Assessing Student Skills in Socio-Scientific Issue Decision-Making using RASCH Modeling

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Abstract. Making accurate and scientific decisions is one of the high-level thinking skills that students need in the problem-solving process. This skill refers to the practice of thinking to make decisions based on certain considerations. This consideration is interpreted as the skill of students using their knowledge to solve problems and is therefore subjective. This study aims to assess students' skills in making social-scientific issue (SSI) decisions using the Partial Credit Model (PCM) analysis approach of the Rasch model. This approach is based on individual-centered statistics, which allows researchers to estimate logit measures of student and item skills. The respondents were 121 chemistry students, who were asked to provide written responses to 18 open-ended questions. Responses were scored using a rubric, which was designed to measure the level of SSI decision-making skills. The study found that the SSI decision-making level of almost half of the students tended to be moderate, especially in considering options and strategies, while more than half tended to be at a low level, especially in giving consideration based on criteria. This finding reinforces the conclusion that in making SSI decisions, all respondents tend not to be based on consideration of the scientific knowledge they have learned.

Keywords: students' skills, social-scientific issue, rasch model analysis, high-level thinking skills

1 Introduction

In science classes, one of the key competencies in determining the meaningfulness of social-scientific issue (SSI)-based learning is accurate and scientific decision-making skills [16]. This skill is one of the higher-order thinking practices needed by students in the problem-solving process, especially in negotiating SSI solutions based on consideration or certain criteria [18]. The consideration aspect in this context is interpreted as the skill of students using their knowledge to solve problems, and therefore its nature becomes subjective, related to the values possessed or believed by students, as decision-makers [9]. The consideration aspect is closely related to learning actions or behaviors that need to be done before students make decisions. In this case, students need to prepare a careful strategy or plan in choosing something among several options by considering several alternatives [1, 23]. Thus it can be said that the decision-making strategy is a plan that has been prepared by students well to take action in choosing something among several choices.

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Conceptually, decision-making refers to the process of choosing the best option among several available alternatives. This process is referred to as consideration, which cannot take place intuitively. The process of consideration tends to require the practice of reflective and evaluative thinking about ethically feasible courses of action, to several criteria/attributes inherent to the SSI context. This consideration process is known as "trade-off," which is the stage of weighing the advantages and disadvantages of each available option based on certain criteria/attributes, based on scientific knowledge and personal values, and is the core of the decision-making process [19]. In the context of this study, students' decision-making is assessed based on their ability to use "trade-offs", which can be described as compensatory and non-compensatory decision-making strategies. A compensatory decision-making strategy is decision-making based on the positive aspects of a choice that can also compensate for the negative aspects of the choice. As for the non-compensatory decision-making strategy, the term "cut-off" is used, which is characterized as the ability of student decision-making to focus on only one aspect [7].

In the science education curriculum in Indonesia, learning practices that emphasize the improvement of students' decision-making skills have been explicitly carried out using a constructivism-based approach, starting from science learning in elementary schools to universities [25]. This learning practice, more articulately negated, since the implementation of the "independent curriculum" in 2020, through the development of reasoning-based approaches or science projects, such as SSI. Unfortunately, so far, scientific information related to how students' learning progress in the aspect of decision-making, especially in using their science knowledge learned formally in class, as a basis for considering negotiating SSI solutions tends to be limited.

Substantively, this study is intended to assess students' consideration in making social-scientific issue (SSI) decisions, especially those related to their ability to use compensatory or non-compensatory strategies [17], to solve SSI-contextualized problems, including (a) the dangers of mercury use in cosmetics, (b) water hyacinth weeds in Lake Limboto, (c) the acid rain phenomenon, (d) the impact of detergent use, (e) the impact of reduced oxygen supply, and (f) the impact of steam power plants on the environment. Each student was asked to provide their responses for decision-making in each context of the SSI problem in three aspects, namely: making choices, describing the reasons for their choices, and explaining the criteria used for their choices. With this instrument, student decision-making can be manifested as a process of interpreting scientific social knowledge, based on selected actions in the real world [13]. This can have a long-term impact on shaping students' core competencies for participatory living in a democratic and pluralistic 21st-century society while promoting the achievement of the SDGs [1].

