilitated students in arguing. Students are not used to solving argumentative test questions because they are discussed directly or in writing (Rahayu et al., 2020). The empowerment of argumentation skills is important for students because, in addition to being scientific in learning concepts, students can also have the opportunity to practice confirming or refuting students' ideas (Hasnunidah et al., 2018). Scientific argumentation skills are an important aspect in improving students' science literacy skills (Chaerunisa et al., 2020) In addition, scientific argumentation skills can help students understand science, especially in biology subjects. Scientific argumentation skills are also a standard of competency for graduates, as stipulated in regulation No. 21: 2016 of Kementerian Pendidikan dan Kebudayaan (Nadifah, 2023).

Based on this, it is clear that scientific argumentation is very important in education so the author is interested in conducting research on the relationship of gender-based scientific argumentation skills in high school students based on Islamic boarding schools to find out if there are scientific argumentation skills based on gender in grade XI students of Bustanul Muhtadiin High School. Therefore, the researcher is interested in a study titled Scientific Argumentation Skills in Male and Female Students of Class XI of Bustanul Muhtadiin Proppo Pamekasan High School.

RESEARCH METHODS

Research Design

This study used quantitative research with a comparative. This comparative study aimed to determine the significance of differences in scientific argumentation skills based on gender in students.

Population and Samples

The samples used in this study were students of class XI IPA SMA Bustanul Muhtadiin Proppo Pamekasan with 22 students. Sampling was carried out using a random sampling technique, in which the population was divided into clusters, and the clusters were randomly selected as the sample.

Instruments

Measurement of scientific argumentation skills based on gender using an essay writing test with a scientific argumentation rubric using the Osborne Argument Model (Osborne et al., 2004).



Aspects measured were based on the quality of rebuttal, data, collateral, support, refutation, or presence of conflicting claims. The learning instruments used in this study included Syllabus, Lesson Plan, and Worksheet.

Procedures

The implementation time of this study began from February to May 2024, in the second semester in class XI IPA SMA Bustanul Mubtadiin Proppo Pamekasan in the academic year 2024/2025. This research utilized the guided inquiry learning model as a key approach to enhance scientific argumentation skills.

Data Analysis

Data analysis was conducted using the Jamovi statistic program. Before testing the research hypothesis, first the normality and homogeneity of data have been tested. The proposed research hypothesis was tested with an Independent Sample T-test with a significance level of 0.05 ($P < 0.05$) using students' scientific argumentation skills data.

Descriptive data on scientific argumentation skills for 9 male students and 13 female students were presented in the form of descriptive statistics in Table 1. The average score of scientific argumentation showed that the average result of the final test of scientific argumentation skills of male students was 12.0 The average result of the median final test of scientific argumentation skills of female students was 15.0.

Table 1. Descriptive Data

	Group	N	Mean	Median	SD	SE
Argumentation	Male	13	10.6	12.0	5.99	1.66
	Female	9	16.9	15.0	7.99	2.66

RESULTS

The normality test is declared normally distributed if the significance is more than 0.05. Table 2 shows that the value is 0.015 which means ($P < 0.05$) which means it is not normally distributed, so the normality assumption test is not met. The summary of assumption test results in data normality assumption test results can be seen in Table 2.

Table 2. Normality Test (Shapiro-Wilk)

	W	P
Score	0.0883	0.014

The homogeneity assumption test is carried out before the hypothesis test. The results of the homogeneity test can be seen in Table 3, which shows that the residual data is homogeneously distributed, this is indicated by a significance value of 0.894 ($P < 0.05$). Therefore, the assumption of homogeneity has been fulfilled.

Table 3. Homogeneity Test Results

	F	df	df2	p
Argumentation	0.0183	1	20	0.894

The results of the hypothesis test are based on the results of scientific argumentation data analysis. The results of the analysis based on the magnitude of the unpaired t-test can be seen in Table 4. The results of the independent samples T-Test hypothesis test showed that there was a



difference in the median score of scientific arguments in both genders using the Mann-Whitney test of ($U=40.0$, $P= 0.226$).

