SPIN
JURNAL KIMIA & PENDIDIKAN KIMIA
https://journal.uinmataram.ac.id/index.php/spin

INTEGRATION OF SOCIO-SCIENTIFIC ISSUES IN CHEMISTRY LEARNING OUTCOME TESTS TO MEASURE HIGH SCHOOL STUDENTS SCIENTIFIC EXPLANATION SKILLS

Annida Fadlila Hanan✉[1], Susila Kristianingrum[1]

[1]Pendidikan Kimia, Universitas Negeri Yogyakarta, Sleman, 55281, Indonesia.
DOI: 10.20414/spin.v6i2.10179

History Article
Accepted:
May 27, 2024
reviewed:
December 2, 2024
Published:
December 20, 2024

Keywords:
Acid-base material; Scientific explanation skills; Socio-scientific issues; Test development.

ABSTRACT

Socio-scientific issues (SSI) are controversial issues related to socio-science. SSI can be integrated into chemistry learning outcome tests to measure students' scientific explanation skills. This research aimed to develop a socio-scientific issues based test to measure the scientific explanation skills of high school students in acid-base material. The development model used is an exploratory mixed method. Qualitative data were collected through needs analysis, literature studies for references for initial test development, expert feasibility test, and usability feasibility test (qualitative) to obtain input from experts and reviewers. The results of the quantitative test showed that the test developed has an ideal percentage of 87% (Very Good) according to the reviewer and 71% (Good) according to the students. The number of valid items based on the item fit test was 15. A total of 10 questions have the discrimination category very good, 3 questions were good, 1 question was fair, and 1 question was not able to discriminate. The difficulty level test revealed that 26,67% of the questions were very difficult, 26,67% of the questions were difficult, 33,33% of the questions were easy, and 13,33% of the questions were very easy. The Cronbach Alpha reliability value of the test was 0.77, categorized as good.

ABSTRAK

Socio-scientific issues (SSI) merupakan isu-isu kontroversial yang berkaitan dengan sosio-sains. SSI dapat diintegrasikan pada tes hasil belajar kimia untuk mengukur *scientific explanation skills* siswa. Penelitian ini bertujuan untuk mengembangkan soal berbasis *socio-scientific issues* untuk mengukur *scientific explanation skills* siswa SMA pada materi asam basa. Model pengembangan yang digunakan dalam penelitian ini adalah *exploratory mixed method*. Data kualitatif diperoleh dari analisis kebutuhan dan studi literatur untuk referensi pengembangan soal awal serta uji kelayakan ahli dan uji kelayakan kedapatgunaan (kualitatif) untuk memperoleh masukan dari ahli dan *reviewer*. Hasil dari uji kuantitatif menunjukkan bahwa soal yang dikembangkan memiliki persentase kelayakan sebesar 87% (Sangat Baik) menurut *reviewer* dan 71% (Baik) menurut siswa. Jumlah item yang valid berdasarkan uji kesesuaian butir sebanyak 15 butir soal. Sebanyak 10 butir soal memiliki kategori daya diskriminasi sangat bagus, 3 butir bagus, 1 butir cukup, dan 1 butir tidak mampu mendiskriminasi. Hasil uji tingkat kesukaran diperoleh 26,67% soal sangat sukar, 26,67% soal sukar, 33,33% soal mudah, dan 13,33% soal sangat udah. Nilai reliabilitas *Cronbach Alpha* soal adalah 0,77 dengan kategori bagus.

How to Cite

Hanan, A. F., & Kristianingrum, S. (2024). Integration of Socio-Scientific Issues in Chemistry Learning Outcome Tests to Measure High School Students Scientific Explanation Skills. *SPIN-Jurnal Kimia & Pendidikan Kimia*. 6(2). 127-134.

