E-ISSN: 3032-6435
https://e-jurnal.iainsorong.ac.id/index.php/jaser

Development and Validation of an Ethnoscience and Chemo-Entrepreneurship Integrated Acid Base Practicum Guide for Senior High School Chemistry

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Abstract

Twenty first century chemistry education requires learning resources that not only improve conceptual understanding but also foster students' creativity and independent learning. However, existing Acid base practicum guides generally emphasize laboratory procedures and have not integrated ethnoscience and Chemo-Entrepreneurship (CEP) in a single instructional resource. This study aimed to develop and validate an ethnoscience and CEP integrated Acid base practicum guide for senior high school chemistry. Educational Design Research (EDR) employing the Plomp model was selected because it provides a systematic framework for designing and validating educational products before classroom implementation. The study was limited to the preliminary research and prototyping phases. Product validity was evaluated through expert review involving five validators and one-to-one evaluation with three students representing different academic ability levels. Validity data were analyzed using Aiken's V. The practicum guide achieved an overall Aiken's V value of 0.93, indicating high validity, with content, presentation, language, and graphical validity indices of 0.93, 0.95, 0.92, and 0.95, respectively. The one-to-one evaluation further demonstrated that students considered the guide clear, systematic, and easy to follow. These findings provide empirical evidence that integrating ethnoscience and Chemo-Entrepreneurship within a chemistry practicum guide is feasible while maintaining scientific validity, thereby offering a contextual instructional resource has the potential to support creativity and independent learning in senior high school chemistry.

Article History:
Received 04 July 2026
Accepted 24 July 2026

Keywords:
Acid base,
Chemo-Entrepreneurship,
Ethnoscience,
Practicum guide,
Validity.

How to Cite:
Kaylla, A., & Yuhelman, N. (2026). Development and Validation of an Ethnoscience and Chemo-Entrepreneurship Integrated Acid base Practicum Guide for Senior High School Chemistry. SEARCH: Science Education Research Journal, 5(1), 38–49. https://doi.org/10.47945/search.v5i1.3252

INTRODUCTION

Twenty first century learning requires students to master real, measurable life skills rather than rote memorization of concepts (Sutarto, 2023). The 4C skills of critical thinking, creativity, communication, and collaboration need to be cultivated so students are prepared to face global challenges (Nurhayati et al., 2024). Creativity and independence, however, remain under addressed in classroom practice even though both are essential competencies for meeting these challenges (Redhana, 2019). Implementation of 21st-century learning in Indonesia still needs strengthening because teacher and student competence in developing these skills, particularly creativity, is not yet optimal (Putri et al., 2023), a gap that urgently needs to be bridged through more contextual and

meaningful learning innovation given the pressing demands of the national curriculum (Indarta et al., 2022).

The Ministry of Education has introduced the Merdeka Curriculum with a deep learning approach targeting eight graduate-profile dimensions, including critical reasoning, creativity, collaboration, and independence (Diputera & Eza, 2024); in chemistry learning, the creativity and independence dimensions in particular support the formation of creative, independent, collaborative students with a lifelong learning spirit (Anom et al., 2023). Several studies nevertheless report that these two dimensions remain under optimized: implementation of critical reasoning dimensions reached only 61.6%, lower than the 84.6% recorded for collaborative dimensions (Santika & Dafit, 2023); senior-high creative thinking skills were the lowest among 21st-century skills at 61.08% (Putri et al., 2023); and learning independence in chemistry reached only 32.88% after instruction, remaining in the fairly-good category (Kamilatunnisa et al., 2025).

A preliminary needs analysis conducted through interviews with chemistry teachers and a questionnaire distributed to students at SMAN 13 Padang reinforced this picture. Practicum activities were positively received (81.3% of students reported that practicum helped them understand the material and 84.8% felt more actively engaged), and most students (89.1%) considered Acid base practicum more interesting when linked to traditional local materials, yet 67.2% had never used such materials in a practicum and 82.8% had never produced an economically valuable product from one. Even so, 95.3% of students believed entrepreneurial activity could build creativity and independence, and 98.5% supported development of a practicum guide that draws on everyday materials and is oriented toward economically valuable products.