Table 4. Hypothesis Test Results

		Statistic	df	p
Argumentation	Student's t	-2.11	20.0	0.048
	Mann-Whitney U	40.0		0.226

DISCUSSION

The results of this study were in line with previous research that there was a significant difference in scientific argumentation skills in male and female students, where female students have better scientific argumentation skills than men. This is because female students tend to be conscientious, diligent, and willing to listen to explanations well (Pujiati et al., 2019). Other research results report that female students in every step of decision-making and conclusion are based on reasons in the form of words and tend to be detailed, complete, clear, and relevant, while male students in each step of decision-making and conclusion are based on reasons that tend to be short (Cahyono, 2017). The difference in scientific argumentation skills in male and female students is also due to the difference in mindset between men and women, where there are differences in certain indicators in the learning process, especially in the process of solving a problem (Hadi et al., 2021) and (Afifah et al., 2019). With different ways of solving problems, male students tend to use methods that they think are easier, but male students cannot apply methods or procedures properly and correctly, while female students tend to remember formulas, concepts, and procedures that have been taught. So female students tend to use the methods that have been explained by the teacher (Hariananda & Zainuddin., 2022).

In this study, the use of problem-based questions can determine the level of students' scientific thinking ability. The problem-based questions used are related to events in daily life. Analysis through the process of reasoning in solving problems will train students' scientific argumentation skills so that problem-based question tests can be used to determine students' scientific argumentation skills (Afinadhita & Abadi, 2022). In this regard, female students provide better justifications for problems that are identified, more constructive, and of higher quality compared to male students (Noroozi et al., 2023).

Another difference was seen in hormones that also influenced the action between male and female students (Sabtri et al., 2018). The testosterone hormone in men makes them like to compete and enjoy challenges, while in women the hormones that have estrogen and progesterone make them more relaxed and peaceful and happy to gather to find information, therefore women tend to enjoy reading and reasoning (Amin, 2018). This causes the verbal ability of female students to be superior to that of male students. The concept of gender or gender can be reviewed from several theories, such as biological theories. In principle, gender according to biological theories is the development of sex which includes hormonal activity as well as individual behavior. Some studies say that men have high testosterone levels. In addition to hormonal influences, gender development can be reviewed from the use of the brain which will later affect their mindset. Male students tend to use their left brain so that they can think abstractly, logically, and analytically, while female students tend to use their right brain, as a result, they will be active linguistically, holistically, imaginatively, perceptively thinking, and some visual abilities (Lestari, 2016). The results of this study are in line with previous research which states that biologically the brain shape of men and women is different which affects the way of thinking, and actions and affects the learning patterns of both (Amin, 2018).

In addition, environmental factors are one of the factors that affect students' intellectual abilities (Anggraini et al., 2018). Environmental factors influence students, where female students prefer quiet learning because the female brain contains more serotonin, so it tends to be calmer. In contrast to male students who prefer challenges and practicum learning that is carried out outside the classroom (Amin, 2018). The significance of the difference in scientific argumentation skills in male and female students does not reduce the importance of empowering these skills in learning, because in real life, argumentation skills are considered necessary to solve various life problems (Wikara et al., 2022). Empowerment of these skills can be done by applying recommended learning models, such as guided inquiry.

CONCLUSION

Scientific argumentation is a crucial skill for students, empowering them to formulate and evaluate arguments while serving as a foundation for strong critical thinking. This study revealed a significant difference in scientific argumentation skills based on students' gender, with female students demonstrating superior abilities compared to their male counterparts. Several factors influence this disparity, both internal and external. Internal factors include hormonal influences, individual behaviors, and aspects of gender development, which can be analyzed in terms of brain utilization. Additionally, external factors, such as the learning environment, play a significant role in shaping students' scientific argumentation skills. In particular, the application of appropriate learning models is essential for effectively enhancing these skills. Relevant learning models to empower students' scientific argumentation skills include guided inquiry, problem-based learning, and project-based learning. Future researchers need to consider the duration of the study and students' readiness to learn using the guided inquiry learning model.

