

## DEVELOPMENT OF TEXTBOOKS TO SUPPORT MERDEKA CURRICULUM LEARNING ON NANOTECHNOLOGY MATERIAL FOR PHASE E

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**Abstract:** The development of a textbook to support Merdeka curriculum learning on nanotechnology material for phase E high school students is equipped with more detailed material content, multi representations that are easy to understand, and a more attractive book display. It is hoped that it can increase students' learning motivation and abilities due to learning loss due to COVID-19 and support the learning process and education in the era of the industrial revolution 4.0. Ministerial Decree of The Minister of Education and Culture of The Republic of Indonesia No.008/H/KR/2022 concerning chemistry learning outcomes in phase E high school students there is nanotechnology material. This study aimed to develop a valid and practical textbook to support learning for the Merdeka curriculum on phase E nanotechnology material. Research in modern chemistry continues to grow, evidenced by the discovery of nanotechnology, which involves measuring and manipulating matter at the atomic, molecular, and supramolecular levels measured on a scale of 1-100 nm. The research conducted is categorized as an educational design study using the Plomp development model and includes three phases: preliminary research, development or prototyping, and evaluation. Validation analysis resulted in a content effectiveness test score 0.91 for one valid category. At the same time, teacher and student practice tests scored 92% and 92%, respectively, in the highly practical practicality category. In summary, it is effective and practical to develop a textbook for Phase E high school students to support learning the Merdeka curriculum on nanotechnology material.

**Keywords:** *Textbook, Merdeka Curriculum, Nanotechnology, Plomp Model*

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### INTRODUCTION

Post-pandemic COVID-19, various difficulties in learning implementation were identified in education units [1-3]. They are learning implementation changes in educational components such as teachers, students, school environment, content, methods, and media. However, the limited adjustment to these changes implements learning less effective and causes learning loss [4]. According to The Education and Development Forum (2020), learning loss is a decrease in students' mastery of competencies because learning state students lose knowledge and skills due to certain conditions [5]. So it is necessary to simplify and improve the curriculum due to learning loss. The use of a more flexible Merdeka curriculum that is refined and adapted to current conditions and needs has proven effective in improving learning outcomes according to the interests and talents of each student [6].

Indonesian Minister of Education Nadiem Makarim launched the Merdeka curriculum as a replacement for the 2013 curriculum to overcome the education problems in Indonesia due to the COVID-19 pandemic [7]. The Merdeka curriculum has diverse intra-curricular learning optimized to give learners enough time to explore concepts and strengthen competencies [8]. The Merdeka curriculum aims to improve learning practices restricted by the COVID-19 pandemic and support education in the era of the Industrial Revolution 4.0 [9].

The industrial revolution is a fundamental transformation of human lifestyles and work processes, including education, with advances in science and technology integrated into the world of life using digital, which has an impact on various fields of science [10-12]. At the beginning of the 21st century, the industrial revolution 4.0 was characterized by the discovery of artificial intelligence, supercomputers, genetic engineering, nanotechnology, automated cars, and innovation [13]. So far, nanotechnology can only be accessed and known by students; the lack of approach and information from teachers about nanotechnology is the main reason for uneven information about nanotechnology, so it becomes a challenge in the industrial revolution 4.0 [14].

The Ministry of Education and Culture No.008/H/KR/2022 decree concerning chemistry learning outcomes in phase E of high school students contains nanotechnology material [8]. Research in the field of modern chemistry continues to grow, as evidenced by the discovery of nanotechnology, which is defined in the National Nanotechnology Initiative committee as follows: 1) Nanotechnology includes the research and development of technologies on the scale of 1 nm to 100 nm; 2) Nanotechnology creates and uses structures with new properties due to their small size; 3) Nanotechnology is based on the ability to control or manipulate at the atomic level [15]. In 1959, before Nanotechnology was defined, Richard

Feynman said in a visionary lecture, "In the future, we can control or manipulate the atoms the way we want" [16]. The central concept of nanotechnology starts with the binding of atoms or ions into molecules to form nanometer-scale structures that help manufacture objects used in everyday life [17].

