



Development Module Practical Based Experiments in Basic Science Courses

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ABSTRACT

Basic Science learning requires practicum modules that facilitate systematic, structured, and learning-outcome-oriented experimental experiences. However, the modules used so far have not fully met the aspects of independent learning, clarity of work steps, and integration between concepts and practice. This study aims to develop experiment-based practicum modules for Basic Biology, Basic Physics, and Basic Chemistry using the 4D development model (Define, Design, Develop, and Disseminate). The development stage involved validation by five experts, namely experts in biology, physics, chemistry, media, and language, as well as student response tests. The data analysis method used in this study was descriptive quantitative analysis, involving calculating percentages of validation scores and student responses, which were then interpreted against predetermined validity criteria. The validation results showed a highly valid category across almost all aspects, with 88–93% in material validation, 88–95% in media validation, and 81% in student responses. The student response test involved 25 respondents, who were selected to assess the practicality and usability of the developed practicum module. Revisions were made based on validator input, such as improving image quality, refining language, and standardizing the practicum structure. Overall, the developed module was deemed feasible and effective as teaching material to support Basic Science practicum learning. This study also recommends further development through the integration of interactive digital media and trials on a larger scale.

Keywords: *development, experimental modules, basic science*

INTRODUCTION

Science education in higher education plays an important role in shaping students' knowledge and skills. Basic science courses, including Basic Biology, Basic Chemistry, and Basic Physics, provide a crucial foundation for students in understanding scientific principles and natural phenomena. Science learning does not depend solely on the theories taught in class; it is also greatly influenced by practical experiences that allow students to apply these concepts in a more realistic context.

Practical work is an important component of science education because it allows students to explore theory through direct experimentation (White et al., 2026). Practical work experience reinforces students' understanding of scientific concepts, improves critical thinking skills, and provides opportunities to develop laboratory skills useful in the workplace (Perkins & Murphy,

2006). Therefore, the development of effective, experiment-based laboratory modules is crucial for improving the quality of science education in higher education (Valakas et al., 2025).

The urgency of developing practical modules for basic science courses stems from the need to align theory with practice. In many universities, science teaching still relies heavily on conventional methods that emphasize lectures and theoretical understanding. Experimental practicums, although important, are often neglected or implemented with a less structured approach (Boyer, 1990). This results in students lacking sufficient direct experience in applying scientific principles, which, in turn, can affect their understanding of the concepts they are studying. Furthermore, Dewey (1938) argued that practical experience in education is crucial for developing a deeper understanding. Therefore, science learning that relies solely on theory will not be sufficient to ensure that students master important experimental skills. The urgency of developing experiment-based practical modules is to provide students with a more holistic and integrative learning experience between theory and practice, which will improve the overall quality of science education.

However, despite the recognized importance of practical work in science education, various problems persist in its implementation across many educational institutions (Banjar et al., 2023). One of the main problems is limited resources, including equipment, materials, and adequate laboratory facilities. Many universities, especially in developing countries, struggle to provide sufficient practical tools and materials to support effective experimentation (Norris & Phillips, 2003). The inadequacy of these facilities often prevents students from conducting experiments in accordance with the theory they have learned in class (Dari & Nasih, 2020). In addition, practical teaching is often poorly structured, making it difficult for students to follow experimental procedures correctly. Most existing practical modules are too technical and lack sufficient conceptual explanations, making it difficult for students to relate the experiments to the underlying theory. It can lead to a lack of in-depth understanding of the scientific concepts that students should master (Hodson, 1993).

Another problem that often arises in the implementation of practical work is low student motivation and engagement. In many cases, students are not interested in the experiments being carried out because they do not see their relevance to real life or to their future career development. Existing practicum modules are often monotonous, uninteresting, and irrelevant to current scientific issues, so students tend to view practicums as an obligation to be carried out without any significant added value to their personal development. In addition, the issue of experimental skills is also an important concern. Many students feel less confident in conducting experiments due to the lack of clear guidance in the practicum module. In fact, experimental skills are a key aspect that students must master in order to solve more complex scientific problems in the future (Linn et al., 2015). Unclear practicum instructions and inadequate laboratory training can hinder students in developing these skills properly (Harefa & Sanga Lamsari Purba, 2019).

Based on a preliminary study conducted in the Tadris IPA Program at UIN Syekh Wasil Kediri, several empirical problems were identified. Observations of laboratory activities, interviews with lecturers, and analysis of students' learning outcomes revealed that: (1) existing practicum modules are not yet fully structured and lack clear experimental guidance; (2) there is limited integration between theoretical concepts and experimental activities; (3) students experience difficulties in following experimental procedures and interpreting results; and (4) laboratory facilities and available materials are not optimally accommodated in the module design. These findings indicate a gap between expected learning outcomes and the actual implementation of practicum activities in basic science courses. To address these issues, the development of more structured, experiment-based practicum modules grounded in a modern approach is essential. This module is designed not only to provide step-by-step instructions for conducting experiments, but also to link the experiments to relevant theoretical concepts. The experiment-based approach is

intended to integrate basic concepts in biology, chemistry, and physics with experiments that can strengthen students' understanding of these concepts (Sari, 2021).