Ethnoscience, an approach that integrates scientific knowledge with communities' local cultural knowledge (Halimah et al., 2024), treats science not merely as theoretical fact but as an accumulation of knowledge born from cultural experience and community practice (Jumriati & Allo, 2024), helping students relate formal science concepts to cultural phenomena they encounter in daily life so that learning becomes more contextual and meaningful (Fikriani & Suyanta, 2025). In chemistry specifically, natural pH indicators, traditional food-processing practices, and regional products can serve as contexts for Acid base and other chemical concepts (Andayani et al., 2021), and this approach has been shown to strengthen cultural identity and support the character formation goals of the Pancasila Student Profile (Nasra et al., 2025).

Developing creativity and independence, however, is not sufficient through ethnoscience alone; students also need productive orientation through the Chemo-Entrepreneurship (CEP) approach, which links chemistry concepts to economically useful products so that learning becomes more applicative and relevant (Suryana, 2016). CEP has been shown to raise student creativity from moderate to high levels (Wibowo & Ariyatun, 2018), particularly when combined with project-based learning that pushes students to innovate in producing useful chemistry based products (Simangunsong et al., 2024); on Acid base material specifically, CEP has been shown to develop both creative thinking skills and the independence needed in real life (Amelia & Yasthophi, 2022).

Prior research and development studies have separately produced ethnosciencebased instructional materials, such as an e-worksheet integrated with ethnoscience on Acid base material (Astuti & Kurniawati, 2025) and an ethnosciencebased module on acid and base themes (Maytrea et al., 2020); CEP-based practical guides, such as an Islamic valuesintegrated e-practicum guidebook (Inayah et al., 2024), a CEP-based practicum guidebook for Acid base material (Febrianti & Ardhana, 2025), a CEP practical instruction on macromolecules (Faizah et al., 2024), a problem based learning e-module oriented to CEP on Acid base material (Putri et al., 2024), an e-module practicum guide on Acid base titration (N. Kurnia et al., 2025), and CEP-based interactive multimedia on hydrocarbons

(Kurnia et al., 2022); and an environment based Acid base practicum guide (Fataanissa et al., 2023). Despite this substantial body of work, an Acid base practicum guide that integrates both ethnoscience and Chemo-Entrepreneurship within a single instrument for SMA/MA remains scarce, which constitutes the novelty and gap addressed by the present study.

This study offers three main contributions to chemistry education research. First, it integrates ethnoscience and Chemo-Entrepreneurship into a single Acid base practicum guide, whereas previous studies have generally examined these approaches separately. Second, it applies the Educational Design Research framework to iteratively design and validate the instructional product before classroom implementation. Third, it proposes a contextual practicum framework that combines scientific concepts, local wisdom, and entrepreneurial learning within one coherent instructional resource, thereby providing a foundation for subsequent practicality and effectiveness studies

Based on this gap, the present study developed an ethnoscience and Chemo-Entrepreneurshipintegrated Acid base practicum guide for SMA/MA and determined its validity, using the Plomp Educational Design Research model limited to the preliminary research and prototyping phases. The remainder of this paper describes the design research method applied, presents the validity findings from expert review and one-to-one evaluation, and discusses their implications for chemistry practicum development.

RESEARCH METHODS

This study employed Educational Design Research (EDR), an approach designed to formulate solutions to complex educational problems that do not yet have a clear solution or guideline (Putrawangsa, 2018), This study employed Educational Design Research (EDR), a research approach intended to develop and systematically refine educational products through iterative design and formative evaluation. EDR is particularly appropriate when the objective is to generate an instructional product that is theoretically grounded and empirically validated before implementation in authentic classroom settings. Accordingly, this study adopted the Plomp development model, which consists of three phases: preliminary research, the prototyping phase, and the assessment phase. The present study was limited to the preliminary research and prototyping phases because its primary objective was to develop and establish the validity of the practicum guide rather than evaluate its practicality or effectiveness in classroom learning (Plomp & Nieveen, 2013). The development model applied was the Plomp model, comprising three main phases: preliminary research, the development or prototyping phase, and the assessment phase. This study was limited to the preliminary research and prototyping phases, since its objective was restricted to producing a valid product through design, development, and expert validation, without extending to practicality or effectiveness testing.

