JPPIPA 9(6) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

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

Increasing Literacy Ability in Chemistry on A Socio-Scientific Basis

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Received: April 10, 2023
Revised: May 16, 2023
Accepted: June 25, 2023
Published: June 30, 2023

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DOI: 10.29303/jppipa.v9i6.3908

Abstract: Chemistry is one of the lessons needed as a form of learning for students in this century. Chemical Literacy plays an important role in building efforts so that students can gain knowledge about developments in the field of chemistry and so that they have the opportunity to live in modern society in this millennial century. This study aims to describe the opportunities for assessing chemical literacy and also to design education and information in the field of chemistry that is oriented toward increasing the chemical literacy side of students. The method used in this study is a qualitative approach by prioritizing the study of literature. The results of this study and research show that this method of assessing chemical literacy can use the framework of Schwartz's chemical literacy and also PISA. In learning chemistry, several aspects of chemical literacy can be optimized with learning based on socio-scientific issues where this knowledge base will have several chemistry topics that have relevance in life, especially the lives of students. And this includes the declarative, epistemic and also procedural sides. Learning with the chemical literacy system can function as a contemporary and relevant contextual determinant as well as an affective value determination. Likewise with the learning system for students who can optimize the literacy side with a socio-scientific basis in chemistry.

Keywords: Chemical literacy; Socio scientific; Students

Introduction

The development of the world now moves very fast and continues to advance without any signs of slowing down or decreasing. Even the development of the world is quite complex entering the new centuries or the millennial era. This can be seen from the changes that continue to have an impact on the technology and information side that are not only happening in one country. However, this change provides a global effect that has goals and targets to improve the quality of life of modern society.

Ofcourse fast and complex developments apart from providing benefits as well as positive changes to society, there are also negative sides that emerge along with these developments. The negative impacts that are of common concern are the energy crisis in developed countries, a global warning and environmental damage that has emerged after world developments moved quite fast. And this cannot be avoided by society. The need for an understanding of scientific facts which have a close relationship with technology, science and society is indeed the main aspect based on the narrative form (Fives et al., 2014).

The community certainly has knowledge and can use and apply this knowledge to provide solutions to problems that arise and arise in their lives. And this society is commonly referred to as a scientifically literate society (Bond, 1989). And today's scientifically literate society has become a very important need in new eras. Scientific literacy itself is an ability, skill and competency that must be possessed by people in this millennial century. And there are 16 skills included as a classification by the World Economic Forum.

Scientific literacy has a role that should not be underestimated. Because this knowledge can be an important point in educating people to have views on the desire to have scientific literacy. And this is the main goal in the reformed education sector, especially in the field of science education. Currently, many educational organizations have issued references and guidelines as well as standards relating to content, assessment to pedagogy related to scientific literacy. Several attempts have even been made to define theoretically in the field

How to Cite:
Haetami, A., Arwien, R. T., Marhadi, M. A., Rudi, L., & Arsyad, M. (2023). Increasing Literacy Ability in Chemistry on A Socio-Scientific Basis. *Jurnal Penelitian Pendidikan IPA, 9*(6), 154-161. https://doi.org/10.29303/jppipa.v9i6.3908

of chemistry by releasing chemical literacy (Holman, 2002; Glynn & Muth, 1994; Shwartz et al., 2005; Shwartz et al., 2013).

In their own country, the scientific literacy of Indonesian students has its own references or guidelines which are usually measured using PISA. And until now PISA or the Program for International Student Assessment has not been able to support or advance skills in the scientific literacy sector, especially in the field of chemistry regarding aspects of context, content, science processes and their applications to attitudes (OECD-PISA, 2005; OECD-PISA, 2016). Students in Indonesia have relatively low scientific and chemical literacy abilities. This is due to several factors that affect these abilities which consist of school location, socio-economic of teachers and students and also gender. Another factor that has no less important influence is the level of primary education to higher education.

