11(3), 2022, 56-64 DOI: 10.23960/jppk.v11.i3.2022.07
Jurnal Pendidikan dan Pembelajaran Kimia
e-ISSN: 2714-9595 | p-ISSN: 2302-1772
http://jurnal.fkip.unila.ac.id/index.php/JPK/index

Development of Chemical Literacy Test Instruments on Electrolyte and Nonelectrolyte Solution Topic

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Received: September 29th, 2022 Accepted: December 12th, 2022 Online Published: December 23rd, 2022

Abstract: This study aims to develop items about chemical literacy in electrolyte solution materials and nonelectrolyte solutions. This research applies research and development methods with ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation). Instrument trial samples of 135 students of class XI and XII one of the senior high schools in Pasuruan Regency with the criteria of having received learning on electrolyte and nonelectrolyte solution topic. Content validation by expert validators shows an average value of 95% so it is categorized as excellent. The results of empirical validity showed the result that 25 questions were declared valid and reliable with a cronbach alpha value of 0.797. It can be interpreted that the question has a very high degree of consistency. Furthermore, the difficulty level of all question items is stated to be very good with 3 questions categorized as difficult and 22 questions categorized as moderate.

Keywords: Assessment instruments, chemical literacy, electrolyte and nonelectrolyte solutions.

Abstrak: ***Penelitian ini bertujuan untuk mengembangkan butir soal literasi kimia pada materi larutan elektrolit dan larutan nonelektrolit.*** *Penelitian ini mengaplikasikan metode penelitian dan pengembangan dengan model pengembangan ADDIE (Analysis, Design, Development, Implementation, dan Evaluation). Sampel uji coba instrumen sebanyak 135 siswa kelas XI dan XII salah satu SMA negeri di Kabupaten Pasuruan dengan kriteria telah mendapatkan pembelajaran pada materi larutan elektrolit dan nonelektrolit. Validasi isi oleh ahli validator menunjukkan nilai rata-rata sebesar 98,8% sehingga dikategorikan sangat baik. Hasil validitas empirik menunjukkan hasil bahwa 25 butir soal dinyatakan valid dan reliabel dengan nilai cronbach alpha sebesar 0,797. Hal ini dapat diinterpretasikan butir soal tersebut memiliki tingkat konsistensi yang sangat tinggi. Selanjutnya, daya beda semua butir soal dinyatakan sangat baik dengan 3 butir soal dikategorikan sukar dan 22 butir soal dikategorikan sedang.*

Kata kunci: *Instrumen penilaian, literasi kimia, larutan elektrolit dan nonelektrolit.*

• INTRODUCTION

Science literacy is one of the main objectives to be achieved in international science learning. Science literacy is an individual's ability to understand, communicate, apply science issues, concepts, and ideas in life (OECD, 2016). In the era of the 21st century, science literacy is an important aspect that plays a very important role in realizing a literate society. 21st century learning focuses on improving 21st century skills which include critical thinking, creative thinking, communication, and collaboration skills (Redhana, 2019; Aslamiah et al., 2021). 21st century skills can be improved if students have good quality science literacy (Turiman et al., 2012). Science literacy is needed in making decisions on issues and problems that occur in the natural and social environment (Yacoubian, 2018). So far, based on the assessment of the Program for International Student Assessment (PISA) in 2018, it shows that the science literacy of students in Indonesia is categorized as very low, which is ranked 70 out of 78 state participants (OECD, 2018). Furthermore, based on Trend in International Mathematics and Science Studies (TIMSS) assessment 2015 also showed that Indonesia's science literacy was in 45^{th} position out of 48 country participants (Martin et al., 2016). It can be interpreted that the quality of science literacy of students in Indonesia is still very low.

The low science literacy in Indonesia can be interpreted that students cannot analyze and apply concepts in solving problems in life. The low of science literacy can be caused by several things, namely learning that tends to be centered on instructions given by teachers, the delivery of material that does not introduce science as a science that focuses on processes and applications, and rarely carried out practicum activities (Anggraeni & Wardani, 2020). The low level of science literacy is also caused by the infrequent implementation of learning evaluations oriented towards science literacy so that students are not used to thinking critically (Jufrida et al., 2019). Furthermore, low science literacy can also be caused by improper selection of textbooks so that learning becomes boring and students do not understand the subject topic, there are demands for the completion of teaching materials in accordance with curriculum targets, causing students to experience many misconceptions because teachers are only oriented towards the target of mastering topic, students' low reading ability, low curiosity of students, unconducive learning environment, and learning is not contextual so that the learning carried out is less relevant (Fuadi et al., 2020; Sumanik et al., 2021; Minata et al., 2022).

