Research and Development in Education
(RaDEn)

Research Article

Validation of undergraduate science process skills tests: Rasch model analysis

Dian Tauhidah [a,1,*], Ndzani Latifatur Rofi'ah [a,2]

[a] Department of Biology Education, Faculty of Science and Technology, Universitas Islam Negeri Walisongo Semarang, Jl. Prof Hamka No.3-5, Semarang, Central Java 50185, Indonesia
[1] diantauhidah@walisongo.ac.id*; [2] ndzani.latifatur@walisongo.ac.id
* Corresponding author

Abstract: Science process skills are essential skills that students must possess. The science process skills test is needed to facilitate the measurement, so that test instruments are developed. The developed instrument needs to be validated before it is used. The purpose of this study was to validate the science process skills test instrument so that the developed instrument is valid and can be used to measure student abilities. The research was conducted using a quantitative descriptive method. The study population was all biology education students at UIN Walisongo Semarang-Indonesia, with a sample of 75 students selected using a purposive sampling technique. Data were analyzed using Rasch analysis which was divided into several categories, namely map analysis based on the items and research samples, analysis of the suitability of the items, analysis of separation and reliability, and items' analysis. The results of Rasch's study show that the developed science process skills test for students proves valid. Participating students have fairly even abilities. The results of the validation of the items did not reveal any misconceptions, the questions were on the abilities of the students, and the questions had varying difficulty ranges. The validity of the science process skills test shows that the test instrument can be used to measure students' science process skills. Test instruments can be used as learning evaluation instruments as well as analysis of student problems related to science process skills.

Keywords: higher education; instrument validation; Rasch; science process skills

Citation: Tauhidah, D., & Rofi'ah, N. L. (2023). Validation of undergraduate science process skills tests: Rasch model analysis. *Research and Development in Education (RaDEn), 3*(1), 51-57. https://doi.org/10.22219/raden.v3i1.24585

Received: 20 January 2023
Revised: 5 February 2023
Accepted: 14 February 2023
Published: 17 February 2023

1. Introduction

Higher education emphasizes student independence in acquiring knowledge according to their developmental age (Gow & Kember, 1990). Independent learning reduces student dependence on learning (Moore & Diehl, 2018), especially in the current internet era, which has begun to shift the role of the teacher in learning (Tan, 2003). Independent learning can be carried out well if the supporting factors can be fulfilled, such as guidance from the teacher, clear task guidelines, and collaborative support from other students in learning (Hockings et al., 2018). Some basic skills in learning also support the independent learning process. The basic skills most often measured in independent learning research are science process skills (Zydney & Warner, 2016).

Science process skills are one of the basic skills in learning that students need to master, especially in science learning. Learning science which is closely related to facts (Cohen, 2018) through practical work requires mastery of research skills (Turiman et al., 2012) and students' understanding of the scientific method to be able to formulate specific questions and then find answers systematically (Gravetter & Forzano, 2018). Students' mastery of research skills and scientific methods can be seen from their science process skills because science process skills are essential skills in carrying out experiments (Turiman et al., 2012).

Science process skills are thinking skills used to solve problems and discover knowledge (Lind, 1998). Science process skills have a relationship with learning outcomes (Mandasari et al., 2021), higher-order thinking skills, communication (Turiman et al., 2012), attitudes toward science (Zeidan & Jayosi, 2014), and creative thinking (Ozdemir & Dikici, 2016; Yildiz & Yildiz, 2021). Based on this, it is essential to continue to monitor the extent of science process skills possessed by students.

The test is an effective measurement tool to determine the extent to which students are capable because of its objective nature (Sappaile, 2007). The development of science process skills tests for students has been carried out previously (Tauhidah & Farikha, 2022) based on Yildiz and Yildiz (2021) science process skills indicators. As a form of test validation that has been developed, it is necessary to analyze the items, one of which is by using Rasch analysis. Rasch analysis is a technique that can be used to evaluate the function of a measurement instrument (Boone et al., 2014).

