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# Development of Student Handbook on the Extraction of Secondary Metabolites Based on *Premna serratifolia* Research

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**Abstract:** This study aims to develop a digital module on the extraction of secondary metabolites based on P. serratifolia research as a self-study resource for students. This study utilized the Thiagarajan 4D development model, which encompasses the stages of definition, design, and development without dissemination. Participants in the study comprised students from Universitas Muhammadiyah Pontianak, Akademi Farmasi Yarsi Pontianak, and Universitas Tanjungpura who had previously studied extraction materials. Subject matter, media, and language experts provided validity scores of 94.69%, 88%, and 84.37%, respectively, resulting in an average validity score of 89.02%, categorizing the student handbook as highly valid. Small and large group trials yielded practicality percentages of 93.81% and 93.69%, respectively, with an average score of 93.75%, indicating the student handbook high practicality. Consequently, the student handbook on secondary metabolite extraction based on *P. serratifolia* research is deemed highly valid and practical as a self-study resource on the topic.

**Keywords:** Extraction; *P. serratifolia*; Student handbook; 4d

## Introduction

Learning resources are crucial in supporting the achievement of learning goals (Ramdoniati et al., 2018). A student handbook represents a structured learning resource adhering to the curriculum and specific time units, delivered through computer or device platforms (Cynthia et al., 2023; Suryadi et al., 2019). The structure of a student handbook encompasses essential elements such as the cover, student handbook profile, student handbook usage guide, learning competencies, concept map, list of activities, evaluations, quizzes, and answer keys (Cheva & Zainul, 2019).

Research-based student handbook have been developed for Biotechnology courses (Fitriyati et al., 2015) with a validation level of 90.91% and practicality of 88.89%. Additionally, research-based student handbook development has been conducted for Plant Anatomy courses, achieving a validation level of 90.91% and readability of 85.35%. Student handbook developed from research can enhance the quality of learning by presenting material that is contextual, in-depth, and engaging, based on scientific facts (Wahyuni et al., 2018). This is crucial for fostering students' initiative, independence, and confidence in the learning process (Fitriyati et al., 2015). Research-based student handbook are systematically designed to support students in independent learning. A review of the literature indicates that no research-based student handbook have been developed for Natural Product Chemistry courses that cover extraction from medicinal plants specific to West Kalimantan.

The plant Buas-buas, also known as *Premna serratifolia* (*P. serratifolia*), is utilized by the people of West Kalimantan as a vegetable source, the main ingredient in making green grass jelly, and in traditional medicine to alleviate various health issues such as stomach disorders, fever, shortness of breath, worm infections, constipation, digestive problems, and to enhance breast milk production (Marbun & Restuati,

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2015; Nurliana et al., 2018). The ethanol extract from the leaves of P. serratifolia has been proven to have various functions such as antioxidant and anti-inflammatory properties (Isnindar et al., 2016; Marbun & Restuati, 2015; Puspita, Sari, et al., 2020), antifungal effects (Wahyuni et al., 2014), antimicrobial activity (Trisna & Leliqia, 2022), anthelmintic properties(Meilina et al., 2019), antibacterial effects (Nurliana et al., 2018), and antidiabetic properties (Hadiarti, 2017; Hadiarti et al., 2023; Simamora et al., 2020; Timotius et al., 2018). Research on the extraction of secondary metabolites from this plant has covered various methods such as maceration, soxhletation, infusion, decoction, and distillation.

The initial step in utilizing P. serratifolia as a medicinal plant involves the extraction process. Maceration using 70% ethanol yields an extract of P. serratifolia leaves with a 21.42% yield (Puspita, Puspasari, et al., 2020; Riduana et al., 2021; Supriningrum et al., 2018), while the distillation method yields a higher 12.876% (Kurniati, 2013). The infusion method using water as a solvent yields 12% (Hasanah et al., 2015), but soxhlet extraction with n-hexane and ethanol solvents provides yields of 10% and 34.1%, respectively (Hadiarti, 2017; Tonius et al., 2016). It is imperative to study the extraction process as it facilitates the understanding of separating or purifying compounds from a mixture using a solvent, as well as extracting the chemical components present in the plant.

