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Development of a Chemo-Entrepreneurship–Based Chemistry Practicum E-Module

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Abstract: Various instructional methods can be implemented by educators to encourage students to think critically, creatively, and innovatively. One approach that can be applied in the learning process is the use of learning resources that are capable of enhancing students' skills and creativity, such as practicum e-modules. The development of a Chemo-Entrepreneurship–based practicum e-module in chemistry learning was motivated by the absence of practicum guides currently used in schools that incorporate Chemo-Entrepreneurship principles. Through the Chemo-Entrepreneurship (CEP) approach embedded in the practicum module, the chemistry content learned by students can be applied in laboratory activities to process materials into useful chemical products with economic value. This approach is expected to foster students' entrepreneurial interest and inspiration through the learning process. This initiative is also aligned with the implementation of the *Merdeka Curriculum*, which emphasizes meaningful, contextual, and student-centered learning. The research problems addressed in this study are: (1) the validity of the developed Chemo-Entrepreneurship–based chemistry practicum e-module, and (2) the responses of teachers and students toward the developed Chemo-Entrepreneurship–based chemistry practicum e-module. This study employed a Research and Development (R&D) method using the 4D model, which consists of four stages: define, design, develop, and disseminate. The research sample consisted of 33 students from class XII MIA 1 at MAN 4. The data collection instruments included interview guidelines for the initial analysis stage, validation sheets, and questionnaire sheets for teachers and students. Data analysis techniques were carried out using percentage formulas. Based on the validation results from three expert validators, the e-module obtained a percentage score of 81.4%, which falls into the "very valid" category. Furthermore, questionnaire responses from two chemistry teachers yielded a percentage of 92.3%, categorized as "very good," while responses from 33 students of class XII MIA 1 resulted in a percentage of 75.8%, categorized as "good".

Keywords: Chemo-Entrepreneurship–Based Chemistry, Practicum Module, Chemistry.

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INTRODUCTION

Practicum activities constitute learning experiences based on experiments or trials. In chemistry education, practicum activities involve experimental work conducted by students to verify theories that have been learned in chemistry classes, as well as to develop basic experimental skills that enable students to better understand chemical concepts. Practicum activities play a crucial role in enhancing students' understanding and experimental skills

(Prasetiowati & Muna, 2022). Students are more likely to understand practicum activities when instructional materials that provide clear guidance are available, one of which is a practicum module. This is in line with Pendit et al. (2022), who state that a practicum module is an instructional material used as a learning aid to ensure that practicum activities are well-directed in accordance with learning objectives.

To date, practicum modules have generally been available in printed or hard-copy formats. Such modules have several limitations, including restricted presentation formats that rely primarily on text and images, as well as distribution through printing or photocopying, which incurs high costs. Along with rapid technological advancements, practicum modules have been developed in electronic formats, commonly referred to as e-modules (Alwanuddin et al., 2022).

Pendit et al. (2022) define an e-module or electronic module as a systematically designed electronic instructional material in the form of a digital book, intended to facilitate students' independent learning with or without guidance from teachers by utilizing internet access and the capabilities of Android-based devices. In the current era of advanced technology, e-modules in the form of links can be integrated into Android-based applications that are easily accessible to students who own smartphones. E-modules are also equipped with comprehensive learning components, including materials, methods, videos, images, animations, audio, and quizzes (evaluations), all integrated into a single module, thereby providing immediate feedback to students. This is consistent with the findings of Milianingsih et al. (2023), who report that most students in the Industry 4.0 era rely heavily on the internet to complete learning tasks. Therefore, additional electronic instructional materials in the form of e-modules are required to support learning facilities.

The e-module developed in this study is a Chemo-Entrepreneurship–based chemistry practicum e-module, which connects chemistry content with entrepreneurial concepts through the Chemo-Entrepreneurship (CEP) approach (Tim Dosen, 2020). Through the CEP approach, the chemistry concepts learned by students can be applied in practicum activities to process materials into useful chemical products with economic value, thereby fostering students' entrepreneurial interest and inspiration through the learning process. Thus, the CEP approach is highly effective for implementation in practicum e-modules and is particularly suitable for school-based laboratory activities, as it can motivate students and make chemistry learning more relevant to real-life contexts (Herdini, Erna, & Indah, 2022).