The study was conducted at the Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, and SMAN 13 Padang during the second semester of the 2025/2026 academic year. The research involved chemistry lecturers and chemistry teachers as expert validators, as well as senior high school students participating in the needs analysis and one-to-one evaluation stages. The object of this study was an ethnoscience and Chemo-Entrepreneurship integrated Acid base practicum guide designed for senior high school chemistry.

Five experts participated in the validation process, consisting of three chemistry education lecturers from Universitas Negeri Padang and two experienced senior high school chemistry teachers. The validators were selected because they possessed expertise in chemistry education, instructional

material development, curriculum implementation, and chemistry practicum learning, enabling comprehensive evaluation of the product from both theoretical and practical perspectives.

The one-to-one evaluation involved three students representing high, medium, and low academic achievement levels. This stage aimed to identify potential difficulties related to readability, clarity of instructions, presentation, and usability of the practicum guide before proceeding to wider-scale implementation.

The preliminary research phase comprised three sequential activities. First, a needs and context analysis was conducted through teacher interviews, classroom observations, and student questionnaires to identify curriculum demands, learner characteristics, laboratory conditions, and the need for an integrated practicum guide. Second, a literature review was undertaken to synthesize theories and empirical findings related to Acid base practicum guides, ethnoscience, Chemo-Entrepreneurship, deep learning, and Educational Design Research. This review also served to identify research gaps and establish the theoretical foundation of the product. Third, the findings from the needs analysis and literature review were synthesized into a conceptual framework that guided the development of the practicum guide, including its structure, instructional components, ethnoscience integration, and entrepreneurial activities, illustrated in Figure 1.

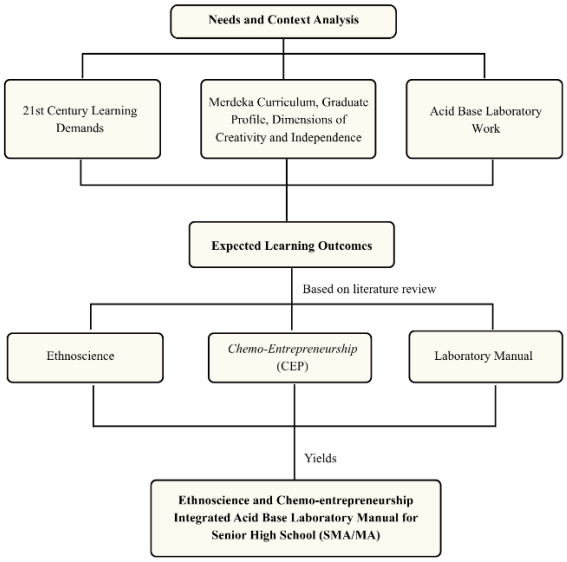


Figure 1. Framework Integrating Ethnoscience, Chemo-Entrepreneurship, and the Practicum Guide

The prototyping phase followed Tessmer's formative evaluation procedure consisting of self-evaluation, expert review, and one-to-one evaluation. Prototype I was first examined through self-evaluation to identify inconsistencies in content, layout, language, and technical presentation. The resulting revisions produced Prototype II. Prototype II subsequently underwent expert review using a validation instrument covering four assessment components: content, presentation, language, and graphics. Suggestions provided by the validators were incorporated into the product revision, resulting in Prototype III. Prototype III was then evaluated through one-to-one evaluation involving three students to assess the clarity of instructions, readability, sequence of activities, and overall usability of the practicum guide from the users' perspective.

The validation instrument was developed based on four assessment dimensions, namely content, presentation, language, and graphics. Each dimension consisted of several indicators evaluated using a five-point Likert scale ranging from 1 (very inappropriate) to 5 (very appropriate). In addition to assigning scores, validators were invited to provide written comments and suggestions to support product refinement shown in Equation.

Quantitative data obtained from the validation sheets were analyzed using Aiken's V to determine the validity of each assessment component. Meanwhile, qualitative feedback from expert validators and students participating in the one-to-one evaluation was analyzed descriptively and used as the basis for revising the practicum guide.