Nanotechnology has the potential to develop into a unique and innovative applied science. Researchers from institutions in Indonesia are increasingly active in nanotechnology research, proving that nano products are in demand in the market and accepted by the public [18]. The study concluded that 90% of participants found nanotechnology learning exciting and fun [19]. In addition, it was stated that nanotechnology learning can provide positive learning outcomes and improve cognitive abilities, interest, and motivation in science [20]. In line with the research conducted, it states that teaching material integrated with the context of nanotechnology can improve students'

process skills and produce cognitive competency outputs that are useful in competing in the global world [21].

Complex abstract concepts require explanations that can visualize material in various forms of representation [22]. For example, combining images, graphs, symbols, formulas, diagrams, or verbal sentences shows a different representation format (multi-representation) [23]. The multi-representation model in chemistry learning proposed by Johnstone (1982) is the Chemistry triplet consisting of 1) macroscale (macroscopic) representation, which is natural and can be seen by the eye; 2) nanoscale (sub-microscopic), which is natural but invisible and consists of particle planes that can be used to describe the motion of electrons, molecules, particles or atoms; and 3) symbols that consist of various types of images and algebraic representations [24-26].

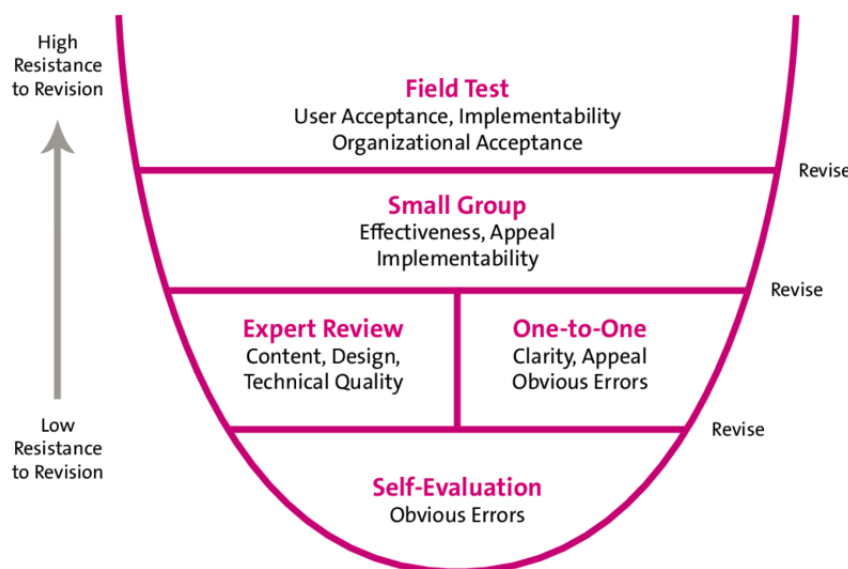


Figure 1. Layers of Formative Evaluation from Tesser [31].

However, these teaching materials have not been adapted to support independent curriculum learning. Textbooks are books used as textbooks in specific fields of study, systematically compiled by experts in the field of study for instructional purposes and objectives, and are easily understood by users so that they can support the implementation of learning in schools [27-28]. The advantages of using textbooks are that they can help manage a systematic learning process and have an attractive design that can increase student learning motivation [29]. A study conducted on the development of textbooks concluded that students' understanding of using the developed textbook was higher than without using the textbook [30].

To overcome the above problems, researchers should develop textbooks that support Merdeka curriculum learning with more detailed teaching material content, multiple easy-to-

understand presentations, and more engaging book presentations. This is expected to improve students' motivation and ability to learn due to learning disabilities caused by the new coronavirus infection and support learning and education in the era of Industrial Revolution 4.0. The researchers, therefore, proposed a solution by developing a textbook to support the Merdeka Curriculum Learning on Nanotechnology Materials for High School Students in Phase E.

