



## Ethno-STEM-Integrated Enriched Chemistry Book to Equip Chemical and Numeracy Literacy

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**Abstract:** Students in Indonesia face chemical literacy and numeracy challenges, which are essential for understanding scientific concepts and solving real-world problems. Ethno-STEM offers a promising approach by helping students learn through contextualized problems. This study aims to develop enrichment books integrating Ethno-STEM, focusing on typical Pati Regency foods, to enhance students' chemical literacy and numeracy. Using the R&D method with the 4D model, the study involved grade XI and XII students from SMAN 2 Pati and SMAN 1 Tayu. Validation by experts and trials confirmed the book's quality, with the Rasch model validating its content and assessments. The results show that (1) the developed enrichment book has 12 characteristics, (2) it was validated as a high-quality enrichment resource, and (3) it received positive feedback from teachers and students, demonstrating its potential to improve chemical literacy and numeracy while fostering cultural appreciation. This study provides a practical solution to improving students' chemical literacy and numeracy through Ethno-STEM integration, offering a culturally relevant resource that supports the goals of the Merdeka Curriculum and promotes appreciation of local cultural wisdom.

**Keywords:** chemical literacy; enrichment books; ethno-stem; numeracy literacy enhancement

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## INTRODUCTION

Scientific and numerical literacy is recognized globally as critical skills for navigating the complexities of modern life, enabling individuals to make informed decisions, solve problems, and contribute to knowledge-based societies (Bybee, 2009; OECD, 2019). Despite their significance, international studies highlight persistent challenges in developing these competencies. The most recent Programme for International Student Assessment (PISA) 2022 results underscore these challenges. Globally, only a minority of students achieved high proficiency levels in mathematics and science, with Indonesia's performance remaining below the OECD average. For instance, only 18% of Indonesian students reached at least Level 2 proficiency in mathematics compared to the OECD average of 69%, signaling significant difficulties in interpreting and applying mathematical concepts. Similarly, Indonesia's scores in reading and science were among the lowest, continuing a trend observed in earlier PISA cycles (OECD, 2023). These findings highlight the need for innovative educational reforms to address scientific and numerical literacy gaps worldwide. In the Indonesian context, these challenges are particularly pressing. Studies have consistently shown low performance levels among students in scientific and numerical literacy, as reflected in international assessments like PISA and TIMSS (Mullis et al., 2020; OECD, 2019). Research on scientific literacy highlights students' struggles to understand scientific concepts, apply them in real-world contexts, and reason through evidence-based arguments (Murti et al., 2024). Similarly, assessments of numerical literacy indicate challenges with mathematical problem-solving, strategy application, and result interpretation (Marhami et al., 2024). Specific to chemical literacy, a recent study shows that students' abilities are categorized as "Not Enough," with weaknesses in content, context, and competency aspects, specifically in colligative topics (Harianto et al., 2025). This result highlights the need to improve students' scientific literacy by addressing their unfamiliarity with scientific literacy questions and lack of training in making arguments based on observations, which can be achieved through learning models like ethnoscience-based learning that connect scientific knowledge to real-world problem-solving (Murti et al., 2024). In addition, comparisons of frameworks like PISA and PIAAC reveal diverse approaches to assessing numeracy and literacy, emphasizing the importance of real-life problem-solving skills (Gal & Tout, 2014).

One promising solution to these challenges is the integration of Ethno-STEM and local wisdom into education. Ethno-STEM combines science, technology, engineering, and mathematics with cultural knowledge and practices, creating a contextualized and engaging learning environment (Martawijaya et al., 2023; Primadianningsih et al., 2023). By incorporating elements of local wisdom, such as traditional foods, crafts, or ecological practices, educators can connect scientific and mathematical concepts to students' real-world

experiences, which not only improves students' understanding of abstract concepts but also fosters cultural appreciation and identity (Khoiri & Haryanto, 2018; Nugroho et al., 2019). Studies show that integrating Ethno-STEM into curricula enhances students' scientific literacy and critical and creative thinking (Putri et al., 2024; Sumarni et al., 2023; Sumarni & Kadarwati, 2020). Furthermore, this strategy aligns with Indonesia's Merdeka Curriculum, which emphasizes contextual and student-centered learning while preserving and promoting cultural heritage (Kemendikbud, 2022). By bridging the gap between global scientific principles and local cultural practices, Ethno-STEM provides a holistic framework to improve literacy and numeracy outcomes while fostering pride in Indonesia's rich cultural heritage. Along with the rapid progress of globalization and modernization, students' knowledge of local cultural wisdom in the regions is increasingly marginalized (Mahdiana, 2019; Maisaroh & Hayani, 2022). The application of culture in the curriculum aims to promote respect for cultural heritage, build a strong national identity, and improve the quality of education holistically (Kemendikbud, 2020). This is in line with the implementation of the independent curriculum, which provides space for teachers to allocate local content based on the characteristics and local wisdom in their area (Kemendikbud, 2022). Ethno-STEM can integrate Local cultural wisdom into chemistry learning (Al-Idrus, 2022). Integrating local wisdom into STEM enhances students' understanding of scientific concepts and fosters cultural appreciation and identity. This approach is in line with the government's commitment to preserving and promoting Indonesia's rich cultural heritage.

