JPPIPA 11(8) (2025)

Jurnal Penelitian Pendidikan IPA

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

Development of Problem-Solving Ability Assessment Instrument in Chemical Calculation Concept

Sri Rubiati[1*], Isana Supiah Yosephine Louise[1]

[1] Department of Chemistry Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia.

Received: May 20, 2025
Revised: July 03, 2025
Accepted: August 25, 2025
Published: August 31, 2025

Corresponding Author:
Sri Rubiati
srirubiati.2021@student.uny.ac.id

DOI: 10.29303/jppipa.v11i8.11990

Abstract: Measuring students' abilities through assessment instruments correctly is very useful so that teachers can guide students effectively. The development of assessment instruments often does not follow formal and scientific preparation steps, so that valid instruments are needed and measurements of problem-solving abilities can produce accurate and correct measurements. Problem solving is a complex activity involving broad objectives in the form of understanding problems, developing strategies, implementing strategies and interpreting results. This study aims to develop an assessment instrument for problem solving skills and to determine the characteristics of the problems solving skills assessment instrument in the concept of chemical calculations. This study uses a 4D development model consisting of the define, design, develop and disseminate stages. The test subjects in this study were 210 high school students. The results of the study showed that: The assessment instrument developed was in the form of 13 descriptive questions arranged based on indicators of problems solving skills; The assessment instrument fits the Rasch PCM 1-PL model in the range of 0.84 logit - 1.16 logit (valid), the reliability estimate is 0.62 reliable category and the level of difficulty of the questions - 0.38 logit to 1.00 logit (good category).

Keywords: Assessment instruments; Chemistry calculation; Problem solving

Introduction

Assessment of learning outcomes is an important part of the learning process, where educators can find out the abilities of students, the accuracy of the teaching methods used, and the success of students in achieving competence, so that assessment instruments are needed that can encourage students to develop these abilities and be able to follow the development of knowledge and technology (Arsiana et al., 2022). Problem-solving skills are important for students in facing the flow of globalization, so it is necessary to develop instruments that can be used as measuring tools. The weight or quality of the assessment can be seen from the quality of the instrument used (Ibarra-Sáiz et al., 2021). Problem-solving skills are students' skills in using cognitive processes to understand and solve problems without direct and explicit solutions (Ling et al., 2024). A problem is defined as a situation that makes an individual feel uncomfortable and a reasonable solution is needed to achieve balance (Hubbart, 2023). A problem is also defined as a person, situation, or thing that needs attention and needs to be addressed. The term problem is related to the word solve which experts call problem solving (Wïcaksono & Korom, 2022).

Problem solving is one of the important scopes so that it becomes one of the goals of teaching (learning process) because it trains critical, logical, and creative thinking skills (Kwangmuang et al., 2021). Problem solving prioritizes the process carried out by students in solving problems rather than the final answer. Problem solving is often challenging for students because they do

How to Cite:
Rubiati, S., & Louise, I. S. Y. (2025). Development of Problem-Solving Ability Assessment Instrument in Chemical Calculation Concept. *Jurnal Penelitian Pendidikan IPA*, *11*(8), 292–297. https://doi.org/10.29303/jppipa.v11i8.11990

not understand the problems solving process (Sinaga et al., 2023). The intelligence of students can be seen from their skills in solving a problem, such as finding solutions and solving problems in everyday life that are around them. The problem-solving ability of students greatly influences the thinking process of students in solving a problem they find (Purwandari et al., 2022). Problem solving has indicators, namely: identifying problems (known, asked and other things needed); formulating or compiling models; implementing strategies; and interpreting the results (Ananda et al., 2023). Problem-solving indicators according to Daulay et al. (2019), consist of four indicators, namely understanding the problem, developing a strategy, implementing the strategy and interpreting the results. Chemical calculations are one of the main topics of chemistry that can be taught through the problem-solving method, because there are many concepts, calculations, and their applications in life (Surif et al., 2014).

