



Development and Validation of a STEM-Based Minimum Competency Assessment Instrument for Reading Literacy and Numeracy in Stoichiometry

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Abstract: This study aimed to develop and validate a STEM-based stoichiometry assessment instrument aligned with the Minimum Competency Assessment (AKM) framework to measure students' reading literacy and numeracy skills. STEM aspects were integrated into the items through science, technology, engineering, and mathematics contexts embedded in stoichiometry problems. The study employed a development and validation research method. Initially, 50 items were developed, and content validation results showed that 48 items met the validity criteria with a Content Validity Ratio (CVR) value of 1.00. From the validated items, 30 items were selected for empirical testing, consisting of 16 numeracy items and 14 reading literacy items distributed across 11 reading texts. The empirical testing results indicated that 23 out of 30 items were valid and reliable. Most items were categorized as having a moderate difficulty level and acceptable discriminative power. Furthermore, students' reading literacy and numeracy competencies were categorized as basic. Therefore, the developed instrument is feasible as an alternative assessment tool to support AKM-oriented chemistry learning and evaluation.

Keywords: Minimum Competency Assessment; Numeracy; Reading Literacy; STEM Education; Stoichiometry

Introduction

The rapid development of science and technology in the 21st century has created new challenges in various sectors, including education (Valiandes, 2015). This era is characterized by the rapid flow of information, advances in digital technology, and globalization, which make the world increasingly interconnected. These challenges encourage the need for curriculum innovation to prepare students with competencies relevant to current educational demands. Curriculum innovation refers to new ideas, concepts, or actions in curriculum and learning intended to address educational problems (Hapidin et al., 2024). In response to these challenges, the Indonesian government implemented the Merdeka Curriculum through Permendikbudristek No. 12 Tahun 2024 concerning the

curriculum for primary and secondary education. This curriculum aims to provide students with opportunities to actively participate in learning and optimally develop their potential (Safitri et al., 2024).

One of the important transformations in the Merdeka Curriculum is the replacement of the National Examination with the National Assessment, which consists of the Minimum Competency Assessment (AKM), character surveys, and learning environment surveys. AKM is designed to prepare students with 21st-century competencies, particularly the 4Cs: critical thinking, creativity, communication, and collaboration (Davis et al., 2014; Hidayah et al., 2021; Khairi & Desnita, 2023; Thornhill-Miller et al., 2023), which reach beyond academic settings and individual needs and have impact on society as a whole (Jones et al., 2022). As part of the National Assessment, AKM measures students'

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fundamental competencies in reading literacy and numeracy, which emphasize logical and systematic thinking as well as the ability to apply knowledge in various contexts (Pusat Asesmen Pendidikan (Pusmenjar, 2022). Therefore, AKM is intended to encourage innovative learning and critical reasoning rather than memorization-oriented learning (Ayuningtyas et al., 2023; Nuri et al., 2025; Rohim, 2021; Shidiq et al., 2022).

However, the results of the Programme for International Student Assessment PISA(2022) indicate that Indonesian students' reading literacy and numeracy skills remain relatively low. Only about 25% of Indonesian students achieved Level 2 or higher in reading literacy, compared to the OECD average of 74%. Similarly, only 18% of students achieved Level 2 or higher in numeracy, while the OECD average reached 69%. These findings indicate that many students still experience difficulties in interpreting information from texts and applying mathematical concepts to solve contextual problems encountered in everyday life. This condition highlights the urgent need for contextual assessment instruments that are aligned with students' needs and current educational demands.

One approach that can support the development of contextual assessment instruments is STEM (Science, Technology, Engineering, and Mathematics) education (Adams, 2021; Shahat et al., 2025). STEM is considered effective not only in improving learning outcomes but also in integrating multiple disciplines into meaningful real-world contexts (Lestari et al., 2025; Ramadhani et al., 2025; Sakti & Defianti, 2022). STEM literacy involves cross-cutting concepts, core disciplinary ideas, and scientific and engineering practices that support students' competencies (Candra et al., 2020). Through STEM, students are encouraged to connect scientific, technological, engineering, and mathematical knowledge to solve contextual problems in daily life and applied situations. However, despite its potential, STEM-based AKM items that strengthen reading literacy and numeracy are still rarely implemented in schools. Existing AKM items generally emphasize information processing and logical reasoning but tend to rely on text-based stimuli and lack integrated STEM contexts that explicitly engage students in scientific and engineering problem solving (Pusmenjar, 2022).

Teachers play an essential role in preparing students for AKM implementation, including through the development of AKM-oriented learning and assessment activities (Yamtinah et al., 2022). However, in practice, teachers tend to use procedural and formula-oriented questions that emphasize memorization and basic understanding rather than encouraging students to develop conceptual understanding, critical thinking,

and contextual problem-solving skills (Ramadhani et al., 2025; Sariningsih et al., 2022). This condition is not fully aligned with the nature of chemistry learning, in which students are expected to understand concepts through scientific processes rather than merely memorizing facts (Komisia et al., 2025). In addition, many teachers still face difficulties in designing AKM-oriented questions, including distinguishing AKM items from conventional questions, developing appropriate stimuli, using suitable language, and selecting appropriate question formats (Astuti et al., 2022). Nevertheless, both students and teachers acknowledge that AKM-oriented questions can improve learning independence, critical thinking, literacy, and numeracy skills (Rokhim et al., 2022).