REFERENCES

- Afgani, T., Hasnunidah, N., & Surbakti, A. (2021). Pengaruh model pembelajaran argument-driven inquiry (ADI) dan gender terhadap keterampilan argumentasi siswa SMP pada materi pokok sistem pencernaan manusia. *Jurnal Bioterdidik: Wahana Ekspresi Ilmiah*, 8(1), 1-10. Retrieved from <https://jurnal.fkip.unila.ac.id/index.php/JBT/article/view/20777>
- Afifah, M. N., Septiarini, F. N., & Afifah, F. H. (2019). Analisis higher order thinking skills siswa smp ditinjau dari perbedaan gender. *Edu-Mat: Jurnal Pendidikan Matematika*, 7(2), 130. Retrieved from <https://doi.org/10.20527/edumat.v7i2.7102>
- Afinadhita, K.R., & Abadi, A.P. (2022). Kemampuan penalaran matematis siswa dalam menyelesaikan soal berbasis masalah. *JPMI – Jurnal Pembelajaran Matematika Inovatif*, 5(3), 907-914. Retrieved from <https://journal.ikipsiliwangi.ac.id/index.php/jpmi/article/view/10641>
- Amin, M. S. (2018). Perbedaan struktur otak dan perilaku belajar antara pria dan wanita; eksplanasi dalam sudut pandang neuro sains dan filsafat. *Jurnal Filsafat Indonesia*, 1(1). Retrieved from <https://doi.org/10.23960/jbt.v8.11.01>
- Anggraini, A.F., & Suciati S., & Marida. (2018). Identifikasi kemampuan berpikir ilmiah siswa kelas XI IPA di SMA negeri I turi, Sseman (studi kasus sekolah daerah pegunungan provinsi daerah istimewa yogyakarta). *Prosiding Seminar Nasional Pendidikan Fisika FITK UNSIQ*, 1(1). Retrieved from <https://ojs.unsiq.ac.id/index.php/semnaspf/article/view/123>
- Anwar, Y., Susanti, R., & Ermayanti. (2019). Analyzing scientific argumentation skills of biology education students in general biology courses. *Journal of Physics: Conference Series*, 1166(1). Retrieved from <https://doi.org/10.1088/1742-6596/1166/1/012001>

- Atqiya, N., Yuliati, L., & Diantoro, M. (2020). Eksplorasi perbedaan gender pada argumentasi ilmiah siswa. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, 5(9), 1327. Retrieved from <https://doi.org/10.17977/jptpp.v5i9.14053>
- Cahyono, B. (2017). *Analisis ketrampilan berfikir kritis dalam memecahkan masalah ditinjau perbedaan gender*. 8(1). Retrieved from <https://doi.org/10.26877/aks.v8i1.1510>
- Chaerunisa, Z., Hasnunidah, N., & Sikumbang. (2020). *Pengaruh model pembelajaran argument-driven inquiry (ADI) dan gender terhadap keterampilan argumentasi*. Retrieved from <https://doi.org/10.17509/aijbe.v1i2.13046>
- Ekanara, B., Hilmi, Y., & Hamdiyati, Y. (2018). Hubungan kemampuan penalaran dengan keterampilan argumentasi siswa pada konsep sistem pencernaan melalui PBL (problem based learning). *Jurnal Biologi Dan Pembelajarannya*, 13(2). Retrieved from <http://dx.doi.org/10.30870/biodidaktika.v13i2.3677>
- Faize, F. A., Husain, W., & Nisar, F. (2018). A critical review of scientific argumentation in science education. *Eurasia Journal of Mathematics, Science and Technology Education*, 14(1), 475–483. Retrieved from <https://doi.org/10.12973/ejmste/80353>
- Fatmawati, D., & Ramli. (2018). *Meningkatkan kemampuan argumentasi siswa melalui action research dengan fokus tindakan think pair share increasing the argumentative skill of students through action research with focus an action of think pair share*. 15. Retrieved from [https://jurnal.uns.ac.id/Fatmawati Proceeding Biology Education Conference](https://jurnal.uns.ac.id/Fatmawati%20Proceeding%20Biology%20Education%20Conference)
- Fitriyyah, R. (2021). *Proses argumentasi matematika siswa dalam mengerjakan pertanyaan terbuka berdasarkan gender (Disertasi Doktor Universitas Siliwangi)*. Retrieved from <https://repository.unsil.ac.id/id/eprint/3817>
- Hariananda & Zainuddin. (2022). Analisis kemampuan berpikir kritis matematis peserta didik ditinjau dari perbedaan gender. *JUMLAH KU: Jurnal Matematika Ilmiah STKIP Muhammadiyah Kuningan*, 8(1), 15–29. Retrieved from <https://doi.org/10.22460/jpmi.v1i4.p631-636>
- Hasnunidah, N., Rosidin, U., & Herlina, K. (2018). *Laporan pengaruh gender terhadap keterampilan argumentasi dan pemahaman konsep ipa smp siswa di kota bandar lampung*. Retrieved from <http://repository.lppm.unila.ac.id/id/eprint/50728>
- Indrawati, D., Rika, B., & Febrilia, A. (2019). *41 Pola argumentasi siswa dalam menyelesaikan soal sistem persamaan linear tiga variabel (SPLTV)*. Retrieved from <https://doi.org/10.24853/fbc.5.2.141-154>
- Kondo, S. A. S. (2018). *Analisis kemampuan penalaran matematis dalam pemecahan masalah aljabar ditinjau dari perbedaan gender pada smp negeri 8 makassar sabtri*. Retrieved from <https://eprints.unm.ac.id/id/eprint/11524>
- Lestari, N. T. (2016). *Novi tri lestari. analisis kemampuan kognitif, menalar dan sikap siswa smp pada materi ekosistem dikaitkan dengan gender analisis kemampuan kognitif, menalar dan sikap siswa smp pada materi ekosistem dikaitkan dengan gender*. Retrieved from <http://hdl.handle.net/11617/8019>
- Nadifah. (2023). *Eksplorasi keterampilan penalaran ilmiah siswa pada materi pertumbuhan dan perkembangan tumbuhan kelas XII MIPA berbasis gender di SMA negeri ambulu jember*. Retrieved from <http://digilib.uinkhas.ac.id/id/eprint/30685>
- Noroozi, O., Banihashem, S. K., Taghizadeh Kerman, N., Parvaneh Akhteh Khaneh, M., Babayi, M., Ashrafi, H., & Biemans, H. J. A. (2023). Gender differences in students' argumentative essay writing, peer review performance and uptake in online learning environments. *Interactive Learning Environments*, 31(10), 6302–6316. Retrieved from <https://doi.org/10.1080/10494820.2022.2034887>