Chemical calculations are material that is difficult for students to understand because they have many complex concepts and calculations, which have an impact on the low problem-solving abilities of students in chemistry learning (Alkan, 2021). Measuring students' abilities through assessment instruments correctly is very useful so that teachers can guide students effectively. The development of assessment instruments often does not follow formal and scientific preparation steps, so valid instruments are needed and measurements regarding problem-solving abilities can produce precise and correct measurements (Darmawan et al., 2020). An instrument can be interpreted as a measuring tool used to determine the value of an object or collect information or data about a variable (Febrianti et al., 2024). Tests as assessment instruments in the field of education are methods used to determine students' ability to complete certain tasks or demonstrate mastery of skills or content knowledge (Adom et al., 2020).

A good test instrument must be able to measure the object being measured with consistent measurement results (Setyaedhi, 2024; Shirali et al., 2018). Therefore, a valid and reliable test instrument is needed (Marar et al., 2023). An instrument can be said to be valid if it measures what should be measured or accurately measures the specified variables. Reliable refers to how well the items in a research instrument consistently measure what the item should measure, meaning that if the measurement is given several times, the results will remain consistent (Cheung et al., 2024). A proper and factual assessment can be obtained with questions or problems that refer to the abilities to be measured. Inaccurate measurement results are produced by poor instruments, therefore appropriate instrument design methods can carry out proper evaluations. The measurement results obtained must include a small error, the level of this error is closely related to the measurement used (Chen et al., 2017). Based on this, the researcher intends to develop an assessment instrument for students' problem-solving abilities, especially in the concept of chemical calculations.

Method

This research is a development researchs with a quantitative approach that aims to produce a product, namely an assessment instrument for problem-solving ability in the concept of chemical calculations. This research is a type of Research and Development (R&D) development research using the 4D development model. This development model consists of several stages, namely define, design, develop and disseminate (Astarina et al., 2024). The research was conducted at SMA Negeri 1 Taman, Sidoarjo, East Java, Indonesia. The subjects of the trial were 210 students of class XII MIPA. The sampling technique used was the random sampling technique. Data collection techniques used in this study were interviews, questionnaires and test techniques. Data collection instruments were in the form of interview guidelines, item validation sheets, and problem-solving ability assessment instruments (13 descriptive questions).

The procedure and stages of instrument development carried out in this study consisted of four stages, namely: define (preliminary study); design (determination of instrument objectives, determination of materials, preparation of grids); develop (Writing questions and scoring guidelines, expert validation, improvement, Trial, results); and disseminate (product distribution in schools and article publication). The data analysis techniques of this study are qualitative and quantitative data analysis. Qualitative analysis is the content validity of the assessment results carried out by experts or expert judgment. Qualitative analysis is carried out by analyzing all instruments developed. Quantitative analysis is used to determine the characteristics of the instruments in this development research with empirical data from the results of the instrument trial on students. Quantitative data analysis is carried out on all instruments developed in the study which include the suitability of the question items (instruments) and item validity (construct validity, reliability, level of difficulty of the question items.

The instrument trial analysis uses the Rasch PCM 1-PL model with the help of the Quest program. The results obtained are: the suitability of the items and and item validity from the infit mean square (infit MNSQ) and outfit-t values, with the MNSQ infit criteria being accepted between 0.77 logit - 1.33 logit and the outfit-t value more ≤ 2.00 (Boone et al., 2014); reliability value of

the reliability of item estimates, with the criteria: 0.80-1.00 (very reliable); 0.60-0.80 (reliable); 0.40-0.60 (quite reliable); 0.20-0.40 (unreliable), 0.00--0.20 (very unreliable) and the level of difficulty of the questions is categorized into easy, moderate and difficult, with the criteria of more than +2.0 (difficult), +2.00 to -2.00 (medium), less than -2.0 (easy).