Local wisdom, often called ethnoscience, integrates cultural traditions and knowledge systems with scientific principles (Kumalasari et al., 2019; Ningsih et al., 2022), yet its application in high schools within the Pati district remains limited. Pati is rich in cultural heritage, including distinctive culinary traditions such as nasi gandul, tape gembong, mangut ndas manyung, and bandeng presto, which offer untapped educational potential. Studies have shown that through the application of Ethno-STEM, these traditional foods can be explored and reconstructed to reveal underlying chemical concepts, such as fermentation, enzymatic reactions, and preservation techniques (Khotimah et al., 2022; Nurhayati et al., 2021; Sapitri et al., 2020). Integrating these culturally relevant examples into chemistry lessons contextualizes scientific concepts and enhances student engagement and appreciation of their cultural heritage. This approach aligns with the goals of the Merdeka Curriculum, promoting contextual and student-centered learning while fostering a deeper connection between students' daily lives and scientific literacy.

These various topics can be included in an enrichment book. The existence of integrated Ethno-STEM chemistry enrichment books is not yet available in several schools in the Pati district. The application of enrichment books in learning in schools can help students to understand better and develop knowledge (Afandi & Zulaeha, 2017), skills (Oktaviane et al., 2018), and personality (Sundari et al., 2020). In addition, enrichment books can also be an effective means of including local cultural elements and aspects of local wisdom in the school curriculum. The enrichment books that are currently needed are those that provide chemical literacy and numeracy literacy. The ethnoscience approach can develop chemical literacy (Sudarmin et al., 2023). Chemical literacy must be taught to students (Melati et al., 2024; Prasemmi et al., 2021; Witono, 2023). Also, numeracy literacy is an important provision for students facing the world of work and social life because it allows them to solve problems, manage resource wealth, and make the right decisions (Khakima et al., 2021). Numeracy literacy is needed to prepare for the Minimum Competency Assessment and 21st-century skills (Megawati & Sutarto, 2021). Therefore, efforts are needed to equip students with chemical literacy and numeracy in the learning process. Ethnoscience learning should be carried out independently (Sumarni et al., 2017).

One promising approach to bridging these gaps is integrating Ethno-STEM and local wisdom into education. Martawijaya et al. (2023) and Primadianningsih et al. (2023) demonstrate that Ethno-STEM enhances student engagement by contextualizing scientific concepts within cultural practices, while Putri et al. (2024) show its potential to improve critical thinking and scientific literacy. Sumarni and Kadarwati (2020) also emphasize how Ethno-STEM fosters cultural appreciation alongside academic achievement. This approach aligns with Indonesia's Merdeka Curriculum, which promotes contextual learning while preserving cultural heritage (Kemendikbud, 2022). By integrating local wisdom into chemistry education, such as exploring traditional foods from Pati Regency to teach chemical concepts like fermentation, this study aims to develop an Ethno-STEM enrichment book that enhances chemical literacy and numeracy and fosters cultural identity and independent learning skills.

## METHODS

This study adopted a Research and Development (R&D) approach, a systematic method widely used for creating educational products to address specific instructional needs (Gall et al., 2007; Sugiyono, 2013). The R&D approach is particularly suitable for educational contexts, as it bridges the gap between theory and practice, allowing researchers to develop and implement solutions grounded in evidence-based practices (Dick et al., 2021). This study's approach was tailored to address the gap in integrating ethno-STEM principles into high

school chemistry education, particularly in the Pati Regency. The study followed the 4D model developed by Thiagarajan (1974), a framework designed to create and refine instructional materials through iterative stages. The 4D model includes four phases: define, design, development, and dissemination, each serving a distinct role in the product development lifecycle. By following the 4D model, the research aimed to develop a culturally relevant enrichment book that aligns with Indonesia's Merdeka Curriculum and promotes chemical literacy and numeracy among students. The iterative nature of the R&D process ensured that the final product was not only educationally sound but also practical and engaging for its users.

The study involved multiple groups of participants, including chemistry teachers, students from high schools in Pati Regency, and academic experts. Ninety students from grades XI and XII of SMAN 2 Pati and SMAN 1 Tayu were selected as participants for the small- and large-scale trials using purposive sampling. Students were chosen because they had already been taught the preliminary topics required, including the periodic table of elements, stoichiometry, and thermochemistry. These participants provided valuable feedback during the product testing phases. Several instruments were used throughout the research process to ensure comprehensive data collection. A structured framework guided interviews with teachers to examine their teaching materials and practices. During the design and development stages, validation sheets for content, media, and instrument experts were utilized to evaluate the enrichment book's quality. Additionally, test items were developed to align with chemistry learning objectives and the Achievement Test Plan (ATP) for classes X and XI. In small- and large-scale trials, surveys were administered using Google Forms to gather qualitative feedback from teachers and students. The Rasch model was employed to analyze the validity of test items in the enrichment book.