Instrument reliability analysis was not conducted because the primary objective of this study was limited to establishing content validity during the prototyping phase. Product refinement therefore relied on expert judgment and qualitative feedback obtained throughout the formative evaluation process. Future studies are recommended to examine the reliability of the validation instrument together with practicality and effectiveness testing. Prior to data collection, permission to conduct the study was obtained from the participating school. All participants voluntarily agreed to participate after receiving an explanation of the purpose of the study, and the collected data were used solely for research purposes while maintaining participant confidentiality.

$$V = \frac{\sum s}{n(c-1)}$$

where $s = r - lo$, lo is the lowest possible score in the rating category, c is the number of rating categories (5), n is the number of validators, and r is the score given by a validator. A product was categorized as valid when $V \geq 0.80$, and invalid when $V < 0.80$ (Aiken, 1985).

RESULTS AND DISCUSSION

1) Preliminary Research Results

Interviews with chemistry teachers indicated that chemistry learning already followed the Merdeka Curriculum with its deep learning approach targeting eight graduate-profile dimensions, but not all dimensions were optimally achieved in daily practice; teachers reported that creativity and collaboration were most frequently developed, while independence remained the least developed dimension because students still relied heavily on teacher guidance. Practicum activities had been carried out for topics close to daily life, such as Acid base indicators, colligative properties, reaction rate, and electrolysis, with adequate tools and materials; students had even been directed to bring traditional materials such as turmeric, mangosteen peel, rose petals, and tea as substitutes for synthetic pH indicators. However, ethnoscience and Chemo-Entrepreneurship had never been formally integrated into the practicum guides used, which consisted of teacher-compiled worksheets with content limited to tools, materials, and procedures. All teachers expressed strong support for a more contextual, systematic guide integrated with both approaches.

The student questionnaire reinforced these findings: 81.3% of students felt practicum helped them understand chemistry better than classroom theory alone, and 84.8% felt more actively engaged through practicum. In terms of ethnoscience, 89.1% considered Acid base practicum more interesting when linked to traditional materials, although 67.2% had never used such materials at school. In terms of entrepreneurial orientation, 82.8% had never produced an economically valuable product from a chemistry practicum, yet 95.3% believed entrepreneurial activity could build creativity and independence, and 98.5% supported development of a practicum guide oriented toward everyday materials and economically valuable products.

The literature review synthesized three pillars underlying the product. First, chemistry practicum guides function as instructional media that connect classroom theory with experimentation, allowing students to interact directly with real chemical phenomena and develop cognitive processes and scientific skills that are difficult to achieve through theoretical learning alone (Agustina et al., 2022). Second, the ethnoscience approach is highly relevant to chemistry because many chemical phenomena originate from local cultural practice; empirically, ethnosciencebased

learning has been shown to strengthen cultural identity, build environmental sustainability awareness, and increase creativity through fluency, flexibility, originality, and elaboration of ideas (Djarwo et al., 2025). Third, Chemo-Entrepreneurship links chemistry concepts to product-making with economic value; a systematic review of 46 articles found that CEP consistently improves creativity, life skills, and learning independence through product oriented chemistry learning (Ni'mah & Suwardi, 2023), including specifically on Acid base material (Amelia & Yasthophi, 2022).

These findings were synthesized into a conceptual framework built on three integration pillars, illustrated in Figure 1: ethnoscience, which raises local materials such as turmeric, purple cabbage, tamarind, and slaked lime into the scientific context of Acid base concepts; Chemo-Entrepreneurship, which provides a creative economic orientation so students identify the sale value of local, chemistry based materials, for example through making a turmeric-tamarind herbal drink or a slaked-lime-based odor neutralizer; and the practicum guide itself, which functions as the instructional medium bridging the two within one systematic, structured format. This conceptual framework subsequently served as the design blueprint for Prototype I.

The findings from the preliminary research demonstrate that the need for an integrated practicum guide extends beyond the availability of laboratory activities. Teachers and students required instructional materials capable of connecting scientific concepts with local cultural contexts while simultaneously fostering entrepreneurial awareness. These findings therefore provide a strong empirical foundation for developing an instructional product that addresses both contextual relevance and Twenty first-century competency development.

2) Prototyping Phase Results

Prototype I, the initial draft, contained the full set of intended components: an ethnoscienceand-CEP concept section, brief underlying theory, tools and materials, work procedures built around local materials, a student worksheet, and reflection activities. Self-evaluation of Prototype I identified minor issues in page layout, typographical errors, and clarity of the working procedures, which were corrected to produce Prototype II.

