JPPIPA 8(4) (2022)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Argumentation Practices to Increase Knowledge and Competence of Acid-Base Materials for Prospective Chemistry Teacher Students

Munnal Hani'ah[1*], Nurfina Aznam[2]

[1]Master of Chemistry Education, Yogyakarta State University, Jalan Colombo No. 1 Karang Malang, Sleman, Yogyakarta, Indonesia.
[2]Chemistry Education, Yogyakarta State University, Jalan Colombo No. 1 Karang Malang, Sleman, Yogyakarta, Indonesia.

Received: July 12, 2022
Revised: October 15, 2022
Accepted: October 24, 2022
Published: October 31, 2022

Corresponding Author:
Munnal Hani'ah
munnal0137pasca.2020@student.uny.ac.id

DOI: 10.29303/jppipa.v8i4.1754

Abstract: This study aims to determine the practice of argumentation to increase the knowledge and competence of acid-base material for prospective chemistry teacher students. This study uses a quantitative approach with a quasi-experimental method. The design of this research is the pretest posttest group. The sample in this study were 54 students of chemistry education at UIN Sunan Kalijaga Yogyakarta who were taking basic chemistry courses. Meanwhile, the knowledge instrument is in the form of a multiple-choice test, while the competency instrument is a test in the form of a description. The data analysis technique in this study was carried out statistically inferential (analysis of independent sample t-test). The results of the study show thaththere is a significant difference between the pretest and posttest values in the knowledge domain with t value is -5.508 and probability value paired t test is 0.00 (p value < 0.05). In addition, the mean is -4.167 (negative value) indicates that there is a tendency to increase knowledge significantly. There is also a significant difference between the pretest and posttest values of the competency domain with t value is -8.686 and probability value paired t test is 0.00 (p value < 0.05). In addition, the mean is -3,796 (negative value) indicates that there is a tendency to significantly increase the value of the competency dimension.

Keywords: Argumentation; Knowledge; Competence; Acid Base

Introduction

Currently, science and technology are developing so rapidly. Thus, the education sector faces increasingly severe challenges, particularly in producing skilled human resources capable of facing the challenges of life in the 21st century. Therefore, students must be equipped with various skills to be able to face the challenges of the 21st century and be able to compete in the era of globalization (Yustin & Wiyarsi, 2019). Students can also adapt to the increasingly rapid technological developments (ÇEVİK et al., 2017). One of the skills needed by students is chemical literacy.

Chemical literacy is one of the important elements that must be developed in education (Sumarni et al., 2017). Chemical literacy is closely related to scientific literacy because chemistry is one of the branches of science, which also has educational goals that are in line with science, namely that a chemically literate society can later form a scientific literate society (Thummathong & Thathong, 2018). In addition, it should also be understood that chemistry is one of the most important branches of science (Thummathong & Thathong, 2016). Chemistry is also a "gateway" to science, technology, engineering, and mathematics (Woodard et al., 2019).

According to Shwartz et al. (2006), chemical literacy consists of four aspects, namely the content of chemical knowledge, chemistry in context, high older learning skills (HOLS), and affective aspects. Content knowledge of chemistry means understanding general chemical ideas and characteristics (key ideas) of chemistry. Chemistry in context means using knowledge of chemistry to explain everyday phenomena, make

How to Cite:
Hani'ah, M., & Aznam, N. (2022). Argumentation Practices to Increase Knowledge and Competence of Acid-Base Materials for Prospective Chemistry Teacher Students. *Jurnal Penelitian Pendidikan IPA*, *8*(4), 1894-1899. https://doi.org/10.29303/jppipa.v8i4.1754

effective decisions, provide social arguments for chemistry problems, and examine the relationship between innovations in chemistry and sociology. High-level learning skills (HOLS) means asking questions, seeking information, and evaluating the pros/cons of a particular problem. The affective aspect means having a chemical perspective and showing interest in the field of chemistry, which aims to acquire technical and scientific knowledge to support scientific investigations.