✉Correspondence Author:
annidafadlila.2020@student.uny.ac.id

p-ISSN: 2580-2623
e-ISSN: 2745-685

INTRODUCTION

The 21[st] century is often characterized as an era of rampant globalization and the rapid development of communication and information technology. In this era, alternative efforts to fulfill life's needs are directed at a knowledge base, so the 21[st] century is also known as the knowledge age (Mukhadis, 2013). The rapid development and knowledge require society to master 21[st]-century skills. Education is one of the fields that is expected to produce human resources with the skills or competencies needed in the 21st century (Wijaya et al., 2016). The World Economic Forum (2015) stated that one of the 16 skills needed in the 21st century is scientific literacy. Based on several studies that have been conducted, students who are scientifically literate can better avoid misinformation and irresponsible news (Fasce & Picó, 2019; Howell & Brossard, 2021). The ranking of Indonesian students' scientific literacy skills based on the 2022 PISA report is 66 out of 80 participating countries (OECD, 2023). This still relatively low ranking needs to be used as a reflection in the field of science education.

One of the competencies in scientific literacy is explaining phenomena scientifically (OECD, 2023) which can also be called the ability to provide scientific explanations (scientific explanation skills). This ability needs to be developed because it can help students understand the main concepts in science (NRC, 2011). The higher the ability to provide scientific explanations, the higher the students' understanding of science content (McNeill & Krajcik, 2008).

One of the changes that teachers are currently progressively making is the application of socio-scientific issues (SSI) as a context in chemistry learning (Rahayu, 2019). SSI are controversial issues related to socio-science (Sadler, 2011). The context of SSI is usually controversial, but has additional elements that require a level of moral reasoning or evaluation related to ethics in the decision-making process regarding various possible solutions to the problem (Sadler, 2004).

SSI can be applied to improve students' scientific explanation skills. In the OECD (2023), scientific explanation skills are referred to as the competence to explain phenomena scientifically. Based on this understanding, SSI can take part as a phenomenon that will be explained by students. Pinzino (2012) also stated that SSI learning encourages students to know the role of science/chemistry in life by providing evidence when explaining the occurrence of an event. This is in accordance with the components of the ability to provide scientific explanations, namely claims, evidence, and reasoning (McNeill & Krajcik, 2008).

One of the chemical materials that is often found in everyday life is acids and bases (Agnia et al., 2021). Controversial issues related to acids and bases are also often found, for example acid rain (Cahyarini et al., 2016), environmental pollution, agricultural problems, hazardous materials in drugs and food, and so on. Therefore, this material can be integrated with SSI to be applied in chemistry learning and to improve students' scientific explanation skills.

Due to the importance of students' mastery of scientific explanation skills, this ability needs to be measured and analyzed further so that teachers can evaluate. The measurement instrument used can be in the form of questions. So far, the question instruments used to measure students' scientific explanation skills include 3 components, namely claims, evidence, and reasoning (McNeill & Krajcik, 2008). However, there has been no research that has developed a question instrument to measure scientific explanation skills by integrating it with SSI as a phenomenon or object to be explained by students. Therefore, this study aims to develop a question instrument in the form of a learning outcome test to measure high school students scientific explanation skills integrated with SSI through expert feasibility tests, teacher usability feasibility tests, student readability tests, and empirical trials to determine the characteristics of the questions developed.

METHOD

The development model used in this study is an exploratory mixed method that shows quantitative data that can support qualitative data (Cresswell & Clark, 2007). This research design consists of the stage of collecting and analyzing qualitative data used as the basis for product development, the product development stage, the stage of collecting and analyzing quantitative data by conducting product trials, and product interpretation (Creswell & Clark, 2007). The chart in the product development design can be seen in Figure 1.