Extraction is a major focus of study in the Natural Product Chemistry course. A video resource addressing the extraction of secondary metabolites from P. serratifolia leaves has been developed, achieving a validation score of 93.9% and practicality rating of 86.39% (Rahayu et al., 2018). While this video has significantly contributed to the learning process, it primarily covers the extraction steps using the maceration and isolation methods.

The survey conducted between September 8-12, 2023, among students from three universities in Pontianak revealed challenges in identifying effective solvents for the extraction process. These challenges included difficulties in selecting solvents and methods that demonstrated effectiveness in terms of yield and bioactivity. The students primarily relied on PowerPoint presentations and scientific articles as their learning resources but faced delays in finding suitable articles.

Similarly, survey results from lecturers teaching Natural Product Chemistry at seven universities in Indonesia indicated that they encountered difficulties in compiling learning materials based on their research. They predominantly used textbooks and international journal articles as their primary resources. These challenges were attributed to their obligations to fulfill other aspects of the university's tridharma.

Understanding the extraction process is a crucial first step in optimizing the use of plants as medicine. The availability of student handbook based on research on P. serratifolia in the extraction material of the Natural Product Chemistry course can serve as a reference for students to explore other plants for medicinal purposes. Aligning the research-based student handbook on P. serratifolia with the characteristics and needs of students can increase their interest in learning Natural Product Chemistry.

This research introduces an innovative approach by developing a research-based digital module for natural product chemistry education, specifically in the context of secondary metabolite extraction based on research of Premna serratifolia in West Kalimantan. Previous studies have focused on developing learning resources in the form of videos, whereas a structured research-based digital module has not yet been developed in this context.

This research is crucial as it addresses a significant gap in the literature in the field of natural product chemistry related to the extraction of secondary metabolites from Premna serratifolia in West Kalimantan. Currently, there are no available learning resources that provide structured and scientifically verified information for this plant. By developing a research-based digital module, this study aims to provide comprehensive guidance for students and researchers in effectively studying this plant. Moreover, the development of this research-based module is expected to be an innovative solution in enhancing the quality of natural product chemistry education by providing easier and more interactive access to in-depth learning materials, which are regularly updated based on the latest research. Focusing on Premna serratifolia as the research object also supports the development of local knowledge in West Kalimantan and the sustainable utilization of natural resources, contributing to the enrichment of scientific literature in the field of natural product chemistry both locally and globally.

## Method

This study employs the research and development (R&D) method by modifying the 4D development model into three stages to develop a student handbook: definition, design, and development, excluding the dissemination stage, based on the model by Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel (Fitriyati et al., 2015; Rahayu et al., 2018; H. Wahyuni et al., 2018). The definition stage includes five main steps: Front-end analysis, student analysis, task analysis, concept analysis, and formulation of learning objectives (Elfrida et al., 2023; Seprianingsih et al., 2017; Zikrullah et al., 2017). The design stage aims to create learning resources

by selecting media, choosing formats, and creating initial drafts. Expert validation, trials, and revisions are the steps carried out in the development stage (Sukmadewi & Jumadi, 2023).