This experiment-based practicum module considers student motivation, for example, by involving students in experiments that are more relevant to everyday life or current scientific issues. It will help students feel more connected to the material they are studying and increase their interest in science learning (Bell et al., 2005). In addition, by providing clearer guidance and introducing students to more practical experimental methods, this module will help them develop stronger laboratory skills. Several previous studies have shown the importance of developing effective laboratory modules for science learning. Research by (Erduran & Dagher, 2004) emphasized the importance of developing modules that link experiments with theoretical understanding, which can improve the quality of learning in science courses. Research by Erduran and Dagher (2004) emphasized the importance of developing modules that link experiments to theoretical understanding, thereby improving the quality of learning in science courses

Another study by Rahman (2018) shows that the use of problem-based practicum modules in physics learning improves students' ability to apply physics principles to solve real-world problems. It shows that integrating experiments and problem-based learning approaches can be highly effective in improving students' understanding and skills. Therefore, the development of experiment-based practical modules with a similar approach is highly relevant for application in basic science learning in higher education (Rohman & Lusiyana, 2018).

Although several previous studies have developed practicum modules using various approaches, such as science process skills-based, constructivist, and web-based modules, these developments are generally limited to specific subjects or educational levels. Previous research (Agnesa & Sari, 2024; Astuti, 2024; Prasetya et al., 2025) demonstrates that practicum modules are effective in improving learning outcomes; however, most studies focus on single-discipline modules and do not integrate multiple basic science domains (biology, physics, and chemistry) into a unified experimental framework. In addition, many existing modules are not developed based on systematic needs analysis derived from real field conditions.

The importance of this research lies in its effort to address various problems in basic science learning in higher education, particularly in developing experiment-based practicum modules. This research aims to create practicum modules that are not only effective in teaching experimental skills but also enhance understanding of basic science concepts through a more contextual and relevant approach. By developing modules tailored to students' needs and existing laboratory conditions, it is hoped that basic science learning will be more effective, interesting, and beneficial to students' intellectual development.

Based on the literature review and field findings, the research gap in this study lies in the absence of an integrated, experiment-based practicum module for basic science courses that is systematically developed based on actual student needs, aligned with laboratory conditions, and capable of connecting theoretical concepts with experimental practice across multiple disciplines. Furthermore, previous studies have not sufficiently emphasized the importance of contextual relevance and structured experimental guidance in improving students' laboratory skills and conceptual understanding. To address this gap, this study proposes the development of an experiment-based practicum module for Basic Science courses that integrates Biology, Chemistry, and Physics in a structured, contextually relevant manner. The novelty of this research lies in the development of an integrated practicum module that combines three fundamental science disciplines (Biology, Chemistry, and Physics) within a single experiment-based framework, grounded in empirical field data and actual laboratory conditions. This study also contributes theoretically by providing a model for developing integrated practicum modules in science education, and practically by offering a feasible solution to improve the quality of laboratory learning, particularly in institutions with limited resources. Through this research, it is hoped that

a solution can be developed that not only improves the quality of practical work but also contributes to innovation in science education in higher education. It is hoped that the module developed can be used by lecturers in various universities, so that it can improve and enhance the standards of practical teaching in basic science courses as a whole.

METHODOLOGY

This research project is centered on the development of an experimental practicum module designed for basic science courses. The subjects of this study consisted of expert validators and a user respondent. The validators were selected based on their expertise and professional qualifications, with a minimum of five years of teaching experience in higher education. The validators included: (1) a biology material expert, Radhwa Hayyu Aufa Haq, M.Si., a biology lecturer; (2) a physics material expert, Ratna Wahyu Wulandari, M.Pd., a physics lecturer; (3) a chemistry material expert, Asisul Khoirot, M.Pd., a chemistry lecturer; and (4) a learning media expert, Dr. Yulianti Yusal, who specializes in science learning media (biology, physics, and chemistry). The selection of these validators was based on the relevance of their academic background and their competence in evaluating instructional materials and media.

The user respondent in this study was 25 undergraduate student. The respondent was selected purposively as a representative user of the practicum module to provide initial insights into its practicality. The respondent's characteristics include being an active student in a science education program, with prior experience in laboratory activities. The instruments used in this study consisted of expert validation sheets and a user response questionnaire. The validation sheets were used to assess the module's feasibility in terms of content, language, presentation, and graphical elements. Meanwhile, the questionnaire was used to evaluate the practicality of the module based on the user's experience.

The development model for the experiment-based practicum module product for basic science courses that will be used by researchers is *the Four-D Model*, which consists of four stages: 1. *Define*, 2. *Design*, 3. *Develop* dan 4. *Disseminate* (Thiagarajan et al., 1974). The development model in this research can be systematically illustrated as shown in Figure 1.



Figure 1. 4D-Model

The description of each stage is as follows:

Define

The definition stage of developing experiment-based practicum modules involves observing and documenting how to facilitate students in basic science practicums used in the Science

Education study program at IAIN Kediri to gather information on the extent to which development is needed. Simply put, this stage is the needs analysis stage.

Design

The design of the experiment-based practicum module is an activity carried out at this stage. The design is based on a needs analysis to produce a design. Product design focuses on the preparation of an experiment-based practicum module design.

Develop

The objective of this stage is to produce a product that has been revised based on validator input. Development focuses on developing the design into a draft, validating the experiment-based practicum module developed by experts to obtain expert advice, where the product is first produced as an initial version and then revised based on the validator's suggestions, and the validation results are obtained after revision and used for testing activities, as well as revising the experiment-based practicum module based on the validation results.

Disseminate

The dissemination stage referred to in this study is conducting practical tests, publishing in nationally accredited journals, and submitting intellectual property rights (IPR) applications.