## RESEARCH METHODS

The study type used in this study was educational design research (EDR). The research studies used in EDR are development studies [31][32]. The development model used is the Plomp development model developed by Tjeerd Plomp. The Plomp development model consists of three phases: Preliminary research, development or

prototyping, and evaluation [31,33]. The evaluation stage in this study is formative evaluation. The formative evaluation phase is performed iteratively during the development process to improve and refine the designs produced. The data from the research results were analyzed using descriptive statistics to obtain the average numbers and percentages. Each data can be analyzed using data analysis techniques, namely:

### Validity Analysis Technique

The validity of the data can be analyzed based on the Aiken validity index based on categorical judgments modified from Boslaugh. The validator's assessment of each statement was analyzed using Aiken's validity formula as follows:

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

Description:

- S : The score determined by the validator minus the lowest score for the category used
- n : Number of validators
- c : Number of categories selected by the validator

The range of Aiken's validity index is 0 to 1, where a high Aiken's validity index indicates product validity (Aiken, 1985) on the items using five validators and five categories of category choices, as attached in Table 1.

Table 1. Aiken's Validity Index Criteria 5 Validators [34].

Skala Aiken's V	Description
$V < 0.80$	Invalid
$V \geq 0.80$	Valid

### Practicality Analysis Technique

Evaluation of the practicality sheet is done by providing learners with a response questionnaire, which is analyzed using the following modified formula by Purwanto [35].

$$NP = \frac{R}{SM} \cdot 100$$

Description:

- NP : Percentage value sought
- R : Scores obtained by students
- SM : The ideal maximum score of the test in question
- 100 : Fixed number

The level of practicality of textbooks to support Merdeka curriculum learning on nanotechnology material in phase E SMA / MA will be seen after being converted to categories, as shown in the table below.

Table 2. Practicality Level [35][36]

Nilai	Validity
86% - 100%	Very practical
76% - 85%	Practical
60% - 75%	Quite Practical
55% - 59%	Less Practical
$\leq 54\%$	Not Practical

## RESULTS AND DISCUSSION

### Preliminary Research

The preliminary research phase in this research included needs and situation analysis, literature review, and conceptual framework development. Here are the steps:

#### 1. Need and Context Analysis

Needs and context analysis aims to find out the problems experienced by teachers and students related to chemistry learning on nanotechnology material. The steps taken to see the picture of the issue were to interview chemistry teachers in several schools, namely SMA Negeri 3 Padang, SMA Negeri 8 Padang, and SMA Pembangunan Laboratorium UNP.

Based on the interview results, it was concluded that students needed help understanding chemistry lessons, especially nanotechnology material. It is because nanotechnology material is new and unfamiliar material for students and material that is abstract. Hence, students need help understanding the material and textbooks as learning tools for teachers. Students are considered less effective because, with less detailed material content, lack of multi-representation, and the appearance of the book could be more attractive, indicated by the presentation of unsupportive images where there are images that are difficult for students to understand.

#### 2. Literature Review

Literature studies are carried out as a theoretical basis for interventions related to the development research and finding solutions to problem-solving through various sources and references in the form of textbooks, journals, articles, and other sources from the internet.

Based on the research conducted, the analysis of students' understanding using the developed textbook obtained an average score of 80.21. Meanwhile, the knowledge of students who did not use the developed textbook received an average score of 65.00. It shows that the understanding of students using books is higher than those without [37]. Another study stated that teaching materials integrated with the context of nanotechnology could improve students' process skills and produce cognitive competency outputs that are useful in competing in the global world [21]. The results of the research stated that learning using teaching materials based on chemical representations

effectively improves students' concept understanding [38].