Stoichiometry, a fundamental area of chemistry concerned with the quantitative ratios of substances in chemical reactions and the composition of chemical compounds and mixtures (Krause et al., 2026), deals with the quantitative relationships between reactants and products in chemical reactions (Borchers et al., 2025). It involves proportional reasoning, quantitative problem-solving, and chemical reaction analysis through concepts such as moles, empirical formulas, limiting reactants, and percentage composition. These concepts are often difficult for students due to their abstract and symbolic nature (Afif et al., 2025; Nilawati et al., 2016; Ningsih & Kamaludin, 2023). Therefore, students are required not only to perform mathematical calculations but also to apply scientific understanding to solve contextual problems in daily life and industrial processes. Stoichiometry is also closely related to STEM principles as it integrates science, mathematics, and technological applications in real-world contexts. The Decree of the Head of BSKAP No. 032/H/KR/2024 further emphasizes that students at the end of Phase F are expected to understand mole and stoichiometric concepts to solve chemical problems.

Previous studies have generally focused on AKM-oriented questions or STEM-based learning separately, while the development of integrated STEM-based AKM assessment instruments for chemistry, particularly on stoichiometry topics, remains limited. Therefore, this study offers novelty by integrating STEM contexts into AKM-oriented reading literacy and numeracy assessment instruments on stoichiometry topics. Based on this gap, this study aims to develop STEM-based reading literacy and numeracy assessment instruments on stoichiometry topics to support the development of students' competencies in accordance with current educational demands.

Method

Research Design and Participants

A development and validation research design was employed in this study, adapted from the instrument development framework proposed by Adams & Wieman (2011). The research was conducted through four stages: planning, development, field testing and data analysis, and conclusion drawing. The developed STEM-based Minimum Competency Assessment (AKM) instrument on stoichiometry was designed to

measure students' reading literacy and numeracy competencies.

The participants consisted of five chemistry education experts, including three university lecturers and two senior high school chemistry teachers, who served as validators. In addition, 32 eleventh-grade science students from one public senior high school in Bandung participated as respondents in the field trial. The students' response data were analyzed to examine the empirical validity, reliability, item difficulty level, discriminative power, and students' competency levels.

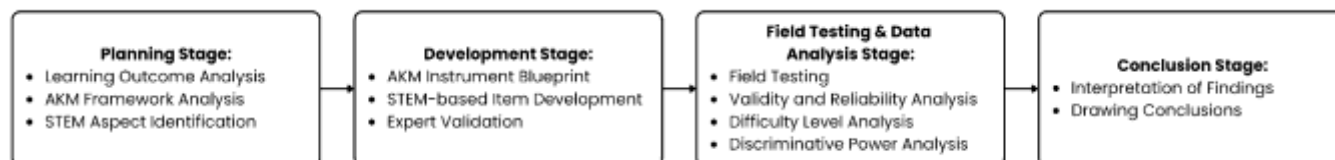


Figure 1. Flowchart of the Research Procedure

Research Procedure

The research procedure was conducted through four stages: planning, development, field testing and data analysis, and conclusion drawing. In the planning stage, learning outcomes related to stoichiometry, relevant references, the Minimum Competency Assessment (AKM) framework, and STEM aspects were analyzed to determine the scope and indicators of the instrument. During the development stage, the test blueprint, item indicators, and scoring rubrics were developed, followed by the construction of STEM-based AKM items on stoichiometry. The developed instrument was then validated by experts to evaluate its content validity and appropriateness.

Furthermore, the validated instrument was administered to eleventh-grade science students in the field testing stage. The field testing stage was conducted on a limited scale to obtain preliminary empirical evidence regarding the quality of the developed instrument. The collected data were analyzed to determine empirical validity, reliability, item difficulty level, discriminative power, and students' reading literacy and numeracy competency levels. For discriminative power analysis, students were grouped into upper and lower groups using the 27% method. Finally, conclusions were drawn based on the overall analysis results to evaluate the quality and feasibility of the developed STEM-based AKM instrument.

Data Collection

Data were collected through expert validation and field testing. Content validity data were obtained using an expert validation sheet completed by five validators consisting of three chemistry education lecturers and two senior high school chemistry teachers. Empirical

data were collected by administering the STEM-based Minimum Competency Assessment (AKM) instrument on stoichiometry to eleventh-grade science students. The students' responses were used to analyze empirical validity, reliability, item difficulty level, discriminative power, and students' reading literacy and numeracy competency levels.

Data Analysis

The collected data were analyzed to evaluate the quality of the developed STEM-based Minimum Competency Assessment (AKM) instrument on stoichiometry. Content validity was examined through expert judgment using the Content Validity Ratio (CVR) to determine the relevance and representativeness of each item (Bashooir & Supahar, 2018; Lawshe, 1975). The CVR was calculated using the Formula 1.

$$CVR = \frac{n_e - \frac{N}{2}}{\frac{N}{2}} \quad (1)$$

Notation:

CVR = Content Validity Ratio

n_e = number of experts who rated the item as essential

N = total number of validators

Empirical validity was analyzed based on students' test responses. Point-biserial correlation was used for dichotomous items to measure the relationship between item scores and total test scores (Mira et al., 2021). The formula is as equation 1.

$$r_{pb} = \frac{M_1 - M_0}{S_t} \sqrt{pq} \quad (1)$$

Notation:

