



Digital pocket book integrated with virtual laboratory of quantities, unit, and measurement for elementary school teacher education students

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Abstract

The teaching of material on quantities, units, and measurements at the university level, particularly for students in Elementary School Teacher Education programs, still largely relies on conventional methods and printed textbooks with limited visualizations. Additionally, laboratory practical sessions often face challenges due to limited laboratory facilities. This situation highlights the importance of developing technology-based learning media that are integrated and support self-directed learning as well as optimal conceptual understanding. The objective of this study is to describe the validity of a digital pocketbook integrated with a virtual laboratory for the subject matter of quantities, units, and measurements for Primary School Teacher Education Students. This type of research is Research and Development using the 4D model (Define, Design, Develop, and Disseminate). The research subjects were six validators. Based on the results and discussion, the digital handbook integrated with the virtual laboratory falls into the highly valid category, with an average score of 4.56. Therefore, this handbook is highly suitable for use as an innovative digital learning medium that supports interactive, self-directed, and meaningful learning of concepts related to quantities, units, and measurements for elementary school teacher education students.

Keyword: quantities; digital pocket book; virtual laboratory; measurement; unit

Abstrak. Pembelajaran materi besaran, satuan, dan pengukuran di tingkat universitas khususnya bagi mahasiswa Program Studi Pendidikan Guru Sekolah Dasar, masih banyak menggunakan metode konvensional dan buku cetak dengan visualisasi yang terbatas. Selain itu, pelaksanaan praktikum kerap mengalami kendala akibat keterbatasan fasilitas laboratorium. Kondisi ini mengindikasikan pentingnya pengembangan media pembelajaran berbasis teknologi yang terintegrasi dan mendukung pembelajaran mandiri serta pemahaman konsep yang lebih optimal. Adapun tujuan dari penelitian ini adalah untuk mendeskripsikan validitas buku saku digital yang terintegrasi dengan laboratorium virtual pada materi besaran, satuan, dan pengukuran. Jenis penelitian ini adalah penelitian pengembangan (Research and Development) dengan model 4D (Define, Design, Develop, dan Disseminate). Subjek penelitian adalah enam orang validator. Berdasarkan hasil dan pembahasan menunjukkan bahwa buku saku digital terintegrasi laboratorium virtual berada pada kategori sangat valid, dengan skor rata-rata 4,56. Dengan demikian, buku saku ini sangat layak digunakan sebagai media pembelajaran digital inovatif yang mendukung pembelajaran konsep besaran, satuan, dan pengukuran secara interaktif, mandiri, dan bermakna bagi mahasiswa Pendidikan Guru Sekolah Dasar.

INTRODUCTION

Physics education covering the topics of quantities, units, and measurements plays an important role in shaping Elementary School Teacher Education students understanding of basic scientific concepts (Angraini et al., 2024). Mastery of this material is essential to equip students with logical, critical, and scientific thinking skills, especially in the 21st century learning era, which emphasizes the importance of science and numeracy literacy (Sanjiartha et al., 2024). As times change, 21st-century learning also requires the integration of technology into the teaching and learning process. Such integration is no longer optional but has become a necessity, as students are required to have digital literacy and be able to master and utilize technology-based tools as part of the core competencies they must master (Prisusanti et al., 2023).

The process of learning about quantities, units, and measurements at the university level, particularly for students in Elementary School Teacher Education programs, is still dominated by conventional approaches (Puspita, 2023). This situation shows that the need for technology-based learning innovation is becoming increasingly urgent to be realized. The learning resources used are generally still in the form of printed books with limited visualization of concepts (Dede et al., 2025), so that it does not optimally support students understanding. In addition, practical activities are often hampered by limited laboratory equipment that is not proportional to the number of students (Arvianti et al., 2024). Therefore, there is a need for innovative learning media that is integrated with technology to support the independent learning process and improve the effectiveness of students conceptual understanding.

Strategic efforts to overcome these problems include developing efficient technology-based learning media, namely digital pocket books integrated with virtual laboratories. This media is designed to present material on quantities, units, and measurements in a concise, interactive, and easily accessible manner for students. The integration of virtual laboratories in this medium aims to improve students understanding of concepts and practical skills in a flexible and independent manner. In addition, the use of this digital pocketbook can also encourage independent learning and increase student engagement in the learning process (Muttaqin & Kumalasari, 2021).