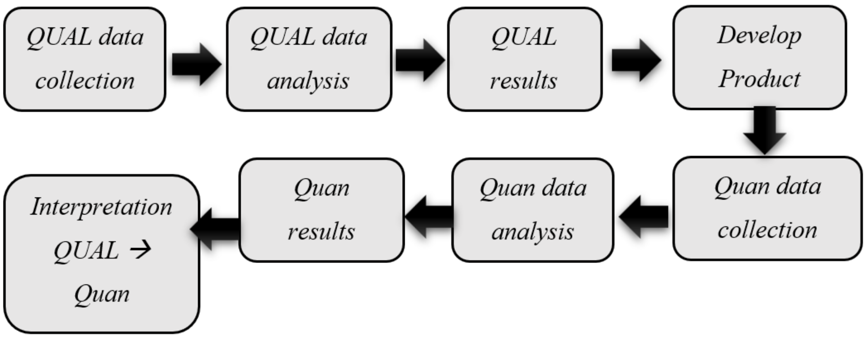

Figure 1. Product development design

The qualitative data collection and analysis stage was carried out by conducting a needs analysis of the product, a literature study related to the components in the ability to provide scientific explanations, the achievement of high school chemistry learning phase F on acid-base material, and various controversial issues related to acids and bases as SSI content used in the questions. The product development stage was in the form of compiling question instruments which included determining the SSI content to be used, compiling grids and scoring guidelines, and compiling question instruments. After that, a feasibility test was carried out by experts, namely 2 Chemistry Education lecturers, and then revisions were made based on the input provided. Furthermore, a feasibility test of usability (qualitative) was carried out by teachers and prospective teachers (peer reviewers) as prospective users. The data obtained was in the form of qualitative data.

The quantitative data collection and analysis stage included a feasibility test of usability (quantitative) by teachers and prospective teachers and a student readability test which was analyzed using descriptive statistics with the ideal assessment category technique. In addition, an empirical trial was also carried out to determine the characteristics of the question instrument being developed. Empirical trials include item suitability tests, discrimination power, item difficulty levels, and instrument reliability tests conducted using Rasch modeling with the Winsteps program.

RESULT AND DISCUSSION

Qualitative Stage

The first stage in this study is the collection and analysis of qualitative data. The qualitative data collection carried out includes a needs analysis and literature study related to the components of scientific explanation skills, SSI, and the scope of acid-base material. The results of the needs analysis indicate that teachers need SSI-based questions to be developed and are willing to use them if the questions have been developed. Meanwhile, the references used for the literature study include literature books, research journals, and scientific articles. The next stage is the product development stage.

This stage includes the preparation of question instruments in the form of grids, scoring guidelines, and question products. The question instruments are compiled based on the results of the previous qualitative analysis. The types of questions developed are multiple-choice questions with reasons that lead to providing answers in the form of claims, evidence, and reasoning. There are four SSI themes and each theme has its own discourse. The total number of questions developed is 15 items with the SSI themes listed in Table 1.

Table 1. SSI context in the question

Theme	Sub-material	SSI Dimensions	Question number
Stomach acid	Acidity level, acid base indicators, acid base properties	Health-social	1.1; 1.2; 1.3; 1.4
River pollution	Acid base theory, acid base indicators, acidity levels	Social environment	2.1; 2.2; 2.3; 2.4; 2.5
Ocean acidification	Acid base properties, acid base theory	Socio-economic environment	3.1; 3.2; 3.3
Acid rain	Acid base properties, acid base theory	Environment	4.1; 4.2; 4.3

A feasibility test was conducted by chemistry learning experts, namely 2 Chemistry Education lecturers. The questions were then revised based on suggestions and input from experts. Some notes on improvements include the content of the questions, the rules for writing multiple-choice questions, the relevance of the questions to the SSI context, improvements to the discourse in the questions, and writing errors.

The feasibility test for usability was then conducted on teachers as reviewers and chemistry education students (prospective teachers) as peer reviewers. The data obtained were qualitative and quantitative data. The results of the feasibility test for usability (qualitative) were in the form of input and suggestions that were generally related to the construction of the questions.

Quantitative Stage

Quantitative data from the feasibility test for usability were in the form of product assessments by 6 teachers as reviewers and 3 Chemistry Education students (prospective teachers) as peer reviewers. The aspects assessed were material aspects, scientific explanation skills or the ability to provide scientific explanations (KMPI), construction, and language. The assessment data were analyzed using descriptive statistics with the ideal assessment category technique. Based on the assessment results, the developed question products have a percentage of feasibility in the material, scientific explanation skills, construction, and language aspects of 88%, 83%, 90%, and 87% respectively or with an overall average of 87%. Thus, the quality of the developed question products can be classified in the Very Good category for use in chemistry learning. The results of the reviewer and peer reviewer assessments on each aspect can be interpreted in a graph in Figure 2.