- M_t = mean total score of correct responses
- M_o = mean total score of incorrect responses
- S_t = standard deviation of total scores
- p = proportion who answered the item correct
- q = proportion who answered the item incorrect

For polytomous items, Pearson Product Moment correlation was applied to measure the relationship between item scores and total test scores (Alwi, 2015; Arifin, 2017). The formula is as follows.

$$r = \frac{n(\sum XY) - (\sum X)(\sum Y)}{\sqrt{[n\sum X^2 - (\sum X)^2][n\sum Y^2 - (\sum Y)^2]}} \quad (3)$$

Notation:

- r = Pearson Correlation Coefficient
- n = number of samples
- X = value of the first variable
- Y = value of the second variable
- $\sum X$ = sum of scores of variable X
- $\sum Y$ = sum of scores of variable Y
- $\sum XY$ = sum of the product of X and Y scores
- $\sum X^2$ = sum of squared values of variable X
- $\sum Y^2$ = sum of squared values of variable Y

Instrument reliability was analyzed using Cronbach’s Alpha to determine the internal consistency of the instrument (Gliem & Gliem, 2003). Item analysis included the examination of item difficulty levels and discriminative power to evaluate the quality of each test item (Ratnawulan & Rusdiana, 2014; Sudijono, 2017).

Furthermore, students’ reading literacy and numeracy competency levels were classified into four categories, namely advanced, proficient, basic, and needs special intervention, based on national AKM standards and index-based classification (Haryani et al., 2023; Pusmenjar, 2022).

Result and Discussion

Content Validity

The development of the STEM-based Minimum Competency Assessment (AKM) instrument resulted in a total of 50 test items distributed across 11 reading texts, which were subsequently subjected to content validity evaluation by experts. The evaluated aspects included the alignment between the reading texts and test items, the conformity of the items with their indicators, and the integration of STEM aspects. Based on the content validity analysis shown in Figure 2, 48 items were classified as valid with a Content Validity Ratio (CVR) value of 1, which exceeded the minimum critical value of 0.99 for five validators (Lawshe, 1975), and were therefore retained for the field testing stage. Meanwhile, two items obtained a CVR value of 0.6, which did not meet the required minimum threshold and were excluded from further testing. This finding is consistent with previous studies indicating that items are considered acceptable or revisable when they achieve a minimum CVR value of 0.99 for five validators (Nahadi et al., 2022). A CVR value of 1 indicates complete agreement among validators regarding the relevance of the developed items.

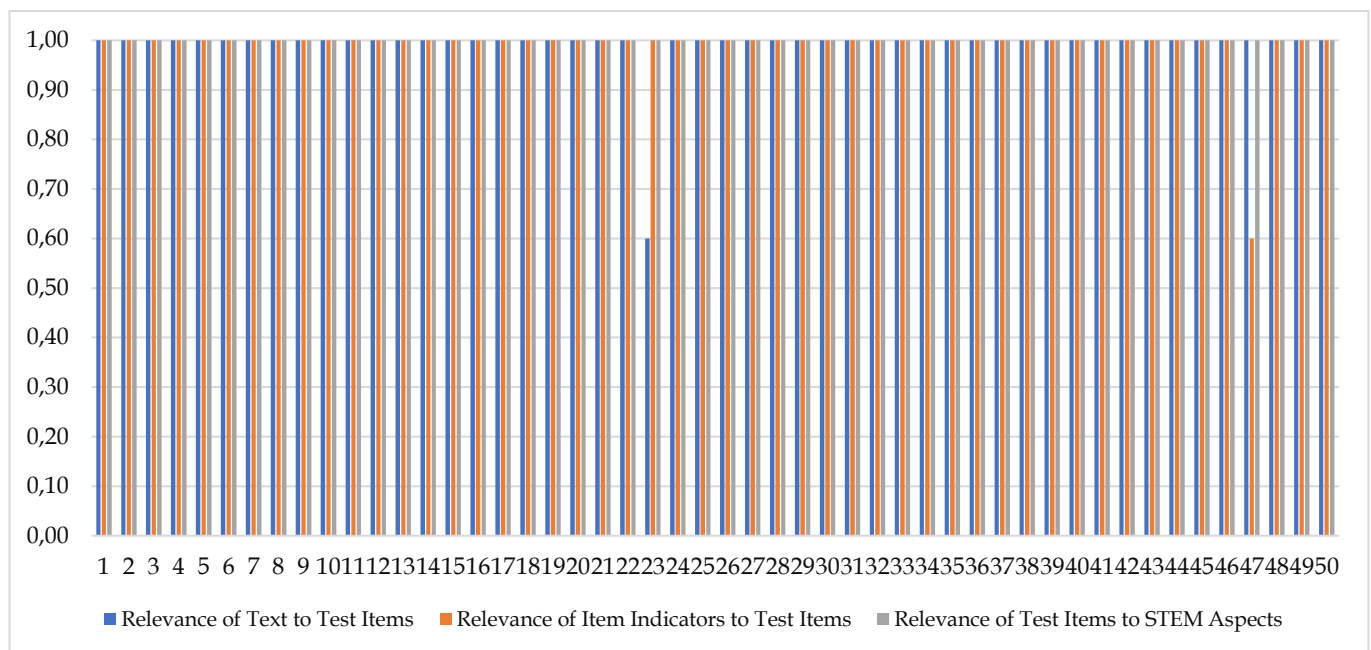


Figure 2. CVR Scores of Test Items Across Content Validity Aspects

From the 48 items that were declared content-valid, 30 items were selected for field testing due to time limitations and students' workload during the test administration process. The selected items were considered representative because they covered all indicators and subtopics of stoichiometry, including both reading literacy and numeracy competencies.