The purpose of this study was to validate the science process skills test so that the developed instrument is valid and can be used to measure student abilities. The development and validation of science process skills tests have been carried out by previous studies with various techniques, such as correlation tests (Nurhayati et al., 2019), SEM (Fitriani et al., 2019), and Rasch (Handayani & Iba, 2020), but there is no science process skills test for undergraduate students in biology learning has yet been conducted. The results of this study can be used as a reference instrument for measuring undergraduate students' science process skills in biology learning.

2. Materials and Methods

This study used a quantitative descriptive design with a population of all biology education students at UIN Walisongo Semarang. The sample used 75 students who were obtained using purposive sampling, namely students who were taking practicum courses. The previous science process skills test was developed from 9 indicators of science process skills owned by Yildiz and Yildiz (2021), then tested on a sample of 75 students. Data were analyzed using Rasch analysis to determine the validity of science process skills tests.

3. Results

The Rasch analysis used in this study was divided into several categories, namely map analysis based on items and research samples, analysis of the suitability of the items, analysis of separation and reliability, and items' analysis.

3.1. Item-Person Map Analysis

The results of item-person map analysis can be seen in Figure 1. Based on these data, the distribution of students' abilities was relatively equally, but the questions looked more accessible than the students' abilities. The most difficult item is in question number 6, and the easiest is in questions 2 and 3.

3.2 . Analysis of the Conformance Level of Items

Checking the conformity of the items using Rasch analysis can be viewed from the standardized z value (ZSTD) and the outfit Mean Square (MNSQ). The criteria for examining the items, according to Boone et al. (2014), questions are said to be appropriate when the MNSQ value is in the range of 0.5 - 1.5, and the ZSTD value is in the range -2.0 - 2.0. Following are the results of Rasch's analysis regarding the suitability of the items on the developed science process skills test (Figure 2).

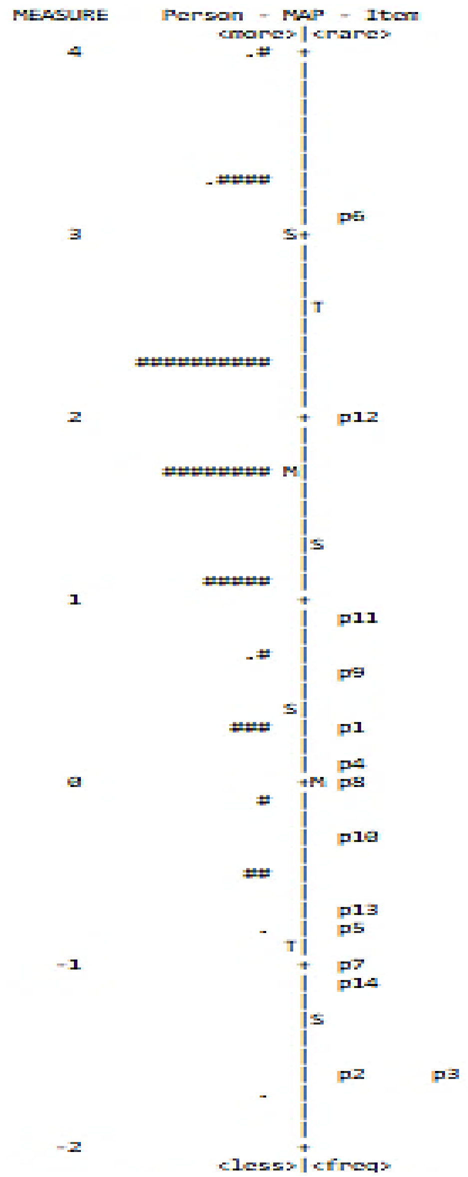

Figure 1. Item-Person Map

	TOTAL SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	56.9	75.0	.00	.36	.98	-.04	1.10	.29
SEM	3.9	.0	.36	.02	.02	.08	.10	.22
P.SD	14.1	.0	1.29	.07	.06	.29	.35	.78
S.SD	14.6	.0	1.34	.08	.07	.30	.37	.81
MAX.	70.0	75.0	3.14	.49	1.09	.44	1.78	1.63
MIN.	19.0	75.0	-1.57	.27	.84	-.46	.45	-.72
REAL RMSE .37 TRUE SD 1.24 SEPARATION 3.37 Item RELIABILITY .92								
MODEL RMSE .36 TRUE SD 1.24 SEPARATION 3.41 Item RELIABILITY .92								
S.E. OF Item MEAN = .36								