The research began with the define stage, which involved direct interviews with teachers to identify existing issues in teaching materials and the potential for integrating local cultural knowledge into chemistry education. Interviews with chemistry teachers from several high schools were conducted to analyze the existing learning materials, focusing on textbooks and teaching practices. This step aimed to assess the current integration of ethno-STEM concepts, evaluate students' chemical literacy and numeracy levels, and identify gaps that the enrichment book could address (Sugiyono, 2013). The design stage is initiated after identifying the problem in the define stage. This stage focused on the development of the enrichment book and supporting tools. The process began with selecting local dishes unique to Pati Regency and conducting observations or interviews to incorporate their cultural significance into scientific chemistry concepts. Test questions were crafted to align with the curriculum and learning objectives, ensuring they effectively assessed students' chemical literacy and numeracy skills. These instruments were created to meet the learning objectives and the Achievement Test Plan (ATP) for chemistry classes X and XI, as the enrichment book was specifically intended for these levels (Sugiyono, 2013). Once the content was drafted, the enrichment book was formatted as an online-accessible resource in PDF and Google Drive formats. At this stage, the final product, including the enrichment book and supporting tools, was prepared for validation by media and research instrument experts to ensure its quality and usability.

The development stage involved several iterations of validation and testing to ensure the quality and effectiveness of the enrichment book. Academic experts, including lecturers and teachers, reviewed the content and media to evaluate their alignment with educational standards and suitability for classroom use. A small-scale trial was conducted with 30 participants from one school, selected using purposive sampling, to assess the readability and appropriateness of the book. Additionally, a teacher opinion survey was administered through Google Forms to gather detailed comments and suggestions for improvement. The feedback and data from this trial were analyzed and used to refine the book before proceeding to a larger-scale trial. The large-scale trial involved 60 participants from two schools and input from several teachers from different schools to evaluate the product's applicability and effectiveness further. Similar to the small-scale trial, Google Forms were used to collect participant responses and teacher feedback, which were then analyzed to identify areas for improvement. The insights gathered from the large-scale trial informed the final revisions of the product. Any outstanding issues were addressed to ensure the enrichment book met the highest quality and usability standards.

Data from both the small- and large-scale trials were analyzed using the Rasch model to validate the test items within the enrichment book. Validity testing played a critical role in evaluating the accuracy and reliability of the assessments (Darma, 2021). Specifically, the validity of the question instruments was examined using item measure criteria (Boone et al., 2014) (Table 1) to determine their suitability. Items meeting the required fit criteria were retained, while those that failed were revised or replaced. Validation feedback from experts was systematically reviewed to identify areas needing refinement. Responses from students and teachers during the trials were analyzed to assess the enrichment book's usability and impact. This rigorous process ensured that the final product was both effective as a teaching resource and scientifically robust.

**Table 1.** Item Measure Criteria in Questions

| Value                                    | Criteria                           |
|------------------------------------------|------------------------------------|
| Outfit Mean Square (MNSQ)                | $0.5 < \text{MNSQ} < 1.5$          |
| Outfit Z-Standard (ZSTD)                 | $-2.0 < \text{ZSTD} < +2.0$        |
| Point Measure Correlation (PT Mean Corr) | $0.4 < \text{PT Mean Corr} < 0.85$ |

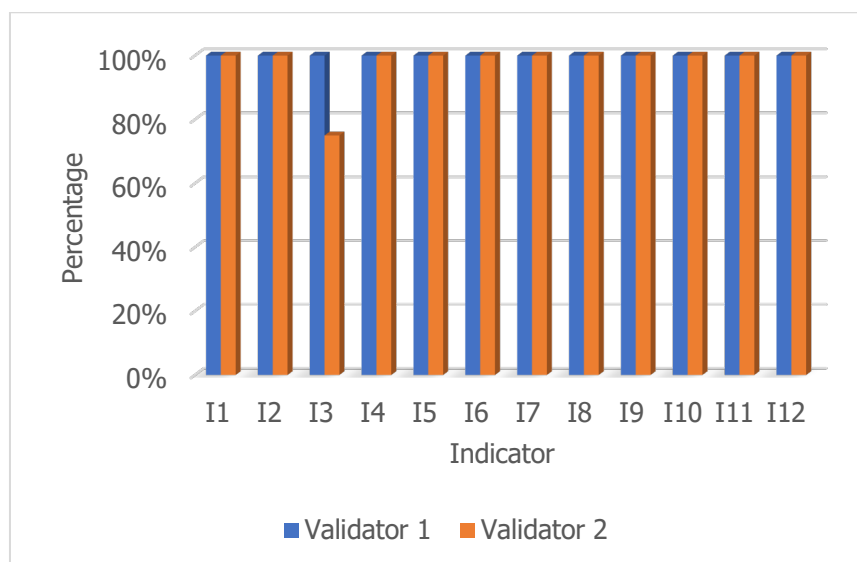
The final stage of the R&D model involved the dissemination of the developed enrichment book. Efforts were made to ensure the product reached a broad audience through publication in academic journals, making it accessible to educators and researchers interested in integrating ethno-STEM concepts into chemistry education. This step aimed to contribute to the body of knowledge and promote the practical application of ethno-STEM in Indonesian high schools.