The subjects of the trial in the experimental module development stage were learning media expert validators, physics material expert validators, chemistry material expert validators, biology material expert validators, science material expert validators, students, and science education lecturers at IAIN Kediri.

The data analyzed in this study were obtained from the validation results conducted by several validators, namely learning media expert validators, physics material expert validators, chemistry material expert validators, biology material expert validators, and science material expert validators. The data were used to assess the feasibility of the experiment-based practicum modules developed. The data used in this study consisted of quantitative and qualitative data. Quantitative data were obtained from the assessment or verification results provided by expert validators in learning media, physics, chemistry, biology, and science, as well as from the module's practicality test results. These data were in the form of assessment scores used to determine the level of feasibility and practicality of the experiment-based practicum module. Meanwhile, qualitative data were obtained from comments, criticisms, suggestions, and validator input. This qualitative data relates to the results of the development of the experiment-based practicum module and is used as material for consideration in improving and refining the module to make it better and more suitable for learning needs.

The instrument used in this study was a validity sheet for experiment-based practicum modules, which was used to assess the validity of the modules developed by the researchers. The validation sheet was completed by five experts who reviewed and assessed the experiment-based practicum module: a learning media expert validator, a physics material expert validator, a chemistry material expert validator, a biology material expert validator, and a science material expert validator. In addition, the instrument used in this study was a questionnaire for lecturers and students to determine the practicality of the science laboratory management model module.

Quantitative data analysis was obtained from the quantitative data results of each validator, and the practicality test results were calculated using the following formula:

$$\text{Percentage} = \frac{\text{total score from validators}}{\text{maximum total score}} \times 100\%$$

The calculations from the validator results are used for each question presented in the questionnaire. The product validity criteria are shown in Table 1.

Table 1. Product Validity Criteria

No	Category	Assessment
1.	Highly valid	85%-100%
2.	Valid	75%-85%
3.	Sufficiently valid	50%-75%
4.	Less valid	25%-50%

The practicality criteria for the module can be stated in Table 2.

Table 2. Practicality Questionnaire Criteria

No	Score Interval	Practicality Criteria
1.	$20 < P \leq 40$	Less Practical
2.	$40 < P \leq 60$	Fairly Practical
3.	$60 < P \leq 80$	Practical
4.	$80 < P \leq 100$	Very Practical
5.	$20 < P \leq 40$	Less Practical

RESULT AND DISCUSSION

This study aims to develop an experiment-based practicum module for Basic Science courses (Biology, Physics, and Chemistry) using the 4D (Define, Design, Develop, Disseminate) model, and to evaluate its validity and practicality in supporting students' scientific process skills, conceptual understanding, and independent laboratory learning. The novelty of this research lies in the development of an integrated, experiment-based practicum module that combines three fundamental science disciplines within a single, structured framework, designed based on empirical field needs and validated through expert and user evaluations. This integrated approach distinguishes this study from previous research, which generally focuses on single-discipline modules.

Furthermore, this study provides a clear contribution by offering an interdisciplinary practicum module that is empirically validated and practically applicable, addressing the gap in previous studies that tend to separate science disciplines and lack an integrated experimental design. This contribution is important in the context of 21st-century science learning, which emphasizes interconnected knowledge and hands-on experience.

Definition Stage

The needs analysis stage in the development of Basic Science practicum modules begins by identifying gaps in student competencies relative to the learning outcomes of the Science Education study program. At this stage, actual needs in the field are explored through observation of previous practicum activities, interviews with lecturers, and analysis of student learning outcomes in Basic Biology, Basic Chemistry, and Basic Physics courses. This information is used to map the core concepts students must master and the basic laboratory skills they must develop to support the profession of prospective science educators.

The needs analysis focuses on the availability of facilities, infrastructure, and learning resources that support the practicum process. An evaluation is conducted on the feasibility of the laboratory, the condition of the equipment and materials, and the readiness of the practicum

modules or guidelines used so far. This stage is important to ensure that the modules developed are relevant to the actual conditions of the Science Education Study Program laboratory and can be implemented effectively using the available equipment. In addition, the analysis includes a review of laboratory safety standards to ensure the modules developed foster a scientific, safe work culture.

The needs analysis was conducted by considering the learning context at UIN Syekh Wasil Kediri, which integrates Islamic values into science. The practicum modules need to be designed not only to hone scientific process skills, but also to foster scientific literacy, scientific attitudes, and ethical values in laboratory practice. The results of this analysis form the basis for determining the structure, scope of material, types of practicum activities, and evaluations to be included in the Basic Biology, Basic Chemistry, and Basic Physics modules, so that the modules are truly in line with student needs and support the comprehensive achievement of Tadris IPA graduate competencies.

The *Define* stage began with an analysis of student needs and learning conditions in the Basic Biology, Basic Physics, and Basic Chemistry courses. An analysis confirmed that students required more structured, accessible, and supportive practical guidelines for independent experimentation. The learning conditions, which are still dominated by limited lecture and demonstration methods, result in students being less able to achieve learning outcomes based on scientific process skills. It is in line with the findings of Tommy (2024), who emphasizes that student involvement in practical work can increase only if clear, systematic experimental modules are available. Thus, the *Define* stage provides initial justification for the urgency of developing experiment-based practical work modules. These findings are not only descriptive but also supported by field data from observations and interviews, indicating that existing modules are incomplete and lack integration between concepts and procedures. It strengthens the argument that module development is based on real learning problems rather than assumptions.