Result and Discussion

Product Results

Analysis The initial stage of product development is carried out by determining the objectives of the instrument, determining the material and compiling the instrument grid. The purpose of the instrument is to measure students' problem-solving abilities regarding the concept of chemical calculations. The compilation of the instrument grid refers to basic competencies, main materials, learning indicators and aspects of problem solving in the concept of chemical calculations (Anisah et al., 2025; Agustini et al., 2021). Furthermore, the writing of test instruments (question items) and scoring guidelines are carried out. The question instruments given refer to the problem-solving indicators according to Rohmah et al. (2017) and Cavallo et al. (2021), which consist of four indicators, namely understanding the problem, formulating strategies, implementing strategies and interpreting results. The initial product of the problem-solving ability assessment instrument consists of 13 descriptive questions.

The instrument product that has been formed is validated by experts or expert judgment and its feasibility is assessed by chemistry teachers who aim to produce an instrument that is valid in terms of content so that it can be used for trials. After that, the instrument product is revised by researchers who will be used for trials in schools. The validation results show that the instrument is valid and feasible to be used to measure students' problem-solving abilities. Product Trial Results the purpose of the product trial analysis is to obtain information related to the characteristics of the instrument being developed. The instrument product trial was conducted in class XII with a time allocation of 2 x 45 minutes (90 minutes). The trial data were analyzed using the PCM-1PL model assisted by the Quest program by looking at the item fit, reliability and item difficulty level. PCM is a scoring model to see test participants in the steps of solving questions sequentially and correctly. 1-PL or Logistic 1 Parameter is a Rasch model that uses 1 item parameter (item difficulty level) (Ofianto & Suhartono, 2015; Robinson et al., 2019; Aryadoust et al., 2019), was developed based on the Rasch model used for polytomous data.

This model is used in contexts where responses to items are not coded dichotomously (0/1), but rather in several score levels, such as 0, 1, 2, etc. PCM assumes that the score categories are ordinal, so that each category reflects a different level of ability of the respondents (Aybek & Demirtasli, 2017; Axelsson et al., 2022; Laliyo et al., 2023; Stefana et al., 2025). The analysis of item suitability or fit aims to determine whether the item analysis model used in this study can predict the response of each student. Item fit is used to see or determine whether a question item in carrying out measurements has a normal function or not. The item fits the Rasch model if the MNSQ infit value is in the range of 0.77 logit - 1.33 logit and the outfit-t value is less than 2.00 (≤ 2.00) (Boone et al., 2014). The results of the item analysis are shown in Table 1.

Table 1. Results of the Item Suitability Analysis (Item Fit)

Item	Infit MNSQ	Outfit-t	Decision
1	1.14	0.2	Fit
2	0.95	-0.5	Fit
3	1.01	0.2	Fit
4	1.16	1.9	Fit
5	1.00	0.1	Fit
6	1.09	1.0	Fit
7	0.96	-0.5	Fit
8	1.03	0.7	Fit
9	0.90	-1.2	Fit
10	0.87	-1.3	Fit
11	1.02	0.1	Fit
12	0.95	-0.4	Fit
13	0.84	-1.0	Fit

Based on Table 1, the test results of the test items show that the MNSQ infit value is in the range of 0.84 logit to 1.16 logit, which is within the acceptable limit of the MNSQ infit value (0.77 - 1.33) and the outfit-t value on all test items shows a value smaller than 2.00 (≤ 2.00). Therefore, the assessment instrument developed is valid and fits the Rasch model. In addition, the results of the test item fit analysis can be seen in the map file. The map file shows that all the items are on the dotted line so it can be concluded that all the items fit the Rasch model and the results of the analysis of the level of fit of the items show that all the items of the solving ability assessment are in the good category or valid for use in conducting research. The map file can be seen in Figure 1.