Previous studies have developed digital learning media on the subject of quantities and units, but these media still have limitations. Rosdiana et al. (2022) developed an Android-based digital pocketbook that has been proven to improve students conceptual understanding, but it does not yet include practical simulation features. Research by Meilina et al. (2023) shows the effectiveness of virtual laboratories in improving understanding of physics concepts, but this medium has not been integrated with concise and portable learning materials such as pocket books. Meanwhile, Hanatan et al. (2023) developed an interactive digital module that focuses on concept visualization, but it does not yet fully incorporate virtual laboratory features. On the other hand, the teaching of quantities, units, and measurement still faces challenges due to limited laboratory practice (Dewa et al., 2025), high levels of misconceptions (Ilmi, 2026), and predominantly conventional approaches with insufficient visualization (Purnomo et al., 2025). Therefore, it is necessary to develop a digital pocket book integrated with a virtual laboratory to support more concrete, interactive, and applicable conceptual understanding.

Based on these findings, the development of a digital pocketbook integrated with a virtual laboratory is an innovative solution that can bridge the need for adaptive, concise, interactive learning media that supports technology-based independent learning. The novelty of this research lies in the digital pocketbook medium, which combines concise material presentation, interactive practical simulations, and learning reflection features in a single flexible and easily accessible digital platform. This media is also designed to support the strengthening of students conceptual understanding and practical skills in an integrated manner. Previous studies have generally only developed theoretical or simulation aspects separately, without integrating them into a comprehensive medium. The purpose of this study is to describe the validity of digital pocketbooks integrated with virtual laboratories on the subject matter of quantities, units, and measurements for Primary School Teacher Education Students.

RESEARCH METHODS

This type of research is research and development using the 4D model (Define, Design, Develop, and Disseminate). The research subjects were six validators. The 4D development model procedure can be seen in Table 1. The data collection instrument is a digital pocketbook validation instrument that covers aspects of material feasibility, language feasibility, and graphic feasibility, as presented in Table 2.



Figure 1 Steps in the 4D development model (Source: Thiagarajan et al., 1974)

Table 1 4D Development Model Procedure

No.	Stage	Explanation
1.	Define	Front-end analysis
		This stage aims to ensure that the product developed truly meets the needs, characteristics of users, and problems in the field.
		Learner analysis
		This stage aims to gain an in-depth understanding of the characteristics of the Elementary School Teacher Education students.
		Task analysis
2.	Design	This stage identifies and outlines the learning outcomes that Elementary School Teacher Education students must achieve.
		Concept analysis
		This stage identifies learning materials.
		Specification of objectives
		This stage identifies the learning objectives that Elementary School Teacher Education students must master.
3.	Develop	Criterion-test construction
		The process of developing evaluation tools in the form of tests used to measure Elementary School Teacher Education students competency achievement based on predetermined learning objectives.
		Media selection
		The process of selecting the most effective, efficient, and appropriate type of media based on student characteristics, course content, and learning objectives.
4.	Disseminate	Format selection
		The process of determining the presentation structure, appearance, and final form of learning media, in this case a digital pocket book.
5.		Initial design
		The process of designing the initial framework of the media to be developed.
6.		Expert appraisal
		The process by which the developed product (digital pocketbook) is evaluated by experts to ensure that it is valid.
7.		Diffusion
		The process of widespread dissemination and utilization of development products, so that they can be used sustainably and have a broad impact.

(Source: Thiagarajan et al., 1974)

Table 2 Outline of Integrated Virtual Laboratory Digital Pocket Book Instrument

No.	Component	Aspects Assessed
1.	Material suitability	Appropriateness of materials to learning objectives
		Conceptual correctness
		Up-to-date material
		Integration with virtual laboratories
2.	Language suitability	Integration with interactive digital features
		Compliance with Indonesian language rules
		Readability
		Consistency in the use of terms
3.	Graphic suitability	Clarity of digital usage instructions
		Be consistent with punctuation
		Digital page layout and composition
		Quality of visual and interactive media
4.		Consistency of digital visual format
		Visual appeal and interactivity
		Accessibility and display comfort

(Source: Noerdiansyah & Sudiana, 2023)

The data analysis technique used quantitative descriptive analysis, which involved calculating the average score from the expert validation results, which was then adjusted to the assessment categories in Table 3.