Chemical literacy not only makes students more critical and creative, but also helps them to solve many everyday problems based on their knowledge (Wiyarsi et al., 2020). Chemical literacy is also a target subject that must be reformed in education (Thummathong & Thathong, 2018). In addition, as part of science education, chemistry education has also undergone changes by placing chemical literacy as the main goal of chemistry education (Muntholib et al., 2020).

Students who have good chemical literacy skills are able to apply aspects of chemical literacy skills, including the ability to explain events in everyday life in chemical concepts; the ability to solve problems in everyday life by using an understanding of chemistry; and the ability to understand and apply chemical applications in everyday life (Fahmina et al., 2019).

Unfortunately, based on the research results, it is known that students' chemical literacy skills are still relatively low. This shows that the achievement of learning chemistry is also low. Therefore, an educational practice is needed that can improve students' chemical literacy skills (Sari et al., 2017).

To improve students' chemical literacy skills, teachers do not only teach chemistry in class or increase activities in the laboratory. In this case, it is necessary to emphasize the importance of "mind" activities rather than just making use of "direct" activities (Cigdemoglu et al., 2017). The "mind" activity referred to here is the practice of argumentation.

Ontologically, argumentation is a scientific skill that connects facts and concepts. Epistemologically, argumentation is a skill that compares theories (rationally) by providing explanations accompanied by logical data (empirically). Meanwhile, axiological argumentation is a skill that is developed for the benefit of living things with a comprehensive understanding of scientific concepts (Farawansyah & Suyono, 2021). Argumentation is positively correlated with learning outcomes, learning motivation, and student satisfaction (Bekiari & Balla, 2017).

Meanwhile, scientific argumentation is the ability to express ideas about scientific phenomena that need to be trained so that students can explain these phenomena based on evidence and relevant scientific concepts (Ginanjar et al., 2015). Scientific argumentation is also a decision-making process that is supported by valid justification and evidence (Ahmad and Ur Rahman, 2018). Scientific argument plays a central role in the development, evaluation, and validation of scientific knowledge, and is an important practice in science that makes science different from others in terms of knowing something (Sampson et al., 2011).

A large number of studies have investigated the impact of argumentation practice to improve students' understanding of scientific concepts, correct misconceptions about a concept, and prioritize thinking skills to improve students' chemical literacy. Mastery of concepts can be observed from the argumentation skills possessed by students (Manz, 2015). The low understanding of students' concepts shows that their argumentation skills are also low, and vice versa (Farawansyah & Suyono, 2021). As for what is meant by mastery of concepts here is the ability of students to repeat the explanations obtained during the learning process.

Basically, students' argumentation skills are still at a low-medium level(Devi et al., 2018). This is because students only make claims without being accompanied by evidence and explanations connecting the claims and scientific evidence that have been submitted (Farawansyah & Suyono, 2021). In argumentation-based learning, scientific argumentation becomes the leading framework for teaching and learning concepts, emphasizing both science and chemistry not as experimental verification, but as a process of scientific argumentation and explanation. Currently, scientific argumentation is emphasized in science and chemistry education because of its ability to improve students' reasoning skills and mastery of students' knowledge (Heng et al., 2015).

Argumentation engagement is not only a process that includes claims, evidence, and reasons, but also a process in which students convince others of the validity of the argument (Wolfson et al., 2014). The construction of scientific arguments involves cognitive aspects, such as analyzing and understanding the data, explaining the data appropriately, and the validity of the argument (Heng et al., 2014).

PISA (OECD, 2017)proposes a science (chemistry) assessment model, which was developed to reveal the extent to which scientific literacy (chemistry) has increased. In this model, students take the context of everyday life involving science (chemistry) and technology as a starting point and create a learning environment in which students are able to make decisions or choices. In this process, students are required to be able to identify scientific problems, understand the underlying science, and use accurate evidence. Scientific knowledge and students' attitudes towards science affect their competence.

Related to that, students also need to understand that the ability to argue is not obtained easily without continuous practice (Wardani et al., 2018). To develop students' abilities in conveying arguments, of course, it cannot be separated from the teacher's role as a facilitator in the field of education (Suartha et al., 2020).