Chemistry does not only focus on understanding in the conceptual sector. However, students are required to be able to apply and use the concepts learned in science to help solve problems related to science in everyday life. The success of learning chemistry can certainly provide far more lifelike benefits if it can be applied to everyday life. The application of understanding the concept of chemistry is determined if students have abilities and capabilities that cover 2 aspects, namely chemical literacy capabilities.

Scientific literacy itself is knowledge in the field of science that is studied by individuals or groups where the use of this knowledge functions as identification of questions and can explain scientific phenomena. And this function can be used to draw conclusions on issues related to science that are capable of producing changes or solving problems in everyday life. Of course this can make students apply knowledge in the fields of science and chemistry to everyday problems and also relate to the science material they are studying.

Scientific literacy itself has another meaning as an ability and capability of individuals who understand and also communicate in the field of science both in writing and orally. Then they apply this knowledge to assist in solving problems that exist in their lives. Sensitivity and also a high attitude towards environmental conditions and the ability to make decisions with scientific considerations, is one of the definitions and meanings of scientific literacy.

PISA determines 3 aspects in the assessment of scientific literacy, namely identifying questions and also explaining scientific phenomena. Then urge an investigation using scientific evidence. This gives reference to several things in a person consisting of: (1) Knowledge of scientific fields and their use in terms of identifying questions, obtaining new knowledge or knowledge, explaining scientific phenomena to the ability to draw conclusions on the basis of evidence on issues related to science. (2) Understanding of the characteristics and characteristics of science as a form of research and knowledge for humans. (3) Awareness of individuals regarding science and technology used to build an intellectual and cultural environment. (4) Availability of knowledge used in issues related to science and also ideas.

It can be concluded that chemical literacy itself is a form of scientific literacy which has an important role in understanding the concept of science. And the application of this concept can be used to solve problems related to science in everyday life. In order to optimize this aspect of chemical literacy, individuals who are engaged in this field of knowledge have the opportunity to hone their skills in understanding these scientific issues. And of course education that can be used is learning by using and applying socio-scientific issues (Kolstø et al., 2006; Roth & Lee, 2004; Sadler & Zeidler, 2004).

This issue is an issue that displays the side of social problems in society which has a close relationship with the conceptual, procedural and technological context of science. The application of socio-scientific science in everyday life must, of course, prioritize moral, cultural, scientific aspects as well as other aspects related to cases in society. This socio-scientific issue approach has the goal of building mentality and also fostering individuals, especially students, so they can reach the level of decision-making in everyday life. This level itself is very important in terms of the development of chemical and scientific literacy which can be the main key in solving problems and solutions to overcome problems in everyday life.

This research has the aim and intent to improve and optimize all aspects of chemical literacy through learning on the side of socio-scientific issues in the modern century. The formulation of the problem in this study is of course related to the assessment of chemical literacy in the current era and also learning in the field of chemistry through iso-scientific science with an orientation towards increasing chemical literacy.

Talking about scientific literacy, scientific literacy is taken from 2 combinations of Latin words consisting of literatus and scientia. Literatus means a sign with a letter for a literal definition. While the broader definition is educated. While scientia means knowledge. Paul de Hart Hurt became the first figure to use the term scientific literacy which has the meaning of an act of understanding science and its application in everyday life and also the needs of society. The assessment of scientific literacy in PISA itself is not only an assessment of understanding in the field of science. However, this is also closely related to understanding aspects of the scientific process and also the ability to apply knowledge and science programs in everyday life. Both related to students and also members of the community.

This definition of scientific literacy was developed by Olsen by prioritizing 3 main dimensions which have

the following scope: (1) Content dimensions: this dimension will carry out the identification process of several areas in science which will be seen as a definition of a whole that is quite relevant. (2) Competency dimension: The competence dimension will identify 3 scientific competencies consisting of: (a) the description and explanation and prediction of scientific phenomena, (b) understanding of scientific inquiry, (c) interpretation of scientific evidence and conclusions. This competency has the advantage of involving an understanding of scientific concepts that can be relabeled as an understanding of scientific processes. The item weight of the three competencies is 50% for the description and explanation competency. Then 50% for competence in understanding scientific investigation and also interpreting scientific evidence. (3) Situation dimension: this dimension will identify 3 contexts in the main fields of application which consist of life and health, earth and environment as well as knowledge contained in the field of technology.