The validity of the student handbook is obtained from the assessments of subject matter, language, and media experts using a validation sheet with a Likert scale. The validity percentage is calculated according to Equation 1 and matched with the criteria in Table 1 (Riduwan, 2011).

$$Percentage = \frac{\Sigma \text{ validator answers}}{\Sigma \text{ highest validator score}} x100\% \quad (1)$$

Explanation:
Percentage = quality percentage of instructional media
Σ validator answers = total validator answers
Σ highest validator score = total highest validator score

**Table 1.** Validity Criteria

| Score range | Description |
|---|---|
| ≥ 81.50 – 100.00 | Very valid |
| ≥ 62.50 – 81.40 | Valid |
| ≥ 43.50 – 62.40 | Less valid |
| ≥ 25.00 – 43.40 | Not valid |

The practicality of the student handbook is obtained from data collected through a Likert scale questionnaire with categories: Strongly Agree (SS), Agree (S), Disagree (TS), and Strongly Disagree (STS). Responses were provided by 27 students who had read the student handbook on secondary metabolite extraction at Muhammadiyah University of Pontianak, Tanjungpura University, and Yarsi Pontianak Pharmacy Academy. After tabulating the scores, the practicality percentage is calculated according to Equation 2 and matched with the criteria in Table 2 (Riduwan, 2011).

$$\text{Percentage} = \frac{\Sigma \text{ respondent answers}}{\Sigma \text{ highest respondent score}} x100\% \quad (2)$$

Explanation:
Response percentage = response percentage
Σ respondent answers = total respondent answers
Σ highest respondent score = total highest respondent score

**Table 2**. Practicality Criteria

| Score range | Description |
|---|---|
| ≥ 81.50 – 100.00 | Very practical |
| ≥ 62.50 – 81.40 | Practical |
| ≥ 43.50 – 62.40 | Less practical |
| ≥ 25.00 – 43.40 | Not practical |