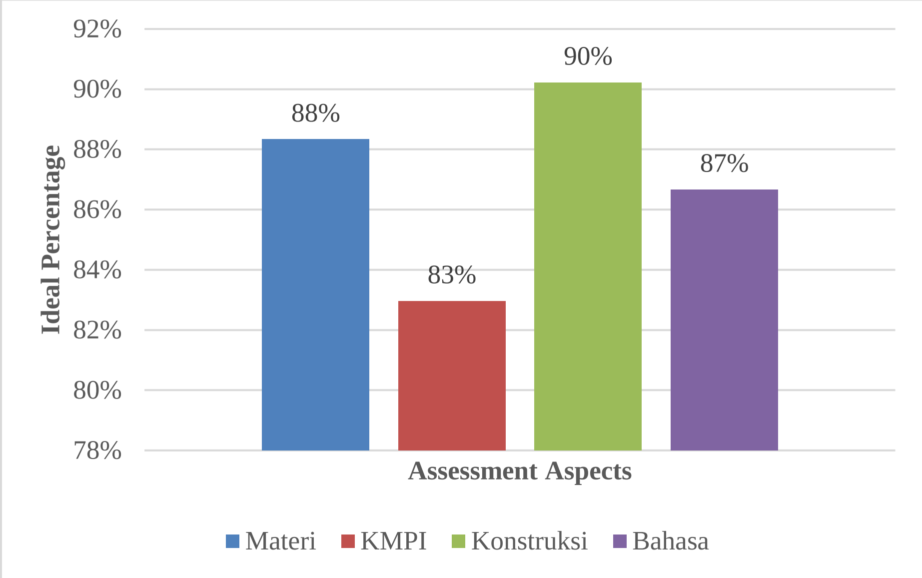

Figure 2. Percentage of usability test results for SSI-based questions

The readability response test was conducted on students as the target of the product. This test was conducted on 15 students with high, medium, and low achievement criteria. The aspects assessed by students in this test include the scientific explanation skills aspect or the ability to provide scientific explanations, construction, and language. The assessment data were analyzed using descriptive statistics with the ideal assessment category technique. Based on the results of the student readability test, the developed question product has a percentage of feasibility in the scientific explanation skills, construction, and language aspects of 77%, 93%, and 90% respectively, or with an overall average of 71% for all aspects. Thus, the quality of the developed question product can be classified in the Good category for use in chemistry learning. The results of student assessments on each aspect can be interpreted in a graph in Figure 3.

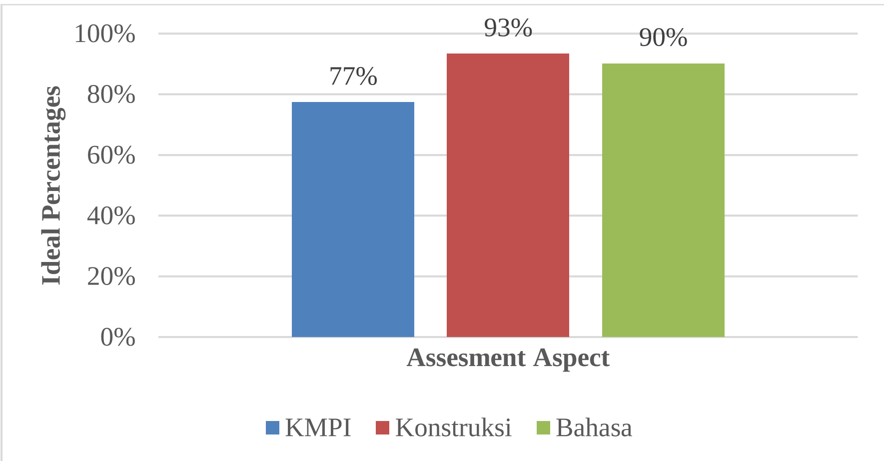

Figure 3. Percentage of SSI-based question readability test

The next stage is an empirical trial conducted on 100 11th-grade high school students who have studied acids and bases. The empirical trial data were analyzed using Rasch modeling with the Winsteps program. The empirical trial includes item suitability tests, discrimination power, item difficulty levels, and reliability. The item suitability test aims to determine valid test items to use. Determination of valid test items is based on Outfit MNSQ (0.5 < x < 1.5), Outfit ZSTD (-2.0 < x < 2.0), and Pt Measure Corr (0.4 < x < 0.85). Test items are said to be valid if they meet at least one criterion and are discarded if they do not meet all three criteria (Sumintono & Widhiarso, 2015). The results of the item suitability test are shown in Table 2.