To assess students' consideration in decision-making in each SSI problem context, a decision-making assessment rubric is used, which consists of three aspects, namely: (a) starting the option, (b) describing the decision-making strategy, and (c) weighing criteria according to personal values [1, 7]. Each aspect is scored based on the decision-making level, viz: low (score 1), moderate (score 2), and high (score 3). The resulting data were analysed using Rasch's Partial Credit Model (PCM)? [7, 6, 12]. This approach is based on an individual-centered statistical approach, which allows researchers to estimate logit measures of student and item skills. There are two questions addressed in this study, namely: (1) Does the instrument measuring SSI decision-making skills used in this study fulfill the validity and reliability aspects of PCM Rasch? (2) Are there differences in student skills in SSI decision-making based on gender differences.

2 Method

2.1 Research Design

This study used a non-experimental quantitative research design, where students' SSI decision-making skills were considered as a measurable variable, using open-ended questions. There was no intervention or treatment of the respondents, which allowed them to have the ability to complete the questions in the instrument. The data generated is in the form of numbers in quantitative research, while the score on each item is obtained based on the criteria/categories on the rubric. The data collected was then analysed quantitatively using the Partial Credit Rasch Model analysis technique [6, 15].

2.2 Respondent

Table 1 presents the demographic profile of the respondents, 121 chemistry students from a university in Sulawesi, Indonesia. The age of the respondents was 16-17 years old, selected by convenience sampling technique. The research was conducted from April to September 2023. Concerning research principles and ethics, as well as Institutional Review Board (IRB) regulations, students who participated voluntarily in this study, have been asked for their consent. The identity of the students was kept confidential and the information obtained was only intended for the development of science [24].

Table 1. Demographic Profile of Respondents

Gender	Code	Respondent	Percentage (%)
Female	F	104	86%
Male	M	17	14%

2.3 Instrument and Procedure Development

The instrument was developed in four stages, namely defining the construct map, item design, outcome space, and assessment and measurement model [26]. The first stage, defining the construct map and substantive definition of the measured construct, namely the level of student skills in SSI decision-making (Table 2). This variable consists of six SSI contexts, where each context has three different items, in terms of determining the choice (O), description of reasons (D), and explanation of criteria (C).

Table 2. Construct Map

SSI context and items	Aspects of decision-making skills
A. The dangers of using mercury in cosmetics	
AO-1	Ability to make choices
AD-2	Able to describe the reasons for their choice
AC-3	Able to explain the criteria used
B. Water hyacinth weed in Limboto lake	
BO-4	Ability to make choices
BD-5	Able to describe the reasons for their choice
BC-6	Able to explain the criteria used
C. Acid rain phenomenon	
CO-7	Ability to make choices
CD-8	Able to describe the reasons for their choice
CC-9	Able to explain the criteria used
D. The impact of using detergents	
DO-10	Ability to make choices
DD-11	Able to describe the reasons for their choice
DC-12	Able to explain the criteria used
E. The impact of reduced oxygen supply	
EO-13	Ability to make choices
ED-14	Able to describe the reasons for their choice
EC-15	Able to explain the criteria used
F. The impact of steam power generation on the environment	
FO-16	Ability to make choices
FD-17	Able to describe the reasons for their choice
FC-18	Able to explain the criteria used

Information: O = option, D = description, C = criteria

The second stage is item design. There were six items in this test in the form of open-ended questions. Previously, the SSI context was presented as a problem, then several alternative decision-making options were given (Table 3). Respondents were asked to make their choice, then explain the reasons for making the choice, and explain in detail the criteria used as consideration in making the choice. This instrument was adapted from instruments developed by Eggert & Bögeholz (2009) and Ardwiyanti & Prasetyo (2021).

Table 3. Examples of Items on The Dangers of Using Mercury in Cosmetics

Read the narrative below!