The curriculum analysis at the *Define* stage also shows that the learning outcomes for the three Basic Science courses emphasize conceptual understanding, application of scientific principles, and experimental skills. Without supporting modules, these outcomes are often not achieved because students rely solely on textbooks and laboratory instructions that are not integrated. This condition is consistent with Nurfantri (2022) research, which states that digital modules and experimental modules integrated with learning outcomes can improve the consistency of laboratory learning. Therefore, the modules developed must be tailored to the needs of the curriculum and the actual learning context (Jamilatun, 2025).

These findings at the *Define* stage directly support the research objective, particularly in identifying the specific needs that must be addressed by the developed module to improve students' scientific process skills and conceptual understanding. In comparison with previous studies (Nurfantri, 2022; Tommy, 2024), this study emphasizes an integrated multi-disciplinary approach, which has not been widely explored, thereby highlighting its distinct contribution in the literature.

Design stage

The Design stage aims to define the module design, including preparing practical activity flows, formulating objectives, providing images and illustrations, and determining appropriate experimental methods. Preparing these flows is important because it makes it easier for students to follow the practical steps independently. In this stage, pedagogical aspects are taken seriously, including the suitability of the material, text readability, and visual quality. It is confirmed by Fitriyani et al. (2023), who found that the quality of module design significantly affects student engagement during learning. Thus, a well-developed module design is the foundation for the success of the next development stage (Meldra, 2022). In the *Design* stage, digital learning media elements are also integrated into the experiment-based module. It is carried out to ensure that the

module can be used flexibly through digital devices, especially given the increasing need for hybrid and independent learning. The integration of visual elements, such as laboratory equipment diagrams, function diagrams, and infographics, was chosen because it has been shown to support understanding of experimental concepts (Widiasih, 2025). The user-friendly concept is also applied by paying attention to accessibility, readability, and format consistency. This entire process demonstrates the importance of harmonious pedagogical and visual design (Riyadi et al., 2025). The design decisions in this stage are directly derived from the needs analysis data, ensuring that the developed module is not only theoretically appropriate but also contextually relevant to student conditions and laboratory facilities.

Based on the results of the needs analysis conducted in the previous stage, the next stage is the design stage. This stage is carried out with the aim of designing and compiling a product.

Selecting Appropriate Topics

In the design stage, practicum topics are selected by reviewing the learning outcomes of the Basic Biology, Basic Chemistry, and Basic Physics courses. Based on the Science Education Study Program at UIN Syekh Wasil Kediri. This process resulted in a list of practicum topics that are considered most essential for students to master, especially those related to the development of basic science process skills. The selection of topics was carried out through syllabus analysis, discussions with lecturers, and reviews of student needs in understanding fundamental science concepts. With these considerations in mind, the selected topics were deemed relevant, applicable, and supportive of graduate competency development.

In addition to academic relevance, the selection of topics also considered the available laboratory facilities. Topics that require chemicals or tools not owned by the laboratory were eliminated to ensure that the practicum modules could be implemented realistically. The result was a list of practicum topics that were feasible, safe, and in line with the characteristics of the UIN Syekh Wasil Kediri laboratory. This selection ensured that the modules developed could be used optimally in practicum activities. This data-based selection process strengthens the practical relevance of the module, distinguishing it from previous studies that often design modules without considering real laboratory constraints.

Media Selection

At the media selection stage, the practicum module was designed with print media as the primary medium. Print media, in the form of modules and worksheets, was chosen because it is effective for providing step-by-step instructions during the practicum. This medium also makes it easier for students to record their observations, analyze data, and answer reflective questions. To clarify the procedures, the modules are equipped with illustrations of tools, step-by-step diagrams, and laboratory safety icons.

Creating a Design

The design process produces a consistent, systematic, practical module structure. Each module is organized into sections that include practical objectives, a brief theoretical basis, a list of tools and materials, work steps, observation tables, data analysis, and learning outcome evaluations. This structure aligns with the scientific workflow, allowing students to follow the experiment's stages in a logical, easy-to-understand manner. This initial design is then adapted to the characteristics of each field of science, whether biology, chemistry, or physics.

In addition to content development, this stage produced a module layout design that considered readability and aesthetics. The layout is designed to be simple yet informative, using illustrations, icons, and ample white space to record observations. The module design is then tested internally by the lecturer in charge to ensure that there is no ambiguous information and that

students can safely carry out all work steps. This refined design forms the basis for the final product development stage. From a theoretical perspective, this stage contributes to the application of instructional design principles in an interdisciplinary practicum context, while practically it produces a structured module that can guide students step-by-step in laboratory activities.