### 3. Development of Conceptual Framework

The conceptual framework phase is carried out after field problems are discovered

through needs analysis, contextual analysis, and literature review conducted. As a subsequent development step, the Conceptual Framework aims to form a prototype essential to the research process. The conceptual framework is shown in Figure 2 below.

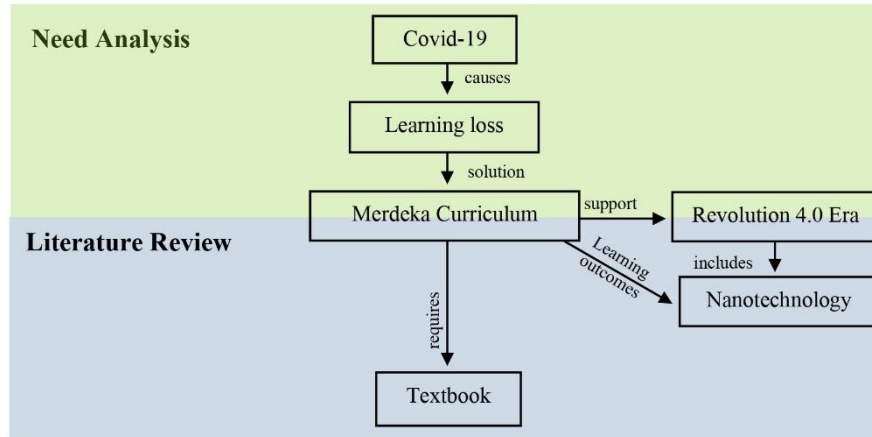


Figure 2. Conceptual Framework

### Development or prototyping

Based on the analysis performed in the preliminary research phase, a textbook will be produced and designed to support the Merdeka curriculum learning of nanotechnology materials for high school students in Phase E. Next is the prototyping phase, where Prototype I, Prototype II, and Prototype III are produced. The activities performed during the prototyping stage are:

#### 1. Prototype I

In developing textbooks to support Merdeka curriculum learning on nanotechnology, the material is designing a book to support Merdeka curriculum learning on nanotechnology material in phase E SMA/MA based on learning outcomes and conducting self-evaluation (self-evaluation) by looking at the completeness of textbook components to support Merdeka curriculum learning. The book component is equipped with a Preface, table of contents, learning outcomes (CP), learning objectives (TP), concept map, instructions for using the book, material content, Pancasila Student Profile, keywords, activities, sample questions, and discussions, comprehension tests for each meeting, end-of-book exercises, summary, reflection, bibliography, glossary, index and answer key.

The following are the components contained in the developed textbooks:

- Cover Textbook, there is the book's title, the author's name, and the relevant institution.
- Cover Book Chapter; this section is the beginning of each chapter, learning objectives, Pancasila student profile, and keywords related to the material in the chapter.
- Table of Contents, the table of contents is a part that is in the form of an arrangement or

explanation of the location of content in a textbook.

- Concept Maps are concept map that illustrates the interconnectedness of the subject matter to be studied.
- In addition to the material presented, this book also offers various activities. These activities include obtaining and reviewing information from articles, simple observations in the surrounding environment, listening to videos, and simple practicums.
- Sample Questions and Discussion contains sample problems and discussions following the material.
- Comprehension Test, located in each chapter, to test mastery and understanding of the learning process. The questions presented consist of multiple-choice questions and essay questions.
- The summary contains essential concepts for each chapter that must be considered.
- End-of-Book Practice Questions contain questions to assess material assignment at the standard's end. The questions are presented as multiple choice, essay, and Minimum Competency Assessment (AKM) type questions.
- Reflection contains questions for yourself so that you can know the competencies that have been understood and have not been understood.

In the development stage, prototype development is carried out through formative evaluation, which aims to revise the developed textbook using validation by experts/validators. Prototype validation and revision occur repeatedly to ensure the book is truly valid before being tested.