Dangers of Mercury Use in Cosmetics

Mercury (Hg) is a naturally occurring element of the transition metal group, the only metal that is liquid at room temperature. According to Government Regulation (PP) Number 74 of 2001, mercury is categorized as a hazardous and toxic material with toxic, carcinogenic, and environmentally harmful characteristics. However, unlicensed cosmetics contain mercury which should not be used as a cosmetic ingredient. Mercury can be found in cosmetics, especially skincare. Most mercury is used as a skin-lightening cream in cosmetics. Researchers revealed that when applied to the face, the mercury will cause skin irritation, rashes, and discoloration, and can generally cause side effects shortly after use on sensitive skin. In the long run, mercury cosmetic products, if absorbed by the body, can cause mercury poisoning with toxicity to the kidneys and nervous system. The World Health Organization (WHO) states that the main side effect of mercury in skincare products is kidney damage. Today, mercury is often misused as one of the additives for cosmetic products. This cannot be separated from the perception that exists in society itself about white skin, considered to be the benchmark of beauty. To prevent the use of cosmetics containing mercury, it is possible to make some alternative decision options below.

Alternative Decision Options	Explanation/Reason for Decision
1. Choose cosmetic products carefully.	1. Each individual has different skin types, so choosing the right product is essential.
2. Check if the product is licensed.	2. Licensed products are regulated and ensure safety.
3. Learn more about dangerous products.	3. Knowing product content helps in identifying harmful cosmetics.

Question:

Based on the above narrative, you are faced with 3 options to avoid mercury cosmetics: (a) Which option do you think is most appropriate? (b) Explain your reasoning in detail.

The third stage is the decision-making assessment rubric. Based on the students' narrative responses to each SSI context, the characteristics of their answers to each item measured can be identified. These answer characteristics are identified as aspects of decision-making, which consist of (a) starting the option, (b) describing the decision-making strategy, and (c) weighing criteria according to personal values. Each of these aspects was rated for its decision-making level, namely low (score 1), moderate (score 2) and high (score 3).

The fourth stage is to define the relationship between the scores and the measured variables, using PCM Rasch measurement. PCM Rasch is a development of the dichotomous Rasch model [27, 22], for the characteristics of polynomous data [7, 3, 4]. The model is based on the assumption that partial success on a particular item is expressed by partial credit. In addition, responses that are given partial credit are hierarchical. This means that higher partial credit responses are qualitatively better than lower partial credit responses. This procedure is particularly useful for the assessment of procedural competencies, such as decision-making, where students' responses are not simply marked as correct or incorrect, but rather scored by category.

2.4 Data Analysis

The ordinal data of students' responses were transformed into interval data having the same logit scale, using WINSTEPS software version 4.5.5 [2, 14]. The result was a calibration of student ability level and item difficulty data in equal interval measures. Test development involves investigating evidence of reliability, statistical fit, and item quality testing. These are statistical techniques for data analysis in educational settings [20]. Item respondent pattern analysis was conducted in three stages: first, converting raw scores into interval measure scores, as well as analysing the effectiveness of the measurement instrument. Second, measuring differences in students' skills in SSI decision-making using the Differential Item Functioning (DIF) item test. Third, determine the level of student decision-making, using the mean and standard deviation of the logit value of items on each aspect of decision-making.

3 Result and Discussion

This section describes the results of the analysis of the validity and reliability of PCM Rasch measurements, and the results of the analysis of differences in student skills in SSI decision-making.

Q1. Do the instruments measuring SSI decision-making skills used in this study meet the validity and reliability aspects of PCM Rasch?

Item validity testing aims to estimate whether the test items used can measure what should be measured [21, 11]. This can be known by using the Fit item test. In using this item fit test, there are several criteria, including; outfit mean-square (MNSQ): $0.5 < y < 1.5$; outfit z-standard: $-2.0 < Z < +2.0$, point measure correlation (PTMEA Corr): $0.4 < x < 0.8$. PTMEA Corr is the correlation of item and person measure scores where the value must be positive and not close to zero [2]. If these criteria are not met, it can be said that the item is not good so it needs to be further examined. Table 4 presents the results of item validity testing.

Based on Table 4, it is known that almost all items meet the MNSQ Outfit criteria and there is no negative PT.MEA Corr. Some items do not meet one of the criteria, but it does not reduce the quality of the item. For example, items FO-16, EC-15, CC-9, DO-10, BC-6, CO-7 and AC-3 do not meet the MNSQ Outfit criteria, while items EC-15, CD-8, DD-11, BC-6, CC-9, FO-16, CO-7, BD-5, DO-10, EO-12, AC-3, BO-4, AO-1, AD-2, EO-13 and FC-18, do not meet the ZSTD outfit criteria. However, there were no items that did not meet all three item validity criteria, meaning that all items were still used for measurement.