Basic Biology Practicum Module



Figure 2. Basic Biology Practicum Module

Basic Physics Practicum Module

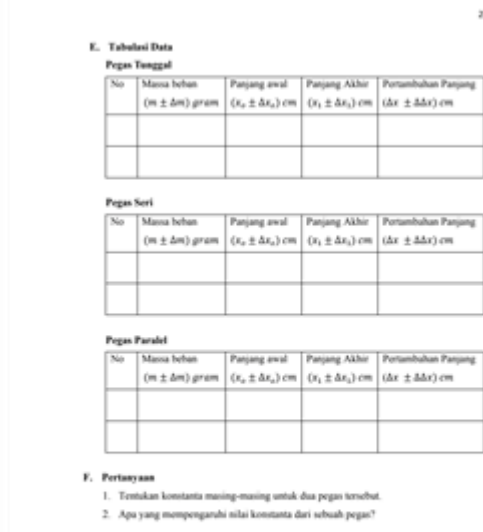
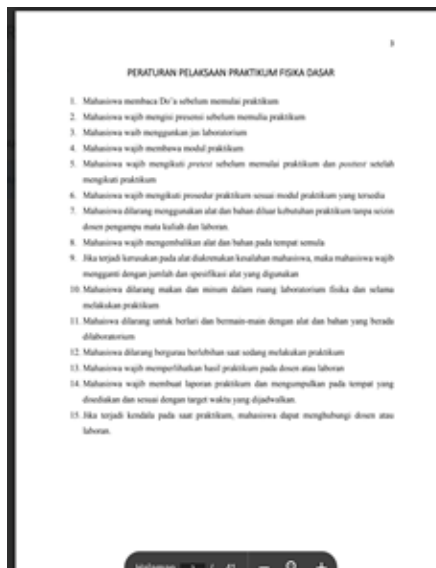


Figure 3. Basic Physics Practicum Module

Basic Chemistry Practicum Module



**PRAKTIKUM I
NAMA DAN LAMBANG UNSUR**

A. Tujuan Praktikum
1. Menuliskan nama dan lambang unsur-unsur yang ada dalam sistem periodik unsur.

B. Topik Percobaan : Sistem periodik unsur

C. Alat dan Bahan

No.	Alat dan Bahan	Jumlah
1.	Tabel sistem periodik unsur	1 buah

D. Pengantar Percobaan
Sistem periodik menggambarkan susunan unsur-unsur berdasarkan kenaikan nomor atom dan pencampuran unsur dengan sifat-sifat mirip dalam satu lajur vertikal. Dengan mengetahui letak suatu unsur dalam sistem periodik, kita dapat memahaminya beberapa sifat unsur tersebut. Sistem periodik yang digunakan saat ini merupakan sistem periodik modern, dengan 7 periode (lajur horizontal) dan 18 golongan lajur vertikal.

Gambar 2.1 Sistem Periodik Unsur

E. Petunjuk Awal
1. Siapkan tabel sistem periodik unsur.

WPraktikum Kimia Dasar 1

TATA TERTIB PRAKTIKUM LABORATORIUM IPA

1. Siapkan tas, jaket, dan barang-barang lainnya yang tidak diperlukan di tempat yang telah disediakan.
2. Lima menit sebelum kegiatan di laboratorium dimulai, peserta harus sudah berada di laboratorium.
3. Pakailah jas laboratorium jika sedang melakukan kegiatan.
4. Dilarang menggunakan sandal dan sepatu yang licin, sepatu terbuka, atau sepatu bertali tinggi.
5. Jangan melakukan kegiatan praktikum atau eksperimen sebelum mengetahui informasi mengenai alat-alat yang akan digunakan.
6. Kumpul semua jenis peralatan keselamatan kerja yang diperlukan sebelum melakukan eksperimen.
7. Lakukanlah kegiatan sesuai petunjuk yang telah diberikan.
8. Tidak diperkenankan makan dan minum di dalam ruang laboratorium.
9. Petakuliah dengan nilai semua alat-alat sebelum digunakan.
10. Menyalakan petakuliah kepada pembimbing apabila ada kesulitan atau keraguan dalam melakukan kegiatan.
11. Saat urusan pengisian alat-alat atau jangan melebihi batas maksimum dan jangan kerang dari batas minimum dari kemampuan alat-alat yang digunakan.
12. Bersihkan dan kembalikan alat-alat yang telah selesai dipergunakan.
13. Kebersihan apapun yang terdapat, hendaknya segera dilaporkan kepada pembimbing.
14. Gunakan nomor pada jas laboratorium.
15. Disarankan menggunakan laporan perubahan yang terdiri dari Bab I, Bab II, dan Bab III.

JANGAN MENYALAKAN PERALATAN ELEKTRONIK SEBELUM DIPERIKSA KEGAPANNYA OLEH PEMBIMBING.

SANKSI:

1. Terlewat datang tanpa alasan, tidak bisa mengikuti praktikum.
2. Tidak menggunakan laporan perubahan tidak diperkenankan praktikum.
3. Terlewat pengumpulan laporan, mengurangi nilai laporan.
4. Merusak/bocorkan/menghancurkan segala peralatan laboratorium wajib tidak mengikuti.
5. Jika terdapat pelanggaran lain yang lebih berat dalam tata tertib, akan diberlakukan hukuman sesuai pasal kebijaksanaan.
6. Segala bentuk pelanggaran yang dilakukan oleh praktikan akan mempengaruhi prestasi akhir semester.

WPraktikum Kimia Dasar 1

Sifat asam dan basa ditentukan oleh derajat disosiasi dari pHnya. pH adalah skala yang menunjukkan sifat asam, basa, dan garam dari suatu zat. pH memiliki skala 1 sampai 14. Unsur-nya, zat asam memiliki pH = 1, sedangkan zat basa memiliki pH = 7, dan garam memiliki pH = 7 (netral). Untuk mengetahui pH dari suatu zat diperlukan alat yang disebut indikator. Indikator merupakan zat atau senyawa yang digunakan untuk menunjukkan sifat asam atau basa yang digunakan untuk menunjukkan sifat suatu zat.