Empirical Validity

A total of 30 items that had been declared content-valid were administered to students during the field testing stage to evaluate their empirical validity and determine the quality of the developed STEM-based AKM instrument on stoichiometry.

Table 1. Empirical Validity Results of the Developed Items

Item	Correlation Method	r-value	Decision	Item	Correlation Method	r-value	Decision
1	Point-Biserial	0.317	Invalid	16	Pearson Product Moment	0.654	Valid
2	Pearson Product Moment	0.389	Valid	17	Point-Biserial	0.290	Invalid
3	Pearson Product Moment	0.805	Valid	18	Pearson Product Moment	0.657	Valid
4	Point-Biserial	0.743	Valid	19	Pearson Product Moment	0.402	Valid
5	Pearson Product Moment	0.475	Valid	20	Pearson Product Moment	0.749	Valid
6	Point-Biserial	0.166	Invalid	21	Point-Biserial	0.190	Invalid
7	Pearson Product Moment	0.592	Valid	22	Pearson Product Moment	0.761	Valid
8	Pearson Product Moment	0.865	Valid	23	Point-Biserial	0.591	Valid
9	Point-Biserial	0.553	Valid	24	Pearson Product Moment	0.263	Invalid
10	Pearson Product Moment	0.385	Valid	25	Point-Biserial	0.460	Valid
11	Pearson Product Moment	0.419	Valid	26	Pearson Product Moment	0.498	Valid
12	Point-Biserial	-0.052	Invalid	27	Point-Biserial	0.511	Valid
13	Pearson Product Moment	0.039	Invalid	28	Pearson Product Moment	0.445	Valid
14	Pearson Product Moment	0.539	Valid	29	Pearson Product Moment	0.435	Valid
15	Pearson Product Moment	0.664	Valid	30	Pearson Product Moment	0.450	Valid

Based on the Table 1, 23 items were declared empirically valid because their r-values exceeded the r-table value of 0.349 at a significance level of 0.05, adjusted to the number of participants involved in the field testing. Meanwhile, seven items were categorized as invalid because their r-values were lower than the required threshold.

The interpretation of the empirical validity values referred to the criteria proposed by Arifin (2017), indicating that the developed items ranged from very low to very high validity categories. Most items were categorized as moderate to high validity, indicating that the instrument generally demonstrated acceptable empirical validity.

Reliability

To ensure the consistency of the developed instrument, reliability analysis was conducted using Cronbach's Alpha, which is appropriate for instruments consisting of mixed item formats and scoring types. The reliability analysis result showed that the developed STEM-based Minimum Competency Assessment (AKM) instrument obtained a Cronbach's Alpha coefficient of 0.86, exceeding the minimum threshold of 0.70 required for a reliable instrument (Maulana, 2022). This finding is also supported by the study conducted by Setyaedhi (2024), which reported a reliability coefficient of 0.82 for the developed assessment instrument, indicating good reliability and consistency in measuring students' competencies.

Similarly, a study conducted by Ariani et al. (2025) reported a Cronbach's Alpha coefficient of 0.71, indicating that the developed instrument demonstrated acceptable reliability and was capable of producing consistent results when administered repeatedly.

According to the reliability criteria proposed by Gliem & Gliem (2003), a reliability coefficient within the range of 0.80–0.90 is categorized as good reliability. Therefore, the obtained Cronbach's Alpha value indicates that the developed instrument demonstrated good internal consistency in measuring students' reading literacy and numeracy competencies. This result also shows that the instrument was capable of consistently assessing students across various item formats and scoring categories.

The acceptable empirical validity and reliability results indicate that the developed instrument can provide meaningful information about students' reading literacy and numeracy competencies and can be used to support the evaluation of learning outcomes (Kurnianto & Mundilarto, 2023), in line with the importance of validity and reliability evidence in educational assessment (Zhang et al., 2023).

Item Difficulty

The difficulty level analysis of the 30 developed items showed that 12 items were categorized as easy, 17 items as moderate, and 1 item as difficult (Nubatonis et al., 2024). These findings indicate that most items were distributed within the moderate difficulty category,

suggesting that the developed instrument was generally appropriate for measuring students' competencies. This finding is consistent with the study conducted by Nahadi et al. (2022), which also reported that the developed assessment items were predominantly categorized within the moderate difficulty level. However, the distribution of item difficulty had not fully met the ideal proportion criteria proposed by Ratnawulan & Rusdiana (2014), which recommend a balanced composition of easy, moderate, and difficult items.