The role of the teacher is very vital, which determines the success of students. The success of students in learning is largely determined by the ability of teachers in teaching. Therefore, a teacher must have strong chemical literacy skills, as well as other knowledge and skills to guide and direct students to have high chemical literacy (Sumarni et al., 2017).

Argumentation ability can be supported by good initial and literacy skills to support students' cognitive processes. In fact, so far, the learning process that is usually done is limited to knowing. Thus, students learn a variety of sciences, but are less required to apply and reason about the knowledge gained from the learning process (Pudjantoro, 2015). Moreover, with his reasoning, students are not used to it, some even have never, sharpened their scientific argumentation skills. That is very rarely done by teachers in the learning process at school. In this case, the teacher only explores students' arguments as personal opinions, which do not demand evidence or support for other opinions(A. Rahman, 2020).

The practice of argumentation contributes to the level of students' chemical literacy, so as to create a learning environment in which critical thinking skills are increasing (Cigdemoglu et al., 2017). Besides that,kCritical thinking and communication skills can also be packaged into a single unit in argumentation skills (Devi et al., 2018).

Argumentation skills are skills in providing reasons to strengthen or reject a problem, which includes submitting claims, data, justification, and support. Claims are conjectures, explanations, conclusions, generalizable principles, or answers to research questions. Meanwhile, data are various components that are used as evidence that has been collected and analyzed. The justification is a statement that explains a data presented, which can support the claim submitted. Meanwhile, support is an additional expression made to support justification in the form of theories or facts that apply (Siswanto et al., 2014).

Argumentation learning is a process of developing students' competencies so that they are able to understand concepts systematically through argumentation. During the learning process, students can be trained to make a simple argument to be able to present relevant data appropriately to answer the problem. In learning, argumentation can be a means to improve competence (Rahman, 2018).

As one of the studies in chemistry, the concept of acid-base has wide applications in everyday life, especially household chemicals, acid rain, and industrial fields, all of which deserve to be studied and researched. A student who has a deep understanding of the concept of acid base allows him to explain the observed phenomena. Unfortunately, the results of the study revealed that many students had difficulty understanding the concept. However, there are those who believe that other students' skills can be fostered, including by intervening arguments against chemical literacy for prospective chemistry teacher students, who will later teach students about chemistry. In this study, the domain of chemical literacy that will be studied further is the knowledge and ability of chemistry, especially acid-base material.

Method

This study uses a quantitative approach with a quasi-experimental method or what is commonly called a quasi-experiment (Hastjarjo, 2019). The design of this research is the pretest posttest group. In this case, the pretest is given in the initial conditions (when the student has not been given treatment), while the posttest is given after the student is given treatment (Rohmatulloh & Winarni, 2015).

In other words, the pretest was given to determine the initial condition of the prospective chemistry teacher students in the experimental group and the posttest to determine the final condition of the prospective chemistry teacher students in the experimental group. The learning used in the experimental class is in the form of argumentation practice. The design of this research can be seen in Table 1.

Table 1. Research design

Group	Pretest	Treatment	Posttest
Experiment	O1, O2	X	O1, O2

Information:
O1 = chemistry knowledge test
O2 = competency test
X = argumentation practice

This research was conducted at UIN Sunan Kalijaga Yogyakarta in the odd semester of the 2021/2022 academic year. This research took place from October to December 2021. The sample of this study was 54 students of chemistry education at UIN Sunan Kalijaga Yogyakarta who were taking basic chemistry courses. The technique used in this study to collect data is a test. The test is in the multiple-choice questions to measure chemical knowledge as well as description questions to measure competence before and after being taught acid-base material with argumentation practice. The data analysis technique in this study was carried out statistically inferential (univariate analysis) *independent sample t-test*using a significance level of 0.05.