Sifat yang dimiliki adalah apakah zat tersebut tergolong asam, basa, ataupun garam (Purwati, Wulandari, & Wulandari, 2019). Pada praktikum ini indikator yang digunakan adalah indikator universal. Indikator universal atau menunjukkan warna yang berbeda-beda pada setiap pH. Indikator universal juga digunakan untuk pH yang menunjukkan harga pH (Santoso, Anshary & Achmad, 2005).

C. ALAT DAN BAHAN

No.	Nama Alat/Bahan	Jumlah
1.	Pipa PVC	1 buah
2.	Pipa 1/2 inchi	1 buah
3.	Selotip putih	10 ml
4.	Lakuk indikator	100 ml
5.	Lakuk indikator	100 ml
6.	Kertas lakmus	100 ml
7.	Kertas lakmus universal	1 buah
8.	Asam klorida (HCl) 1 N	100 ml
9.	Asam klorida (HCl) 0,1 N	100 ml
10.	Soda natrium (NaOH) 1 N	100 ml

WPraktikum Kimia Dasar 1

B. LANGKAH PRAKTIKUM

1. Menyiapkan pipa sesuai ketentuan bahan nomor 1 sampai dengan 7 pada tiap lajur.
2. Mengukur setiap lajur yang telah diberi nomor dengan air suling, air jeruk, soft drink, cairan pembersih paku, larutan HCl, 0,1 M, larutan CH₃COOH, dan La Murnai masing-masing masing sebanyak 5 ml.
3. Pada masing-masing lajur dituangkan lakus indikator universal.
4. Amati warna pada lakus indikator dan tentukan pH larutan berdasarkan warna dari indikator tersebut.

E. HASIL PRAKTIKUM

No lajur	Zat	pH yang terukur	Sifat
1.			
2.			
3.			
4.			
5.			
6.			
7.			

F. PEMBAHASAN
G. KESIMPULAN
H. DAFTAR PUSTAKA

Figure 4. Basic Chemistry Practicum Module

The development of experiment-based practicum modules in Basic Science courses is a response to 21st-century learning needs that emphasize active student involvement in understanding basic science concepts through hands-on practice. Experiment-based modules have been proven to improve students' observation, scientific process, and analytical skills, especially when systematically designed using a valid development model. In this study, the 4D (*Define, Design, Develop, Disseminate*) model developed by Thiagarajan, Semmel, and Semmel is used and remains relevant in the digital era (Brown, 2024). This model enables the development of structured modules, from needs analysis to dissemination of the final product. Thus, the use of the 4D model

provides a strong conceptual basis for producing modules that are pedagogically and empirically sound.

Develop Stage

The Develop stage is the core of the module development process, during which the module draft is validated by experts and revised based on their feedback. The validation stage is carried out by five validators, namely learning media experts, physics experts, chemistry experts, biology experts, and student respondents. The purpose of this validation activity is to obtain assessments, suggestions, and input to improve the quality of the module being developed. The validation data show that the biology module scored 93%, physics 90%, and chemistry 88% with subject-matter experts. These percentages fall into the "highly valid" category, indicating that the modules have met the content feasibility criteria. These high percentages provide strong empirical evidence that the developed module is scientifically accurate and suitable for learning, not merely based on subjective judgment. The validity of the material is a fundamental aspect because it determines whether the experiments accurately and precisely reflect scientific concepts (Rahmawati et al., 2020). Thus, the modules are suitable for use after undergoing the revision process provided by the validators. The details of the validation results from the biology, physics, and chemistry subject matter experts are presented in Tables 3, 4, and 5 below.

Table 3. Results of Expert Validation of Biology Learning Materials

Aspect	Score	Percentage	Criteria
<i>Self Instruction</i>	26	93%	Very valid
<i>Self Contained</i>	8	100%	Very valid
<i>Adaptive</i>	7	88%	Very valid
<i>User Friendly</i>	14	88%	Very valid
Total Score from Validator		56	
Total Score Maximum		60	
Percentage		93%	

Table 4. Results of Expert Validation of Physics Learning Materials

Aspect	Score	Percentage	Criteria
<i>Self Instruction</i>	26	93%	Very valid
<i>Self Contained</i>	8	100%	Very valid
<i>Adaptive</i>	7	88%	Very valid
<i>User Friendly</i>	14	88%	Very valid
Total Score from Validator		54	
Total Score Maximum		60	
Percentage		90%	

Table 5. Results of Expert Validation of Chemistry Learning Materials

Aspect	Score	Percentage	Criteria
<i>Self Instruction</i>	25	89%	Very valid
<i>Self Contained</i>	7	88%	Very valid
<i>Adaptive</i>	7	88%	Very valid
<i>User Friendly</i>	14	88%	Very valid
Total Score from Validator		53	
Total Score Maximum		60	
Percentage		88%	

The assessment of the Self-Instruction aspect shows that students can learn independently through the modules because the experimental steps are clearly and systematically arranged. Scores

of 93% for biology, 93% for physics, and 89% for chemistry reflect that the practicum instructions have been well designed. The claim that the module supports independent learning is directly supported by high scores (above 89%), indicating that the procedural clarity is empirically validated. The clarity of the instructions has a significant impact on students' independence in the laboratory, as emphasized by OECD (2022), which found that procedural knowledge skills improve when students follow standardized experimental procedures. Therefore, this achievement demonstrates the pedagogical strength of the modules.