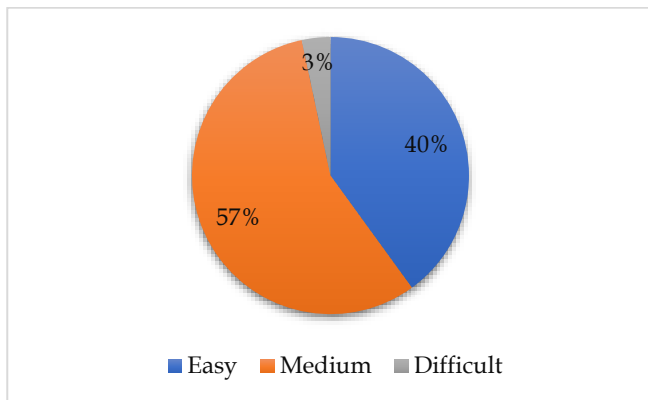


Figure 3. Proportion of Item Difficulty

Discrimination Index

To evaluate the quality of the items in distinguishing between high- and low-performing students, a discriminative power analysis was conducted. For the analysis, students were divided into upper and lower groups using the 27% method based on the ranking of their total test scores (Pradita et al., 2023). Based on the interpretation criteria proposed by (Sudijono, 2017), the analysis of the 30 developed items showed that 8 items were categorized as very good, 11 items as good, 8 items as moderate, 2 items as poor, and 1 item as very poor. These findings indicate that most items demonstrated acceptable discriminative power in differentiating students based on their competency levels. These results are consistent with previous research by Ariani et al. (2025), which also reported that most items had good discrimination power.

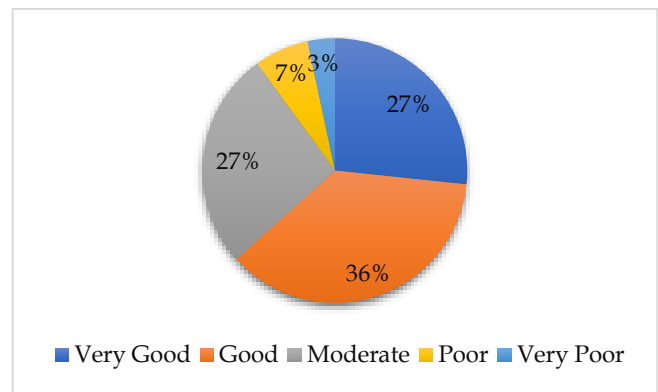


Figure 4. Proportion of Item Discrimination

Reading Literacy and Numeracy Competency Levels

Following the validity, reliability, difficulty level, and discriminative power analyses, students' reading literacy and numeracy competency levels were identified based on their test scores. The competency levels were classified into four categories, namely Advanced, Proficient, Basic, and Needs Special Intervention, according to the AKM classification proposed by Pusmenjar (2022). The intervals for the four competency levels were determined based on the mean score and standard deviation of the test results obtained from 32 students (Haryani et al., 2023).

Table 2. Reading Literacy Competency Intervals of Students

Interval	Students' Reading Literacy Competency Level
Score > 22	Advanced
17 < X ≤ 22	Proficient
12 ≤ X ≤ 17	Basic
Score < 12	Needs Special Intervention

Furthermore, to provide a more detailed overview of students' reading literacy competency levels, an analysis was conducted on the number and percentage of students in each category, along with the calculation of weights and indices representing the overall tendency of students' reading literacy competencies, as presented in Table 3.

Table 3. Distribution of Students by Reading Literacy Competency Level

Reading Literacy Competency Level	Frequency	Percentage	Weight	Index	Total Index
Advanced	1	3%	3	0.09	1.73
Proficient	17	53%	2	1.06	
Basic	9	28%	1.5	0.42	
Needs Special Intervention	5	16%	1	0.16	

The total index of students' reading literacy competency is 1.73, which falls into the "basic" category (Pusmenjar, 2022). This indicates that students have

mastered the basic concepts but still face difficulties in applying them in relevant contexts. Overall, the results show that students' reading literacy competency is

predominantly at the basic level, indicating the need for further improvement in higher-order reading literacy skills, particularly in interpreting and applying information from complex texts. In addition to reading literacy competency, students' numeracy competency levels were also analyzed using the same classification procedure.

Table 4. Numeracy Competency Intervals of Students

Interval	Students' Numeracy Competency Level
Score > 29	Advanced
21 < X ≤ 29	Proficient
13 ≤ X ≤ 21	Basic
Score < 13	Needs Special Intervention

Table 5. Distribution of Students by Numeracy Competency Level

Numeracy Competency Level	Frequency	Percentage	Weight	Index	Total Index
Advanced	3	9%	3	0.281	1.78
Proficient	14	44%	2	0.875	
Basic	10	31%	1.5	0.468	
Needs Special Intervention	5	16%	1	0.156	

Table 4 presents the intervals for students' numeracy competency levels, while Table 5 shows the distribution of students across each competency category, including the percentage, weight, and index values. The total index of students' numeracy competency was 1.78, which falls into the "basic" category (Pusmenjar, 2022). This finding indicates that students have acquired fundamental mathematical skills, including basic computations and the ability to solve simple routine mathematical problems.

Conclusion

The STEM-based Minimum Competency Assessment (AKM) instrument for reading literacy and numeracy on stoichiometry developed in this study was demonstrated to be valid and reliable. Content validity analysis showed that 48 out of 50 developed items were declared valid, while empirical validity analysis indicated that 23 out of 30 tested items met the validity criteria. The developed instrument also demonstrated good internal consistency, with a Cronbach's Alpha coefficient of 0.86. The item analysis revealed that most items were categorized at moderate and easy difficulty levels, while the discriminative power analysis showed that the majority of items had good to moderate ability in distinguishing students' competency levels. Based on students' performance, both reading literacy and numeracy competencies were classified at the basic level, indicating that students have acquired foundational skills but still require further development in applying them to contextual problems. Overall, the instrument can serve as an alternative assessment tool for measuring students' reading literacy and numeracy competencies in chemistry learning, particularly in stoichiometry topics. Future research is recommended to improve the balance of item difficulty levels and involve larger and more diverse samples to enhance the robustness of the instrument.