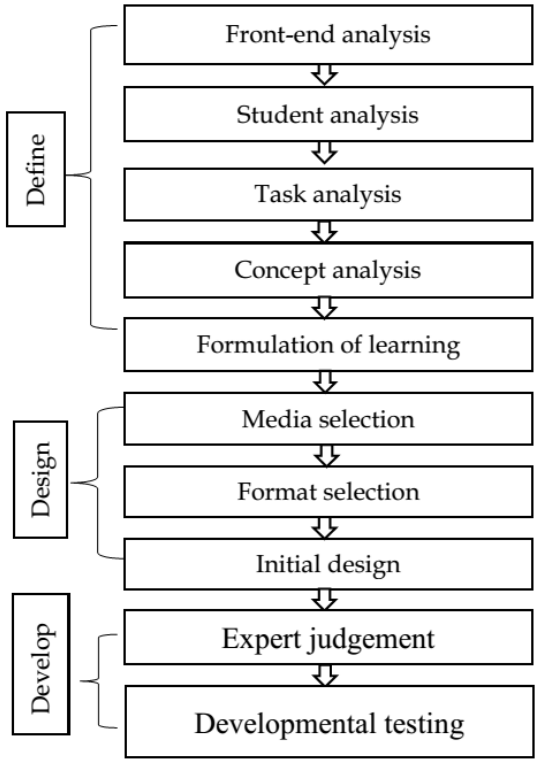



**Figure 1.** Stages of the 3D model (Nurani, 2024; Tanjung & Louise, 2024; Utami et al., 2024)

## Result and Discussion

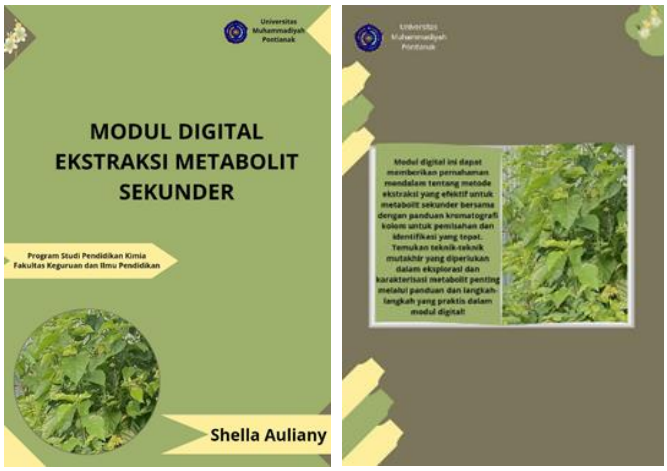
*Definition*

The definition stage is the phase to establish and define the conditions of learning. Front-end analysis is the first step in the definition stage, consisting of field studies and curriculum review (Vinata et al., 2023). Field studies involving lecturers and students indicated the absence of self-study resources for the extraction of secondary metabolites based on research. The learning outcomes (CPL) for the Chemistry Education Study Program in the 2021 curriculum assigned to Natural Product Chemistry include P1, P2, P4, KU1, and KK8. Student analysis showed difficulties in determining effective extraction methods and solvents, making it challenging to complete assignments given by lecturers. These assignments include group reviews of medicinal plant articles and individual research proposals that encompass the extraction and isolation of secondary metabolite compounds (Hakim et al., 2023). The analysis of the material studied in secondary metabolite extraction includes extraction methods (maceration, soxhletation, infusion, decoction, and distillation), fractionation, extraction solvents, extraction yield, column chromatography techniques, thin-layer chromatography (TLC), and determination of the retardation factor (Rf) (Zhang et al., 2018). The sub-learning outcomes (CPMK) for the extraction topic are the ability to determine effective extraction methods and

solvents to obtain yield and bioactivity and the ability to determine the best column chromatography eluent based on spot separation on TLC plates (Shalihin et al., 2022).

*Planning*

The student handbook was created as a learning resource for extracting information related to P. serratifolia research. The selection of this format corresponds with the fact that 61.5% of students spend 7-8 hours per day on the internet. The student handbook was initially typed using Microsoft Word and then saved in PDF format. For reader convenience, the student handbook was transformed into a flipbook format using the Heyzine website (Salsabila & Nurjayadi, 2019). The student handbook is formatted using A5 paper, Arial font, size 9, with 1.15 line spacing, and margins of 1.5 cm at the top, 1.4 cm on the left, 1.5 cm at the bottom, and 1.4 cm on the right. The introductory section of the student handbook includes a front cover, back cover, usage instructions, preface, table of contents, material overview, CPL (course learning outcomes), sub-CPL, and concept map. As illustrated in Figure 2, the front and back cover feature images of the P. serratifolia plant to reflect the content of the student handbook. The student handbook cover consists of a front cover in green and a back cover in dark green. The main content pages consist of extraction material, column chromatography, assignments, summaries, and formative tests. The final pages include the formative test answer key, bibliography, glossary, index, and author information.




A B

**Figure 2.** (A) Front cover and (B) Back cover

*Development*

Nine validators, consisting of subject matter experts, media experts, and language experts, provided an overall rating of 89.02% in the first step of the development stage, categorizing the student handbook as highly valid (Rusmanto & Rukun, 2020). Figure 3 (A) demonstrates that the aspects of competency, material quality, material coverage, and material accuracy in the student handbook achieved a rating of 94.69% based on the assessment of three subject matter experts, which also falls into the highly valid category. The highest score was awarded for the competency aspect at 100%, while the lowest score was for material quality at 92%. Validators offered suggestions regarding the concept map and the sub-course learning outcomes, as detailed in Table 3.