Table 5 presents the summary of fit statistic data, based on the quality of the response pattern, as well as the interaction between person and item [10]. The test results indicate that the high item separation index (3.14 logits), and high item reliability index

Table 4. Item Fit Statistic: Measure Order

Item	M	Outfit		PTMEA Corr
		MNSQ	ZSTD	
AO-1	-.64	0.55	-4.1	0.28
AD-2	-.51	0.57	-4.0	0.42
C-3	-.87	1.73	4.7	0.66
BO-4	-.74	0.57	-3.9	0.38
BD-5	-.45	0.63	-3.3	0.53
BC-6	0.37	2.10	6.7	0.68
CO-7	-.51	0.43	-5.7	0.39
CD-8	-.10	0.59	-3.8	0.53
CC-9	0.66	1.82	5.7	0.70
DO-10	-.55	0.42	-5.8	0.43
DD-11	0.90	0.72	-2.5	0.58
DC-12	0.50	1.88	6.0	0.69
EO-13	-.51	0.54	-4.2	0.35
ED-14	0.12	0.88	-1.0	0.45
EC-15	1.34	1.82	5.6	0.68
FO-16	-.26	0.39	-6.4	0.30
FD-17	0.75	0.92	-0.6	0.36
FC-18	1.31	1.36	2.8	0.68

(.91 logits), are evidence of the students' skill level, and support the construct validity of the instrument [3, 14]. The higher the index (separation and reliability) of the item, the stronger the researcher's confidence about replicating the placement of the item on other suitable learners [3, 4, 14]. The results of the person separation index (2.10 logits) and the person reliability index (.82 logits) indicate a good sensitivity of the instrument in distinguishing students' skill levels in SSI decision-making. The student mean was -.23 logits, indicating that all respondents were considered to have skills below the test item mean (.00 logits). The standard deviation was 1.07 logits, indicating a wide dispersion of decision-making skills among students [3, 4, 14]. These various evidences suggest that the instrument has excellent validity and reliability [14, 8, 5].

Figure 1 is the Wight map. This map is used to determine the consistency of respondents' skill levels and items. From the map, it is known that all items can cover most of the distribution of students' skill levels. Students and items with the highest decision-making level are at the top; and conversely, students and items with the lowest decision-making level are at the bottom. The highest student logit measure was 2.61, and the lowest -3.20 logit. The item with the highest difficulty was EC-15 (1.34 logit), while the item with the lowest difficulty was AC-3 (-0.87 logit).

Q2. Are there differences in students' SSI decision-making skills based on gender?

Based on Wright's map, differences in item sizes can be identified, which reflect differences in students' skills in SSI decision-making. First, item size FO-16 $>$ AO-1 $>$ CO-7 $>$ DO-10 $>$ EO-13 $>$ BO-4, means that in the aspect of stating choices, item BO-4 is easier than item EO-13, and so on. This means that making choices in

Table 5. Summary of Fit Statistic

Measure	Student (N=121)	Item (N=18)
Mean	-0.23	0.00
Standard Error	0.11	0.16
Standard Deviation	1.07	0.63
Reliability	0.82	0.91
Infit mean-square	1.00	1.00
Outfit mean-square	0.99	0.99
Infit ZSTD	-0.1	-0.7
Outfit ZSTD	-0.2	-0.8
Separation Index	2.10	3.14
Cronbach Alpha (KR-20): 0.84		

context B (water hyacinth weeds in Limboto Lake) is easier than in context F (the impact of steam power plants on the environment). Second, items FD-17 > DD-11 > ED-14 > CD-8 > BD-5 > AD-2, means that in the aspect of explaining the reasons for the choices made, item AD-2 (the dangers of using mercury in cosmetics) is easier to explain than item BD-5 (water hyacinth weeds in Lake Limboto), and so on. In other words, students' skills in using "trade-offs" when explaining item AD-2 were better than when explaining item BD-5. This may happen because context A is more often done or encountered by students than context B. Third, item EC-15 > FC-18 > CC-9 > BC-6 > DC-12 > AC-3, means that in the aspect of explaining the criteria or values used as a consideration in decision-making, item AC-3 (the danger of using mercury in cosmetics) is easier than item DC-12 (the impact of using detergents), and so on. This means that decision-making based on criteria/values adopted by students is easier to do in context A, compared to context D, and so on. This tendency may be because context A is more often encountered by students than other contexts.