#### 2. Prototype II

Prototype II resulted from a formative self-evaluation of prototype I. At this stage, corrections were made to the completeness of the textbook's

contents to support the learning of the Merdeka curriculum on nanotechnology material in phase E high school students. Based on the results of the self-evaluation that has been carried out, the contents of the textbook developed are complete, so there is no need for revisions to prototype I.

### 3. Prototype III

Prototype III was created following the expert review and one-to-one evaluation of Prototype II. Designs for the production of Prototype III include:

#### a) Expert Review

The expert evaluation aims to determine the degree of meaning in terms of content, design, and language. The experts involved in this evaluation are three lecturers from the Chemistry Department of FMIPA UNP and two chemistry teachers from SMA Negeri 3 Padang, who act as validators and evaluate the Prototype II product using an evaluation questionnaire.

The validity test on prototype two was carried out by five experts/validators by filling out the validation sheet. The validation sheet prepared was used to measure the feasibility of textbook components which included content feasibility components, language feasibility components, and presentation feasibility components. Validators 1, 2, and 4 stated that the textbook was suitable for use with minor revisions, while validators 3 and 5 noted that the textbook was ideal for use without correction.

Some suggestions given by validators that can be used as guidelines in revising prototype two are 1) The writing of the book should not have copyright violations, including the cover and illustrations used; 2) There should be In Text Activity in the book so that it is not monotonous, 3) there are errors in the concept map and table of contents.

From the results of the validation that has been carried out, then revisions are made to the textbook as follows figure 3:

Based on the results of interviews conducted on textbooks to support study in the nanotechnology material Merdeka curriculum, the cover's appearance is attractive and rational in design, color, font, language, and quality. It turns out. Engaging and relevant in design, colors, fonts, wording, and layout arouses students' interest in learning. It is a layout that stimulates students' interest in using the textbook. Use a textbook. Using questions, images, videos, and activities is good and exciting to support learning and help students learn. Help students learn to understand nanotechnology material. It's good and exciting overall and helps students understand what nanotechnology is all about. The results of the prototype I validation is presented in Figure.6, which shows that the textbook includes valid criteria.