Table 2. Results of the item suitability test

Test results	Interpretation	Question item number
Meet 3 criteria	Valid	1.1; 1.2; 1.4; 2.2; 2.4; 2.5; 4.2
Meet 2 criteria	Valid	1.3; 2.1; 2.3; 3.1; 3.2; 4.1; 4.3
Meet 1 criteria	Valid	3.3

Discriminatory power is a measure of an item's ability to distinguish between individuals who have and do not have the attribute being measured (Azwar, 2011). Rasch Discriminatory Power or the correlation value of item scores and Rasch scores (Pt Measure Corr) is seen from the measure score. The classification of Pt Measure Corr values is very good (>0.40), good (0.30-0.39), sufficient (0.20-0.29), unable to discriminate (0.00-0.19), and requires examination of the item (<0.00) (Alagumalai et al., 2005). A total of 10 items have Very Good discriminatory power, 3 items are Good, one item is Good, 1 item is Sufficient, and 1 item is Unable to Discriminate. Although unable to discriminate, one item is valid because it meets the item validity criteria according to Sumintono & Widhiarso (2015). The level of difficulty of the items can be seen from the Measure Logit table. In Rasch modeling, a high logit value indicates a high level of question difficulty and corresponds to the number of correct answers. Questions with a high level of difficulty mean that the number of correct answers to the question is less than the number of correct answers to questions with a low level of difficulty, and vice versa (Sumintono & Widhiarso, 2015).

Furthermore, Sumintono and Widhiarso (2015) explained that the level of item difficulty with Rasch modeling can be grouped based on the Measure Logit and Standard Deviation (SD) of the item logit into four categories which can be seen in Table 3. The Standard Deviation (SD) of the item logit in the questions developed is 0.90. Based on the SD value, the results of the distribution of the level of item difficulty are shown in Table 4.

The results of the analysis of the level of item difficulty in Table 4 show that questions with the Easy level of difficulty category have the largest number, namely with a percentage of 33.33% or 5 out of 15 questions. Questions in the Very Difficult and Difficult categories have the same percentage, which is 26.67% or 4 out of 15 questions. As for questions in the Very Easy category, they have the smallest percentage, which is 13.33% or 2 out of 15 questions.

Table 3. Item Difficulty Level Categories

Measure value (logit)	Interpretation of item difficulty
Measure logit > SD logit	Very difficult
0 ≤ Measure logit ≤ SD logit	difficult
– SD logit ≤ Measure logit ≤ 0	Easy
Measure logit < – SD logit	Very Easy

Table 4. Results of Item Difficulty Level Analysis

Measure value (logit)	Interpretation of item difficulty	Question item number	Percentage
Measure logit > 0,90	Very difficult	3.1; 3.3; 4.1; 4.2	26,67%
0 ≤ *Measure logit* ≤ 0,90	difficult	1.1; 2.3; 2.4; 2.5	26,67%
– 0,90 ≤ *Measure logit* ≤ 0	Easy	1.3; 1.4; 2.2; 3.2; 4.3	33,33%
Measure logit < – 0,90	Very Easy	1.2; 2.1	13,33%

Next is the analysis of instrument reliability. Respondent reliability or Person Reliability shows the consistency of respondent answers, while item reliability or Item Reliability shows the consistency of item questions during measurement. Meanwhile, the reliability of the interaction between person and item as a whole is seen from the Cronbach Alpha value. The categorization of each reliability value is based on Sumintono and Widhiarso (2015). The results of the reliability analysis of the developed question instrument can be seen in Table 5.

Table 5. Results of instrument reliability analysis

Criteria	Reliability value	Category
Person reliability	0,79	Adequate
Item reliability	0,99	Special
Cronbach alpha	0,77	Good

CONCLUSION

The results of the study showed that the developed questions had an ideal percentage of 87% (Very Good) according to the reviewer and 71% (Good) according to the students. The number of valid items based on the item suitability test was 15 items. A total of 10 questions had a Very Good discrimination power category, 3 questions were Good, 1 question was Sufficient, and 1 question was Not Able to Discriminate. The results of the difficulty level test obtained 26.67% of questions were Very Difficult, 26.67% of questions were Difficult, 33.33% of questions were Easy, and 13.33% of questions were Very Easy. The Cronbach Alpha reliability value of the questions was 0.77 with a Good category. The SSI-based learning outcome test instrument developed can be used to measure the scientific explanation skills of high school students in acid-base material. This instrument can also be used as an example in compiling SSI-based questions or questions to measure students' scientific explanation skills. Thus, students can practice to improve their scientific explanation skills. The limitation of this study is that the trial class was not given special treatment to train scientific explanation due to time constraints, so the results of the empirical trial were only based on the assumption that students' learning activities met the standards for measuring scientific explanation.