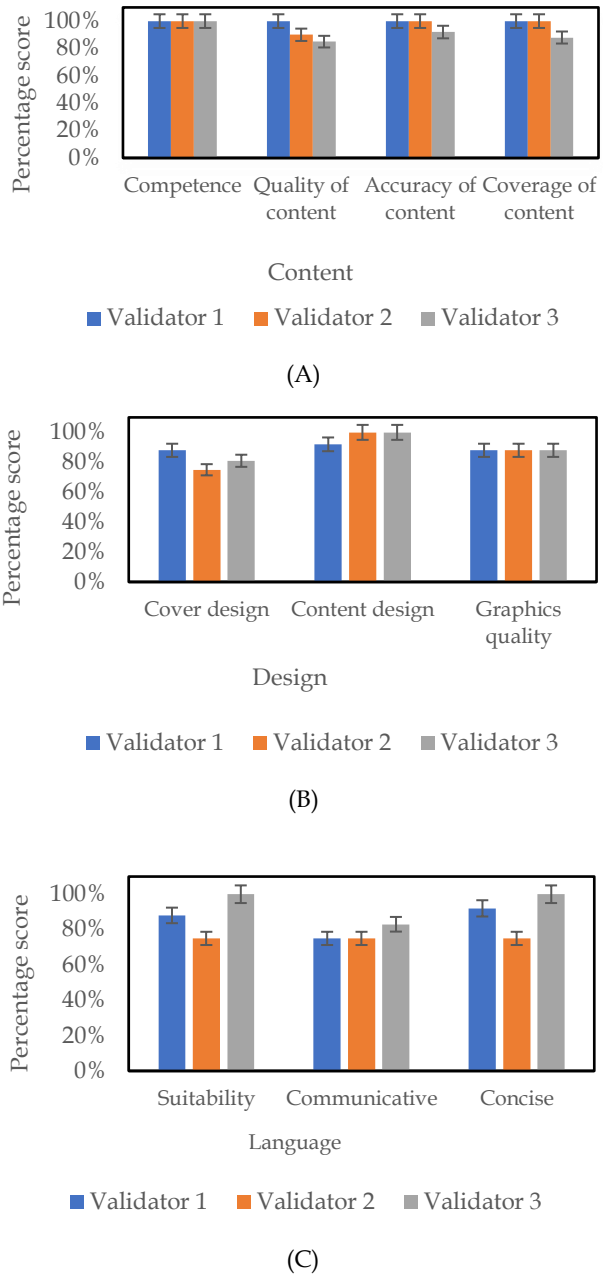
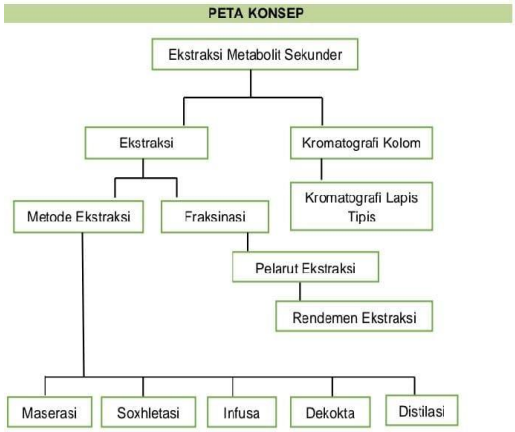
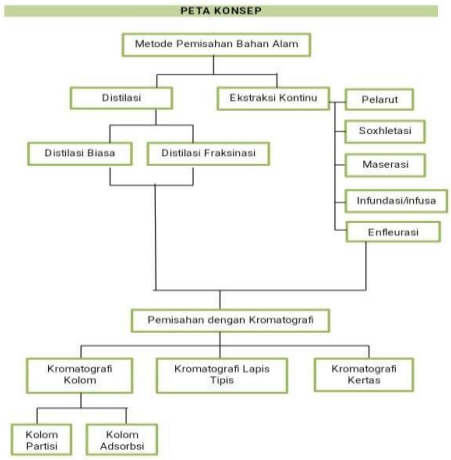
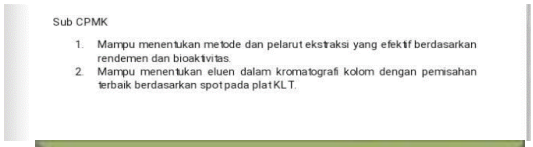
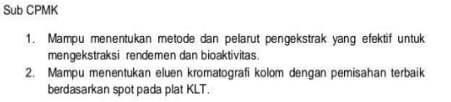