## RESULT AND DISCUSSION

This research produces a product in the form of an integrated chemical enrichment book of Etno-STEM typical food of Pati district to equip students with chemical and numeracy literacy. The typical foods of the Pati district include mangut, ndas manyung, bandeng presto, tape gembong, and nasi gandul. SMAN 2 Pati and SMAN 1 Tayu were chosen as the places to research because they represent high schools in the city and regional areas. This study aimed to determine the characteristics, feasibility, and responses of students and teachers to the integrated chemical enrichment book of Etno-STEM typical food in the Pati district to equip students with chemical literacy and numeracy. The results of the research that has been conducted are described as follows. The define stage is the initial needs analysis stage to collect various information related to the research theme. Data was collected through interviews at two high schools in Pati district: SMAN 2 Pati and SMAN 1 Tayu. Based on the results of the interviews, it can be seen that the follow-up plan for the research is to develop an enrichment book that is integrated with local culture and add chemical literacy and numeracy literacy practice questions. The analysis of the interview results is a guideline for compiling a draft of a chemical enrichment book. In addition, a literature study was carried out that was related to the research theme. The literature study showed that chemical and numeracy literacy still needs improvement ([Khakima et al., 2021](#); [Witono, 2023](#)). One solution is implementing an enrichment book ([Hernani et al., 2017](#)).

This stage is the stage of compiling a draft of the enrichment book. Information obtained during the analysis stage is used as a reference in the creation and design. The enrichment book developed has characteristics that are tested based on expert validation results. The enrichment book compiled has several characteristics, including: (1) The material presented in the book can be real, meaning that the material is easy for students to understand through images and videos. (2) The development of the book's contents is not tied to the curriculum or its basic framework, meaning the enrichment book can be used in various curricula. (3) The presentation of the material is carried out innovatively and popularly. (4) The form of the material presented in the book is adjusted to the related material. (5) The presentation is carried out creatively by using relevant images and innovative language or image media. (6) There are independent practice question instruments. (7) There are group work question instruments. (8) There are chemical literacy and numeracy literacy practice questions and answers. (9) Chemical literacy and numeracy literacy evaluation (assessment) question instruments are used. (10) Contains information from interviews (observations) about the history and process of making typical Pati district food. (11) It contains information on the results of scientific reconstruction of typical Pati district food, and (12) It contains a link between chemical material and typical Pati district food.

Based on the characteristics of the enrichment book, the following is how it can equip chemical and numeracy literacy: (1) Real material, the use of images and videos makes the chemistry concepts easier to understand. This characteristic helps chemical literacy by providing a visual and practical context to abstract chemical concepts. (2) Scientific reconstruction of food: Information on the results of scientific reconstruction of typical Pati district food helps link chemical material with real-world applications. Connecting chemistry to food enhances chemical literacy through practical examples. (3) Practice questions with answers, including specific chemical literacy and numeracy literacy practice questions, along with answers, directly address these skills. This allows students to test their knowledge and understanding, reinforcing their chemical and numeracy literacy. (4) Independent practice, group, and assessment questions evaluate what students can work on to train their chemical literacy and numeracy skills. These assessment questions evaluate the students' grasp of chemical and numerical concepts. This provides a measure of their chemical and numeracy literacy and identifies areas for improvement. The characteristics of the enrichment book were analyzed through a questionnaire validated by an Expert. This validation was carried out through three aspects, namely the presentation aspect, the content aspect, and the aspect of the relevance of the material to Ethno-STEM. Based on the research results from the two experts' validation sheets, it can be presented in Figure 2.



**Figure 2.** Percentage of enrichment book characteristic validation results

The enrichment book characteristics obtained from the two validators have shown good results. The decision to use two experts in this case likely reflects a combination of practical considerations, a focus on in-depth feedback, and the specific design of the validation process. Based on the presentation validation aspect, both validators agreed that the material presented was real. This aligns with the characteristics presented by [Adriani et al. \(2018\)](#) and [Kemdikbud \(2013\)](#). Then, the material is presented innovatively and popularly. This aligns with the characteristics presented by [Sayuthy \(2020\)](#) and [Pusbuk \(2008\)](#). However, one of the validators still disagreed with the presentation indicator being done creatively with relevant images. Based on the content aspect, both validators agreed that the content is not tied to the curriculum or its basic framework. This aligns with the characteristics explained by [Sayuthy \(2020\)](#). Then, the form of material presented in the book is adjusted to the related material. This aligns with the characteristics explained by [Adriani et al. \(2018\)](#). The advantage of this book is that it has characteristics not mentioned in various sources of existing enrichment books. This enrichment book contains independent practice question instruments, group work question instruments, chemical literacy, and numeracy literacy practice questions along with the answers, and there are evaluation (assessment) questions for chemical literacy and numeracy literacy. Based on the relevance of the material to Ethno-STEM, this enrichment book also has advantages compared to existing enrichment books. Both validators agreed that the compiled enrichment book contained information from interviews (observations) about the history and process of making typical Pati district foods, information from the results of scientific reconstruction of typical Pati district foods, and a connection between chemical material and typical Pati district foods. The results of the analysis of the characteristics of the enrichment book were quite followed what was expected by the author and in line with the characteristics presented by [Pusbuk \(2008\)](#), [Kemdikbud \(2013\)](#), [Adriani et al. \(2018\)](#), and [Sayuthy \(2020\)](#).