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Author Contributions

Conceptualization: W.P.J., N., W.S.; Methodology: W.P.J., N., W.S.; Validation: N., W.S.; Investigation: W.P.J.; Formal analysis: W.P.J.; Visualization: W.P.J.; Writing – original draft preparation: W.P.J.; Writing – review and editing: W.P.J.; Supervision: N., W.S. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

There is no conflict of interest.

References

Adams, E. L. (2021). The effect of a middle grades STEM initiative on students' cognitive and non-cognitive outcomes. *Studies in Educational Evaluation*, 68, 100983. <https://doi.org/10.1016/j.stueduc.2021.100983>

Adams, W. K., & Wieman, C. E. (2011). Development and validation of instruments to measure learning of expert-like thinking. *International Journal of Science Education*, 33(9), 1289-1312. <https://doi.org/10.1080/09500693.2010.512369>

Afif, H. A., Ulfa, M., Yamtinah, S., Masykuri, M., Mulyani, B., & Shidiq, A. S. (2025). Analysis of Literacy Ability of 10th Grade High School Students Using the Minimum Competency Assessment (AKM) Based on Chemical Science at SMAN Karangpandan. *Jurnal Penelitian Pendidikan IPA*, 11(7), 873-883. <https://doi.org/10.29303/jppipa.v11i7.4314>

- Alwi, I. (2015). Kriteria Empirik Dalam Menentukan Ukuran Sampel. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, 2(2), 140–148. <https://doi.org/10.30998/formatif.v2i2.95>
- Ariani, W., Nahadi, & Munawaroh, H. S. H. (2025). Development of PISA-based Chemistry Test Instrument for Measuring Madrasah Aliyah Students' Scientific Literacy. *Jurnal Penelitian Pendidikan IPA*, 11(11), 1291–1302. <https://doi.org/10.29303/jppipa.v11i11.12808>
- Arifin, Z. (2017). *Evaluasi pembelajaran* (Vol. 8). Bandung: Remaja Rosdakarya.
- Astuti, I., Mering, A., Soal, A., & Belajar, H. (2022). Analisis Kemampuan Guru Sekolah Menengah Pertama Kota Pontianak Menyusun Soal Asesmen Kompetensi. *Jurnal Education and Development*, 10(1), 602–609. Retrieved from <https://shorturl.asia/b7ELV>
- Ayuningtyas, V. E. H., Viyanti, & Setyarini, M. (2023). Teachers' Perception of the Minimum Competency Assessment Instrument (AKM) based on Lynk.id to measure Students. *Scientific Literacy on Solar System Material. Jurnal Penelitian Pendidikan IPA*, 9(11), 9883–9892. <https://doi.org/10.29303/jppipa.v9i11.5198>
- Bashoor, K., & Supahar, S. (2018). Validitas dan reliabilitas instrumen asesmen kinerja literasi sains pelajaran Fisika berbasis STEM. *Jurnal Penelitian Dan Evaluasi Pendidikan*, 22(2), 219–230. <https://doi.org/10.21831/pep.v22i2.19590>
- Borchers, C., Fleischer, H., Yaron, D. J., McLaren, B. M., Scheiter, K., Aleven, V., & Schanze, S. (2025). Problem-solving strategies in stoichiometry across two intelligent tutoring systems: A cross-national study. *Journal of Science Education and Technology*, 34(2), 384–400. <https://doi.org/10.1007/s10956-024-10197-7>
- Candra, N., Setiawan, E., Kimia, J., Universitas, F., Malang, N., No, J. C., Malang, K., Timur, J., & Korespondensi, E. (2020). Pengenalan STEM (Science, Technology, Engineering, and Mathematics) dan Pengembangan Rancangan Pembelajarannya untuk Merintis Pembelajaran Kimia dengan Sistem SKS di Kota Madiun. *Lumbung Inovasi: Jurnal Pengabdian Kepada Masyarakat*, 5(2), 56–64. <https://doi.org/10.36312/linov.v5i2.465>
- Davis, O., Band, G., & Pirinen, M. (2014). The correlation between reading and mathematics ability at age twelve has a substantial genetic component. *Nat Commun*, 5, 4204. <https://doi.org/10.1038/ncomms5204>
- Gliem, J. A., & Gliem, R. R. (2003). Calculating, Interpreting, And Reporting Cronbach's Alpha Reliability Coefficient For Likert-Type Scales. *M Conference (Columbus, Ohio : Ohio State University)*, 82–88. Retrieved from <https://shorturl.asia/FE2JW>
- Hapidin, A., Ruswandi, A., & Zaqiah, Q. Y. (2024). Inovasi Kurikulum Sebagai Sebuah Keniscayaan dalam Pendidikan di Indonesia. *Journal of Teacher Training and Educational Research*, 2(2), 47–57. <https://doi.org/10.71280/jotter.v2i2.400>
- Haryani, S., Pratiwi, D., & Wardani, S. (2023). Analisis kemampuan literasi Dan numerasi ditinjau Dari soal akm berorientasi konteks saintifik Dan sosial budaya pada materi kesetimbangan asam Dan Basa. *EDUSAINS*, 15(2), 136–149. <https://doi.org/10.15408/es.v15i2.34086>
- Hidayah, I. R., Kusmayadi, T. A., & Fitriana, L. (2021). Minimum competency assessment (AKM): An effort to photograph numeracy. *Journal of Mathematics and Mathematics Education*, 11(1), 14–20. <https://doi.org/10.20961/jmme.v11i1.52742>
- Jones, M. G., Chesnutt, K., Ennes, M., Macher, D., & Paechter, M. (2022). Measuring science capital, science attitudes, and science experiences in elementary and middle school students. *Studies in Educational Evaluation*, 74, 101180. <https://doi.org/10.1016/j.stueduc.2022.101180>
- Khairi, L., & Desnita, D. (2023). Conformity Level Analysis of Physics Daily Test Questions Based on Minimum Competency Assessment. *Jurnal Penelitian Pendidikan IPA*, 9(3), 1283–1291. <https://doi.org/10.29303/jppipa.v9i3.2336>
- Komisia, F., Tukan, M. B., Fallo, D. Y. A., Hale, G. J. P., Meta, G. B., Lanmai, P. O., & Leba, M. A. U. (2025). Validity Analysis of a Science Process Skills Assessment Instrument for High School Students in Chemistry. *Jurnal Penelitian Pendidikan IPA*, 11(12), 185–193. <https://doi.org/10.29303/jppipa.v11i12.12860>
- Krause, A., Polarz, S., Hoppe, A., Ewerth, R., & Nehring, A. (2026). *Towards defining, assessing and modelling competency levels in stoichiometry*. Chemistry Education Research and Practice. <https://doi.org/10.1039/D5RP00077G>
- Kurnianto, A. A., & Mundilarto, M. (2023). Assessment: The Quality of Instrument to Measure Student's Scientific Attitude (SSA) based on Content Validity and Empirical Testing. *Jurnal Penelitian Pendidikan IPA*, 9(SpecialIssue), 732–739. <https://doi.org/10.29303/jppipa.v9iSpecialIssue.6816>
- Lawshe, C. H. (1975). A quantitative approach to content validity. *Personnel Psychology*, 28(4). Retrieved from <https://parsmodir.com/wp-content/uploads/2015/03/lawshe.pdf>