Scientific literacy based on the National Science Education Standard has a definition as a science and also an understanding in terms of scientific concepts and processes that have the possibility to make decisions with mastered knowledge and have involvement in matters of culture, statehood to economic growth. Scientific literacy itself has an understanding as a form of understanding about science and also applications for the needs and needs of society. And based on these things it can be concluded that scientific literacy is the use of individual knowledge that is used as a response to issues or phenomena that occur in society that have a close relationship with science.

Scientific literacy based on the thoughts of Chabalengula states that there are 4 aspects consisting of: (1) Knowledge of science. (2) The investigative nature of science. (3) Science is used as a step for learning and knowledge. (4) The interaction of science, technology and society.

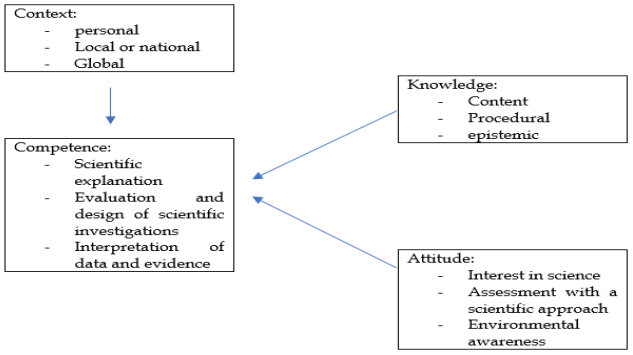

Figure 1. Framework regarding PISA scientific literacy

Meanwhile according to Shen's opinion that scientific literacy has identification in the form of 6 components consisting of: (1) Basic concept of science. (2) The nature of science. (3) Work ethics of scientists. (4) Attachment and linkage between society and science. (5) Attachment of science and humanities. (6) Understanding of connectivity and differences between science and technology.

PISA has a definition of scientific literacy where this characteristic has 4 aspects that have attachments consisting of knowledge, context, attitude and competence. There is a chart that displays a framework regarding PISA scientific literacy in Figure 1.

Method

This research uses a qualitative approach method that has a type of literature study. This approach is a step as well as a procedure that can be used to obtain descriptive data consisting of speech or words and writing as well as the behavior of individuals who can be observed and examined. This study uses this approach which is used as a way to design a learning process on a socio-scientific basis which will analyze documents related to the chemistry curriculum.

From all types of data sources obtained and also related to documentary data, the analysis process and also the collectivity of the data in this study used a documentation system. Data analysis can be carried out by prioritizing the document analysis method where the design results built can be verified by content analysis and also suitability for the chemistry education curriculum in the world of education.

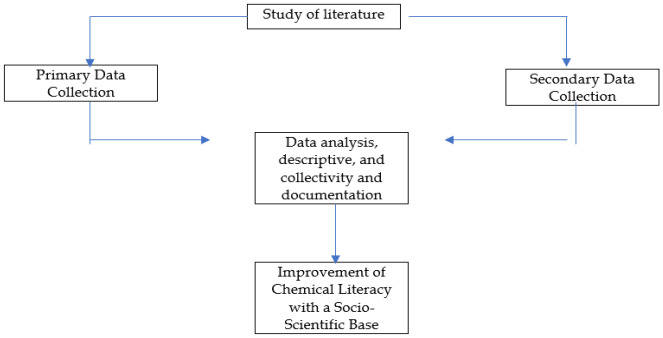

Figure 2. Process research methods conducted

Result and Discussion

Scientific literacy is actually quite common in the world of education, and not something new. However, scientific literacy has long been a topic of conversation and is also a topic that is quite hot in every conversation related to the world of science education in schools. Literature in the field of science education is proof that this is considered to be the result of the teaching and learning process which is the hope for all parties in the field of education. This scientific literacy has indeed become a method by emphasizing the important side as an emerging transferable outcome.