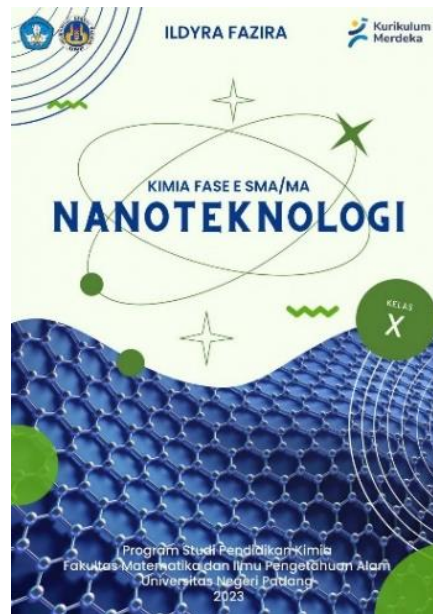


Figure 3. Cover Textbook After Revision

DAFTAR ISI	
KATA PENGANTAR	i
DAFTAR ISI	ii
PETUNJUK BELAJAR	iii
PETA KONSEP	iv
BAB I NANOTEKNOLOGI	1
A. PENGERTIAN NANOTEKNOLOGI	1
B. RANGKAIAN NANOTEKNOLOGI	2
C. PENGERTIAN NANOTEKNOLOGI	3
D. ALOSI PADA NANOTEKNOLOGI	4
BAB II PEMERIKSAAN NANOTEKNOLOGI	5
A. APLIKASI NANOTEKNOLOGI	5
B. BIDANG PETYAKSIAN	6
C. BIDANG KOSMETIK	7
D. BIDANG KESEHATAN	8
E. BIDANG PANGAN	9
F. BIDANG TEKNOLOGI	10
BAB III NANOMATERIAL	11
A. PENGERTIAN NANOMATERIAL	11
B. KLASIFIKASI NANOMATERIAL	12
C. METODE SINTESIS NANOMATERIAL	13
D. FAKTOR YANG MEMPENGARUH SIPAT NANOMATERIAL	14
E. KELINGKARAN SIPAT NANOMATERIAL	15
F. BAHAYA NANOMATERIAL	16
RANGKAIAN	17
LAMPIRAN	18
A. LAMPIRAN I	18
B. LAMPIRAN II	19
C. LAMPIRAN III	20
D. LAMPIRAN IV	21
E. LAMPIRAN V	22
F. LAMPIRAN VI	23
G. LAMPIRAN VII	24
H. LAMPIRAN VIII	25
I. LAMPIRAN IX	26
J. LAMPIRAN X	27
K. LAMPIRAN XI	28
L. LAMPIRAN XII	29
M. LAMPIRAN XIII	30
N. LAMPIRAN XIV	31
O. LAMPIRAN XV	32
P. LAMPIRAN XVI	33
Q. LAMPIRAN XVII	34
R. LAMPIRAN XVIII	35
S. LAMPIRAN XIX	36
T. LAMPIRAN XX	37
U. LAMPIRAN XXI	38
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X. LAMPIRAN XXIV	41
Y. LAMPIRAN XXV	42
Z. LAMPIRAN XXVI	43
AA. LAMPIRAN XXVII	44
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AC. LAMPIRAN XXIX	46
AD. LAMPIRAN XXX	47
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AM. LAMPIRAN XXXIX	56
AN. LAMPIRAN XL	57
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AS. LAMPIRAN XLV	62
AT. LAMPIRAN XLVI	63
AU. LAMPIRAN XLVII	64
AV. LAMPIRAN XLVIII	65
AW. LAMPIRAN XLIX	66
AX. LAMPIRAN L	67
AY. LAMPIRAN LI	68
AZ. LAMPIRAN LII	69
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BB. LAMPIRAN LIV	71
BC. LAMPIRAN LV	72
BD. LAMPIRAN LVI	73
BE. LAMPIRAN LVII	74
BF. LAMPIRAN LVIII	75
BG. LAMPIRAN LIX	76
BH. LAMPIRAN LX	77
BI. LAMPIRAN LXI	78
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BK. LAMPIRAN LXIII	80
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BM. LAMPIRAN LXV	82
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BO. LAMPIRAN LXVII	84
BP. LAMPIRAN LXVIII	85
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BT. LAMPIRAN LXXII	89
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BV. LAMPIRAN LXXIV	91
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BZ. LAMPIRAN LXXVIII	95
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CF. LAMPIRAN LXXXXXX	127
CG. LAMPIRAN LXXXXXXI	128
CH. LAMPIRAN LXXXXXXII	129
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CJ. LAMPIRAN LXXXXXXIV	131
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CN. LAMPIRAN LXXXXXXVIII	135
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CQ. LAMPIRAN LXXXXXXXI	138
CR. LAMPIRAN LXXXXXXXII	139
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CU. LAMPIRAN LXXXXXXXV	142
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Figure 4. Table of Content After Revision