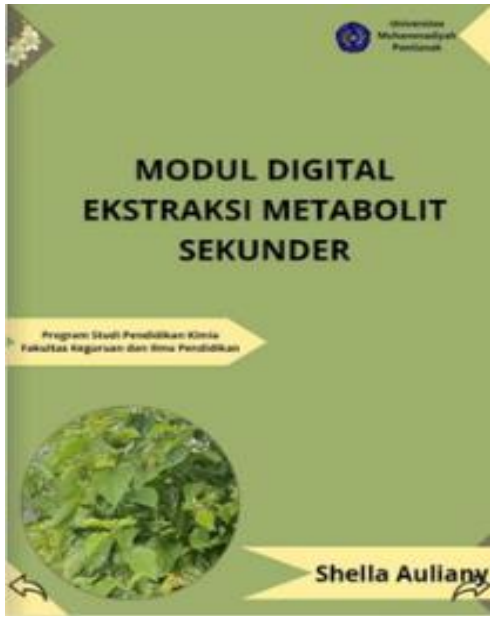
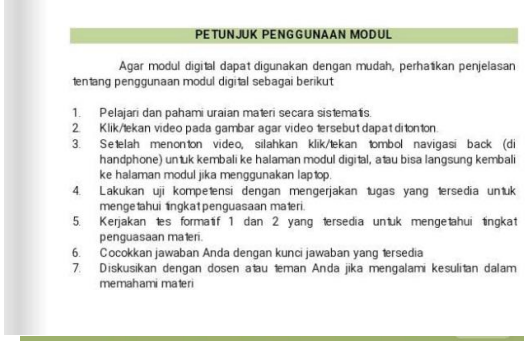
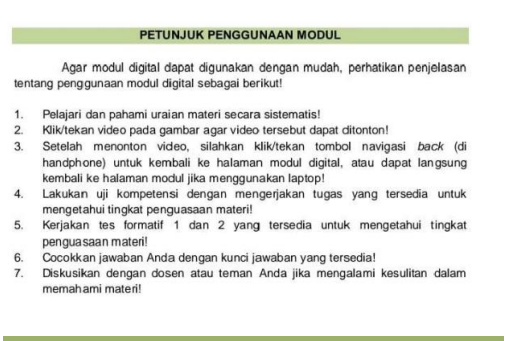
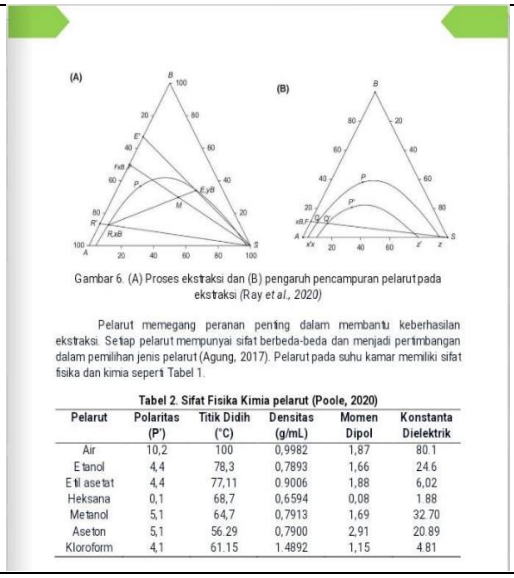
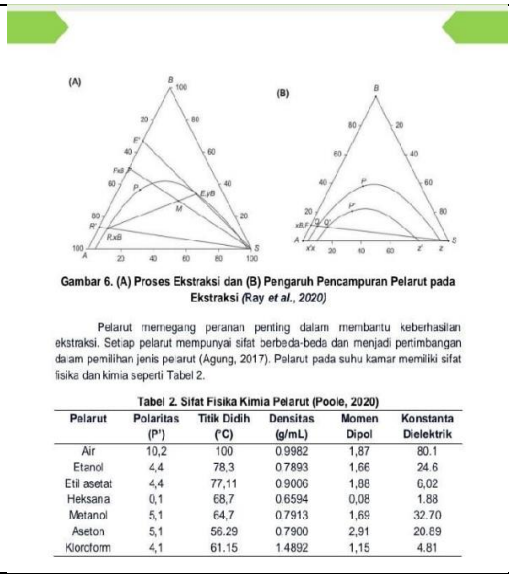