Education in the field of science often emphasizes scientific literacy which is the hope for the world of

education so that it can be carried out and applied by students who are the result of this learning. Scientific literacy itself has a close relationship with the implementation of the teaching and learning process which can improve in terms of developing the abilities and capabilities of students in science and technology who can participate in everyday life (Abd-El-Khalick & Lederman, 2000; Bell et al., 2000).

Scientific literacy has a focus on the process of building the knowledge side of students in order to put forward science concepts so that they have more meaning and think critically about decisions that have interactions with problems that have relevance to people's lives, especially from the lives of the students themselves (DeBoer, 2000). And education about science can be an encouragement to develop the capabilities and abilities of students to be more active in participation in the community (Hofstein et al., 2011).

There are 2 groups of individuals who have views on scientific literacy that are interconnected. The first group is called the scientific literacy group which has the view that an important component in this literacy is an understanding of the field of science with the basic concepts of science where this understanding is more widely shared by science teachers in Indonesia and also abroad. While the second group of scientific literacy thinks that literacy has connectivity that is in line with the development and improvement of skills or skills in life or commonly called life skills (Millar & Osborne, 1998; National Academy Press, 2012).

In this second group, they have the view and also understand that skills in terms of reasoning in social contexts and also scientific literacy are very necessary for all individuals. Not only to scientists who choose a profession in the field of science, but to all individuals. Scientific literacy which has a basis of ability and competence is the result of the intersection of the concepts of *what do people know* and *what do people value.* Both of these concepts have an understanding that science material and epistemological abilities or capabilities of science interact with abilities on the moral and ethical side in scientific literacy. Another supporting factor is *what can people do* which has the essence as the ability to learn, socialize, procedures as well as communication and interaction with the surrounding community which functions to apply scientific literacy.

This model of scientific literacy emphasizes that the balance between capabilities and skills in making decisions is very important. Especially decisions on socio-scientific issues according to the thoughts of Holbrook et al. (2007). Both of them carried out the development of a definition of scientific literacy which presents the target of science education where an appreciation of the nature of science is very important. And this has relevance to the science that is developed and also studied. Practically the development of scientific literacy via the educational pathway is an effort in developing scientific abilities and knowledge and skills that have a very strong evidence base and foundation. And of course it still has relevance to everyday life in solving quite important problems (Lederman, 2004; Lederman, 1992).

This scientific literacy also requires the ability to develop capabilities in collective interactions, communicative approaches and self-development. And this, of course, requires reasoning that is easy to understand and also persuasive when expressing arguments in these socio-scientific issues and sciences.

There are various definitions of scientific literacy. However, there are 3 general aspects that have been agreed and become a mutual agreement, namely: (1) Knowledge of concepts and ideas from science. (2) Understanding of the inquiry process and also the essence of acquiring knowledge or the nature of science. (3) Awareness of the influence of scientific activities on the social context of the activities carried out. And have an influence on everyday life and social decisions about scientific ideas and practices.

Each description of scientific literacy focuses on the ability to read and write quite well. This is of course a reference as good language skills in understanding and also explaining phenomena and evaluating information, communicating ideas to other parties. The application of scientific knowledge and reasoning abilities to everyday situations in the decision-making process is a form of description of scientific literacy. In addition, science literacy has the ability to present aspirations for curriculum development and teaching materials for assessment practice. Practically making science material and learning will be given facilities regarding this level of competence so that the scientific literacy of students who are studying this knowledge will develop and also increase.