Prototype II was evaluated through expert review by five validators across four components, summarized in Table 1. The overall Aiken's V was 0.93 (valid). The content component scored 0.93, with perfect agreement (V = 1.00) on the accuracy of reaction notation/formulas, the application of ethnoscience, and the eco friendly and economical character of the resulting CEP products, while the lowest score (V = 0.80) concerned clarity of the working mechanism explanation, which was subsequently strengthened through additional and clearer illustrations at each work step. The presentation component scored 0.95, the highest of the four, reflecting a systematic flow from local context to formal concept and finally to applied CEP reflection. The language component scored 0.92, with clear, unambiguous sentences and accurate scientific terminology. The graphics component scored 0.95 across all four items, reflecting a cover, layout, and typography judged attractive and proportional; based on validator feedback, the cover was simplified by removing excessive text shadow on the title, adjusting the typeface, repositioning the subtitle, and softening the background silhouette so that the title and institutional identity remained the primary visual focus.

Beyond demonstrating that the practicum guide fulfilled validity criteria, the expert-review results indicate that integrating ethnoscience and Chemo-Entrepreneurship can be achieved without reducing scientific accuracy or instructional quality. The consistently high validity across all assessment components suggests that local cultural knowledge and entrepreneurial contexts can complement rather than replace core chemistry concepts when systematically embedded within instructional materials.

Table 1. Aiken's V Validity Results by Assessment Component (Expert Review, n = 5 validators)

Assessment Component	Aiken's V	Category
Content (materi asam basa, notasi, aplikasi konsep, integrasi etnosains dan CEP)	0.93	Valid
Presentation / construct (systematics, sequencing, completeness of components)	0.95	Valid
Language (readability, clarity, adherence to Indonesian spelling rules)	0.92	Valid
Graphics (cover, layout, typography, color combination)	0,95	Valid
Overall average	0,93	Valid

The high presentation and graphical validity further indicate that integrating contextual learning resources requires not only scientifically accurate content but also systematic organization and effective visual communication. These aspects are essential because instructional materials with strong pedagogical design are more likely to facilitate meaningful learning and encourage students to independently construct scientific understanding.

Prototype III, revised from expert-review feedback, was then evaluated through one-to-one evaluation involving three students of SMAN 13 Padang representing high, medium, and low academic ability. Students across all three ability levels found the display, sequencing of steps, and integration of ethnoscience and Chemo-Entrepreneurship clear, coherent, and easy to follow, and reported that the images and tables in the guide helped them independently discover chemistry concepts and understand both the practicum procedure and the entrepreneurship project. With this stage completed, Prototype III was considered valid and ready for subsequent practicality and effectiveness testing. The positive responses obtained from students with different academic ability levels indicate that the integration of ethnoscience and Chemo-Entrepreneurship did not increase the cognitive complexity of the practicum guide. Instead, the contextual examples and familiar local materials appeared to support students in understanding abstract Acid base concepts through meaningful real-life experiences.

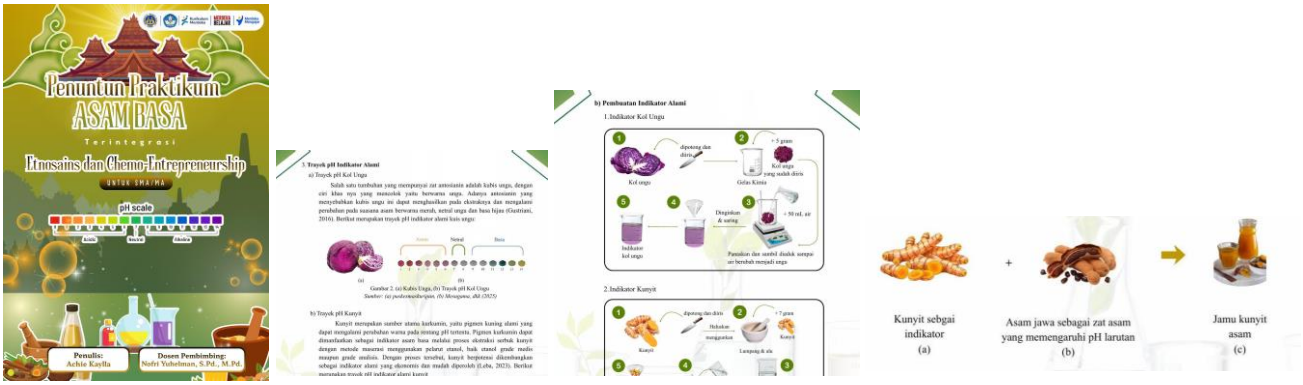
Table 2. Results of the One-to-One Evaluation