Based on interviews with two teachers—a chemistry teacher and an extracurricular entrepreneurship teacher—it was found that during chemistry learning activities, students relied on practicum guides from textbooks provided by the school, student worksheets (LKPD) prepared by teachers, and practicum manuals supplied by the school. However, the existing chemistry practicum modules had not yet incorporated the CEP approach. In addition, MAN 4 Aceh Besar offers an extracurricular entrepreneurship program. The implementation of entrepreneurship education at MAN 4 Aceh Besar has demonstrated positive outcomes in fostering students' independence and entrepreneurial interest. Students not only learn theoretical concepts but also engage in entrepreneurial practices, such as producing food and beverage products and compiling reports based on the products they create. During celebrations of the Prophet Muhammad's birthday (*Maulid Nabi Muhammad SAW*), students are taught to prepare traditional Acehnese dishes such as *kuah beulangong*, *mie Aceh*, and *keumamah* to be shared after the event. Furthermore, during report card distribution events, the school organizes a bazaar aimed at introducing students' products to the school community and parents, while also providing opportunities for students to learn entrepreneurship within a small-scale context.

Nevertheless, entrepreneurial activities to date have primarily focused on general food and beverage processing and have not yet integrated entrepreneurship-based chemistry practicum activities due to the absence of CEP-based practicum modules. Several benefits of Chemo-Entrepreneurship–based chemistry practicum modules include instilling entrepreneurial spirit, values, and character in students to enable them to adapt and contribute positively to their environment. Considering that markets will continue to

develop toward 2045, it is essential for students to acquire entrepreneurial competencies. Entrepreneurship education is highly important for fostering motivation and equipping students with the entrepreneurial skills required for the future (Ramdani et al., 2022). Therefore, the researcher was motivated to develop a Chemo-Entrepreneurship–based chemistry practicum module.

In the development of this module, four senior high school chemistry topics across grades X MIA to XII MIA are addressed. For grade X MIA, the topic of substances and their changes covers physical and chemical changes, exemplified by the production of aromatherapy candles made from lime peel and lemongrass. For grade XI MIA, the topics include salt hydrolysis (e.g., the production of toothpaste from eggshells) and buffer solutions (e.g., the production of liquid detergent from hibiscus leaves). For grade XII MIA, the topic focuses on colligative properties of solutions related to osmotic pressure, exemplified by the production of candied *kolang-kaling* with butterfly pea flowers. These four chemistry topics are connected to the processing of materials into products commonly encountered in daily life that have economic value and practical benefits, thereby motivating students to engage in entrepreneurial activities through the learning process and enhancing their understanding of chemical concepts.

Budiono (2017) states that one of the products of development research is a practicum module. Therefore, this study aims to determine the validity of the Chemo-Entrepreneurship–based chemistry practicum e-module and to examine teachers' and students' responses toward the developed Chemo-Entrepreneurship–based chemistry practicum e-module.

METHODS

The method employed in this study was Research and Development (R&D) using the 4-D model, which consists of four stages: definition (*define*), design (*design*), development (*develop*), and dissemination (*disseminate*) (Qurniati, 2021).

The *define* stage was conducted to collect information related to the instructional materials to be developed, including student analysis, needs analysis, and curriculum analysis. The *design* stage involved designing the draft of a Chemo-Entrepreneurship–based chemistry practicum module, as well as developing research instruments in the form of expert validation questionnaires, teacher response questionnaires, and student response questionnaires. The *develop* stage aimed to produce the Chemo-Entrepreneurship–based chemistry practicum module designed in the previous stage. During this stage, expert validation was carried out by three expert lecturers to determine the validity of the developed practicum module in terms of three aspects: media, content, and language.

The data obtained from the expert validation process were analyzed using a Likert scale ranging from 1 to 5, as presented in Table 1.

Table 1. Likert Scale Categories for Validation Assessment

Score	Criteria
5	Very Good
4	Good
3	Fairly Good
2	Poor
1	Very Poor

The total scores provided by the validators were then analyzed by calculating the percentage in order to determine the level of validity of the developed Chemo-Entrepreneurship–based chemistry practicum module, using the following formula:

$$\text{Percentage} = \frac{\text{Total score obtained from validators}}{\text{Total ideal score}} \times 100\%$$

The percentage obtained from the calculation was subsequently analyzed and categorized according to the validity criteria of the practicum module, as shown in Table 2.