This design stage also involves the preparation of test and non-test instruments. The test instrument consists of chemical literacy and numeracy literacy evaluation (assessment) questions to determine the ability or mastery of students to develop chemical literacy and numeracy literacy. The non-test instrument contains a questionnaire of student and teacher responses to determine the feasibility and success of the enrichment book developed. The development stage in this study began with experts' validation of materials, media, and test and non-test instrument sheets. Experts validate or assess the validity or feasibility of the compiled enrichment book. Validation of material and media experts was carried out using seven aspects, namely aspects of content feasibility, presentation feasibility, language feasibility, effectiveness aspects, graphic aspects, media display aspects of integrated Ethno-STEM enrichment books to provide chemical literacy and numeracy literacy, and interactive aspects. The results of this material and media validation are used to correct deficiencies according to the suggestions and input of the experts so that the draft of the enrichment book that is not yet valid can be revised before being tested. Based on the number of validator scores obtained, it can be concluded that the compiled enrichment book has met the very good criteria, with an average score of 87 out of a total score of 92. The number of scores shows that the compiled enrichment book is valid and suitable for use with a few revisions. Suggestions and input from the validator that need to be improved include writing the reconstruction table, links for working on each independent/group exercise, barcodes, font size, font type, and layout.

Instrument validation consists of test instruments and student and teacher response questionnaires. Validation of enrichment book test instruments uses five aspects: presentation, content, construct, language,

and use. Meanwhile, questionnaire validation consists of clarity of title, clarity of instructions for filling out the questionnaire, accuracy of use of indicators in the questionnaire, selection of questionnaire statements related to research objectives, statements under the aspects to be achieved, statements expressing correct information, statements containing one complete idea, easy-to-understand language, language effectiveness, number of statements from each indicator, total number of statements in the questionnaire, and selection of alternative questionnaire response answers. Based on the number of validator scores obtained, it can be concluded that the enrichment book that has been compiled has met the criteria of very valid. The number of scores can be stated that the instrument that has been compiled is valid and suitable for use with a few revisions. Suggestions and input from the validator that need improvement include the language in the questions, some of which still need improvement. The enrichment book that has been validated and improved will be tested on students at SMAN 2 Pati. A small-scale test was conducted on 30 students using assessment questions consisting of 10 chemical literacy questions and 10 numeracy literacy questions. The results of the first trial analysis include validity tests that can be represented in Table 2 and Table 3.

**Table 2.** Misfit Order Details of Small-Scale Chemical Literacy Test

| Question Number | Question Code | Outfit |       | PT Measure Corr. | Number of Criteria Fit | Interpretation |
|-----------------|---------------|--------|-------|------------------|------------------------|----------------|
|                 |               | MNSQ   | ZSTD  |                  |                        |                |
| 1               | Q1            | 0.90   | -0.42 | 0.29             | 2 Criteria             | Valid          |
| 2               | Q2            | 1.56   | 1.21  | 0.56             | 2 Criteria             | Valid          |
| 3               | Q3            | 0.71   | -1.41 | 0.44             | 3 Criteria             | Valid          |
| 4               | Q4            | 0.79   | -0.69 | 0.60             | 3 Criteria             | Valid          |
| 5               | Q5            | 1.47   | 1.74  | -0.10            | 2 Criteria             | Valid          |
| 6               | Q6            | 0.72   | -0.60 | 0.51             | 3 Criteria             | Valid          |
| 7               | Q7            | 0.83   | -0.61 | 0.03             | 2 Criteria             | Valid          |
| 8               | Q8            | 0.76   | -1.09 | 0.49             | 3 Criteria             | Valid          |
| 9               | Q9            | 1.24   | 1.14  | 0.65             | 3 Criteria             | Valid          |
| 10              | Q10           | 1.56   | 1.87  | 0.12             | 1 Criteria             | Valid          |

Table 2 shows no questions that do not meet any criteria (MNSQ, ZSTD, and Pt Measure Corr). All chemical literacy assessment questions in the enrichment book have met at least one criterion so that it can be stated that all questions are "valid."