Figure 2 shows the DIF plots by gender concerning students' SSI decision-making skills. In terms of gender differences, the following differences can be identified. First, regarding the level of choice-making, male students tended to have the skill of stating more difficult choices, on items (DO-10 = FO-16) > (CO-7 = EO-13) > AO-1 > BO-4, while female students stated more difficult choices on items FO-16 > (CO-7 = EO-13) > DO-10 > AO-1 > BO-4. Male students found it more difficult to make choices on item DO-10 than female students, while female students found it more difficult to make choices on item FO-16 (the impact of steam power plants on the environment), compared to male students.

Second, for male students, in terms of describing the reasons for their decision choices, it is more difficult on items DD-11 > FD-17 > (ED-14 = CD-8) > AD-2 > BD-5, while for female students, it is more difficult to describe the reasons for their decision choices, on FD-17 > ED-14 > DD-11 > CD-8 > BD-5 > AD-2. Based on this evidence, the skills of male students in terms of explaining the reasons for the decisions they have made, are easier in the context of item BD-5 (water hyacinth weed in Lake Limboto); while female students are easier in the context of item AD-2 (the dangers of using mercury in cosmetics).

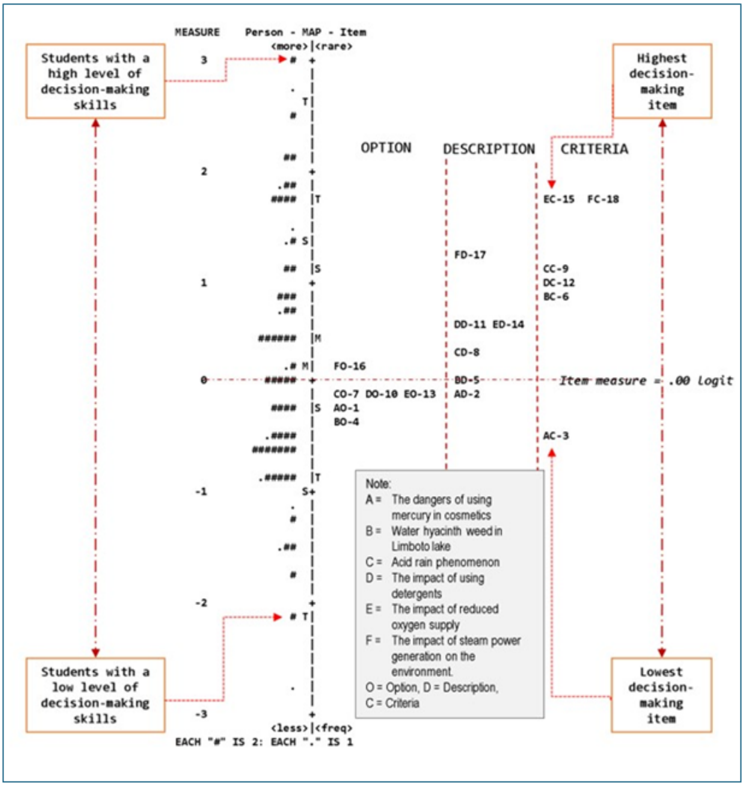

Fig. 1. Wright map

Third, there is a difference between male and female students in weighing the criteria or values they understand as the basis for decision-making. For male students, they have skills in weighing criteria based on personal values, more difficult in items EC-15 > (FC-18 = DC-12) > CC-9 > BC-6 > AC-3. Female students have skills in weighing criteria based on personal values, more difficult on items FC-18 > EC-15 > CC-9 > DC-12 > BC-6 > AC-3.