The Indonesian Ministry of Education and Culture (Kemendikbud) has made efforts to improve the quality of science literacy, one of which is implementing the Minimum Competency Assessment program which focuses on analyzing and evaluating student literacy and numeracy (Rohim, 2021). Chemical literacy is an important part of science literacy that refers to the ability of individuals to explain phenomena scientifically using chemical concepts, solve problems in life with chemical concepts, and applying chemical applications in everyday life (Fahmina et al., 2019). Science literacy can be divided into four important aspects, namely context (personal, national, and global), knowledge (content, procedural, and epistemic knowledge), and competence (explaining phenomena scientifically, designing and evaluating scientific investigations, and interpreting scientific data and evidence), and attitudes (OECD, 2016). Science literacy is very important to learn because it is able to provide education to the public in solving problems in everyday life through assessment of information and science concepts (Chen & Osman, 2017).

Based on the needs analysis launched by researchers, it shows that chemistry learning in several high schools in the Pasuruan Regency area rarely implements learning evaluations oriented towards science literacy, especially on chemistry topics. In addition, teachers also rarely develop and implement assessments oriented towards science literacy assessments. Furthermore, teachers tend to take assessment questions from learning textbooks and student worksheets to be used as a reference for questions used in learning evaluation. Therefore, the questions used by the teacher have not been clearly described regarding the indicators of the problem and their cognitive level. It can be interpreted that the assessment problem implemented has not fully measured what is to be measured in learning.

One of the efforts that can be made in overcoming low science literacy is to develop a science literacy-based assessment instrument, especially on the topic of chemistry. Several studies on the analysis and development of chemical literacy instruments have been carried out by researchers. Arabbani et al., (2019) analyzing the quality of high school level chemical literacy assessment instruments using the rasch model. Shwartz et al., (2006) developed several types of scoring instruments using likert scales, open questionnaires, and multiple choice questionnaires. Cigdemoglu & Geban (2015) developed open-ended chemical literacy test in thermochemical and thermodynamic topic. Thummathong & Thathong (2016) developed multiple-choice chemical literacy question instruments on basic chemical materials. Then, Muntholib et al., (2020) developed a chemical literacy multiple-choice question instrument on reaction kinetics topic. Based on the research that has been carried out, there is still no research that develops chemical literacy assessment instruments on electrolyte and nonelectrolyte solution materials.

Assessment instruments are an important component in the evaluation of chemistry learning (Stowe & Cooper, 2019). Electrolyte and nonelectrolyte solutions are one of the chemical materials that are abstract, have an applicable context in everyday life, and contain macroscopic, submicroscopic, and symbolic representations (Nur & Santi, 2022; Suja et al., 2021). Some examples of the context and application of electrolyte and nonelectrolyte solution materials in life are electrolyte drinks, electrolyte shocks due to flood disasters, accumulator water, oralyte, and fishing using shock devices. It can be interpreted that electrolyte and nonelectrolyte solution materials are closely related in life and can be used to improve students' chemical literacy. Electrolyte and nonelectrolyte solution materials have several submaterials including the electrical conductivity properties of electrolyte and nonelectrolyte solutions, the characteristics of electrolyte and nonelectrolyte solutions, the grouping of electrolyte and nonelectrolyte solutions, the causes of electrolyte solutions being able to conduct electric current, the constituent compounds of electrolyte and nonelectrolyte solutions, and the degree of association or ionization (conductivity strength) of electrolyte and nonelectrolyte solutions (Adadan & Savasci, 2012; Devetak et al., 2009). Electrolyte and nonelectrolyte solution topics have many concepts and theories. This material will be difficult to understand and cause misconceptions in students if the teacher does not involve submicroscopic representation in learning (Lu et al., 2019; Calik, 2005; Parlan et al., 2022).