Results and Discussion

Here are the dataresultst test for domainknowledgeand the domain of competenceg hcurrents observed in this study:

T-Test Results for Knowledge Domain

Table 2. Paired Sample Statistics

	Mean	N	Std. Deviation	Std. Error Mean
Pretest Knowledge	76.9444	54	9.58658	1.30457
Posttest Knowledge	81.1111	54	8.66933	1.17975

The mean value of the knowledge domain pretest = 76.94 with a standard deviation is 9.59. Meanwhile, the average value of the knowledge domain posttest is 81.11 with a standard deviation is 8.97. If you look at the mean value of the pretest and posttest of the knowledge domain, there is an increase from before and after treatment. In addition, the correlation between the results of the pretest and posttest domain knowledge has a very strong and significant relationship, as evidenced in Table 3.

Table 3. Paired Samples Correlations

		N	Correlation	Sig.
Pairs 1	Pretest Knowledge & Posttest Knowledge	54	0.819	0.000

There is also a significant difference between the pretest and posttest values of the knowledge domain which can be observed in Table 4.

Table 4. Paired Samples Test

		Paired Differences		t	df	Sig.(2-tailed)
		mean	Std. Deviation			
Pairs 1	Pretest & Posttests Know.	-4.16667	5.55844	-5.508	53	0.000

Based on Table 4, there is a significant difference between the pretest and posttest values of the knowledge domain with t value is -5.508 and probability value paired t test is 0.00 (p value < 0.05).

In addition, the mean is -4.167 (negative value) indicates that there is a tendency to significantly increase the value of the knowledge domain. This is supported by research conducted by Cigdemoglu et al (2017) which explains an increase in the knowledge domain between pretest and posttest scores.

T-Test Results for Competency Domain

Table 5. Paired Samples Statistics

		mean	N	Std. Deviation	Std. Error Mean
Pairs 1	Pretest Comp.	76.2037	54	8.12260	1.10535
	Posttest Comp.	80.000000	54	8.29867	1.12931

The mean value of the competency domain pretest = 76,203 with a standard deviation = 8.12. Meanwhile, the average value of the competency domain posttest = 80 with a standard deviation = 8.29.

If you look at the mean values of the pretest and posttest domains of competence, there is an increase from before and after treatment. In addition, the correlation between the results of the pretest and posttest domain competencies has a very strong (0.924) and significant relationship, as evidenced in Table 6.

Table 6. Paired Samples Correlations

		N	Correlation	Sig.
Pairs 1	Pretes t Competence & Posttest Competence	54	0.924	0.000

In addition, there is a significant difference between the pretest and posttest values of the competency domain which can be observed in Table 7.

Table 7. Paired Samples Test

		Paired Differences				
		mean	Std. Deviation	T	df	Sig.(2-tailed)
Pairs 1	Pretest& Posttest Comp.	-3.79630	3.21189	-8,686	53	.000

Based on Table 7, there is a significant difference between the pretest and posttest values for the competency domain with a t value is -8.686 and a probability value for the paired t test is 0.00 (p value < 0.05). In addition, the mean is -3,796 (negative value) indicates that there is a tendency to significantly increase the value of the competency domain. This is supported by research conducted by Cigdemoglu et al (2017) which explains the occurrence of an increase in the competence domain between pretest and posttest scores.

Conclusion

Based on the results of the analysis and discussion, it can be concluded that the practice of argumentation has an effect on increasing knowledge and understanding of acids and bases. This supports the skills of prospective chemistry teacher students in transferring their knowledge to other concepts, so that their overall competence is increasing.

Acknowledgment

The authors would like to thank Yogyakarta State University andUIN Sunan Kalijaga Yogyakarta, which has supported this research. Without that support, this research would not have been possible to do well.

References

Ahmad, F., & Ur Rahman, F. (2018). Investigating the transfer of argumentation skills through engagement in an online learning platform. *Pakistan Journal of Distance & Online Learning*, *I*, 81–94.