One branch of science from scientific literacy is chemical literacy. This literacy has a definition consisting of 2 theoretical frameworks where the definition of PISA and Shwartz et al. (2006) is built from agreements that occur between teaching staff or educators, chemistry teachers and scientists. These two definitions themselves come from the definition of Bybee (1997). Based on PISA, this definition has developed and also improved. In PISA 2000 and 2003, this definition of literacy is an ability in the application of scientific knowledge and also the process of identifying questions that can draw conclusions from various kinds of evidence. And this is used to understand and make decisions related to the environment and also human activities.

Meanwhile according to PISA 2006 itself that literacy is the process of decomposing the concept of scientific knowledge into 2 aspects consisting of knowledge of science and also knowledge of science. There is a major difference described in that the idea of knowledge about science becomes clearer with the

division into 2 factors consisting of epistemic and procedural knowledge.

Based on the narrative from the OECD (2015) that in efforts to understand and engage in a discussion related to issues of science and technology, there are 3 specific competencies which consist of the ability to explain scientific phenomena in scientific aspects, evaluation and design of investigations or so-called with inquiry and interpretation of the data obtained in a scientific aspect. This competence has a need for knowledge in its implementation.

Explanation of phenomena in the field of science and technology in a scientific manner, of course, requires knowledge of scientific material, which is known as content knowledge. The next competency requires knowledge and understanding of how knowledge in this scientific field is built and also believed in. This procedural knowledge becomes a standard procedure that forms the basis of the various methods and practices needed to build knowledge on a scientific basis.

Epistemic knowledge itself is often referred to as the essence of science. And based on the thinking of Shwartz et al. (2006), there are 4 aspects that are dominant and closely related to chemical literacy. And the 4 aspects consist of:

Chemical Material Knowledge and Ideas in the Scientific Sector

Individual figures who have an understanding of chemical literacy will have an understanding of scientific ideas in general and also the main ideas of chemistry. For scientific ideas in general it consists of: (a) Chemistry is an experimental science where scientists will make generalizations, scientific inquiry and explain theories related to natural phenomena. (b) Chemistry provides the availability of knowledge that can explain phenomena in other fields that are connected and synergized.

Meanwhile, the main ideas in chemistry itself consist of: (a) Chemistry has an explanation of the macroscopic phenomena contained in the molecular structure of matter. (b) Chemistry will carry out the identification process regarding the investigation of the dynamics of processes and reactions. (c) Chemistry has the capability to carry out investigations of the changes that occur in chemical reactions, especially energy changes. (d) Chemistry has a goal in terms of explaining life which is closely related to structure, processes and chemical reactions. (e) Chemistry has a special and special language which has contributed to the development of the chemical discipline.

Aspects of Chemistry in a Context

Individuals who have an understanding of chemical literacy must be able to do several things including: (a) Giving recognition to the knowledge of chemistry that this science has a very important role in explaining phenomena and events in everyday life. (b) Use in the understanding of chemistry in everyday life. Including an active role in social discussions that are closely related to the science of chemistry. (c) Understanding the relationship between chemical innovation and social processes in society.

High Learning Capability

Individuals who have chemical literacy have the view that they have the ability to: (a) Presents an explanation of scientific phenomena, especially in the field of chemistry. (b) Identification of scientific and chemical issues. (c) Use of scientific evidence. (d) Evaluate the pros and cons in the discussion process.

Aspects on the Affective Side

Individuals who have chemical literacy are certainly expected to have a rational and fair perspective regarding abilities in the field of chemistry and also its application in everyday life. This can show the ability to solve problems in the chemical field, especially in the non-formal sector. The attitude of the individual plays a very important role in chemical and scientific literacy. This is due to opinions regarding scientific issues as well as support from actors on issues as well as a sense of responsibility for situations and phenomena that occur.