REFERENCES

Agnia, A. N., Permanasari, A., & Hernani, H. (2021). Uji Kelayakan Modul Asam-Basa Berbasis *Socioscientific Issues* dan Berorientasi Literasi Sains. *Jurnal Riset dan Praktik Pendidikan Kimia. 9(1).* 1-8.

Alagumalai, S., Curtis, D. D., & Hungi, N. (2005). *Applied Rasch Measurement: A Book of Exemplars*. Dordrecht: Springer.

Azwar, S. (2011). *Metode Penelitian.* Yogyakarta: Pustaka Pelajar.

Cahyarini, A., Rahayu, S., & Yahmin, Y. (2016). The Effect of 5E Learning Cycle Instructional Model Using Socioscientific Issues (SSI) Learning

Context on Students' Critical Thinking. *Jurnal Pendidikan IPA Indonesia. 5(2).* 222-229.

Fasce, A., & Picó, A. (2019). Science as a Vaccine: The Relation Between Scientific Literacy and Unwarranted Beliefs. *Science & Education. 28(7).* 109-125.

Howell, E. L., & Brossard, D. (2021, April). (Mis)informed About What? What it Means to be a Science-Literate Citizen in a Digital World. *Proceedings of the National Academy of Sciences*. Gainesville.

McNeill, K. L., & Krajcik, J. (2008). Scientific Explanations: Characterizing and Evaluating the Effects of Teachers' Instructional Practices on Student Learning. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching. 45(1).* 53-78.

Mubarak, S., Susilaningsih, E., & Cahyono, E. (2016). Pengembangan Tes Diagnostik Three Tier Multiple Choice Untuk Mengidentifikasi Miskonsepsi Peserta Didik Kelas XI. *Journal of Innovative Science. 5(2)*. 101-110.

Mukhadis, A. (2013). Sosok Manusia Indonesia Unggul dan Berkarakter dalam Bidang Teknologi sebagai Tuntutan Hidup di Era Globalisasi. *Jurnal Pendidikan Karakter. 4(2).* 115-136.

[NRC]. National Research Council. (2011). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington DC: The National Academic Press.

[OECD]. Organisation for Economic Operation and Development. (2023). *PISA 2022 Results: Combined Executive Summaries*. Paris: OECD Publishing.

Pinzino, D. W. (2012). *Socioscientific Issues: A Path towards Advanced Scientific Literacy and Improved Conceptual Understanding of Socially Controversial Scientific Theories*. (Tesis). University of South Florida, Tampa.

Rahayu, S. (2019, Juni). Socio-Scientific Issues (SSI) in Chemistry Education: Enhancing Both Students' Chemical Literacy & Transferable Skills. *Journal of Physics: Conference Series (Vol. 1227, No. 1, p. 012008).* Jawa Timur.

Sadler, T. D. (2004). Informal Reasoning Regarding Socioscientific Issues: A Critical Review of Research. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching. 41(5).* 513-536.

Sadler, T. D. (Ed.). (2011). *Socio-Scientific Issues in the Classroom: Teaching, Learning and Research (Vol. 39).* New York: Springer Science & Business Media.

Sumintono, B. & Widhiarso, W. (2015). *Aplikasi Pemodelan Rasch pada Assessment Pendidikan*. Cimahi: Trim Komunikata.

Wijaya, E. Y., Sudjimat, D. A., Nyoto, A., & Malang, U. N. (2016, September). Transformasi Pendidikan Abad 21 sebagai Tuntutan Pengembangan Sumber Daya Manusia di Era Global. *Prosiding Seminar Nasional Pendidikan Matematika I*. Malang.

World Economic Forum. (2015). *New Vision for Education*. Geneva: World Economic Forum.