Bekiari, A., & Balla, K. (2017). Instructors and students relations: argumentativeness, leadership, and goal orientations. *Open Journal of Social Sciences*, *05*(07), 128–143. https://doi.org/10.4236/jss.2017.57009

ÇEVİK, M., ŞANLITÜRK, A. D., & YAĞCI, A. (2017). Ortaokul oğretmenlerinin FeTeMM (Fen-Teknoloji-Mühendislik-Matematik) farkındalıklarının farklı değişkenlere göre değerlendirilmesi. *Sakarya University Journal of Education*, *7*, 584–599. https://doi.org/10.19126/suje.335008

Cigdemoglu, C., Arslan, H. O., & Cam, A. (2017). Argumentation to foster pre-service science teachers' knowledge, competency, and attitude on the domains of chemical literacy of acids and bases. *Chemistry Education Research and Practice*, *18*(2), 288–303. https://doi.org/10.1039/c6rp00167j

Devi, N. D. C., Susanti VH, E., & Indriyanti, N. Y. (2018). Analysis of high school students' argumentation ability in the topic of buffer solution. *JKPK (Jurnal Kimia Dan Pendidikan Kimia)*, *3*(3), 141. https://doi.org/10.20961/jkpk.v3i3.23308

Fahmina, S. S., Indriyanti, N. Y., Setyowati, W. A. E., Masykuri, M., & Yamtinah, S. (2019). Dimension of chemical literacy and its influence in chemistry learning. *Journal of Physics: Conference Series*, *1233*(1). https://doi.org/10.1088/1742-6596/1233/1/012026

Farawansyah, K. I., & Suyono, S. (2021). Pengembangan lembar penugasan terstruktur pada materi laju reaksi untuk melatihkan keterampilan argumentasi. *Chemistry Education Practice*, *4*(2), 142–152. https://doi.org/10.29303/cep.v4i2.2315

Ginanjar, W. S., Utari, S., & Muslim, D. (2015). Penerapan model argument-driven inquiry dalam pembelajaran IPA untuk meningkatkan kemampuan argumentasi ilmiah siswa SMP. *Jurnal Pengajaran Matematika Dan Ilmu Pengetahuan Alam*, *20*(1), 32. https://doi.org/10.18269/jpmipa.v20i1.559

Hastjarjo, T. D. (2019). Rancangan eksperimen-kuasi. *Buletin Psikologi*, *27*(2), 187. https://doi.org/10.22146/buletinpsikologi.38619

Heng, L. L., Surif, J., & Seng, C. H. (2014). Individual versus group argumentation: student's performance in a Malaysian context. *International Education Studies*, *7*(7), 109–124. https://doi.org/10.5539/ies.v7n7p109

Heng, L. L., Surif, J., Seng, C. H., & Ibrahim, N. H. (2015). Mastery of scientific argumentation on the concept of neutralization in chemistry: a Malaysian perspective. *Malaysian Journal of Learning and Instruction*, *12*(1), 85–101. https://doi.org/10.32890/mjli2015.12.5

Manz, E. (2015). Representing student argumentation as functionally emergent from scientific activity. *Review of Educational Research* (Vol. 85, Issue 4). https://doi.org/10.3102/0034654314558490

Muntholib, Ibnu, S., Rahayu, S., Fajaroh, F., Kusairi, S., & Kuswandi, B. (2020). Chemical literacy: performance of first year chemistry students on chemical kinetics. *Indonesian Journal of Chemistry*, *20*(2), 468–482. https://doi.org/10.22146/ijc.43651

OECD. (2017). PISA 2015 assessment and analytical framework: science, reading, mathematic, financial literacy and collaborative problem solving, revised edition. *OECD Publishing*. Retrieved from http://www.oecd-ilibrary.org/education/pisa-2015-assessment-and-analytical-..264255425-en

Pudjantoro, P. (2015). Sikap kritis dan keterampilan berargumentasi. *Jurnal Pendidikan Pancasila dan Kewarganegaraan*, *28*(2), 137–144.