4 Conclusion

The results of this study indicate that the instrument used to measure students' skills in SSI decision-making is in accordance with PCM Rasch. In addition, it was found that students' skills in SSI decision-making, related to skills in making choices and explaining the reasons for the choices they made, were generally at a moderate level. Aspects of decision-making based on criteria or personal values that students believe in, tend to be at a low level, namely level 1. This finding is important evidence, related to the superiority of using PCM Rasch, in estimating the tendency of different levels of skills in SSI decision-making.

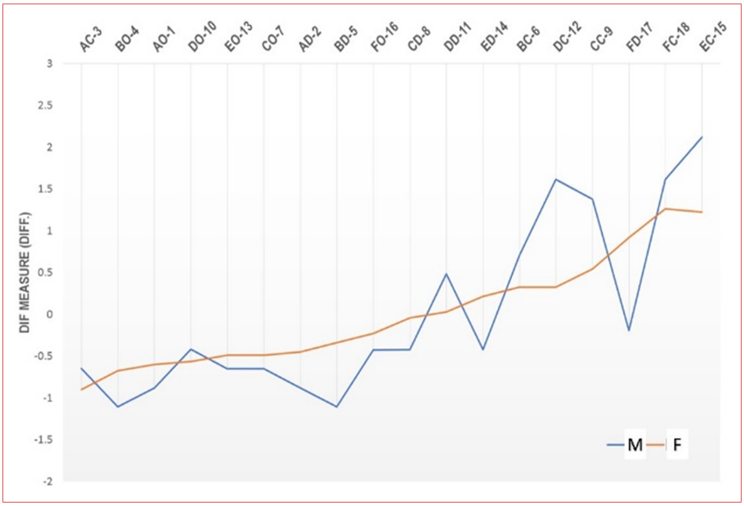

Fig. 2. Person DIF plot by gender

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References

1. Ardwiyanti, D., Prasetyo, Z.: Exploring students' decision-making ability in the context of socio-scientific issues. In: Proceedings of the 6th International Seminar on Science Education (ISSE, p. 541 (2021). DOI 10.2991/assehr.k.210326.096
2. Bond, T.: Applying the Rasch Model: Fundamental Measurement in the Human Sciences, third edn. Routledge (2015). DOI 10.4324/9781315814698. URL https://doi.org/10.4324/9781315814698
3. Boone, W., Staver, J.: Advances in rasch analyses in the human sciences. In: Advances in Rasch Analyses in the Human Sciences (2020). DOI 10.1007/978-3-030-43420-5
4. Boone, W., Yale, M., Staver, J.: Rasch analysis in the human sciences. In: Rasch Analysis in the Human Sciences (2014). DOI 10.1007/978-94-007-6857-4. URL https://doi.org/10.1007/978-94-007-6857-4
5. Chan, S., Looi, C., Sumintono, B.: Assessing computational thinking abilities among singapore secondary students: a rasch model measurement analysis. Journal of Computers in Education **8**(2) (2021). DOI 10.1007/s40692-020-00177-2. URL https://doi.org/10.1007/s40692-020-00177-2
6. Chi, S., Wang, Z., Liu, X.: Assessment of context-based chemistry problem-solving skills: Test design and results from ninth-grade students. Research in Science Education **53**(2), 295–318 (2023)