Assessment in chemical literacy itself is a very vital component and also has a role that should not be underestimated in the teaching and learning process. And on average research will identify chemical literacy on the basis of research related to scientific literacy. This is of course one of the efforts in terms of measuring scientific literacy which has a dependence on research on this literacy. The scientific literacy framework itself was developed by Bybee (1997) where this framework is used as a way to measure the level of scientific and chemical literacy. From this framework, the commonly used literacy level framework is obtained, namely:

Scientific illiteracy

This framework has to do with the response of scientific questions about the world of science. The framework does not present words, concepts to context and cognitive abilities in the process of identifying scientific questions.

Nominal Scientific Literacy

Individuals who are familiar with vocabulary and also issues related to science, but cannot explain these issues with meaning. At this level, individuals or students only memorize concepts and terms. And this is due to misconceptions about the definition.

Functional Scientific Literacy

Students can define concepts that can be understood. However, the process of understanding the concept is very limited.

Conceptual Scientific Literacy

Conceptual understanding can be done well regarding scientific concepts and also the interactions between these concepts and habits in thinking scientifically. Procedural ability and understanding of the scientific inquiry process can be carried out well. This framework requires an integration process and also organizes information that can be done not just by memorizing knowledge.

Multi-Dimensional Scientific Literacy

This framework requires the concept of science and technology to be taken from a philosophical perspective as well as from a historical perspective that has a relationship with everyday people's lives. Connectivity will occur between disciplines as well as interactions between science, technology and issues that have much broader challenges and complexities in society.

Assessment of chemical literacy itself can be used using guidelines or guidelines from the latest PISA scientific literacy framework, namely the 2015 PISA framework. And this framework will be integrated with the scientific literacy framework based on an assessment from Graber et al. (2001), namely:

Context

According to PISA 2015, the context in question is personal to local or national and global issues where the issue is currently occurring which requires an understanding in the field of technology and science that can explain in detail the issue to the public. Meanwhile, according to Graber's own scientific literacy, the context is a contemporary issue or an issue that is based on socio-scientific.

Knowledge

According to PISA 2015, knowledge is the ability to understand facts and concepts to theories that build the foundation of knowledge in the scientific field. This knowledge consists of knowledge about events in the universe as well as artifact technology. Knowledge is an idea or idea that is built and an understanding of the rational side that forms the basis of the procedure and the justification for its use. Meanwhile, according to Graber himself knowledge is the ability to understand material in the field of science and also the nature of science itself.

Competence

Competence is the ability to explain phenomena that occur through scientific explanations as well as the evaluation process and scientific inquiry design. According to Graber himself competence is the ability to learn, socialize and also procedures as well as communication and interaction in the scientific field.

Attitude

An attitude related to science which displays an interest in science as well as technology. This is determined by the scientific approach to inquiry that fits the perception of environmental awareness and issues. Based on Graber's thought, attitude is an ability in the field of morals as well as ethics.

The nature of science itself is an aspect that has an important role in scientific or chemical literacy which has a definition as the epistemology of science which is a way of learning and knowing as well as values and beliefs that have a close relationship with the development and validation of knowledge in the scientific sector. In the public sector there are 7 aspects that can be applied to science education and learning which consist of: (1) Knowledge that has a tentative nature that can change at any time. (2) Knowledge with an empirical nature with a basis obtained from observations of surrounding conditions. (3) Scientific knowledge with a subjective nature with the interpretation of individuals or groups. (4) Knowledge by involving the side of imagination and also human creativity. (5) Knowledge related to socio-culture where this knowledge can be applied in people's lives. (6) Different knowledge between observation and inference. (7) Knowledge of functions and the connectivity between theory and scientific laws.

The PISA 2015 framework with Graber has an adjustment to the description. Education on the side of chemical literacy itself has a goal so that knowledge about chemical literacy can be achieved for students where there are various kinds of principles that can be carried out by educators in this plan consisting of:

Determination in Chemical Knowledge

Knowledge of chemistry has a scope of knowledge regarding the declarative side as well as procedures and epistemic knowledge. This declarative knowledge is knowledge about concepts as well as theories and facts in the field of chemistry. While procedural knowledge itself is a skill that must be learned in a standard way so that in carrying out scientific inquiry one can gain knowledge. Then for epistemic knowledge itself is knowledge about the nature of science with relevance to everyday life.