- Osborne, J., Erduran, S., & Simon, S. (2004). *Meningkatkan kualitas argumentasi dalam ilmu sekolah*. Retrieved from <https://doi.org/10.1002/tea.20035>
- Pujiati, A., & Retariandalas, R. (2019). Literasi sains dan kecerdasan adversity siswa sekolah menengah di cilodong, kota depok. *Prosiding Seminar Nasional Pendidikan KALUNI*, 2. Retrieved from <https://doi.org/10.30998/prokaluni.v2i0.6>
- Puspita Hadi, W., Khamsatul Muharrami, L., & Sri Utami, D. (2021). *Identifikasi kemampuan penalaran ilmiah berdasarkan gender* (Vol. 15, Issue 2). Retrieved from <https://doi.org/10.37630/jpm.v12i13.689>
- Rahayu, Y., Suhendar, S., & Ratnasari, J. (2020). Keterampilan argumentasi siswa pada materi sistem gerak sma negeri kabupaten sukabumi-indonesia. *Biodik*, 6(3), 312–318. Retrieved from <https://doi.org/10.22437/bio.v6i13.9802>
- Sholihah. (2019). *Analisis kemampuan argumentasi siswa dalam memecahkan masalah pembuktian kongruensi segitiga berdasarkan gender*. Retrieved from <https://digilib.uinsa.ac.id/id/eprint/38415>
- Suendang. (2017). Pengaruh kemampuan penalaran matematis diinjau dari perspektif gender melalui pendekatan open-ended di sma patra mandiri I palembang. Retrieved from <https://perpus.radenfatah.ac.id>
- Suprpto, S., & Zubaida. (2018). *Pengaruh gender terhadap keterampilan berpikir kreatif siswa pada pembelajaran biologi*. Retrieved from <https://journal.um.ac.id/index.php/jptpp/>
- Sutopo. (2016). Students understanding of fundamental concepts of mechanical wave. *Jurnal Pendidikan Fisika Indonesia* 12, 12(5), 41–53. Retrieved from <https://doi.org/10.15294/jpfi.v12i11.3804>
- Widhi, M. T., Hakim, A. R., Wulansari, N. I., Solahuddin, M. I., & Admoko, S. (2021). Analisis keterampilan argumentasi ilmiah peserta didik pada model pembelajaran berbasis toulmin's argumentation pattern (TAP) dalam memahami konsep fisika dengan metode library research. *PENDIPA Journal of Science Education*, 5(1), 79–91. Retrieved from <https://doi.org/10.33369/pendipa.5.1.79-91>
- Wikara, B., Sutarno, S., Suranto, S., & Sajidan, S. (2022). Implementation of 5e plus learning model on energy subject matter to improve students' argumentation skills. *Jurnal Pendidikan IPA Indonesia*, 11(2), 237–245. Retrieved from <https://doi.org/10.15294/jpii.v11i12.30567>