Table 2. Percentage Criteria for the Validity Level of the Practicum Module

Percentage (%)	Qualification
< 21	Very Invalid
21–40	Invalid
41–60	Fairly Valid
61–80	Valid
81–100	Very Valid

At this stage, the designed practicum module was further developed or revised based on suggestions and feedback from the validators. The revised module was designed to be as engaging as possible to attract students' interest in learning the materials contained in the Chemo-Entrepreneurship–based chemistry practicum module. After the revision process was completed, the developed e-module product was ready to be implemented in learning activities.

The *disseminate* stage involved distributing the Chemo-Entrepreneurship–based chemistry practicum e-module to madrasahs that had not yet implemented such practicum modules. At this stage, the researcher conducted a trial of the developed practicum e-module involving teachers and students of class XII MIA. The purpose of this trial was to identify teachers' and students' responses to the use of the Chemo-Entrepreneurship–based chemistry practicum e-module in chemistry learning activities.

The data obtained from teacher and student response questionnaires were analyzed using a Likert scale, as presented in Table 3.

Table 3. Likert Scale Categories for Teacher and Student Responses

Score	Criteria
5	Very Good
4	Good
3	Fairly Good
2	Poor
1	Very Poor

(Arikunto, 2016)

The scores were then analyzed by calculating the percentage using the following formula:

$$\text{Percentage} = \frac{\text{Total responses obtained}}{\text{Highest score} \times \text{Number of items} \times \text{Number of respondents}} \times 100\%$$

The resulting percentage values were subsequently categorized based on the percentage criteria for teacher and student responses, as shown in Table 4.

Table 4. Percentage Criteria for Teacher and Student Responses

Percentage (%)	Criteria
81–100	Very Good
61–80	Good
41–60	Fair
21–40	Poor
0–20	Very Poor

RESULTS

The product resulting from this development research is a Chemo-Entrepreneurship–based chemistry practicum e-module, which covers four chemistry topics at the Madrasah Aliyah (MA) level, namely physical and chemical changes, salt hydrolysis, buffer solutions, and osmotic pressure. The e-module has undergone expert validation to determine its validity in terms of media, content, and language aspects, and has also been tested through teacher and student response questionnaires to evaluate users' perceptions of the developed Chemo-Entrepreneurship–based chemistry practicum e-module.

The development of the Chemo-Entrepreneurship–based chemistry practicum e-module is necessary because existing practicum modules have not yet integrated chemistry content with the Chemo-Entrepreneurship concept through the Chemo-Entrepreneurship (CEP) approach. As a practicum guide, this e-module is expected to assist teachers in conducting chemistry learning, particularly laboratory activities, and to help students connect chemistry concepts with products commonly found in their surrounding environment. Consequently, the chemistry material learned by students can be applied through practicum activities to process raw materials into useful and economically valuable chemical products, thereby fostering students' entrepreneurial interest and inspiration through the learning process.

Define Stage

The results of the **front-end analysis** were obtained through interviews with two teachers, namely a chemistry teacher and a Chemo-Entrepreneurship extracurricular instructor. The analysis revealed that students demonstrated a strong interest in learning, possessed contextual knowledge of chemistry concepts, and actively participated in practicum activities based on the required material. Students had also previously produced several products and compiled reports based on their products, supported by the existence of Chemo-Entrepreneurship extracurricular activities.

The **needs analysis** indicated that learning resources used as practicum guides included textbooks provided by the school, student worksheets (LKPD) developed by teachers, and modules. However, although practicum modules were available, none were based on Chemo-Entrepreneurship. The **curriculum analysis** showed that Grades X and XI had implemented the Merdeka Curriculum, while Grade XII was still applying the 2013 Curriculum. These findings formed the basis for designing a Chemo-Entrepreneurship–based practicum e-module, which had not previously been utilized in the learning process (Anwar, 2023).