Rahman, A. (2020). Argumentative skill: sebuah hasil dari proses pembelajaran melalui model inquiry pada siswa madrasah aliyah. *Jurnal Pendidikan Geografi Undiksha*, *8*(3), 110–118. Retrieved from https://scholar.google.com/citations?view_op=view.. _ZNEOYC

Rahman, D. F. (2018). Analisis argumentasi dalam isu sosiosaintifik siswa SMP. *Thabiea: Journal of Natural Science Teaching*, *01*(01), 9–13.

Rohmatulloh, & Winarni, S. (2015). Evaluasi hasil pembelajaran diklat menggunakan disain pretest posttest nonequivalent control group. *Prosiding Seminar Nasional Statsisitka III*, *October*, 1–11.

Sampson, V., Grooms, J., & Walker, J. P. (2011). Argument-driven inquiry as a way to help students learn how to participate in scientific argumentation and craft written arguments: an exploratory study. *Science Education*, *95*(2), 217–257. https://doi.org/10.1002/sce.20421

Sari, D. N. A., Rusilowati, A., & Nuswowati, M. (2017). Pengaruh pembelajaran berbasis proyek terhadap kemampuan literasi sains siswa. *PSEJ (Pancasakti Science Education Journal)*, *2*(2), 114. https://doi.org/10.24905/psej.v2i2.741

Shwartz, Y., Ben-Zvi, R., & Hofstein, A. (2006). The use of scientific literacy taxonomy for assessing the development of chemical literacy among high-school students. *Chemistry Education Research and Practice*, *7*(4), 203–225. https://doi.org/10.1039/B6RP90011A

Siswanto, Kaniawati, I., & Suhandi, A. (2014). Penerapan model pembelajaran pembangkit argumen menggunakan metode saintifik untuk meningkatkan kemampuan kognitif dan keterampilan berargumentasi siswa. *Jurnal Pendidikan Fisika Indonesia*, *10*(2), 104–116. https://doi.org/10.15294/jpfi.v10i2.3347

Suartha, I. N., Setiawan, I. G. A. N., & Sudiatmika, A. A. (2020). Pola argumen Toulmin pada proses pembelajaran IPA SMP. *Jurnal Ilmiah Pendidikan Dan Pembelajaran*, *4*(April), 1–11.

Sumarni, W., Sudarmin, Wiyanto, Rusilowati, A., & Susilaningsih, E. (2017). Chemical literacy of teaching candidates studying the integrated food chemistry ethnosciences course. *Journal of Turkish Science Education*, *14*(3), 60–72. https://doi.org/10.12973/tused.10204a

Thummathong, R., & Thathong, K. (2016). Construction of a chemical literacy test for engineering students. *Journal of Turkish Science Education*, *13*(3), 185–198. https://doi.org/10.12973/tused.10179a

Thummathong, R., & Thathong, K. (2018). Chemical literacy levels of engineering students in Northeastern Thailand. *Kasetsart Journal of Social Sciences*, *39*(3), 478–487. https://doi.org/10.1016/j.kjss.2018.06.009

Wardani, A. D., Yuliati, L., & Taufiq, A. (2018). Kualitas argumentasi ilmiah siswa pada materi hukum Newton. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, *3*(10), 1364–1372. http://journal.um.ac.id/index.php/jptpp/

Wiyarsi, A., Pratomo, H., & Priyambodo, E. (2020). Vocational high school students' chemical literacy on context-based learning: a case of petroleum topic. *Journal of Turkish Science Education*, *17*(1), 147–161. https://doi.org/10.36681/tused.2020.18

Wolfson, A. J., Rowland, S. L., Lawrie, G. A., & Wright, A. H. (2014). Chemistry education research and practice. *Chemistry Education Research and Practice*, *15*(2), 168–183.

Woodard, J., Miller, H., DeVore-Wedding, B. R., & Griep, M. A. (2019). The pathway to chemical literacy: a resource guide of chemistry courses at Tribal Colleges and Universities. *Tribal College and University Research Journal, Volume 4*.

Yustin, D. L., & Wiyarsi, A. (2019). Students' chemical literacy: a study in chemical bonding. *Journal of Physics: Conference Series*, *1397*(1). https://doi.org/10.1088/1742-6596/1397/1/012036