In terms of Self-Contained, the module scored 100% in biology and 88% in physics and chemistry. It means that the module provides all the necessary information without the need to search for additional sources. This condition is important because many students struggle when they have to combine multiple sources to understand experiments. Mamujaja et al. (2023) emphasize that a complete, self-contained, integrated module can increase learning efficiency and reduce students' cognitive load. Therefore, this aspect's validity supports the module's effectiveness in independent learning.

The Adaptive aspect was considered highly valid, with an 88% score across all modules (biology, physics, and chemistry). The adaptive aspect relates to the module's ability to provide flexibility of use, both in offline and digital learning. In this context, the modules are assessed as utilizing modern technology and being accessible through digital platforms. It aligns with Utami's (2025) findings, which emphasize that adaptive digital modules can increase student participation by providing greater access. Thus, the modules developed meet the standards of adaptivity in line with developments in educational technology.

The user-friendly aspect also shows a highly valid category with a score of 88% in all three courses. Thus, it indicates that the module is easy to use, has clear navigation, and displays content consistently. This advantage is particularly important, given that students often have varying levels of digital literacy. Nadifah (2024) Research also confirms that readability and ease of use are key factors determining the success of digital module implementation. Thus, these validation results reinforce the module's suitability from a user experience perspective.

Table 6. Results of Expert Validation of Biology Learning Media

Aspect	Score	Percentage	Criteria
Appearance	25	89%	Very valid
Presentation	11	92%	Very valid
Media			
Visual	18	90%	Very valid
Total Score from Validator		54	
Score Maximum		60	
Percentage		90%	
Category		Highly Valid	

Table 7. Results of Expert Validation of Physics Learning Media

Aspect	Score	Percentage	Criteria
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Appearance	25	89%	Very valid
Presentation	10	83%	Very valid
Media			
Visual	19	95%	Very valid
Total Score		54	
from			
Validator			
Score		60	
Maximum			
Percentage		90%	
Category		Highly Valid	

Table 8. Results of Expert Validation of Chemistry Learning Media

Aspect	Score	Percentage	Criteria
Appearance	24	86%	Very valid
Presentation	10	83%	Very valid
Media			
Visual	19	95%	Very valid
Total Score		53	
from			
Validator			
Score		60	
Maximum			
Percentage		88%	
Category		Highly Valid	

Expert validation of the learning media shows that the module has an attractive and consistent appearance, with a score of 89–86% for appearance and over 90% for visual aspects. Good visual appearance is closely related to student learning motivation, especially when the module is used in experiment-based learning that requires high concentration. Research by (Setyaningsih et al., 2022) states that an attractive module display increases information retention and positive perceptions of experiments. Thus, these validation results reinforce the argument that the module is not only valid in terms of content but also aesthetics.

In terms of Media Presentation, the module scored 92% in biology, 83% in physics, and 83% in chemistry. Although the latter two modules were only categorized as "valid," these scores still indicate adequate presentation quality. Media presentation includes content structure, image suitability, and format consistency. It is even more important when students need visualizations of complex tools or experimental phenomena. These results align with Ishafit (2024), who emphasizes that media presentations in digital modules play an important role in improving students' scientific representation skills

The Visual aspect received a very high score of 90–95% in all three modules. Appropriate visualization is very important in science learning because many experimental concepts are abstract and difficult to understand without visual representations. OECD (2022) emphasizes that effective science learning requires integrating diagrams, graphs, and illustrations. Therefore, the modules' high visual quality is a significant advantage in supporting the learning process. The overall validation results from subject-matter and media experts demonstrate that the module is suitable for practical learning. High validity indicates that the module meets the pedagogical principles, scientific logic, aesthetic design, and digital accessibility required in modern learning. It is reinforced by Brown (2024), who states that experimental modules that undergo a comprehensive validation process have a significant impact on learning outcomes. Thus, the Develop stage has successfully produced a high-quality module.

Student responses are used to determine the level of acceptance and user assessment of the developed practicum modules. This assessment is important because students act as direct users

who experience the ease, clarity, and quality of the module in the learning process. The aspects assessed include the presentation and quality of the practicum module, including the clarity of instructions, completeness of content, and ease of use in practicum activities. The results of student responses to the practicum module are presented in Table 9 below.

Table 9. Student Response Results

Aspect	Score	Percentage	Criteria
Module Presentation Practical	11	92%	Very valid
Quality Practical Module	15	75%	valid
Total Score from Validator		26	
Total Score Maximum		32	
Percentage		81%	
Category		Valid	

Student responses to the experiment-based practicum module showed very high acceptance, with a total validity score of 81%. Although this falls into the "valid" category, the results still show that students can understand the module content and follow the practicum procedures independently. These findings confirm that the module has met the principles of readability and procedural clarity required in laboratory learning. According to Tommy (2024), student perceptions are an important indicator of the success of module implementation because they reflect the module's suitability to actual learning needs. Thus, student responses provide additional empirical evidence of the effectiveness of the developed module.

The Presentation aspect of the Practicum Module received a score of 92%, indicating that students found it easy to understand, clear, and systematic. Clarity of presentation is very important in the context of laboratory learning, which requires precise instructions and detailed experimental steps. It aligns with Widiasih's (2025) view, which emphasizes that the module presentation's structure directly impacts the practicum's success. Thus, a valid module presentation indicates that the module has met the principles of explicit pedagogy. The Quality Aspect of the Practicum Module, which scored 75%, shows that although students consider the module effective, several technical aspects and material presentations can still be improved. In general, improvements to module quality involve adding visuals, simplifying diagrams, or providing further explanations in certain sections. According to Mamujaja et al. (2023), students often need variety in how information is presented, especially in complex experiments. Thus, although the module's quality meets the validity category, follow-up improvements are still needed to achieve module perfection.