Reliability is used to prove the consistency of measurement results. Reliability can be analyzed using Quest by looking at the summary of item estimates and summary of case estimates. The reliability coefficient categories according to Taber (2018) and Zakariya (2022), are 0.80-1.00 (very reliable); 0.60-0.80 (reliable); 0.40-0.60 (quite reliable); 0.20-0.40 (unreliable), 0.00 - 0.20 (very unreliable), based on the results of the trial, the reliability coefficient value of the instrument was

obtained from the summary of items estimates of 0.68, so it is included in the reliable criteria. Student abilities can also be seen in the summary of case estimates with the following criteria: >1.00 (high ability), -1.00 to -1.00 (moderate ability) and <-1.00 (low ability) (Setyawarno, 2017). Base on the reliability value of case estimates, the student's ability is moderate. Analysis of item difficulty levels aims to determine the level of the items, which are categorized into easy, medium and difficult. Good questions are in the medium category (not too easy and not too difficult). Items are said to be good if they have a difficulty index between -2.0 logit to +2.0 logit, items of more than +2.0 are said to be difficult and less than -2.0 are said to be easy (Tesio et al., 2024; Tyas et al., 2020). The results of the analysis of the difficulty level of the questions are shown in Table 2.

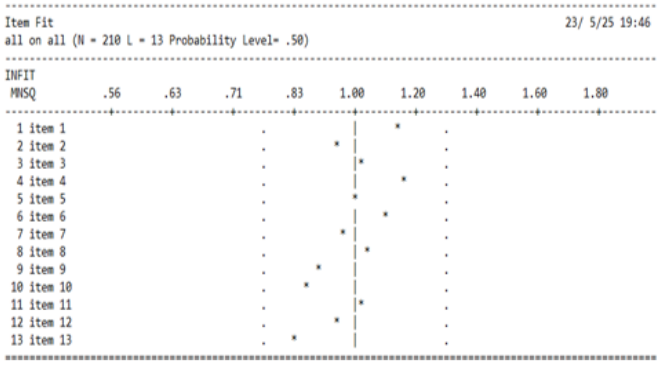

Figure 1. Instrument map file

Based on Table 2, the level of difficulty of the test items is -0.38 logit to 1.00 logit which shows that all test items have a level of difficulty in the good category. Based on the results of the trial, the developed instrument is feasible to be used to measure students' problem-solving abilities in the concept of chemical calculations (Amelia et al., 2022; Muhsin et al., 2023).

Table 2. Item Difficulty Level

Item	Difficulty Level	Category
1	-0.12	Medium
2	1.00	Difficult
3	-0.25	Medium
4	0.01	Medium
5	-0.38	Medium
6	-0.18	Medium
7	0.10	Medium
8	0.07	Medium
9	0.89	Difficult
10	0.59	Difficult
11	0.18	Medium
12	-0.35	Medium
13	-0.10	Medium

Conclusion

Based on the research results, it can be concluded that: The assessment instrument product developed is in the form of 13 descriptive questions that are formally and scientifically arranged based on indicators of problem-solving ability (understanding problems, developing strategies, implementing strategies and interpreting results) and can measure the problem solving ability of students; The assessment instrument fits the Rasch PCM 1-PL model which is in the range of 0.84 logit to 1.16 logit and all items are valid for use in conducting research, the reliability estimate is 0.62 with a reliable category and the level of difficulty of the questions is -0.38 logit to 1.00 logit with a good category. Therefore, this instrument is suitable for measuring students' problem-solving skills on the concept of chemical calculations.

Acknowledgments
The author would like to thank: the Supervisor for his guidance during the research, SMA Negeri 1 Taman for giving the author the opportunity to conduct the research and all parties who have helped and provided support to the author, whom the author cannot mention one by one.

Author Contributions
Conceptualization, S.R. and I.S.Y.L.; methodology, S.R. and I.S.Y.L.; software, S.R.; validation, I.S.Y.L.; formal analysis, S.R.; investigation, I.S.Y.L.; resources, S.R.; data curation, S.R.; writing—original draft preparation, S.R.; writing—review and editing, S.R. and I.S.Y.L.; visualization, S.R.; supervision, I.S.Y.L.; project administration, S.R. All authors have read and agreed to the published version of the manuscript.