Figure 2. Analysis of ZSTD and MNSQ tests of science process skills for students

Based on the analysis above, it is known that the ZSTD value is 0.29, and the MNSQ value is 1.10. Based on the criteria of Boone et al. (2014), the items developed were appropriate, and there were no students' misconceptions about the items. The Bond and Fox (2015) criterion explains that the ideal MNSQ expected through Rasch analysis has a value of 1. A value that is less than one or more than 1 indicates a variation in the work on the questions. Based on the data above, the MNSQ infit value is 0.98, which indicates that the data has 2% less variation, and the MNSQ outfit value is 1.10, which indicates that the data has 10% more variation.

Meanwhile, the ZSTD value is expected to be close to 0 (zero). Based on the data above, the ZSTD infit value is -0.04, and the ZSTD outfit value is 0.29, which means that the ZSTD value is still close to 0 (zero). The analysis shows that the questions are appropriate, where students with high abilities can answer correctly, and students with low abilities can answer incorrectly.

3.3. Separation and Reliability Analysis

The following analysis is the measurement of separation and reliability. This analysis is used to analyze the distribution of items and persons presented in Figure 3.

Person	75 INPUT		75 MEASURED		INFIT		OUTFIT	
	TOTAL	COUNT	MEASURE	REALSE	IMNSQ	ZSTD	OMNSQ	ZSTD
MEAN	10.6	14.0	1.71	.91	.99	.0	1.10	.1
P.SD	2.3	.0	1.28	.31	.40	.9	1.04	.9
REAL RMSE	.96	TRUE SD	.84	SEPARATION	.88	Person	RELIABILITY	.43
Item	**14 INPUT**		**14 MEASURED**		**INFIT**		**OUTFIT**	
	TOTAL	COUNT	MEASURE	REALSE	IMNSQ	ZSTD	OMNSQ	ZSTD
MEAN	56.9	75.0	.00	.36	.98	.0	1.10	.3
P.SD	14.1	.0	1.29	.08	.06	.3	.35	.8
REAL RMSE	.37	TRUE SD	1.24	SEPARATION	3.37	Item	RELIABILITY	.92

Figure 3. Separation and reliability analysis

Based on Fisher's criteria (2018), an instrument is said to be good when it has a separation value of more than three and reliability of more than 0.8. Based on these data, the science process skills test item has a separation value of 3.37 and a reliability value of 0.92. This value indicates that the item questions have varying difficulty ranges. However, for the person (research respondents), the separation value was only 0.88 with a reliability value of 0.43 which indicated that the respondents were relatively homogeneous in their level of ability.

3.4. Analysis Question Item

The questions were also analyzed per question item to get more detailed validation results. The results of the analysis per item of questions are described in Figure 4.