**Table 3.** Misfit Order Details of Small-Scale Numeracy Literacy Test

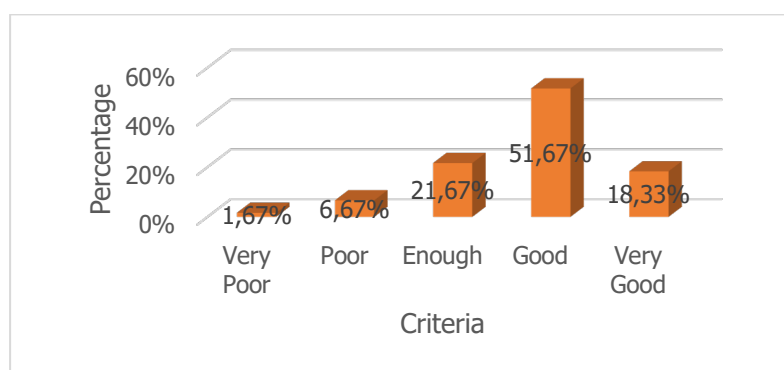
| Question Number | Question Code | Outfit |       | PT Measure Corr. | Number of Criteria Fit | Interpretation |
|-----------------|---------------|--------|-------|------------------|------------------------|----------------|
|                 |               | MNSQ   | ZSTD  |                  |                        |                |
| 1               | Q1            | 0.79   | -0.33 | 0.49             | 3 Criteria             | Valid          |
| 2               | Q2            | 0.78   | -0.26 | 0.41             | 3 Criteria             | Valid          |
| 3               | Q3            | 0.67   | -1.33 | 0.29             | 2 Criteria             | Valid          |
| 4               | Q4            | 0.64   | -0.69 | 0.48             | 3 Criteria             | Valid          |
| 5               | Q5            | 0.66   | -0.78 | 0.43             | 3 Criteria             | Valid          |
| 6               | Q6            | 1.47   | 1.48  | 0.07             | 2 Criteria             | Valid          |
| 7               | Q7            | 1.24   | 0.55  | 0.34             | 2 Criteria             | Valid          |
| 8               | Q8            | 0.79   | -0.44 | 0.12             | 2 Criteria             | Valid          |
| 9               | Q9            | 1.10   | 0.43  | -0.15            | 2 Criteria             | Valid          |
| 10              | Q10           | 1.30   | 1.08  | 0.35             | 2 Criteria             | Valid          |

Table 3 shows no questions that do not meet any criteria (MNSQ, ZSTD, and Pt Measure Corr). All questions in the numeracy literacy assessment in the enrichment book have met at least one criterion so that it can be stated that all questions are "valid". The small-scale test showed that all chemical literacy and numeracy literacy questions were valid, so there was no revision of the assessment questions, and it could be continued with a large-scale test with a sample size of 60 students consisting of two high schools (regional and city). The results of the large-scale test analysis are represented in Table 4 and Table 5.

**Table 4.** Misfit Order Details of Large-Scale Chemical Literacy Test

| Question Number | Question Code | Outfit |       | PT Measure Corr. | Number of Criteria Fit | Interpretation |
|-----------------|---------------|--------|-------|------------------|------------------------|----------------|
|                 |               | MNSQ   | ZSTD  |                  |                        |                |
| 1               | Q1            | 1.21   | 1.03  | 0.21             | 2 Criteria             | Valid          |
| 2               | Q2            | 1.12   | 0.88  | 0.38             | 2 Criteria             | Valid          |
| 3               | Q3            | 0.53   | -1.85 | 0.32             | 2 Criteria             | Valid          |
| 4               | Q4            | 0.84   | -0.59 | 0.23             | 2 Criteria             | Valid          |
| 5               | Q5            | 1.05   | 0.30  | 0.36             | 2 Criteria             | Valid          |
| 6               | Q6            | 0.73   | -0.94 | 0.08             | 2 Criteria             | Valid          |
| 7               | Q7            | 0.92   | -0.09 | 0.24             | 2 Criteria             | Valid          |
| 8               | Q8            | 0.91   | -0.18 | 0.08             | 2 Criteria             | Valid          |
| 9               | Q9            | 1.18   | 1.03  | 0.33             | 2 Criteria             | Valid          |
| 10              | Q10           | 1.09   | 0.62  | 0.42             | 3 Criteria             | Valid          |

Table 4 shows no questions that do not meet any criteria (MNSQ, ZSTD, and Pt Measure Corr). All chemical literacy assessment questions in the enrichment book have met at least one criterion so that it can be stated that the questions are "valid." Based on the eligibility of each question, the percentage of students' chemical literacy mastery results in the large-scale test can be presented in Figure 3.