Funding
This research received no external funding

Conflicts of Interest
The authors declare no conflict of interest.

References

Adom, D., Adu-Mensah, J., & Dake, D. A. (2020). Test, measurement, and evaluation: Understanding and use of the concepts in education. *International Journal of Evaluation and Research in Education (IJERE)*, *9*(1), 109. https://doi.org/10.11591/ijere.v9i1.20457

Agustini, Rery, R. U., & Anwar, L. (2021). The Development and Validity of CPS-Based Assessment Instrument for Critical Thinking Ability on Stoichiometry Materials. *Journal of Physics: Conference Series*, *1788*(1), 012026. https://doi.org/10.1088/1742-6596/1788/1/012026

Alkan, F. (2021). Problem Solving in Chemistry: Example of Neutralization Titrations. *MIER Journal of Educational Studies Trends and Practices*, 306–328. https://doi.org/10.52634/mier/2021/v11/i2/1955

Amelia, O., & Listyarini, R. V. (2022). Test Instrument to Measure Student's Level of Chemical Literacy in Macromolecules Topic. *JPI (Jurnal Pendidikan Indonesia)*, *11*(3), 480–491. https://doi.org/10.23887/jpiundiksha.v11i3.39560

Ananda, L. R., Rahmawati, Y., & Khairi, F. (2023). Critical thinking skills of Chemistry students by integrating design thinking with STEAM-PjBL. *Journal of Technology and Science Education*, *13*(1), 352. https://doi.org/10.3926/jotse.1938

Anisah, D. C., Nasrudin, H., & Sukarmin. (2025). Profile of Critical Thinking Skills of Phase F Learning in Chemistry Subjects Acid-Base Material. *Jurnal Penelitian Pendidikan IPA*, *11*(1), 17–27. https://doi.org/10.29303/jppipa.v11i1.9842

Arsiana, K. E. A., Yudiana, K., & Antara, P. A. (2022). Pengembangan Instrumen Penilaian Higher Order Thinking Skill (Hots) pada Pembelajaran Tema 8 (Bumiku) di Kelas VI Sekolah Dasar Gugus Iii Kecamatan Gerokgak. *Journal for Lesson and Learning Studies*, *5*(2), 267–273. https://doi.org/10.23887/jlls.v5i2.52798

Aryadoust, V., Tan, H. A. H., & Ng, L. Y. (2019). A Scientometric Review of Rasch Measurement: The Rise and Progress of a Specialty. *Frontiers in Psychology*, *10*, 2197. https://doi.org/10.3389/fpsyg.2019.02197

Astarina, R., Yerizon, Bentri, A., & Zainil, M. (2024). Development of Interactive Learning Media Assisted by Google Sites in Building Materials for Elementary Schools Grade V. *Jurnal Penelitian Pendidikan IPA*, *10*(SpecialIssue), 226–233. https://doi.org/10.29303/jppipa.v10iSpecialIssue.8555

Axelsson, M., Kottorp, A., Carlson, E., Gudmundsson, P., Kumlien, C., & Jakobsson, J. (2022). Translation and validation of the Swedish version of the IPECC-SET 9 item version. *Journal of Interprofessional Care*, *36*(6), 900–907. https://doi.org/10.1080/13561820.2022.2034762

Aybek, E. C., & Demirtasli, R. N. (2017). Computerized Adaptive Test (CAT) Applications and Item Response Theory Models for Polytomous Items. *International Journal of Research In Education And Science*, 475–475. https://doi.org/10.21890/ijres.327907

Boone, W. J., Staver, J. R., & Yale, M. S. (2014). *Rasch Analysis in the Human Sciences*. Springer Netherlands. https://doi.org/10.1007/978-94-007-6857-4

Cavallo, A., Sanasi, S., Ghezzi, A., & Rangone, A. (2021). Competitive intelligence and strategy formulation: Connecting the dots. *Competitiveness Review: An International Business Journal*, *31*(2), 250–275. https://doi.org/10.1108/CR-01-2020-0009