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	JMLE MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMEASUR-AL CORR.	PTMEASUR-AL EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Item
6	19	75	3.14	.31	.97	-.12	1.37	1.10	.44	.46	81.9	79.0	p6
12	34	75	1.96	.27	.95	-.43	.97	-.09	.51	.48	72.2	69.4	p12
11	49	75	.89	.28	.99	-.04	1.03	.22	.47	.47	76.4	73.5	p11
9	53	75	.57	.29	.94	-.39	.89	-.44	.50	.46	80.6	76.2	p9
1	56	75	.32	.30	.92	-.46	.85	-.52	.50	.44	81.9	78.1	p1
4	58	75	.13	.31	.97	-.11	.83	-.56	.47	.43	79.2	79.9	p4
8	59	75	.03	.32	1.01	.14	1.48	1.51	.37	.43	83.3	80.8	p8
10	62	75	-.29	.34	1.06	.35	1.65	1.63	.33	.40	79.2	83.6	p10
13	65	75	-.67	.37	.94	-.19	.86	-.19	.41	.37	88.9	86.8	p13
5	66	75	-.82	.39	1.09	.44	1.14	.44	.30	.36	87.5	88.0	p5
7	67	75	-.97	.41	1.04	.24	.86	-.10	.33	.35	90.3	89.3	p7
14	68	75	-1.15	.43	1.04	.24	1.78	1.29	.28	.33	88.9	90.6	p14
2	70	75	-1.57	.49	1.01	.15	1.22	.53	.26	.29	91.7	93.1	p2
3	70	75	-1.57	.49	.84	-.34	.45	-.72	.41	.29	94.4	93.1	p3
MEAN	56.9	75.0	.00	.36	.98	-.04	1.10	.29			84.0	83.0	
P.SD	14.1	.0	1.29	.07	.06	.29	.35	.78			6.2	7.2	

Figure 4. Analysis question item

Measures in the Figure 4 show the order of difficulty of the questions. The more numerous the measure, the more complex the questions. Sumintono and Widhiarso (2015) categorizes the difficulty level of the item into four categories based on the measured value, namely very easy (less than -1), easy (-1 to 0), difficult (0 to 1), and very difficult (more than 1). Based on Rasch analysis data per item in the table above, there are two questions in the very difficult category (numbers 6 and 12), five questions in the difficult category (numbers 11, 9, 1, 4, and 8), four questions in the easy category (numbers 10, 13, 5, and 7), as well as three questions in the very easy category (numbers 14, 2, and 3).

4. Discussion

The results of the Rasch analysis show that the participating students have fairly even abilities. Even academic ability indicates if there are students with high, medium, and low academic abilities among research participants. Varied academic abilities can provide an advantage in the validation of the instruments carried out so that it can be seen how the response to the science process skills tests instrument testing in each student's academic abilities. Conditions in the classroom will naturally consist of students with varying academic abilities, so we need to choose the appropriate type of learning and measurement instruments (Suciono, 2021). The diversity of academic abilities can be influenced by students' economic conditions (Destin et al., 2019) and class climate (Wang et al., 2020).

The results of item validation on the science process skills test showed no misconceptions in the process. Misconceptions can affect students' understanding in taking tests (Prinz et al., 2019). Misconceptions often occur in prospective teacher students in science learning, including biology (Kumandaş et al., 2019; Soeharto et al., 2019), so it is essential to control student misconceptions in instrument trials.

The results related to the suitability of the items also show that the questions are in accordance with the student's abilities. Students with high abilities will tend to answer correctly, and vice versa; students with low abilities will tend to answer wrong. Analysis of the suitability of the items is essential to do so that the measurement results using this instrument explain how students' actual abilities are. A good instrument is an instrument that can identify the diversity of student abilities (Hamdu et al., 2020). The primary purpose of developing the instrument is to identify how the knowledge or skills previously possessed by students (Crisp, 2012) serve as the basis for preparing learning objectives (Van der Kleij et al., 2015). More broadly, even tests can provide input on efforts to improve the quality of education in schools (Haertel, 2013).

The developed science process skills test questions also have varying difficulty ranges based on the results of the Rasch analysis. A more detailed analysis per item of questions regarding the range of difficulty of the items showed similar results, where the range of difficulty of the items varied. Of all the items developed, there are questions with very difficult, difficult, easy, and very easy categories. This indicates that the test instrument developed has good validity. A problem difficulty level that is too high can frustrate students because of the difficulty in doing it, while a difficulty level that is too low can cause boredom in working on it (Hamdu et al., 2020). Question items that do not vary will also complicate the accuracy of classifying student abilities (Yan et al., 2016).