Table 3 Category of Validity of Integrated Digital Pocket Books for Virtual Laboratories

No.	Interval	Categories
1.	$X > 4.2$	Very valid
2.	$3.4 < X \leq 4.2$	Valid
3.	$2.6 < X \leq 3.4$	Sufficiently valid
4.	$1.8 < X \leq 2.6$	Less valid
5.	$X \leq 1.8$	Invalid

(Source: Widoyoko, 2016)

RESULTS AND DISCUSSION

This research produced a digital pocketbook integrated with a virtual laboratory on the subject of quantities, units, and measurements for Primary School Teacher Education Students. The activities carried out in the define stage are presented in Table 4. The activities carried out in the design stage are presented in Table 5. The digital pocketbook developed in this study has undergone a process of review, assessment, and evaluation by six validators. Each validator provided constructive feedback and suggestions regarding the suitability of the material, language, and graphics. This feedback served as the basis for revising and refining the product design to make it more effective, engaging, and aligned with learning needs. Some of the suggestions provided by the validators are presented in Table 6.

Table 4 Activities in the Define Stage

No.	Activities	Result
1.	Front-end analysis	a) The learning process is still conducted conventionally. b) The learning resources used are still printed books. c) Practical activities are hampered by limited laboratory equipment.
2.	Learner analysis	a) Elementary School Teacher Education students are at the formal operational stage, enabling them to think logically, abstractly, and systematically. b) Most Elementary School Teacher Education students have never used virtual laboratories intensively, so a pocket book is needed as a guide for use and understanding of the practical context.
3.	Task analysis	The learning outcome is that Elementary School Teacher Education students are able to master basic knowledge of fundamental physics concepts in elementary school.
4.	Concept analysis	a) Quantities and unit b) Measurement
5.	Specification of objectives	The learning objective is for students to be able to analyze the concepts of quantity and measurement.

Table 5 Activities in the Design Stage

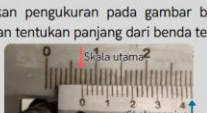
No.	Activities	Result
1.	Criterion-test construction	The test consists of 5 essay questions. a) Analyzing units and dimensions of different quantities (C4). b) Comparing different units (C5). c) Determining the measurement results of the ruler (C3). d) Analyzing the results of screw micrometer measurements (C4). e) Drawing the results of caliper measurements (C6).
2.	Media selection	The chosen medium is an integrated virtual laboratory digital guidebook, designed to combine concise learning materials with interactive simulations to support students' conceptual understanding.
3.	Format selection	The pocketbook that has been developed can be used offline or online. It is also integrated with supporting media such as YouTube videos and virtual laboratory links.

No.	Activities	Result
		The structure of the integrated virtual laboratory digital pocket book format is as follows cover, foreword, table of contents, list of figures, list of tables, guide to using the book, concept map, concept explanation, YouTube link, virtual laboratory link, evaluation questions, glossary, and bibliography.
4.	Initial design	The opening screen of the digital handbook, integrated with the virtual laboratory, is designed to provide users with a visually appealing, informative, and accessible experience. This interface serves as an entry point that introduces users to the handbook's overall structure, including content organization and key embedded features. In addition to presenting important information, this initial display is also designed to facilitate intuitive navigation, allowing users to quickly access learning materials, instructions, and integrated virtual lab features. Visual elements, such as layout, color composition, typography, and icons, are carefully arranged to enhance readability and user engagement. Furthermore, the integration of the virtual laboratory is clearly highlighted on the home screen, allowing users to seamlessly transition from theoretical content to interactive simulation activities. An image of the digital handbook's home screen is presented below (Figure 2).