Chen, C., Twycross, J., & Garibaldi, J. M. (2017). A new accuracy measure based on bounded relative error for time series forecasting. *Plos One*, *12*(3), e0174202. https://doi.org/10.1371/journal.pone.0174202

Cheung, G. W., Cooper-Thomas, H. D., Lau, R. S., & Wang, L. C. (2024). Reporting reliability, convergent and discriminant validity with structural equation modeling: A review and best-practice recommendations. *Asia Pacific Journal of Management*, *41*(2), 745–783. https://doi.org/10.1007/s10490-023-09871-y

Darmawan, A., Asa, B. N., Kurniawan, F., Nukhba, R., Albab, U., & Parno, P. (2020). Pengembangan Instrumen Tes Pemecahan Masalah Bagi Mahasiswa Jurusan Fisika Pada Materi Dinamika Partikel. *Jurnal Pendidikan Fisika dan Keilmuan (JPFK)*, *6*(1), 55. https://doi.org/10.25273/jpfk.v6i1.5579

Daulay, K. R., & Ruhaimah, I. (2019). Polya theory to improve problem-solving skills. *Journal of Physics: Conference Series*, *1188*, 012070. https://doi.org/10.1088/1742-6596/1188/1/012070

Febrianti, T. S., Fatimah, S., & Afgani Dahlan, J. (2024). Identifying Learning Obstacles in Pre-Service Mathematics Teachers' Understanding of Circle Concepts: A Preliminary Study within A Didactical Design Research Framework. *Jurnal Pendidikan MIPA*, *25*(1), 419–439. https://doi.org/10.23960/jpmipa/v25i1.pp419-439

Hubbart, J. A. (2023). Organizational Change: The Challenge of Change Aversion. *Administrative Sciences*, *13*(7), 162. https://doi.org/10.3390/admsci13070162

Ibarra-Sáiz, M. S., Rodríguez-Gómez, G., & Boud, D. (2021). The quality of assessment tasks as a determinant of learning. *Assessment & Evaluation in Higher Education*, *46*(6), 943–955. https://doi.org/10.1080/02602938.2020.1828268

Kwangmuang, P., Jarutkamolpong, S., Sangboonraung, W., & Daungtod, S. (2021). The development of learning innovation to enhance higher order thinking skills for students in Thailand junior high schools. *Heliyon*, *7*(6), e07309. https://doi.org/10.1016/j.heliyon.2021.e07309

Laliyo, L. A. R., Utina, R., Husain, R., Umar, M. K., Katili, M. R., & Panigoro, C. (2023). Evaluating students' ability in constructing scientific explanations on chemical phenomena. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(9), em2328. https://doi.org/10.29333/ejmste/13524

Ling, Y., Zhou, L., Zhang, B., & Ren, H. (2024). Developing middle school students' problem-solving ability through interdisciplinary project-based learning. *Education for Chemical Engineers*, *46*, 43–53. https://doi.org/10.1016/j.ece.2023.11.001

Marar, S., Hamza, M. A., Ayyash, M., & Abu-Shaheen, A. (2023). Development and validation of an instrument to assess the knowledge and perceptions of predatory journals. *Heliyon*, *9*(11), e22270. https://doi.org/10.1016/j.heliyon.2023.e22270

Muhsin, L. B., & Laksono, E. W. (2023). Development of integrated Assessment to Measure student's Analytical Thinking Skills and Scientific Attitudes for Chemical Equilibrium Topic. *Jurnal Penelitian Pendidikan IPA*, *9*(2), 556–562. https://doi.org/10.29303/jppipa.v9i2.2191

Ofianto, O., & Suhartono, S. (2015). An assessment model of historical thinking skills by means of the RASCH model. *REID (Research and Evaluation in Education)*, *1*(1), 73–83. https://doi.org/10.21831/reid.v1i1.4899