The development of chemical literacy assessment instruments on electrolyte and nonelectrolyte solution materials refers to the 2018 PISA framework which measures three important indicators, namely context, knowledge, and competence (OECD, 2018). This study aims to develop and evaluate the validity and reliability of chemical literacy instruments with multiple-choice form. The question instrument developed is expected to train students to think critically and creatively and be able to apply the chemical concepts studied in various phenomena in everyday life so as to be able to solve all problems and challenges in the 21st century by mastering good chemical literacy. Furthermore, the chemical literacy assessment instrument on the reaction rate material that has been developed can be a reference for teachers in developing chemical literacy questions on other topics as an evaluation of chemistry learning.

- **METHOD**

This research applies the research and development method (Creswell, 2013). The product developed in the study is a multiple-choice question to measure students' chemical literacy ability in electrolyte and nonelectrolyte solution materials. Stages in the design and development of this assessment instrument using the ADDIE framework (*Analysis, Design, Development, Implementation*, and *Evaluation*) (Aldoobie, 2015). Furthermore, the design and development stages are only carried out until the "Development" stage because it is only limited to measuring the level of validity and reliability of the questions developed. The first stage, analysis is carried out to analyze the needs of problem development, curriculum analysis, indicator analysis, and material analysis that is needed in the field. The second stage, design is an activity to design and compile indicators of competency achievement, indicators of question items based on basic competencies, and question assessment rubric. Furthermore, the third stage is a development carried out by conducting a content validation test by validators who are two chemistry teachers and continued with tests of empirical validity, reliability, difficulty level, and differentiability using the help of the *SPSS 23 for Windows program*. The test sample in this study was 100 students of class XI and XII one of senior high schools in Pasuruan Regency, East Java with the criteria of having received learning electrolyte and nonelectrolyte solution topic.

▪ RESULT AND DISCUSSION

The product developed by the researcher is an instrument on chemical literacy in electrolyte and nonelectrolyte solution materials which includes indicators of question items, question items, and assessment rubrics. The question instrument developed is in the form of 25 multiple-choice questions that include three aspects of chemical literacy, namely context, knowledge, and competence. The description of the question item indicators along with the aspects of chemical literacy that have been developed can be seen in Table 1. Some examples of items about chemical literacy that have been developed can be presented in Table 2.

Table 1. Description of Context, Domain, and Item of Chemical Literacy Test

Context	Subtopics	Chemical Literacy Domain	Number
Accumulator water (Global)	Electrical conductivity properties of electrolyte and nonelectrolyte solutions	PK, MF	1
		PP, MF	2
		PK, MF	3
	Characteristics of electrolyte and nonelectrolyte solutions	PP, MF	4
Young coconut water (Local)	Characteristics of electrolyte and nonelectrolyte solutions	PK, MF	5
		PE, MM	6
Oralyte medicine (National)	Causes of the ability of the electrolyte solution to conduct electric current	PE, MF	7
		PE, MF	8
Fish shock (Local)	Causes of the ability of the electrolyte solution to conduct electric current	PE, MF	9
		PE, MF	10
Electrical conductivity of the solution (Global)	Grouping of electrolyte and nonelectrolyte solutions	PK, MD	11
		PK, MD	12
	Constituent compounds of electrolyte and nonelectrolyte solutions	PK, MF	13
		PK, MD	17
		PK, MD	18
	Causes of the ability of the electrolyte solution to conduct electric current	PK, MF	14
		PE, MF	15
		PE, MF	16
Electrical conductivity experiment (Global)	The electrical conductivity strength of electrolyte and nonelectrolyte solutions	PP, MD	19
		PE, MD	21
		PP, MM	22
		PP, MM	23
	Constituent compounds of electrolyte solutions and noelectrolytes	PE, MD	20
Salt form experiment (Global)	Causes of the ability of the electrolyte solution to conduct electric current	PK, MF	24
	The electrical conductivity strength of electrolyte and nonelectrolyte solutions	PE, MD	25