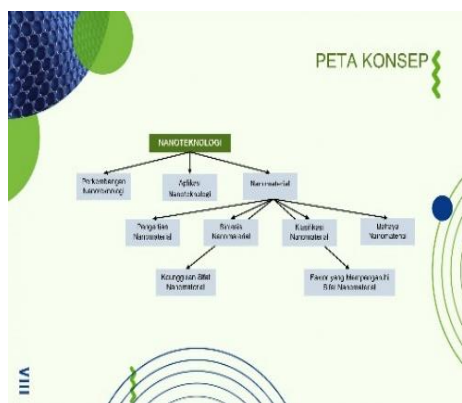


Figure 5. Concept Maps After Revision

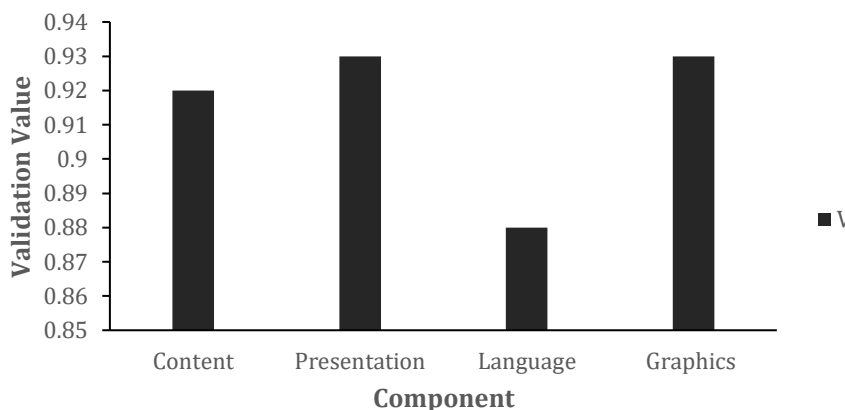


Figure 6. Bar Chart Validity Test

b) One-To-One Evaluation

After the design was revised according to the validators' suggestions, a one-to-one evaluation was performed. The researcher interviewed one-on-one with a high school phase E student with high, intermediate, and low abilities. This stage examines how students will react to the textbooks that will be produced. Based on the results of this stage, we found that the appearance of the images in the textbook was evident and exciting, making it easier for the students to understand the textbook's content. The rework of Prototype II aims to improve the quality of the prototype to produce a valid Prototype III.

4. Prototype IV

Prototype IV was created from a formative evaluation of the small group evaluation of Prototype III. This evaluation was conducted to determine the level of practicality of textbooks supporting the Merdeka curriculum in studying nanotechnology materials for Phase E students. There are four evaluation items: ease of use, appearance, learning efficiency, and advantages of the textbook. A small

group assessment was conducted with two chemistry teachers and 12 high-, intermediate-, and low-level students studying nanotechnology materials. The table below shows the practical results of small group evaluation and the practical effects on teachers.

Based on Figure 7, the practicality value for each item above with an average is 92%, which means that the developed product is practical in terms of ease of use, display, learning efficiency, and benefits textbook. These results were then revised to produce a valid and practical prototype IV.

The advantage of this research from previous research [39] is that the textbook developed is a textbook on nanotechnology material which is material in the Merdeka curriculum. The developed textbook has been equipped with more detailed material content, multiple presentations that are easy to understand, and a more attractive book display. It is hoped that it will increase the motivation to learn and the ability of students due to learning loss due to COVID-19 and support the learning process and education in the era of the industrial revolution 4.0.