Design Stage

The design stage resulted in the initial draft of the practicum module, module validation sheets, and user response questionnaires for teachers and students. This stage involved designing the product to be developed in order to obtain an initial draft (Hanifah et al., 2023). The initial design of the Chemo-Entrepreneurship–based chemistry practicum e-module includes the following components:

a) **Cover**
   The cover displays the title *"Chemo-Entrepreneurship–Based Chemistry Practicum E-Module (CEP)"* along with images of Chemo-Entrepreneurship products, such as aromatherapy candles, toothpaste, liquid detergent, and candied kolang-kaling.
b) **Preface**
   The preface contains a brief explanation of the developed e-module, its objectives, and its potential benefits for readers.
c) **Table of Contents**
   The table of contents presents the sequence of topics and corresponding page numbers.
d) **List of Figures**
   This section lists all figures along with their respective page numbers.

e) **Instructions for Using the Practicum Module**
This section provides guidance for students prior to using the practicum module to ensure proper utilization.

f) **Practicum Module Approach**
An explanation of the Chemo-Entrepreneurship (CEP) approach applied in the e-module.

g) **Science Laboratory Rules**
Laboratory regulations that must be followed by students when conducting practicum activities at MAN 4 Aceh Besar.

h) **Stages of Laboratory Work**
These include preparation, implementation, and closing stages.

i) **First Aid for Laboratory Accidents**
Immediate assistance provided to individuals involved in laboratory accidents due to improper handling of chemicals or equipment.

j) **Chemical Hazard Symbol**
Symbols representing the characteristics and potential hazards of chemical substances.

k) **Introduction to Laboratory Equipment and Materials**
An overview of laboratory tools and materials along with their functions.

l) **Personal Protective Equipment and Laboratory Safety Devices**
According to Nurhidayati (2021), personal protective equipment (PPE) minimizes injuries and prevents occupational diseases, while laboratory safety devices reduce potential hazards.

m) **Experiments**
The e-module contains four experiments, each integrating Chemo-Entrepreneurship components such as constructivism, questioning, modeling, inquiry, learning community, reflection, and authentic assessment.
- Experiment 1: Physical and chemical changes through the production of aromatherapy candles from lime peel and lemongrass
- Experiment 2: Salt hydrolysis through toothpaste production from eggshells
- Experiment 3: Buffer solutions through liquid detergent production from hibiscus leaves
- Experiment 4: Colligative properties (osmotic pressure) through candied kolang-kaling with butterfly pea flowers

n) **Report Format**
A structured report format to be completed collaboratively by students after conducting experiments.

o) **Assessment Rubrics**
Rubrics covering attitude, psychomotor skills, reports, and product outcomes.

p) **Inspirational Story**
An inspirational story of Samrotul Azizah, a housewife who succeeded in a pineapple juice business.

q) **References**
References include university textbooks, school library books, and journal articles used in developing the e-module.

Validation Results

The overall validation results from three expert validators across media, content, and language aspects showed an average score of **81.4%**, categorized as **"very valid."** Therefore, the Chemo-Entrepreneurship–based chemistry practicum e-module is highly valid and suitable for implementation in chemistry learning activities.

Revisions were made based on validators' suggestions, including improvements to the cover design, formatting of foreign terms, correction of chemical reaction arrows, addition of reference links for product preparation, and clarification of image captions.

Dissemination Stage

The dissemination stage involved administering response questionnaires to **two chemistry teachers** (17 items) and **33 Grade XII MIA students** (14 items). The teacher response analysis yielded an average percentage of **92.3%**, categorized as **"very good,"** indicating that the e-module is highly suitable as a practicum guide in chemistry learning. This finding aligns with Annisa and M. Sari (2021), who reported that Chemo-Entrepreneurship–oriented practicum modules were highly practical for teachers.

Student response analysis produced an average percentage of **75.8%**, categorized as **"good,"** suggesting that the e-module effectively increases students' learning interest. This result is consistent with previous studies (Annisa & M. Sari, 2021; Masriadi et al., 2023), which indicate that Chemo-Entrepreneurship–based practicum modules enhance student engagement by linking chemistry concepts to real-world product creation.

DISCUSSION

The present study aimed to develop and validate a Chemo-Entrepreneurship–based chemistry practicum e-module and to examine teachers' and students' responses toward its implementation. The findings indicate that the developed e-module achieved a validity score of 81.4%, which falls into the "very valid" category. This result suggests that the e-module meets essential quality standards in terms of content accuracy, media design, and language clarity, thereby confirming its feasibility for use in chemistry learning, particularly in practicum-based instruction.

The high level of validity obtained in this study is consistent with the principles of instructional material development proposed by Najuah et al. (2020) and Anwar (2023), which emphasize systematic alignment between learning objectives, content structure, and assessment components. The integration of Chemo-Entrepreneurship (CEP) elements into the practicum activities strengthens the contextual relevance of chemistry concepts, enabling students to connect abstract chemical theories with real-life applications and economically valuable products. This contextualization aligns with constructivist learning theory, which posits that knowledge is constructed through meaningful experiences and interactions with the environment (Hanifah et al., 2023).