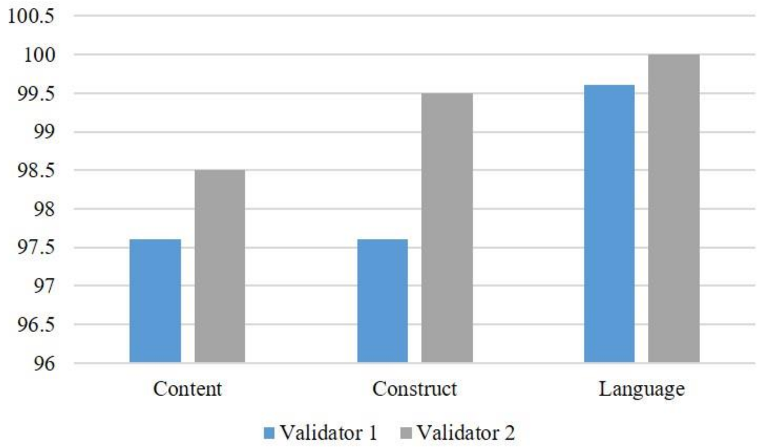
*PK = Content knowledge; PP = Procedural knowledge; PE = Epistemic knowledge; MF = Explaining the phenomenon scientifically; MM = Evaluating and designing scientific investigations; MD = Interpreting data and scientific evidence.

Table 2. Examples of Chemical Literacy Questions

Context	Chemical Literacy Domain	Question Description
Orayte medicine (Global)	Epistemic knowledge, Explaining phenomena scientifically	 Diarrhea is a disease characterized by an increased frequency of bowel movements more than three times a day. Symptoms of diarrhea can be eased by using solutions containing electrolyte substances. One of the solutions that can be used is oralyte. Oralyte contains electrolytes needed by the body. The content in oralyte includes sodium chloride (NaCl), potassium chloride (KCl), anhydrous trisodium citrate, and anhydrous glucose. With the appropriate electrolyte intake, the biochemical reaction in the body will go smoothly. In everyday life we know oralyte as a first aid to overcome diarrhea. Oralyte is a mixture of sugar and salt solutions. How can the solution maintain electrolyte balance in the body? a. Salt and sugar will mix into a solution that can neutralize the bacteria that cause diarrhea b. Salts in solution can ionize into sodium and chloride ions that restore ions lost in the body c. Sugar in solution can produce energy that increases the stamina of the body d. Salt in the solution can kill the bacteria that cause diarrhea e. Salt and sugar undergo dissociation so that they decompose into ions needed by the body
	Epistemic knowledge, Explaining phenomena scientifically	Oralyte sold in pharmacies are generally packaged in the form of tablets and powders. Based on the rules of use indicated on the packaging of the drug, oralyte can be consumed by first dissolving it in water. Why is this necessary? a. In the form of solutions of NaCl and KCl salts contained in oralyte are nonelectrolyte In the form of solutions of NaCl and KCl salts contained in ORS are nonelectrolyte b. In the form of solutions of NaCl and KCl salts contained in oralyte are weak electrolytes c. In the form of solutions of NaCl and KCl salts contained in oralyte have very strong polar

	covalent bonds d. In the form of solutions of NaCl and KCl salts contained in oralyte can form ions e. In the form of solutions of NaCl and KCl salts contained in oralyte can form free-moving electrons

Validation of the content of the chemical literacy assessment instrument involves two experts who are chemistry teachers. Content validation is performed on material, construction, and language indicators. A percentage description of the assessment results of the three expert validators can be presented in Figure 1.



Empirical validity data are obtained from students' answers. The chemical literacy assessment score is categorized into a score of 1 if the answer is correct and a score of 0 if the answer is wrong. Based on the analysis, it was found that as many as 25 items of chemical literacy questions were declared valid assuming $r_{count} \geq r_{table}$ (r_{table} = 0,195) (Arikunto, 2015). Furthermore, the results of the question reliability test showed a cronbach alpha value of 0.797 which was categorized as having a very good consistency. A description of the test results of validity, power difference, and difficulty level of items regarding chemical literacy can be presented in Table 3.

Table 3. Description of Item Analysis Results on Chemical Literacy

Number	**Validity**		**Power Difference**		**Difficulty Level**	
	Value	**Interpretation**	**Value**	**Interpretation**	**Value**	**Interpretation**
1	0,473	Valid	3,28	Excellent	0,60	Moderate
2	0,527	Valid	4,80	Excellent	0,52	Moderate
3	0,293	Valid	2,66	Excellent	0,30	Moderate
4	0,346	Valid	2,11	Excellent	0,60	Moderate
5	0,223	Valid	2,00	Excellent	0,49	Moderate
6	0,566	Valid	11,5	Excellent	0,46	Moderate
7	0,450	Valid	6,33	Excellent	0,40	Moderate
8	0,264	Valid	3,66	Excellent	0,25	Difficult
9	0,272	Valid	1,38	Excellent	0,60	Moderate
10	0,412	Valid	2,30	Excellent	0,60	Moderate
11	0,681	Valid	12,5	Excellent	0,56	Moderate
12	0,461	Valid	4,75	Excellent	0,32	Moderate
13	0,448	Valid	4,75	Excellent	0,32	Moderate
14	0,479	Valid	2,50	Excellent	0,36	Moderate
15	0,641	Valid	8,33	Excellent	0,55	Moderate