5. Conclusions

The science process skills test for students that was developed proved valid after being analyzed using Rasch analysis. Participants have fairly even abilities. The results of the validation of the items did not reveal any misconceptions, the questions were fit the abilities of the students, and the questions had varying difficulty ranges. The validity of the science process skills test shows that the test instrument can be used to measure students' science process skills. Test instruments can be used as learning evaluation instruments as well as analysis of student problems related to science process skills.

Author Contributions: Methodology, Dian T.; validation, Dian T., Ndzani L. R..; analysis, Dian T.; writing—original draft preparation, Dian T.; review and editing, Ndzani L. R.

6. References

Bond, T. G., & Fox, M. C. (2015). *Applying the Rasch model fundamental measurement in the human sciences third edition*. Routledge.

Boone, W. J., Staver, R. J., & Yale, S. M. (2014). *Rasch analysis in the human sciences*. Springer International Publishing.

Cohen, M. R. (2018). *Reason and nature*. Routledge. https://doi.org/10.4324/9780429459344

Crisp, G. T. (2012). Integrative assessment: Reframing assessment practice for current and future learning. *Assessment & Evaluation in Higher Education*, *37*(1), 33–43. https://doi.org/10.1080/02602938.2010.494234

Destin, M., Hanselman, P., Buontempo, J., Tipton, E., & Yeager, D. S. (2019). Do student mindsets differ by socioeconomic status and explain disparities in academic achievement in the United States? *AERA Open*, *5*(3), 233285841985770. https://doi.org/10.1177/2332858419857706

Fisher, W. P. J. (2018). Rasch measurement: Transactions of the Rasch measurement SIG. *American Educational Research Association.*, *21*(1), 1087–1096.

Fitriani, L., Ramalis, T. R., & Efendi, R. (2019). Karakterisasi tes keterampilan proses sains materi fluida statis berdasarkan teori respon butir. *Omega: Jurnal Fisika Dan Pendidikan Fisika*, *5*(2), 27-32. https://doi.org/10.31758/OmegaJPhysPhysEduc.v5i2.27

Gow, L., & Kember, D. (1990). Does higher education promote independent learning? *Higher Education*, *19*(3), 307–322. https://doi.org/10.1007/BF00133895

Gravetter, F. J., & Forzano, L.-A. B. (2018). *Research methods for the behavioral sciences*. Cengage Learning.

Haertel, E. (2013). How is testing supposed to improve schooling? *Measurement: Interdisciplinary Research & Perspective*, *11*(1–2), 1–18. https://doi.org/10.1080/15366367.2013.783752

Hamdu, G., Fuadi, F. N., Yulianto, A., & Akhirani, Y. S. (2020). Items quality analysis using Rasch model to measure elementary school students' critical thinking skill on STEM learning. *JPI (Jurnal Pendidikan Indonesia)*, *9*(1), 61-74. https://doi.org/10.23887/jpi-undiksha.v9i1.20884

Handayani, S. L., & Iba, K. (2020). Karakteristik tes keterampilan proses sains: validitas, reliabilitas, tingkat kesukaran dan daya pembeda soal. *Publikasi Pendidikan*, *10*(2), 100-106. https://doi.org/10.26858/publikan.v10i2.13051

Hockings, C., Thomas, L., Ottaway, J., & Jones, R. (2018). Independent learning – what we do when you're not there. *Teaching in Higher Education*, *23*(2), 145–161. https://doi.org/10.1080/13562517.2017.1332031

Kumandaş, B., Ateskan, A., & Lane, J. (2019). Misconceptions in biology: A meta-synthesis study of research, 2000–2014. *Journal of Biological Education*, *53*(4), 350–364. https://doi.org/10.1080/00219266.2018.1490798

Lind, K. K. (1998). Science in early childhood: Developing and acquring fundamental concepts and skills. *Retrieved from ERIC (ED418777)*, 85. http://files.eric.ed.gov/fulltext/ED418777.pdf