Evaluation Aspect	Indicator	Summary of Students' Responses
Clarity of Instruction	Word selection	All three students stated that the wording used in the practical guide was clear, appropriate, and easy to understand
	Sentence clarity	The sentences were considered clear, well-structured, and easy to comprehend
	Question clarity	The questions were perceived as clear and easy to understand, enabling students to respond without difficulty.
	Clarity of images, videos, and objects	The images, videos, and learning objects were considered clear and supportive of students' understanding of the practical activities
	Sequence of content presentation	The organization and sequence of the practical guide were regarded as systematic and easy to follow.
	Layout and page size	The layout, font size, and page format were considered appropriate and comfortable for reading
Impact on Learners	Creativity and independent learning	All students agreed that the practical guide has the potential to enhance their creativity and encourage independent learning during laboratory activities.
	Understanding of theoretical concepts	The introductory theory was considered easy to learn and helpful in preparing students before conducting the experiment.
Feasibility	Applicability in Acid base learning	All students agreed that the practical guide is feasible for use in Acid base learning activities at the senior high school level

These qualitative findings complement the quantitative validity results obtained from expert review. While expert judgment confirmed the scientific and instructional appropriateness of the practicum guide, the one-to-one evaluation demonstrated that these qualities were also perceived by

prospective users. The consistency between both forms of evaluation strengthens confidence that the developed practicum guide possesses satisfactory content validity as an instructional product.

To illustrate the final practicum guide obtained through this development process, Figures 2 (a) to 2 (d) present selected key sections of the product. Figure 2 (a) shows the cover of the ethnoscience and Chemo-Entrepreneurship integrated Acid base practicum guide. Figure 2(b) presents the pH-color ranges of the natural indicators used in the guide, purple cabbage and turmeric, both familiar local materials. Figure 2 (c) illustrates the step by step procedure for preparing these two natural indicators. Figure 2 (d) shows the Chemo-Entrepreneurship product developed from the Acid base concept, *Jamu Kunyit Asam* (a turmeric-tamarind herbal drink), through which students practiced calculating production cost and break-even point.



a b c d

Figure 2: (**a**). Cover of the ethnoscience and Chemo-Entrepreneurship integrated Acid base practicum guide (**b**). pH-color ranges of the purple cabbage and turmeric natural indicators presented in the practicum guide (**c**). Step by step procedure for preparing the purple cabbage and turmeric natural indicators (**d**). Turmeric and tamarind processed into *Jamu Kunyit Asam*, the Chemo-Entrepreneurship product developed in the practicum guide

The overall Aiken's V of 0.93 across all four components indicates that the developed guide met the content, construct, linguistic, and graphic validity criteria (Aiken, 1985). This result is consistent with prior ethnoscience and CEP-based development studies: an ethnosciencebased acid base module obtained Aiken's V of 0.99 for content and 0.97 for media (Maytrea et al., 2020); a CEP-based practical instruction on macromolecules obtained Aiken's V of 0.846 (Faizah et al., 2024); a discovery learning e-worksheet integrated with ethnoscience on Acid base material obtained Aiken's V of 0.94 (Astuti & Kurniawati, 2025); and an environment-based Acid base practicum guide reached 83% validity (Fataanissa et al., 2023). Taken together, these findings indicate that instructional products integrating ethnoscience and Chemo-Entrepreneurship consistently possess a strong validity foundation, extending prior single-approach studies by showing that the two approaches can be combined without diminishing product quality.