Figure 2 Initial display of the digital pocket book

Table 6 Advice from Validators

Validator Suggestions	Before Revision	After Revision
Add an opening sentence to the example question	Klik icon lab tested disamping untuk melakukan praktikum virtual mengenai jangka sorong CONTOH SOAL  - NST = 0,02 (jumlah skala nonius adalah 50) - Skala utama = 7,00 mm - Skala nonius = $22 \times 0,02 = 0,44$ mm - Hasil = $7,00 + 0,44$ mm = 7,44 mm 2.3 Mikrometer sekrup 2.3.1 Pengertian mikrometer sekrup Mikrometer sekrup adalah alat ukur yang digunakan untuk mengukur panjang, tebal, atau diameter benda kecil dengan NST 0,01 mm.	Klik icon lab tested disamping untuk melakukan praktikum virtual mengenai jangka sorong CONTOH SOAL Perhatikan pengukuran pada gambar berikut, kemudian tentukan panjang dari benda tersebut  - NST = 0,02 (jumlah skala nonius adalah 50) - Skala utama = 7,00 mm - Skala nonius = $22 \times 0,02 = 0,44$ mm - Hasil = $7,00 + 0,44$ mm = 7,44 mm 2.3 Mikrometer sekrup 2.3.1 Pengertian mikrometer sekrup Mikrometer sekrup adalah alat ukur yang digunakan untuk mengukur panjang, tebal, atau diameter benda kecil dengan NST 0,01 mm.

Validator Suggestions	Before Revision	After Revision																
Add an explanation of standard and non-standard units	No explanation of standard and non-standard units	1.4 Satuan Baku dan Tak Baku Satuan baku adalah satuan yang telah ditetapkan secara internasional, konsisten, dan dapat digunakan oleh siapa saja dengan hasil yang sama. Satuan ini digunakan dalam kegiatan ilmiah. Satuan tak baku adalah satuan yang tidak diakui secara internasional dan dapat berbeda-beda tergantung pada siapa yang menggunakannya. Tabel 1.4 Satuan baku dan tak baku <table><tr><th>No.</th><th>Besaran</th><th>Satuan Baku</th><th>Satuan Tak Baku</th></tr><tr><td>1.</td><td>Panjang</td><td>Meter</td><td>Jengkal, depa, langkah</td></tr><tr><td>2.</td><td>Massa</td><td>Kilogram</td><td>Genggam, butir, ikat</td></tr><tr><td>3.</td><td>Volume</td><td>Liter</td><td>Gelas, gayung, sendok</td></tr></table>	No.	Besaran	Satuan Baku	Satuan Tak Baku	1.	Panjang	Meter	Jengkal, depa, langkah	2.	Massa	Kilogram	Genggam, butir, ikat	3.	Volume	Liter	Gelas, gayung, sendok
No.	Besaran	Satuan Baku	Satuan Tak Baku															
1.	Panjang	Meter	Jengkal, depa, langkah															
2.	Massa	Kilogram	Genggam, butir, ikat															
3.	Volume	Liter	Gelas, gayung, sendok															
Add glossary	No glossary	GLOSARIUM Alat ukur : alat yang digunakan untuk mengukur suatu besaran. Besaran : segala sesuatu yang dapat diukur dan dinyatakan dengan angka serta memiliki satuan. Besaran pokok : besaran yang satuannya telah ditetapkan terlebih dahulu dan tidak diturunkan dari besaran lain. Besaran turunan : besaran yang diturunkan dari satu atau lebih besaran pokok Intensitas cahaya : ukuran terang atau kuatnya suatu cahaya. Jumlah zat : mengukur banyaknya partikel. Jangka sorong : alat ukur panjang. Kuat arus listrik: banyaknya muatan listrik yang mengalir per satuan waktu. Massa : ukuran banyaknya materi dalam suatu benda. Mikrometer sekrup : alat ukur panjang. Neraca : alat untuk mengukur massa suatu benda.																
Add a list of references		DAFTAR PUSTAKA 1. Abdullah, M. (2016). <i>Fisika Dasar I</i>. bandung: Institut Teknologi Bandung. 2. Bahtiar, B. (2017). <i>Pengantar Fisika Dasar I</i>. Mataram: LP2M UIN Mataram. 3. Giacoli, D. C. (2015). <i>Physics: Principles with Applications</i>. USA: Pearson Education. 4. Halliday, D., & Resnick, R. (2014). <i>Fundamentals of Physics Tenth Edition</i>. USA: John Wiley & Sons. 5. Haryanti, S. (2020). <i>Fisika Dasar 1</i>. Bandung: Media Sains Indonesia. DAFTAR PUSTAKA 1. Abdullah, M. (2016). <i>Fisika Dasar I</i>. bandung: Institut Teknologi Bandung. 2. Bahtiar, B. (2017). <i>Pengantar Fisika Dasar I</i>. Mataram: LP2M UIN Mataram. 3. Giacoli, D. C. (2015). <i>Physics: Principles with Applications</i>. USA: Pearson Education. 4. Halliday, D., & Resnick, R. (2014). <i>Fundamentals of Physics Tenth Edition</i>. USA: John Wiley & Sons. 5. Haryanti, S. (2020). <i>Fisika Dasar 1</i>. Bandung: Media Sains Indonesia. 6. Narpila, S. D. (2021). <i>Teori dan Aplikasi Fisika Dasar</i>. Aceh: Yayasan Penerbit Muhammad Zaini. 7. Prayogi, S. (2022). <i>Fisika Dasar Bagian Mekanika dan Kalor</i>. Banyumas: Wawasan Ilmu. 8. Putra, V. G. V. (2017). <i>Pengantar Fisika Dasar</i>. Yogyakarta: CV. Mulia Jaya Publisher. 9. Rosyid, M. F., Firmansyah, E., & Prabowo, Y. D. (2014). <i>Fisika Dasar Jilid I: Mekanika</i>. Yogyakarta: Periuk. 10. Utami, A. U. (2024). <i>Buku Ajar Fisika Dasar</i>. Banten: Minhaj Pustaka.																