**Figure 3.** (A) Material expert validation results, (B) Media expert validation results, and (C) Language expert validation results

**Table 3.** Revisions and Suggestions from Content, Media, and Language Experts Validation

| Feedback/Comment | Before | After |
|---|---|---|
| The concept map section needs to include separation with column chromatography and its stages |  |  |
| Replace with "extractor." |  |  |
| Add suitable colors to blend with the green background and include the researcher's study program and faculty. |  |  |
| At the end of the sentence, replace with "(!)". |  |  |
| Write titles in all capital letters |  |  |

| Feedback/Comment | Before | After |
|---|---|---|
| Write titles with a capital letter at the beginning of each word |  Gambar 6. (A) Proses ekstraksi dan (B) pengaruh pencampuran pelarut pada ekstraksi (Ray *et al., 2020)* Pelarut memegang peranan penting dalam membantu keberhasilan ekstraksi. Setiap pelarut mempunyai sifat berbeda-beda dan menjadi pertimbangan dalam pemilihan jenis pelarut (Agung, 2017). Pelarut pada suhu kamar memiliki sifat fisika dan kimia seperti Tabel 1. Tabel 2. Sifat Fisika Kimia pelarut (Poole, 2020) |  Gambar 6. (A) Proses Ekstraksi dan (B) Pengaruh Pencampuran Pelarut pada Ekstraksi (Ray *et al., 2020)* Pelarut memegang peranan penting dalam membantu keberhasilan ekstraksi. Setiap pelarut mempunyai sifat berbeda-beda dan menjadi pertimbangan dalam pemilihan jenis pelarut (Agung, 2017). Pelarut pada suhu kamar memiliki sifat fisika dan kimia seperti Tabel 2. Tabel 2. Sifat Fisika Kimia Pelarut (Poole, 2020) |

| Pelarut | Polaritas (P') | Titik Didih (°C) | Densitas (g/mL) | Momen Dipol | Konstanta Dielektrik |
|---|---|---|---|---|---|
| Air | 10,2 | 100 | 0,9982 | 1,87 | 80.1 |
| Etanol | 4,4 | 78,3 | 0,7893 | 1,66 | 24.6 |
| Etil asetat | 4,4 | 77,11 | 0.9006 | 1,88 | 6,02 |
| Heksana | 0,1 | 68,7 | 0,6594 | 0,08 | 1.88 |
| Metanol | 5,1 | 64,7 | 0,7913 | 1,69 | 32.70 |
| Aseton | 5,1 | 56.29 | 0,7900 | 2,91 | 20.89 |
| Kloroform | 4,1 | 61.15 | 1.4892 | 1,15 | 4.81 |

| Pelarut | Polaritas (P') | Titik Didih (°C) | Densitas (g/mL) | Momen Dipol | Konstanta Dielektrik |
|---|---|---|---|---|---|
| Air | 10,2 | 100 | 0.9982 | 1,87 | 80.1 |
| Etanol | 4,4 | 78,3 | 0.7893 | 1,66 | 24.6 |
| Etil asetat | 4,4 | 77,11 | 0.9006 | 1,88 | 6,02 |
| Heksana | 0,1 | 68,7 | 0.6594 | 0,08 | 1.88 |
| Metanol | 5,1 | 64,7 | 0.7913 | 1,69 | 32.70 |
| Aseton | 5,1 | 56.29 | 0.7900 | 2,91 | 20.89 |
| Klorcform | 4,1 | 61.15 | 1.4892 | 1,15 | 4.81 |

Media validation was conducted by three lecturers who assessed the cover design, content design, and graphical elements of the student handbook, as presented in Figure 3 (B). The resulting average rating of 88% categorized the student handbook as highly valid. The content design aspect received the highest score, averaging 97.22%, while the cover design aspect received the lowest score, averaging 81.33%. Table 3 details the improvements made based on the validators' suggestions, including additions to the cover and color combinations.