Determine Strategy on the Basis of Inquiry

Scientific inquiry is a systematic approach commonly used by scientists where this method is a combination of skills in science processes with content and scientific reasoning. The science process itself consists of observation, interference, classification and also prediction to measurement and data analysis in the field of science. Actors in the field of science must have a critical mindset in order to carry out the development of science. Another goal is on the educational side where it can make a difference to scientific inquiry in the

development of science by prioritizing the nature of science. This is to make emerging knowledge have its own characteristics. Understanding from the side of the nature of science and also the process is a requirement that can be an efficient and effective science learning which is closely related to the implementation of scientific inquiry.

Determination of the Context that has Relevance

The context chosen must of course have a side that is relevant to chemistry. This can be taken from personal issues, local and national conditions, especially problematic events that occur. Then there are global issues. This issue may occur in the present or in the past which has a relationship of understanding on the side of science and technology. This issue has a side of controversy that could become the main material. This contemporary problem can be one of the steps and solutions for: (a) The learning process in the chemical sector has relevance to everyday life. (b) Ways and steps to direct the learning process to the nature of science. (c) Increase the argumentative side in discussions and dialogues. (d) Increased ability in the process of evaluating information on the scientific side. (e) A very important aspect of scientific literacy.

Determination of Learning Capabilities Developed in Chemistry

Skills in learning in activities that have a scientific and chemical literacy orientation are skills in communication, interaction to argumentation with collaborative scientific explanations and metacognition. In these inquiry activities both in investigative activities to discussions on socio-scientific issues, students as individuals will be trained in these skills.

Affective Aspect

This aspect is an attitude of individual perception which is an issue that arises from discussion activities and also investigations that arise on the matter. The morale of students as individuals will be trained by discussing socio-scientific issues that can increase the morale and knowledge of students.

Conclusion

Scientific literacy and also chemical literacy are of course very much needed as a role that can be an educational side for students as individuals in the field of teaching and learning. This is of course so that students can apply this knowledge to everyday people's lives. Efforts and efforts that have already been made in Indonesia today by increasing the literacy side in science and also in the field of chemistry for students and also teaching staff. One of these efforts is the launch of the latest curriculum in the fields of science and chemistry. The teaching staff is one of the determining pillars of the success of the business which of course must obtain a very good understanding in the scientific and chemical literacy sectors. Teaching staff must be able to assess and also design learning and education in the field of chemistry so that students or students have increased abilities and skills. This is one of the orientations and targets of teachers in advancing chemical literacy. In order to assess whether chemical literacy has developed and increased is to use the scientific literacy framework from PISA and also Shwartz's chemical literacy. Meanwhile, chemistry lessons must have a design that can maximize and optimize literacy aspects by having chemistry topics with relevance to people's lives, especially students who study this field of science. Coverage of procedural, declarative and also epistemic knowledge is one way to maximize and optimize chemical literacy for students. Likewise with educational strategies based on inquiry and also determining the context in the field of science that has the right level of relevance. Contemporary contexts or socio-scientific issues are quite relevant in terms of chemical and scientific literacy. This can be a determinant of affective values and ways of learning from students that can develop to improve the educational side with a chemical literacy orientation.

Acknowledgements

The author would like to thank the other authors, because they have struggled together so that this article can be completed. Likewise for my institution Department of Chemistry Education, FKIP, Universitas Halu Oleo, Kendari, Indonesia.

Author Contributions

All authors contribute equally to this article, starting from the preparation of sentences, translating, checking the completeness of the article, so that it can be submitted to the JPPIPA journal.

Funding

This research work did not receive a specific grant from any funding agency in the public, commercial, or not-for-profit sectors. Purely from the joint venture of all authors.

Conflicts of Interest

The author's views and opinions are those of the article, not necessarily the official viewpoint or policy of any of the author's connected organizations.

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