A summary of the validity results of the integrated virtual laboratory pocketbook assessed by six validators is presented in Table 7. Each validator provided an assessment based on specific aspects that had been determined. The assessment results were used to assess the overall validity of the product and as a reference for improving the pocketbook.

Table 7 Results of the Validity of the Digital Pocketbook

Components	Aspects Assessed	Score						X	Categories
		V1	V2	V3	V4	V5	V6		
Material suitability	Appropriateness of materials to learning objectives	5	4	4	5	5	5	4.63	Very valid
	Conceptual correctness	4	5	4	5	4	5		
	Up-to-date material	5	5	4	4	4	5		
	Integration with virtual laboratories	5	5	5	5	4	5		
	Integration with interactive digital features	5	5	5	4	4	5		
Language suitability	Compliance with Indonesian language rules	5	4	4	4	4	5	4.40	Very valid
	Readability	5	4	5	4	4	5		
	Consistency in the use of terms	5	5	4	4	4	5		
	Clarity of digital usage instructions	5	5	4	5	3	4		
	Be consistent with punctuation	5	4	4	5	3	5		
Graphic suitability	Digital page layout and composition	5	4	5	5	4	4	4.63	Very valid
	Quality of visual and interactive media	5	4	5	5	4	5		
	Consistency of digital visual format	5	5	4	5	4	4		
	Visual appeal and interactivity	5	4	4	5	5	4		
	Accessibility and display comfort	5	5	5	5	5	5		
X		4.56							
Categories		Very valid							

After validation with the validators and revision based on their suggestions, here is the link to the digital pocketbook: <https://bit.ly/BSPUPR>. Distribution is carried out online by sending a link that can be easily accessed and used by Elementary School Teacher Education students or others.

Based on Table 7, the integrated digital pocketbook of the virtual laboratory is highly valid in terms of material feasibility. The assessment results show that the material presented in the pocketbook is in line with the learning objectives set, thereby effectively supporting the achievement of Elementary School Teacher Education students competencies (Huda, 2024). In addition, the concepts presented in the pocketbook are scientifically accurate and free from misconceptions, demonstrating high academic quality (Kundi & Ducha, 2024). The material compiled also reflects the latest information, in line with current developments in science and technology, especially in the context of virtual laboratory-based learning. This pocket book also successfully integrates the material with virtual experiments, so that students not only understand the concepts theoretically but also apply them through interactive digital-based activities (Rif'ati et al., 2025). In addition, the integration of content and digital features further enhances the pocketbook's ability to deliver comprehensive, engaging, and meaningful learning experiences (Adillah et al., 2025). These findings indicate that, in terms of material, pocket books have met the standards of feasibility as innovative technology-based learning media.