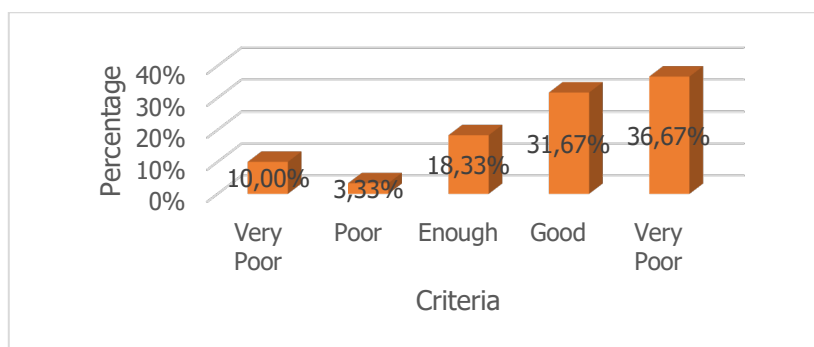
**Figure 3.** Large-Scale Test of Chemical Literacy Mastery

Based on the percentage of the results of the mastery of students' chemical literacy in large-scale tests, it shows that 18.33% of students have chemical literacy with the criteria of "Very Good," 51.67% of students have chemical literacy with the criteria of "Good," 21.67% of students have chemical literacy with the criteria of "Enough," 6.67% of students have chemical literacy with the criteria of "Poor," and 1.67% of students have chemical literacy with the criteria of "Very Poor". The results of the analysis of chemical literacy mastery in large-scale tests show that most students have good mastery. This shows that enrichment books containing chemical literacy have effectively equipped students.

**Table 5.** Misfit Order Details of Large-Scale Numeracy Literacy Test

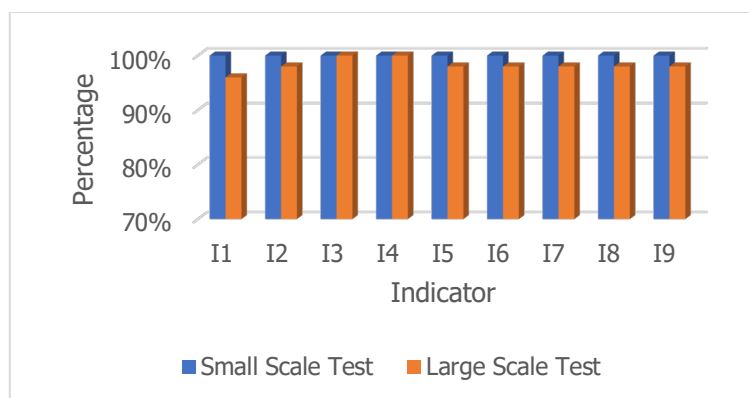
| Question Number | Question Code | Outfit |       | PT Measure Corr. | Number of Criteria Fit | Interpretation |
|-----------------|---------------|--------|-------|------------------|------------------------|----------------|
|                 |               | MNSQ   | ZSTD  |                  |                        |                |
| 1               | Q1            | 0.98   | 0.11  | 0.48             | 3 Criteria             | Valid          |
| 2               | Q2            | 0.69   | -0.47 | 0.51             | 3 Criteria             | Valid          |
| 3               | Q3            | 0.60   | -1.54 | 0.66             | 3 Criteria             | Valid          |
| 4               | Q4            | 0.82   | -0.54 | 0.63             | 3 Criteria             | Valid          |
| 5               | Q5            | 0.75   | -1.02 | 0.48             | 3 Criteria             | Valid          |
| 6               | Q6            | 1.57   | 1.49  | 0.31             | 1 Criteria             | Valid          |
| 7               | Q7            | 1.04   | 0.23  | 0.54             | 3 Criteria             | Valid          |
| 8               | Q8            | 0.77   | -0.40 | 0.48             | 3 Criteria             | Valid          |
| 9               | Q9            | 0.59   | -0.99 | 0.62             | 3 Criteria             | Valid          |
| 10              | Q10           | 0.97   | 0.03  | 0.57             | 3 Criteria             | Valid          |

Table 5 shows no questions that do not meet any criteria (MNSQ, ZSTD, and Pt Measure Corr). All questions in the numeracy literacy assessment in the enrichment book have met at least one criterion so that it can be stated that the questions are "valid". Based on the feasibility of each question item, the percentage of students' mastery of numeracy literacy results in the large-scale test can be presented in Figure 4.



**Figure 4.** Mastery of Numeracy Literacy Large-Scale Test

Based on the percentage of the results of the mastery of students' numeracy literacy in large-scale tests, it shows that 36.67% of students have chemical literacy with the criteria of "Very Good," 31.67% of students have chemical literacy with the criteria of "Good," 18.33% of students have chemical literacy with the criteria of "Enough," 3.33% of students have chemical literacy with the criteria of "Poor," and 10% of students have chemical literacy with the criteria of "Very Poor". The results of the analysis of numeracy literacy mastery in large-scale tests show that most students have good mastery. This shows that enrichment books containing numeracy literacy have effectively equipped students. Small-scale and large-scale tests stated that the chemical and numeracy literacy questions were valid overall so that the enrichment book could be categorized as suitable for use as an additional source. This shows that students who were previously less familiar with chemical literacy have received chemical literacy supplies and can do it well. This aligns with [Prasemmi et al. \(2021\)](#) and [Sutiani et al. \(2022\)](#), which show that local culture-based chemical literacy teaching materials and tests can improve students' understanding and chemical literacy skills. In addition, students' numeracy literacy showed good results. This is in line with [Fikrina et al. \(2023\)](#), which shows that chemical concepts, by integrating local culture and the surrounding environment, can provide a more relevant context to improve students' literacy and numeracy. At this development stage, an analysis of student and teacher responses obtained from the questionnaire was also carried out. This aims to determine the success of the compiled enrichment book. Analysis of student responses was carried out twice. The distribution of questionnaire sheets in the small test was carried out to determine the feasibility of the compiled enrichment book. The distribution of questionnaire sheets in the large-scale test was carried out to determine the success of the enrichment book. The results of the recapitulation of student response questionnaires in the small-scale and large-scale tests are presented in Figure 5.