The overall student response indicates that the module is suitable for the learning style of the current generation, which tends to be visual and interactive. The experiment-based digital module provides the flexibility of access that students accustomed to using electronic devices for learning need. This is supported by Utami's (2025) findings, which show that digital modules increase student engagement due to their flexibility and open-access nature. Therefore, the developed module has successfully bridged student needs and learning outcomes. Data synthesis from experts and students indicates that this module has a comprehensive level of validity, both in terms of material, visual design, and practicality of use. This empirical data supports the theoretical argument that experiment-based modules increase student interaction with scientific concepts through hands-on activities. Research by Rahmawati et al. (2020) shows that modules that integrate experiments provide a deep learning experience and foster scientific literacy. These results are in line with the findings of current research, strengthening the legitimacy of modules in the context of modern learning.

Disseminate Stage

The *Disseminate* stage in this research involves disseminating the results through publication in nationally accredited journals and filing for Intellectual Property Rights (IPR). This stage is not

merely a final formality, but an important process to ensure that the development products are accessible to the wider scientific community. Dissemination through scientific publications encourages scientific validation by academics and other education practitioners. It aligns with modern educational product development standards that emphasize scientific transparency and open dissemination (Brown, 2024). Thus, this stage strengthens the module's credibility as an innovative, experimental product. Applying for intellectual property rights is a strategic step to provide legal protection for the developed modules. Copyright protection in the context of education is important to prevent unauthorized duplication and to reward researchers' ideas and innovations. By obtaining intellectual property rights, these modules can be recognized as official products that make a real contribution to the development of laboratory learning in higher education. This practice aligns with international trends that promote intellectual property protection in educational technology (OECD, 2022). Thus, the dissemination stage provides legal and academic legitimacy to the module.

Despite the positive findings, this study has several limitations. First, the implementation was limited, so the module's effectiveness in improving learning outcomes has not been extensively tested. Second, this study focuses on validity and practicality, without quantitatively measuring the direct impact on students' academic achievement. Therefore, future research is recommended to involve larger samples, employ experimental designs, and examine the module's effectiveness on learning outcomes more comprehensively.

The development of this module has important implications for improving students' science literacy through a structured experimental approach. Students who are accustomed to following experimental modules will find it easier to understand abstract concepts through direct experience. It aligns with constructivist theory, which emphasizes the formation of knowledge through active interaction with objects and phenomena (Tommy, 2024). In the context of basic science practicums, this implication is particularly significant because learning focuses not only on cognitive aspects but also on procedural skills.

Another implication is an increase in the quality of laboratory learning, making it more effective and efficient. Structured modules enable lecturers to consistently organize practical workflows and reduce technical barriers to conducting experiments. It is important to consider that many basic education laboratories face limitations in terms of equipment, time, and student numbers. According to Setyaningsih et al. (2022), structured and digital modules help overcome the limitations of traditional laboratories. Thus, these modules contribute to improving the quality of laboratory services in various conditions. The development of this module also has implications for students' critical thinking and problem-solving skills. Experiments encourage students to develop hypotheses, take measurements, analyze data, and draw conclusions based on evidence, in line with the profile of higher education graduates. Research by Fitriyani et al. (2023) confirms that experiment-based modules provide students with opportunities to develop higher-level scientific thinking skills. Thus, this module not only provides cognitive benefits but also improves students' 21st-century skills.

Overall, the findings confirm that the integrated experiment-based practicum module developed in this study offers a novel contribution by combining multidisciplinary science content, structured experimental design, and empirical validation within a single framework, thereby addressing limitations identified in previous studies. The findings of this study are consistent with previous studies showing that experiment-based digital modules can improve conceptual understanding, student engagement, and learning outcomes. For example, Brown (2024) found that inquiry-based modules significantly improved laboratory competence. Similarly, Ishafit (2024) emphasized that digital laboratories can be an effective alternative when laboratory facilities are limited. This consistency indicates that the basic science practicum modules currently being developed are on the right track, aligned with current developments in educational research.

The relationship with previous research is also evident in terms of visual aspects and instructional design. Widiasih (2025) found that visual appearance has a direct effect on student engagement, and this study supports that finding through very high validation scores for appearance and visual aspects. Visual integration in the module is key to improving understanding of experimental material, especially in the context of abstract science learning. This study reinforces the importance of integrating visual design in the development of experimental modules. Thus, the experiment-based practicum module developed through the 4D model has been proven to be valid, practical, and suitable for use in Basic Science learning and has the potential to be further developed in other courses and levels of education.

CONCLUSION

The development process for experiment-based practicum modules in Basic Science courses follows the 4D model: definition, design, development, and dissemination. The validation results show that the module is highly valid in terms of content, appearance, and presentation system. Practicality tests conducted by lecturers and students also show that the module is easy to use, clear, and helpful for conducting practical work. These findings indicate that the experiment-based practicum module developed for Basic Science courses has met the expected feasibility criteria, both in terms of validity and practicality. Thus, the experiment-based practical module developed has been proven to be valid and practical for use in Basic Science learning.

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