Based on Table 7, the integrated virtual laboratory digital pocketbook is also categorized as highly valid in terms of language appropriateness. The assessment results show that the language used in the pocketbook complies with the rules of proper and correct Indonesian. This is very important because language is the main medium for conveying learning messages effectively (Haptanti et al., 2024). The sentence structure used is effective, communicative, and easy for Elementary School Teacher Education students to understand in accordance with their language development level. In addition, the readability of the pocket book is very good, as demonstrated by the selection of simple but appropriate diction and the presentation of sentences that are not too long or complex. Readability is an important indicator in the development of teaching materials because it affects student comprehension (Nissa et al., 2023). On the other hand, the use of terminology in the pocketbook is also very consistent and relevant to the scientific context, which prevents misinterpretation. Instructions for using digital features are also written clearly and structurally, making it easier for students to utilize the available interactive media. Punctuation usage is also consistent and in

accordance with the rules, supporting the clarity of sentence structure and flow. As a result, the high linguistic quality makes this pocket guide suitable as a communicative and easy-to-understand learning medium, capable of enhancing the effectiveness of digital information delivery in education.

Although the language aspect is generally considered highly valid, there are still some weaknesses, particularly regarding the clarity of digital usage instructions and the consistency of punctuation usage. In the usage instructions section, some guidelines remain unclear and have not been systematically organized, potentially causing confusion for students when operating the available digital features. Additionally, regarding punctuation, inconsistent usage is still observed, such as the use of periods, commas, and symbols.

This situation can impact the effectiveness of the media's use, as unclear instructions can hinder user interaction with the media (Hidayat et al., 2024), while inconsistent punctuation can reduce reading comfort (Lestari et al., 2023). Therefore, improvements are needed by drafting usage instructions in a more systematic, clear, and communicative manner, as well as ensuring consistency in punctuation usage so that the media is easier to understand and can be optimally utilized by students.

Based on Table 7, the integrated virtual laboratory digital pocketbook is also categorized as highly valid in terms of graphic design. Graphic design plays an important role in attracting attention, enhancing user comfort, and supporting visual understanding of the material. This handbook features a systematic and proportional page layout, with a neat and balanced composition of text, images, and interactive media elements. The neat arrangement helps Elementary School Teacher Education students understand information more easily without overloading their memory (Hanyfah et al., 2025). The quality of the visual media displayed is also excellent, from image resolution to the suitability of illustrations for learning content. The visual elements presented are not merely decorative, but reinforce conceptual understanding in a representational manner.

In addition, this pocket book demonstrates consistency in digital visual format, including the use of fonts, colors, icons, and graphic styles that are uniform throughout. This consistency not only creates a professional look, but also helps readers recognize patterns and information structures more easily (Setiawan & Amayati, 2025). The visual appeal and interactivity are also very strong, as seen in the aesthetically pleasing design and interactive features such as simulations, animations, and responsive navigation buttons. This is in line with the principle of Universal Design for Learning (UDL), which emphasizes the importance of flexible and adaptive access for all types of users (Hidayat & Ikromi, 2025). Thus, the graphic aspects of this pocket book contribute significantly to the effectiveness and efficiency of modern and enjoyable digital-based learning.

Overall, this integrated pocket book and virtual laboratory provide interactive simulations that allow Elementary School Teacher Education students to conduct virtual experiments through various activities, such as using digital measuring instruments, adjusting variables, and observing the measurement process step by step. Through these simulations, abstract concepts such as derived quantities, unit conversion, and measurement accuracy and uncertainty can be visualized more clearly and concretely. Students can also directly observe measurement results displayed in real-time, making it easier for them to understand the relationship between theory and practice. Additionally, these interactive features allow students to repeat experiments, try various scenarios, and conduct independent exploration without limitations.

CONCLUSION

Based on the results of the analysis and discussion, it was concluded that the integrated virtual laboratory digital pocketbook was valid because it met the criteria for material, language, and graphics. This pocket book also offers specific advantages over conventional learning materials and pocket books that are not integrated with a virtual laboratory. This pocket book provides interactive simulations that allow students to conduct virtual experiments, visualize abstract concepts, and observe measurement results directly. Thus, this pocket book is highly suitable for use by Elementary School Teacher Education students as an innovative digital learning medium that supports independent, interactive, and contextual learning, and aligns with the demands of 21st-century learning.

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