**Figure 5.** Analysis of Student Response Questionnaire

The results showed a positive student response, so the compiled enrichment book can be categorized as feasible. The distribution of student questionnaire sheets in the second trial was carried out to determine the success of the enrichment book. The student responses in the second trial showed a positive response, so the enrichment book can be categorized as successfully developed. In addition, it is strengthened by the suggestions and experiences of students. One student argued that enrichment books can improve understanding of chemistry material. This is in line with [Maisaroh and Hayani \(2022\)](#). The large-scale test sheets were strengthened by suggestions and experiences obtained. The advantages of this book are that it has characteristics that are not mentioned in various existing sources of enrichment books, namely this enrichment book contains independent practice questions, group work questions, chemical literacy and numeracy practice questions and their answers, and evaluation questions (assessment) for chemical literacy and numeracy. Based on the relevance of the material to Ethno-STEM, this enrichment book also has advantages compared to existing

enrichment books. Both validators agreed that the compiled enrichment book contained information from interviews (observations) about the history and process of making typical Pati district foods, contained information from the results of scientific reconstruction of typical Pati district foods, and contained links between chemical material and typical Pati district foods. However, it also has disadvantages, namely that the material presented does not cover all grade levels and does not conduct direct observations with students regarding the processing of typical Pati district foods. Some suggestions and experiences of students can be seen in Table 6.

**Table 6.** Students' suggestions and experiences

|             |                                                                                                                                                                   |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Suggestions | "Buku pengayaannya sudah bagus, saran saya untuk ukuran huruf sedikit diperbesar supaya lebih jelas"                                                              |
|             | "menambah penjelasan materi pada buku pengayaan"                                                                                                                  |
| Experiences | "Untuk kalimat atau kata yang dipakai seharusnya memperhatikan kata baku, karena saya menemukan beberapa kata tidak baku yang membuat lebih sulit untuk dipahami" |
|             | "buku pengayaan dapat membekali kemampuan literasi dan numerasi saya"                                                                                             |
|             | "sangat menarik untuk dibaca karena terdapat gambar utk menambah wawasan"                                                                                         |
|             | "membuat saya lebih memahami materi kimia"                                                                                                                        |
|             | "menyenangkan dan dapat menambah wawasan/mengulas kembali mengenai materi kimia dari kelas X sampai kelas XII"                                                    |

Teacher response analysis was given to chemistry teachers in each trial. The results of the teacher response questionnaire showed a positive response, so it can be stated that the compiled enrichment book was suitable for use and excellent if implemented. This is reinforced by the comments or suggestions given. Comments or suggestions from teachers can be seen in Table 7.

**Table 7.** Comments or suggestions from teachers

| Teachers  | Comments or suggestions                                                                                                                                                                                                           |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Teacher 1 | "Buku pengayaan yang disusun bagus dan informatif. Akan lebih bagus jika dilengkapi materi yang lain. Kemudian untuk penyusunan buku pengayaan bisa disesuaikan bab per jenjang kelasnya, jadi bisa diterapkan langsung di kelas" |
| Teacher 2 | -                                                                                                                                                                                                                                 |
| Teacher 3 | "Buku pengayaan kimia sudah baik dan sudah disertai dengan materi dan soal-soal serta pembahasannya"                                                                                                                              |
| Teacher 4 | "Menurut saya, lebih baik lagi jika direncanakan untuk siswa kunjungan langsung melihat proses pengolahan makanan khas tertentu"                                                                                                  |

## CONCLUSION

The developed chemistry enrichment book has characteristics: the material presented is factual, flexible to the curriculum, the material is presented innovatively and popularly, the form of the material presented is appropriate, the presentation is creative and innovative, presents instruments for independent practice questions, group work questions, chemical literacy and numeracy literacy practice questions along with their answers and chemical literacy and numeracy literacy evaluation (assessment) questions, presents the results of interviews (observations) of typical Pati district foods and the results of their scientific reconstruction, and relates chemical material to typical Pati district foods. Based on the analysis of the questions, the enrichment book can be declared suitable for use as an additional source. The responses of teachers and students to the developed chemistry enrichment book showed a positive response so that the enrichment book can be categorized as successful for development.

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