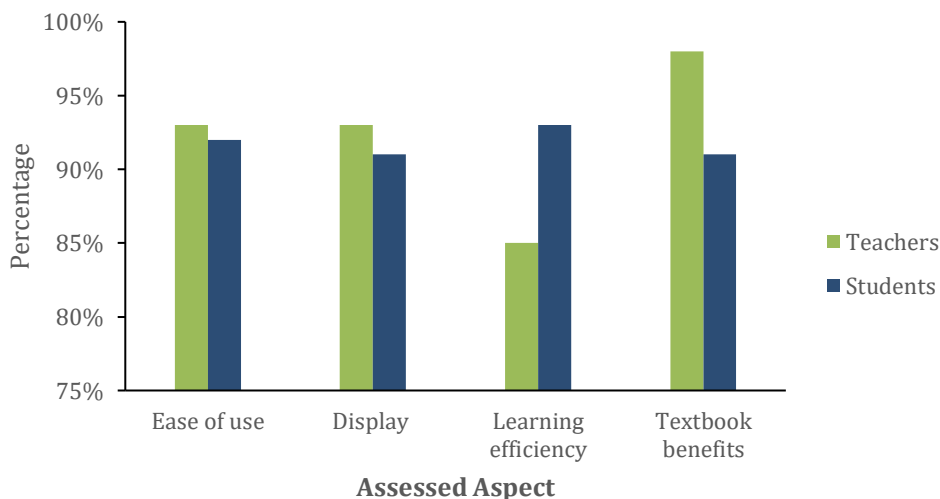


Figure 7. Bar Chart of Practicality Test



Figure 8. Activity in the textbook to Support Merdeka Curriculum Learning on Nanotechnology Material for Phase E High School Student

The developed textbook contains learning activities that can increase learning motivation and learners' abilities and develop learners' attitudes based on the dimensions of the Pancasila student profile following the Merdeka curriculum. The activity includes obtaining and reviewing information from articles, simple observations in the surrounding environment, listening to videos, and simple practicum. Figure 8. is the 3rd activity that examines the Nano-TiO<sub>2</sub> Applications in Life article. The

textbook's exercises follow the learning objectives of explaining nanotechnology applications in everyday life. The description of the image in action is in the image (a) Nano-TiO<sub>2</sub>, (b) Scanning Electron Microscope (SEM) Nano-TiO<sub>2</sub>, (c) Crystal structure of titanium dioxide. The picture has learning material equipped with multiple chemical representations that attract students' attention. Students' attention is what then fosters student understanding [40].

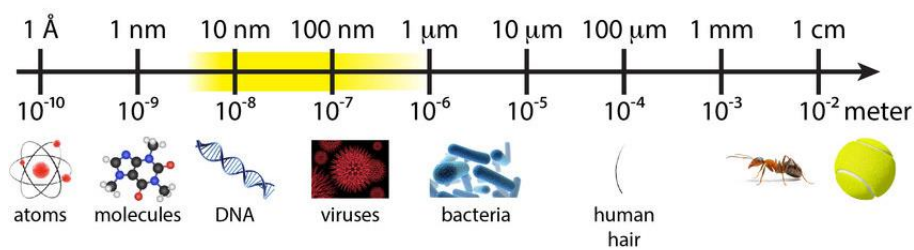


Figure 9. One of the pictures in the question in the textbook [41]

One model of a critical question that students must answer can be seen in Figure 9. Here students are relied upon to know nano-sized objects. From the interview conducted with the students, it is known that the size of nanotechnology is  $10^{-9}$  meters depending on the image given in Fig. At this point, the student is relied upon to answer the fundamental questions accurately, not only by utilizing the image that must be seen by the eye (naturally visible) but also from the drawing of the image and the drawing of smaller images (the smaller (sub-microscopic) depictions of the image. Because when only

naturally visible images are given, there are still students who answer that the photos shown are the scale of objects with nanoscale and micro-scale that when a visual picture of the scale and things has been given, students can quickly answer the questions given that determine objects that are nanomaterial-sized, if without a scale students will not know what objects are nanoscale, this is where the capacity of the image so that the ideas found by students are not flawed so that they become correct.

Based on the results of the study, in general, in the activities of expert assessment, individual

evaluation, and small group evaluation, it was found that the developed textbook met the criteria of valid and practical. The developed textbook can be classified as valid because the textbook follows the learning outcomes as appropriate components as a textbook. The textbook developed is classified as very practical because it benefits teachers and students. The benefit of this textbook is as one of the textbooks to support Merdeka curriculum learning in nanotechnology material phase E.

## CONCLUSION

Based on the research and data analysis that has been carried out, it is concluded that textbooks to support Merdeka curriculum learning on nanotechnology material phase E high school students can be developed with the Plomp development model. The developed textbook is categorized as valid, with an average validity value of 0.92. Categorized as very practical with an average value of practicality by students of 92% and practicality by teachers of 92%

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