Purwandari, I. D., Rahayu, S., & Dasna, I. W. (2022). Inquiry Learning Model in Chemistry Learning: A Review. *JRPK: Jurnal Riset Pendidikan Kimia*, *12*(1), 38–46. https://doi.org/10.21009/JRPK.121.06

Robinson, M., Johnson, A. M., Walton, D. M., & MacDermid, J. C. (2019). A comparison of the polytomous Rasch analysis output of RUMM2030 and R (ltm/eRm/TAM/lordif). *BMC Medical Research Methodology*, *19*(1), 36. https://doi.org/10.1186/s12874-019-0680-5

Rohmah, M., & Sutiarso, S. (2017). Analysis Problem Solving in Mathematical Using Theory Newman. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(2). https://doi.org/10.12973/ejmste/80630

Setyaedhi, H. S. (2024). Comparative Test of Cronbach's Alpha Reliability Coefficient, Kr-20, Kr-21, And Split-Half Method. *Journal of Education Research and Evaluation*, *8*(1), 47–57. https://doi.org/10.23887/jere.v8i1.68164

Setyawarno, D. (2017). Penggunaan AplikasiSoftware Iteman (Item and Test Analysis) untuk Analisis Butir Soal Pilihan Ganda Berdasarkan Teori Tes Klasik. *Jurnal Ilmu Fisika dan Pembelajarannya (JIFP)*, *1*(1), 11–21. https://doi.org/10.19109/jifp.v1i1.866

Shirali, G., Shekari, M., & Angali, K. A. (2018). Assessing Reliability and Validity of an Instrument for Measuring Resilience Safety Culture in Sociotechnical Systems. *Safety and Health at Work*, *9*(3), 296–307. https://doi.org/10.1016/j.shaw.2017.07.010

Sinaga, B., Sitorus, J., & Situmeang, T. (2023). The influence of students' problem-solving understanding and results of students' mathematics learning. *Frontiers in Education*, *8*, 1088556. https://doi.org/10.3389/feduc.2023.1088556

Stefana, A., Damiani, S., Granziol, U., Provenzani, U., Solmi, M., Youngstrom, E. A., & Fusar-Poli, P. (2025). Psychological, psychiatric, and behavioral sciences measurement scales: Best practice guidelines for their development and validation. *Frontiers in Psychology*, *15*, 1494261. https://doi.org/10.3389/fpsyg.2024.1494261

Surif, J., Ibrahim, N. H., & Dalim, S. F. (2014). Problem Solving: Algorithms and Conceptual and Open-ended Problems in Chemistry. *Procedia - Social and Behavioral Sciences*, *116*, 4955–4963. https://doi.org/10.1016/j.sbspro.2014.01.1055

Taber, K. S. (2018). The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education*, *48*(6), 1273–1296. https://doi.org/10.1007/s11165-016-9602-2

Tesio, L., Caronni, A., Kumbhare, D., & Scarano, S. (2024). Interpreting results from Rasch analysis 1. The "most likely" measures coming from the model. *Disability and Rehabilitation*, *46*(3), 591–603. https://doi.org/10.1080/09638288.2023.2169771

Tyas, A. S., Senam, Wiyarsi, A., & Laksono, E. W. (2020). Chemistry teaching self-efficacy: A scale development. *Journal of Physics: Conference Series*, *1440*(1), 012005. https://doi.org/10.1088/1742-6596/1440/1/012005

Wïcaksono, A. G. C., & Korom, E. (2022). Review of problem-solving measurement: An assessment developed in the Indonesian context. *Participatory Educational Research*, *9*(1), 116–136. https://doi.org/10.17275/per.22.7.9.1

Zakariya, Y. F. (2022). Cronbach's alpha in mathematics education research: Its appropriateness, overuse, and alternatives in estimating scale reliability. *Frontiers in Psychology*, *13*, 1074430. https://doi.org/10.3389/fpsyg.2022.1074430