Mandasari, F., Iwan, I., & Damopolii, I. (2021). The relationship between science process skills and biology learning outcome. *Journal of Research in Instructional*, *1*(1), 23–32. https://doi.org/10.30862/jri.v1i1.9

Moore, M. G., & Diehl, W. C. (Eds.). (2018). *Handbook of distance education*. Routledge. https://doi.org/10.4324/9781315296135

Nurhayati, Saputri, D. F., & Assegaf, S. L. H. (2019). Pengembangan instrumen tes keterampilan proses sains pada materi fisika untuk siswa sekolah menengah pertama. *Edukasi: Jurnal*

Pendidikan, *17*(2), 145-158. https://doi.org/10.31571/edukasi.v17i2.1250

Ozdemir, G., & Dikici, A. (2016). Relationships between scientific process skills and scientific creativity: mediating role of nature of science knowledge. *Journal of Education in Science, Environment and Health*, *3*(1), 52–52. https://doi.org/10.21891/jeseh.275696

Prinz, A., Golke, S., & Wittwer, J. (2019). Refutation texts compensate for detrimental effects of misconceptions on comprehension and metacomprehension accuracy and support transfer. *Journal of Educational Psychology*, *111*(6), 957–981. https://doi.org/10.1037/edu0000329

Sappaile, B. I. (2007). Konsep instrumen penelitian pendidikan. *Jurnal Pendidikan Dan Kebudayaan*, *13*(66), 379–391. https://doi.org/10.24832/jpnk.v13i66.356

Soeharto, S., Csapó, B., Sarimanah, E., Dewi, F. I., & Sabri, T. (2019). A review of students' common misconceptions in science and their diagnostic assessment tools. *Jurnal Pendidikan IPA Indonesia*, *8*(2), 247-266. https://doi.org/10.15294/jpii.v8i2.18649

Suciono, W. (2021). *Berpikir kritis*. Penerbit Adab.

Sumintono, B., & Widhiarso, W. (2015). *Aplikasi pemodelan Rasch pada assessment pendidikan*. Trim Komunikata.

Tan, O.-S. (2003). *Problem-based learning innovation: Using Problems to power learning in the 21st century*. Cengage Learning.

Tauhidah, D., & Farikha, Y. (2022). Analisis keterampilan proses sains mahasiswa selama praktikum daring. *Jurnal Education and Development Institut Pendidikan Tapanuli Selatan*, *10*(2), 240–249. https://journal.ipts.ac.id/index.php/ED/article/view/3481

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. https://doi.org/10.1016/j.sbspro.2012.09.253

Van der Kleij, F. M., Vermeulen, J. A., Schildkamp, K., & Eggen, T. J. H. M. (2015). Integrating data-based decision making, assessment for learning and diagnostic testing in formative assessment. *Assessment in Education: Principles, Policy & Practice*, *22*(3), 324–343. https://doi.org/10.1080/0969594X.2014.999024

Wang, M.-T., L. Degol, J., Amemiya, J., Parr, A., & Guo, J. (2020). Classroom climate and children's academic and psychological wellbeing: A systematic review and meta-analysis. *Developmental Review*, *57*, 100912. https://doi.org/10.1016/j.dr.2020.100912

Yan, D., von Davier, A. A., & Lewis, C. (Eds.). (2016). *Computerized multistage testing*. Chapman and Hall/CRC. https://doi.org/10.1201/b16858

Yildiz, C., & Yildiz, T. G. (2021). Exploring the relationship between creative thinking and scientific process skills of preschool children. *Thinking Skills and Creativity*, *39*, 100795. https://doi.org/10.1016/j.tsc.2021.100795

Zeidan, A. H., & Jayosi, M. R. (2014). Science process skills and attitudes toward science among palestinian secondary school students. *World Journal of Education*, *5*(1), 13-24. https://doi.org/10.5430/wje.v5n1p13

Zydney, J. M., & Warner, Z. (2016). Mobile apps for science learning: Review of research. *Computers & Education*, *94*, 1–17. https://doi.org/10.1016/j.compedu.2015.11.001