From the media perspective, the electronic format of the practicum module offers advantages over conventional printed modules, particularly in terms of accessibility, interactivity, and flexibility. Alwanuddin et al. (2022) argue that e-modules facilitate independent learning by integrating multimedia elements such as images, videos, and hyperlinks that support diverse learning styles. In this study, validators highlighted improvements in layout, visual clarity, and reference integration, indicating that media quality plays a crucial role in enhancing the usability and pedagogical value of digital learning resources. These findings corroborate previous research by Pendit et al. (2022), which demonstrated that well-designed e-modules significantly improve students' engagement and comprehension.

In terms of content validity, the incorporation of four chemistry topics—physical and chemical changes, salt hydrolysis, buffer solutions, and colligative properties—into CEP-oriented practicum activities reflects strong curricular alignment. This alignment is particularly relevant within the context of the Merdeka Curriculum, which emphasizes meaningful, student-centered, and contextual learning experiences. By transforming raw materials into marketable products such as aromatherapy candles, toothpaste, liquid detergent, and candied kolang-kaling, the e-module operationalizes chemistry concepts in ways that are both scientifically accurate and socially relevant. Similar approaches have been reported by Herdini et al. (2022) and Annisa and Sari (2021), who found that CEP-based modules effectively bridge chemistry learning with entrepreneurial skill development.

The teachers' response score of 92.3%, categorized as "very good," indicates strong acceptance of the developed e-module as a practicum guide. Teachers perceived the module as practical, systematic, and supportive of laboratory-based instruction. This finding aligns

with Saputro (2017), who emphasizes that development research products must demonstrate not only validity but also practicality from the users' perspective. Teachers' positive responses also suggest that the e-module can reduce instructional burdens by providing structured guidance for experiments, assessment rubrics, and safety procedures, as recommended by Nurhidayati et al. (2021) in laboratory learning contexts.

Meanwhile, the students' response score of 75.8%, categorized as "good," indicates that the e-module successfully attracted students' interest and supported their learning processes, although there remains room for improvement. The slightly lower score compared to teachers' responses may be attributed to students' varying levels of digital literacy, prior experience with e-modules, and familiarity with entrepreneurship-based learning. Nevertheless, this result is consistent with findings by Milaningsih et al. (2023) and Masriadi et al. (2023), who reported that CEP-oriented learning materials positively influence students' motivation and engagement by emphasizing product creation and real-world relevance.

Importantly, the CEP approach embedded in the practicum e-module contributes to the development of entrepreneurial attitudes and skills, which are increasingly recognized as essential competencies for students in the 21st century. Ramdani and Simamora (2022) argue that entrepreneurship-oriented learning fosters creativity, independence, and problem-solving abilities. Through authentic assessment components such as product evaluation and practicum reports, the developed e-module encourages students to reflect on both scientific processes and economic value creation, thereby supporting holistic learning outcomes.

Although this study demonstrates the validity and positive reception of the developed e-module, it is important to note that the research focused primarily on validation and user responses rather than learning effectiveness. Consequently, the findings do not yet provide empirical evidence regarding the impact of the e-module on students' cognitive achievement, psychomotor skills, or entrepreneurial competencies. Future research should therefore extend this work by conducting experimental or quasi-experimental studies to evaluate learning effectiveness, as suggested by Prasetiowati and Muna (2022) and Qurniati (2021).

The results of this study contribute to the growing body of literature on Chemo-Entrepreneurship–based learning by demonstrating that a systematically developed practicum e-module can achieve high validity and positive user responses. By integrating chemistry content with entrepreneurial contexts and digital learning media, this study offers a practical instructional innovation that supports curriculum reform and prepares students for future academic and economic challenges.

CONCLUSION

Based on the results and discussion, it can be concluded that the Chemo-Entrepreneurship–based chemistry practicum e-moduledeveloped in this study is categorized as highly valid, with a validity percentage of 81.4%. The teachers' responses indicate a very good category, with a percentage of 92.3%, while the students' responses fall into the good category, with a percentage of 75.8%. As a recommendation for future research, it is suggested that an effectiveness test be conducted on the implementation of the Chemo-Entrepreneurship–based chemistry practicum e-module to examine its impact on students' practicum activities and to further enhance students' entrepreneurial interest.

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