16	0,445	Valid	3,28	Excellent	0,43	Moderate
17	0,223	Valid	2,40	Excellent	0,28	Difficult
18	0,360	Valid	2,50	Excellent	0,43	Moderate
19	0,445	Valid	2,16	Excellent	0,69	Moderate
20	0,389	Valid	2,18	Excellent	0,66	Moderate
21	0,284	Valid	1,90	Excellent	0,60	Moderate
22	0,228	Valid	1,77	Excellent	0,58	Moderate
23	0,510	Valid	5,50	Excellent	0,50	Moderate
24	0,343	Valid	2,00	Excellent	0,49	Moderate
25	0,246	Valid	2,00	Excellent	0,30	Difficult

The results of the empirical validity of the differentiating power and the degree of difficulty of the entire question item can be seen in Table 3. The results of the differentiability test show that all question items are stated to be very good. This is evidenced by the value of the differentiation power index being in the range of (0,71 < D < 1,00) (Arikunto, 2015). It can be interpreted that the item can distinguish students who have high abilities from students who have low abilities. Furthermore, the results of testing the difficulty level of the question items obtained there are 3 questions were declared difficult and 22 questions were declared medium. This is evidenced by the difficulty level index (0,31 < P < 0,70) categorized medium and (0,00 < P < 0,30) dikategorikan sukar (Arikunto, 2015). Based on the results of the analysis, it can be interpreted that the chemical literacy assessment instrument meets the categories of content validity and empirical validity. In addition, the question instrument developed is expected to be a reference for teachers as an evaluation of literacy-based learning on chemistry topics.

• CONCLUSION

The development of instruments on chemical literacy is carried out to the stage of development in the ADDIE development model. The result of developing a chemical literacy assessment instrument fullfill the criteria of content validity and empirical validity. The average content validation by expert validators shows a percentage of 98.8% which is categorized as excellent. Empirical validity shows that as many as 25 items of chemical literacy questions are declared valid with a very high level of reliability (0,797). All question items have a very good difference with 3 questions categorized as difficult and 22 questions categorized as medium. The results of the chemical literacy questions that have been developed can be used as an evaluation of students' chemical literacy, especially on electrolyte and nonelectrolyte solution topic. Furthermore, the chemical literacy question instrument developed is expected to train students to think critically, creatively, and apply chemical concepts in solving problems and challenges in the 21st century.

• REFERENCES

Adadan, E., & Savasci, F. (2012). An analysis of 16-17-year-old students' understanding of solution chemistry concepts using a two-tier diagnostic instrument. *International Journal of Science Education*, *34*(4), 513–544.

Aldoobie, N. (2015). ADDIE Model. *American International Journal of Contemporary Research*, *5*(6), 361–373.

Anggraeni, A. Y., & Wardani, S. (2020). Profil Peningkatan Kemampuan Literasi Kimia Siswa Melalui Pembelajaran Inkuiri Terbimbing Berbasis Kontekstual. *Jurnal Inovasi Pendidikan Kimia*, *14*(1), 2512–2523.

Arabbani, F. K., Mulyani, S., Mahardiani, L., & Ariani, S. R. D. (2019). Analysis the quality of instrument for measuring chemical literacy abilities of high school student using Rasch model. *AIP Conference Proceedings*, *2194*(December).

Arikunto, S. (2015). *Dasar-Dasar Evaluasi Pendidikan*. Bumi Aksara.

Aslamiah, A., Abbas, E. W., & Mutiani, M. (2021). 21st-Century Skills and Social Studies Education. *The Innovation of Social Studies Journal*, *2*(2), 82.

Calik, M. (2005). A cross-age study of different perspectives in solution chemistry from junior to senior high school. *International Journal of Science and Mathematics Education*, *3*(4), 671–696.

Chen, C. W., & Osman, C. (2017). Cultivating Marginalized Children's Scientific Literacy in Facing the Challenges of the 21st Century Cindy. *K-12 STEM Education*, *3*(1), 157–167.