Based on Figure 3 (C), a rating of 84.37%, categorized as highly valid, was given by three language experts for the aspects of appropriateness, communicativeness, and clarity of the student handbook. The clarity aspect received the highest score at 89%, while the communicativeness aspect received the lowest score at 77.66%. Validators suggested improvements in the use of standard Indonesian (EYD), writing the student handbook title, and naming images and tables, as detailed in Table 3.

The second step in the student handbook development stage involved individual and small group trials, followed by product revisions. The trial procedure was conducted by sending the student handbook via WhatsApp, accompanied by an introductory sentence, researcher introduction, and a request for feedback using the attached questionnaire. The individual trial involved 9 students, while the small group trial included 18 students from Universitas Muhammadiyah Pontianak, Akademi Farmasi Yarsi Pontianak, and Universitas Tanjungpura. The trial results indicated a practicality score of 93.74%, categorized as very practical, based on the assessments of 27 students (Indriana & Kamaludin, 2023; Sari et al., 2020; Yulinda et al., 2022). The percentage of student responses was higher compared to the research-based student handbook on Animal Tissue Culture Techniques, which had a practicality score of 88.89% (Fitriyati et al., 2015). All aspects of the practicality assessment for the student handbook on secondary metabolite extraction received scores above 90%, whereas the Animal Tissue Culture Techniques student handbook had three out of four aspects scoring below 90%.

The individual trials conducted from April 26-29 resulted in a practicality score of 93.81%, categorized as very practical. This assessment covered the aspects of usefulness, ease of use, and appearance, as presented in Table 4. The highest score, 94.44%, was obtained for the aspects of ease of use and appearance, while the lowest score, 92.55%, was for the aspect of usefulness. There were no suggestions or feedback provided during these individual trials.

**Table 4.** Results of Individual Testing

| Aspect | Percentage | Category |
|---|---|---|
| Usefulness | 92,55% | Very practical |
| Ease of use | 94,44% | Very practical |
| Appearance | 94,44% | Very practical |
| Average | 93,81% | Very practical |

Table 5 shows the results of the small group trials conducted from May 8-12, which obtained a percentage score of 93.69, categorized as very practical. The ease of use aspect obtained the highest score at 93.76%, while the usefulness aspect received the lowest score at 93.51%. Students suggested providing the student handbook in PDF format so that it can be accessed even when offline.

**Table 5.** Small Group Testing Results

| Aspect | Percentage | Category |
|---|---|---|
| Usefulness | 93,51% | Very practical |
| Ease of use | 93,76% | Very practical |
| Appearance | 93,74% | Very practical |
| Average | 93,67% | Very practical |

## Conclusion

This study successfully developed a digital module on the extraction of secondary metabolites based on P. serratifolia research, which was deemed highly valid and practical as a self-study resource for students. Using the Thiagarajan 4D development model, the module received an average validity score of 89.02% from subject matter, media, and language experts, and an average practicality percentage of 93.75% from small and large group trials. These results indicate that the digital module is highly effective and suitable for self-study in the extraction of secondary metabolites.

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**Author Contributions**

The study idea and plan were created by DH. The investigation was conducted by SA, DH, and RA. The data was analyzed and interpreted by SA, DH, and RA. SA and DH wrote the manuscript and made major revisions to ensure its quality. RA was responsible for statistical analysis, whereas SA and DH provided administrative, technical, and material assistance.

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**Conflicts of Interest**

The authors declare no conflict of interest.

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