- Lestari, S. T., Uswatun, D. A., & Sutisnawati, A. (2025). Pengembangan Instrumen Penilaian Kognitif Siswa Berbasis STEM. *EDP Pada Mata Pelajaran IPA Di Sekolah Dasar*, 14(1), 813–826. <https://doi.org/10.58230/27454312.2043>
- Maulana, A. (2022). *Analisis Validitas, Reliabilitas, dan Kelayakan Instrumen Penilaian Rasa Percaya Diri Siswa* (Vol. 3, Issue 3, pp. 133–139). <https://doi.org/10.51651/jkp.v3i3.331>
- Mira, K., Hayon, V. H., & Tinenti, Y. R. (2021). Analisis butir soal pilihan ganda pada materi pokok larutan elektrolit dan nonelektrolit kelas X IPA SMA Negeri 1 Lamba Leda Manggarai Timur. *Wahana: Tridarma Perguruan Tinggi*, 73(2), 209–220. <https://doi.org/10.36456/wahana.v73i2.4201>
- Nahadi, S., W., P., P., L., T., E., A., & Rohmawati, T. (2022). Development of Minimum Competency Assessment (AKM) on Chemical Materials. *Moroccan Journal of Chemistry*, 3, 452–463. <https://doi.org/10.48317/IMIST.PRSM/morjche-m-v10i3.33067>
- Nilawati, P. A., Utomo, Y., Universitas, P. K., & Malang, N. (2016). Keefektifan pembelajaran interkoneksi multipel representasi dalam mengurangi kesalahan konsep siswa pada materi stoikiometri. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, 2016(2004), 2076–2082. <https://doi.org/10.17977/jp.v1i11.7773>
- Ningsih, N. R., & Kamaludin, A. (2023). Development of Higher Order Thinking Skills-Based Assessment Instrument on Acid-Base Materials in High School. *Jurnal Penelitian Pendidikan IPA*, 9(1), 13–19. <https://doi.org/10.29303/jppipa.v9i1.1457>
- Nubatonis, O. E., Jupri, A., & A, E. C. M. (2024). Interpretasi Validitas dan Reliabilitas Instrumen Kemampuan Berpikir Aljabar. *Jambura Journal of Mathematics Education*, 5(1), 16–28. <https://doi.org/10.37905/jmathedu.v5i1.23435>
- Nuri, B., Isnani, W., & Rizani, F. (2025). Development of Desmos Application Design Integrated PBL Assisted Liveworksheet Based on Mathematical Literacy in AKM Preperation Efforts. *Jurnal Penelitian Pendidikan IPA*, 11(1), 265–274. <https://doi.org/10.29303/jppipa.v11i1.9940>
- PISA, O. E. C. D. (2022). *Results (Volume I): The State of Learning and Equity in Education*. OECD Publishing. Retrieved from <https://shorturl.asia/xXTiV>
- Pradita, E., Megawanti, P., & Yulianingsih, Y. (2023). Analisis tingkat kesukaran, daya pembeda, dan fungsi distraktor pts matematika smpn Jakarta. *Himpunan: Jurnal Ilmiah Mahasiswa Pendidikan Matematika*, 3(1), 109–118. Retrieved from <https://jim.unindra.ac.id/index.php/himpunan/article/view/8645>
- Pusmenjar. (2022). *Buku Panduan Capaian Hasil Asesmen Nasional untuk Satuan Pendidikan*. Jakarta: Kemendikbud.
- Ramadhani, D., Kenedi, A. K., Rafli, M. F., Harahap, H., & Mardin, A. (2025). STEM-Based HOTS Digital Assessment Model in Measuring Higher-Order Thinking Skills of Prospective Teacher Students. *Jurnal Penelitian Pendidikan IPA*, 11(10), 111–120. <https://doi.org/10.29303/jppipa.v11i10.12812>
- Ratnawulan, E., & Rusdiana, H. A. (2014). *Evaluasi Pembelajaran*. Pustaka Setia.
- Rohim, D. C. (2021). Konsep Asesmen Kompetensi Minimum Meningkatkan Kemampuan Literasi Numerasi Sekolah Dasar untuk Siswa. *Jurnal Varidika*, 54–62. <https://doi.org/10.23917/varidika.v33i1.14993>
- Rokhim, D. A., Tyas, F. K., & Rahayu, S. (2022). Perspektif Siswa dan Guru Dalam Pelaksanaan AKM (Asesmen Kompetensi Minimum Pada Mata Pelajaran Kimia. *JAMP: Jurnal Administrasi Dan Manajemen Pendidikan*, 5, 46–52. <https://doi.org/10.17977/um027v5i12022p46>
- Safitri, E., Yunita, L., Bahriah, E. S., Kimia, P., Kimia, P., & Kimia, P. (2024). Implementasi Asesmen Kompetensi Minimum (AKM) Pada Pembelajaran Kimia di SMA. *Prosiding Seminar Nasional Fakultas Ilmu Tarbiyah Dan Keguruan UIN Syarif Hidayatullah Jakarta*, 1(1), 252–264. Retrieved from <https://e-proceeding.fitkuinjktconferences.com/index.php/semnas/article/view/76>
- Sakti, I., & Defianti, A. (2022). Implementasi Pembelajaran Berbasis STEM Pada Mata Kuliah Kajian IPA-1 Materi Suhu dan Kalor Untuk Meningkatkan Literasi Sains Mahasiswa. *Jurnal Kumparan Fisika*, 5(2), 131–140. <https://doi.org/10.33369/jkf.5.2.131-140>
- Sariningsih, R., Kadarisma, G., & Ristiana, M. G. (2022). PKM: Pelatihan Penyusunan Soal AKM Bagi Guru di Kabupaten Pangandaran. *Abdimas Siliwangi*, 5(2), 357–366. <https://doi.org/10.22460/as.v5i2.10376>
- Setyaedhi, H. S. (2024). Literacy and numeracy questions based on minimum competency assessments to improve the competency of private high school teachers. *Jurnal Penelitian Dan Pengembangan Pendidikan*, 8(2), 398–409. <https://doi.org/10.23887/jppp.v8i2.71373>
- Shahat, M. A., Emam, M. M., Alhinai, M., Omara, E. M., Alhabsi, N., Alhosni, K., & Al-Balushi, S. M. (2025). Enhancing middle school science education: Evaluating a competency-based STEM training program for teachers. *Social Sciences & Humanities Open*, 11, 101457. <https://doi.org/10.1016/j.ssaho.2025.101457>