7. Eggert, S., Bögeholz, S.: Students' use of decision-making strategies with regard to socio-scientific issues: An application of the rasch partial credit model. Science Education **94**(2) (2010). DOI 10.1002/sce.20358. URL https://doi.org/10.1002/sce.20358
8. Fisher, W.: Rating scale instrument quality criteria. Rasch Measurement Transactions **21**(1) (2007)
9. Kinslow, A., Sadler, T., Nguyen, H.: Socio-scientific reasoning and environmental literacy in a field-based ecology class. Environmental Education Research **25**(3) (2019). DOI 10.1080/13504622.2018.1442418. URL https://doi.org/10.1080/13504622.2018.1442418
10. Laliyo, L., Hamdi, S., Pikoli, M., Abdullah, R., Panigoro, C.: Implementation of four-tier multiple-choice instruments based on the partial credit model in evaluating students' learning progress. European Journal of Educational Research **10**(2) (2021). DOI 10.12973/EU-JER.10.2.825
11. Laliyo, L., Sumintono, B., Panigoro, C.: Measuring changes in hydrolysis concept of students taught by inquiry model: stacking and racking analysis techniques in rasch model. Heliyon **8**(3) (2022). DOI 10.1016/j.heliyon.2022.e09126. URL https://doi.org/10.1016/j.heliyon.2022.e09126
12. Laliyo, L., Utina, R., Husain, R., Umar, M., Katili, M., Panigoro, C.: Evaluating students' ability in constructing scientific explanations on chemical phenomena. Eurasia Journal of Mathematics, Science and Technology Education **19**(9) (2023). DOI 10.29333/ejmste/13524. URL https://doi.org/10.29333/ejmste/13524
13. Leung, J.: Shifting the teaching beliefs of preservice science teachers about socioscientific issues in a teacher education course. International Journal of Science and Mathematics Education **20**(4) (2022). DOI 10.1007/s10763-021-10177-y. URL https://doi.org/10.1007/s10763-021-10177-y
14. Linacre, J.: A user's guide to winstep ministep rasch-model computer programs program manual 4.5.5 (2020). URL https://www.winsteps.com/winman/copyright.htm
15. Myford, C., Wolfe, E.: Detecting and measuring rater effects using many-facet rasch measurement: Part i. Journal of Applied Measurement **4**(4) (2003)
16. Owens, D., Sadler, T., Friedrichsen, P.: Teaching practices for enactment of socio-scientific issues instruction: an instrumental case study of an experienced biology teacher. Research in Science Education **51**(2) (2021). DOI 10.1007/s11165-018-9799-3. URL https://doi.org/10.1007/s11165-018-9799-3
17. Putriana, S., Diawati, C.: Pengaruh penggunaan isu sosiosaintifik untuk meningkatkan kemampuan metakognisi siswa pada materi larutan elektrolit dan non-elektrolit. Jurnal Pendidikan Dan Pembelajaran Kimia **7**(2) (2018)
18. Romine, W., Sadler, T., Kinslow, A.: Assessment of scientific literacy: Development and validation of the quantitative assessment of socio-scientific reasoning (quassr. Journal of Research in Science Teaching **54**(2) (2017). DOI 10.1002/tea.21368. URL https://doi.org/10.1002/tea.21368
19. Siegel, M.: High school students' decision making about sustainability. Environmental Education Research **12**(2) (2006). DOI 10.1080/13504620600689003. URL https://doi.org/10.1080/13504620600689003
20. Stevenson, C., Hickendorff, M., Resing, W., Heiser, W., Boeck, P.: Explanatory item response modeling of children's change on a dynamic test of analogical reasoning. Intelligence **41**(3) (2013). DOI 10.1016/j.intell.2013.01.003. URL https://doi.org/10.1016/j.intell.2013.01.003
21. Sumintono, B., Widhiarso, W.: Aplikasi model rasch untuk penelitian ilmu-ilmu sosial (2014)
22. Sumintono, B., Widhiarso, W.: Aplikasi pemodelan rasch pada asesmen pendidikan (2015)
23. Suwarno, S., Nusantara, T., Susiswo, S., Irawati, S.: The decision making strategy of prospective mathematics teachers in improving lots to be hots problem. Int. J. Nonlinear Anal. Appl **13** (2022)

24. Taber, K.: Ethical considerations of chemistry education research involving “human subjects. Chemistry Education Research and Practice **15**(ue 2)) (2014). DOI 10.1039/c4rp90003k. URL https://doi.org/10.1039/c4rp90003k
25. Widjanarko, B., Indraswari, R., Handayani, N., Kusumawati, A.: Critical thinking and decision-making skills regarding reproductive health among pupils in central java. International Journal of Public Health Science **12**(2) (2023). DOI 10.11591/ijphs.v12i2.22138. URL https://doi.org/10.11591/ijphs.v12i2.22138
26. Wilson, M.: Constructing measures: An item response modeling approach, second edition. In: Constructing Measures: An Item Response Modeling Approach. Second Edition (2023). DOI 10.4324/9781003286929. URL https://doi.org/10.4324/9781003286929
27. Wolins, L., Wright, B., Rasch, G.: Probabilistic models for some intelligence and attainment tests. Journal of the American Statistical Association **77**(377) (1982). DOI 10.2307/2287805