The content validity achieved here can be explained by the scientific verifiability of the local materials selected: turmeric and purple cabbage function as natural indicators through their curcumin and anthocyanin content, tamarind has a pH of approximately 3-4 as an acid test solution, and slaked lime, $Ca(OH)_2$, has a pH above 7 as a base test solution, so their use carries both cultural and chemical validity, consistent with the principle that content validity requires accuracy relative to the curriculum and the characteristics of the material taught (Azaly & Fitrihidajati, 2022). The entrepreneurship tasks embedded in the content, such as cost-of-production and break-even-point calculations for a turmeric-tamarind herbal drink, were pitched at a level appropriate to SMA/MA students' cognitive capacity, in line with the view that entrepreneurial context in chemistry learning should be integral to the content rather than a procedural add on (Supartono et al., 2009).

From a theoretical perspective, this study supports the view that contextual chemistry learning becomes more meaningful when scientific concepts are simultaneously connected with cultural knowledge and entrepreneurial activities. Unlike previous studies that integrated either ethnoscience or Chemo-Entrepreneurship separately, the present study demonstrates that both approaches can coexist within a single practicum guide without diminishing instructional quality. This finding enriches the growing body of Educational Design Research in chemistry education by providing empirical support for multi-approach instructional design.

The high presentation/construct validity reflects the internal coherence among the guide's components (Rochmad, 2012), visible in the logical progression from local ethnoscience context to formal Acid base concept and finally to applied CEP reflection, so that the two integrated approaches are presented proportionally without compromising the depth of the chemistry content. The language validity aligns with criteria for readability, clarity of information, adherence to correct Indonesian spelling, and effective, efficient use of language in instructional texts (Kemendikbud, 2017) , while the graphic validity aligns with instructional design principles for producing engaging, proportional visual media that support effective learning (Mahnun, 2012).

The qualitative results from one-to-one evaluation triangulate the quantitative Aiken's V findings: a valid instrument should not only satisfy expert judgment but also be usable and comprehensible to its actual end users (Yusup, 2018). That students across high, medium, and low ability levels consistently reported clarity of instructions and ease of understanding indicates that the integration of ethnoscience and Chemo-Entrepreneurship did not compromise accessibility for a heterogeneous classroom. More broadly, these findings suggest that local wisdom and entrepreneurial orientation can be embedded within a single chemistry instructional tool without sacrificing scientific rigor, offering a concrete, contextual response to the gap between 21st-century and Merdeka Curriculum aspirations and current classroom practice (Nuroni et al., 2026).

This study has several limitations. First, the development process was limited to the preliminary research and prototyping phases of the Plomp model. Consequently, the practicality and effectiveness of the practicum guide have not yet been evaluated through classroom implementation. Second, the product was developed using local cultural contexts from West Sumatra; therefore, further adaptation may be required before implementation in regions with different local resources and cultural characteristics. Despite these limitations, the developed practicum guide provides practical guidance for chemistry teachers wishing to implement more contextual laboratory learning. The integration framework proposed in this study may also serve as a reference for instructional material developers seeking to incorporate local wisdom and entrepreneurial learning into chemistry practicum activities while maintaining alignment with curriculum objectives.

CONCLUSION

The present study successfully developed and validated an ethnoscience and Chemo-Entrepreneurship integrated Acid base practicum guide for senior high school chemistry through the preliminary research and prototyping phases of the Plomp Educational Design Research model. The findings demonstrate that integrating local cultural knowledge with entrepreneurial learning can be systematically incorporated into a chemistry practicum guide while maintaining scientific accuracy, instructional quality, and pedagogical coherence.

From a theoretical perspective, this study extends previous instructional material development research by demonstrating that ethnoscience and Chemo-Entrepreneurship are complementary approaches rather than separate instructional orientations. Their integration provides a more contextual learning framework capable of simultaneously supporting concept mastery, creativity,

and independent learning. the developed practicum guide may serve as a reference for chemistry teachers and instructional material developers seeking to design laboratory activities that are more relevant to students' local environments while promoting entrepreneurial awareness. The integration framework proposed in this study may also be adapted for other chemistry topics with appropriate modifications to local cultural contexts.

this study was limited to the preliminary research and prototyping phases. Consequently, the findings should be interpreted only in terms of product validity, since classroom practicality and instructional effectiveness have not yet been examined. Future studies are therefore recommended to investigate the practicality and effectiveness of the practicum guide through small-group implementation and wider classroom field testing.

ACKNOWLEDGMENT

The authors thank the chemistry lecturers of Universitas Negeri Padang and the chemistry teachers and students of SMAN 13 Padang who participated as validators and respondents in this study.

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