- Shidiq, A. S., Yamtinah, S., Masykuri, M., Ulfa, M., Mulyani, B., Studi, P., Kimia, P., & Maret, U. S. (2022). Penguatan Kemampuan Guru-Guru Kimia SMA di Surakarta dalam Menyiapkan Instrumen AKM. *Literasi Membaca Dan Numerasi Berbasis Sains Kimia*, 4(4), 1402–1407. <https://doi.org/10.20527/btjpm.v4i4.6158>
- Sudijono, A. (2017). *Evaluasi Pendidikan*. PT Raja Grafindo Persada.
- Thornhill-Miller, B., Camarda, A., Mercier, M., Burkhardt, J.-M., Morisseau, T., Bourgeois-Bougrine, S., Vinchon, F., El Hayek, S., Augereau-Landais, M., Mourey, F., Feybesse, C., Sundquist, D., & Lubart, T. (2023). Creativity, Critical Thinking, Communication, and Collaboration: Assessment, Certification, and Promotion of 21st Century Skills for the Future of Work and Education. *Journal of Intelligence*, 11(3). <https://doi.org/10.3390/jintelligence11030054>
- Valiandes, S. (2015). Evaluating the impact of differentiated instruction on literacy and reading in mixed ability classrooms: Quality and equity dimensions of education effectiveness. *Studies in Educational Evaluation*, 45, 17–26. <https://doi.org/10.1016/j.stueduc.2015.02.005>
- Yamtinah, S., Utami, B., Masykuri, M., Mulyani, B., Ulfa, M., & Shidiq, A. S. (2022). Secondary School Science Teacher Response to Minimum Competency Assessment: Challenges and Opportunities. *Jurnal Penelitian Pendidikan IPA*, 8(1), 124–131. <https://doi.org/10.29303/jppipa.v8i1.1075>
- Zhang, L., Liu, X., & Feng, H. (2023). Development and validation of an instrument for assessing scientific literacy from junior to senior high school. *Disciplinary and Interdisciplinary Science Education Research*, 5(1), 21. <https://doi.org/10.1186/s43031-023-00093-2>