Cigdemoglu, C., & Geban, O. (2015). Improving Students' Chemical Literacy Level on Thermochemical and Thermodynamics Concepts through Context-Based Approach. *Chemistry Education Research and Practice*, *3*, 10715–10722.

Creswell, J. W. (2013). *Educational Research Planning, Conducting, and Evaluating Quantittaive and Qualitative Research* (Fourth Edi). Pearson.

Devetak, I., Lorber Drofenik, E. D., Juriševič, M., & Glažar, S. A. (2009). Comparing Slovenian year 8 and year 9 elementary school pupils' knowledge of electrolyte chemistry and their intrinsic motivation. *Chemistry Education Research and Practice*, *10*(4), 281–290.

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).

Fuadi, H., Robbia, A. Z., Jamaluddin, J., & Jufri, A. W. (2020). Analisis Faktor Penyebab Rendahnya Kemampuan Literasi Sains Peserta Didik. *Jurnal Ilmiah Profesi Pendidikan*, *5*(2), 108–116.

Jufrida, J., Basuki, F. R., Kurniawan, W., Pangestu, M. D., & Fitaloka, O. (2019). *Scientific literacy and science learning achievement at junior high school*. *8*(4), 630–636.

Lu, S., Bi, H., & Liu, X. (2019). A phenomenographic study of 10th grade students' understanding of electrolytes. *Chemistry Education Research and Practice*, *20*(1), 204–212.

Martin, M. O., Mullis, I. V. S., Foy, P., & Hooper, M. (2016). *TIMSS 2015 International Results in Science - Eighth Grade Science*.

Minata, Z. S., Rahayu, S., & Dasna, I. W. (2022). Context-Based Chemistry Learning: A Systematic Literature Review. *Jurnal Pendidikan Mipa*, *23*((4)), 1446–1463.

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.

Nur, A., & Santi, I. (2022). Analysis of Students Misconceptio on Electrolyte and Non Elektrolyte Solutions Using Multiplerepresentation Four-Tier Diagnostic Test Based Pictorial. *Unesa Journal Of Chemical Education*, *11*(3), 210–219.

OECD. (2016). *Overview: Excellence and Equity in Education: Vol. I*.

OECD. (2018). *PISA 2018: Insight and Interpretations*. OECD Publishing.

Parlan, P., Minata, Z. S., Suryadharma, I. B., Sulistina, O., & Marfu'ah, S. (2022). The Effect of Triangulation-Based Metacognitive Learning Strategy on Students' Chemistry Literacy and Learning Achievement. *JTK (Jurnal Tadris Kimiya)*, *7*(1), 14–24.

Redhana, I. W. (2019). Mengembangkan Keterampilan Abad Ke-21 Dalam Pembelajaran Kimia. *Jurnal Inovasi Pendidikan Kimia*, *13*(1).

Rohim, D. C. (2021). Konsep Asesmen Kompetensi Minimum untuk Meningkatkan Kemampuan Literasi Numerasi Siswa Sekolah Dasar. *Jurnal VARIDIKA*, *33*(1), 54–62.

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.

Stowe, R. L., & Cooper, M. M. (2019). Assessment in Chemistry Education. *Israel Journal of*

Chemistry, *59*(6), 598–607.
Suja, I. W., Sudiana, I. K., Redhana, I. W., & Sudria, I. B. N. (2021). Mental Model of Prospective Chemistry Teachers on Electrolyte and Nonelectrolyte Solutions. *IOP Conference Series: Materials Science and Engineering*, *1115*(1), 012064.
Sumanik, N. B., Nurvitasari, E., & Siregar, L. F. (2021). Analisis Profil Kemampuan Literasi Sains Mahasiswa Calon Guru Pendidikan Kimia. *Quantum: Jurnal Inovasi Pendidikan Sains*, *12*(1), 22.
Thummathong, R., & Thathong, K. (2016). Construction of a chemical literacy test for engineering students. *Journal of Turkish Science Education*, *13*(3), 185–198.
Turiman, P., Omar, J., Daud, A. M., & Osman, K. (2012). Fostering the 21st Century Skills through Scientific Literacy and Science Process Skills. *Procedia - Social and Behavioral Sciences*, *59*, 110–116.
Yacoubian, H. A. (2018). Scientific literacy for democratic decision-making. *International Journal of Science Education*, *40*(3), 308–327.