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## Development of digital handout on particle wave dualism material

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## Development of digital handout on particle wave dualism material

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**Abstract.** A valid and practical digital handout on particle wave dualism material was produced in this study. The adaptation of Rowntree product development model and Tessmer formative evaluation was used as the method on the Physics Education Study Program, FKIP, Sriwijaya University. The walkthrough and questionnaire techniques was used to collect data. The result showed the mean score for the validity of the digital handout was 4,53 for the design, content, and linguistic aspects with highly valid category. The practicality average score in the one-to-one evaluation stage was 79,08% (practical) and in the small group evaluation stage was 84,59% (practical). The product can be used as an additional material in modern physics learning to improve students' technological literacy.

### 1. Introduction

Mastery of science and technology is a significant indicator in improving the quality of education in the current era of the industrial revolution 4.0 [1]. The industrial revolution 4.0 is marked by automation and digitization in various fields, especially in education. The improvement of learning outcomes and the quality of the process is supported by several factors [2]. Two of the are the capabilities of educators and the learning resources used during the learning process. One of the learning resources that is most often used is teaching materials [3], [4]. One type of teaching material that can be used is handout. Handout is one type of printed teaching material that contains a summary of the material prepared by educators to make it easier for students to take part in learning [5], [6].

The material in the handout raises the components needed in learning, including; learning objectives or competencies, prerequisites, namely learning materials that support or need to be studied beforehand, learning procedures, systematically arranged learning materials, exercises or assignments and evaluation questions [7]–[9]. The rapid development of education provides challenges for educators to continue to innovate from basic education to higher education. Changes in the learning model have developed into distance education which does not require lecturers and students to be in the same place. There are more choices of available learning sources such as e-books or digital books with easy access and currently handout can also be developed in digital form [10], [11]. The development of technology, especially modern technology, has a very close relationship with the development of science, especially physics. One of the main concepts of physics is the particle wave



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dualism, for example the use of electromagnetic waves in the health sector which continues to grow rapidly [12].

## 2. Experimental

This study was conducted in Physics Education Study Program, FKIP, Sriwijaya University through the adaptation of Rowntree product development model and Tessmer formative evaluation.

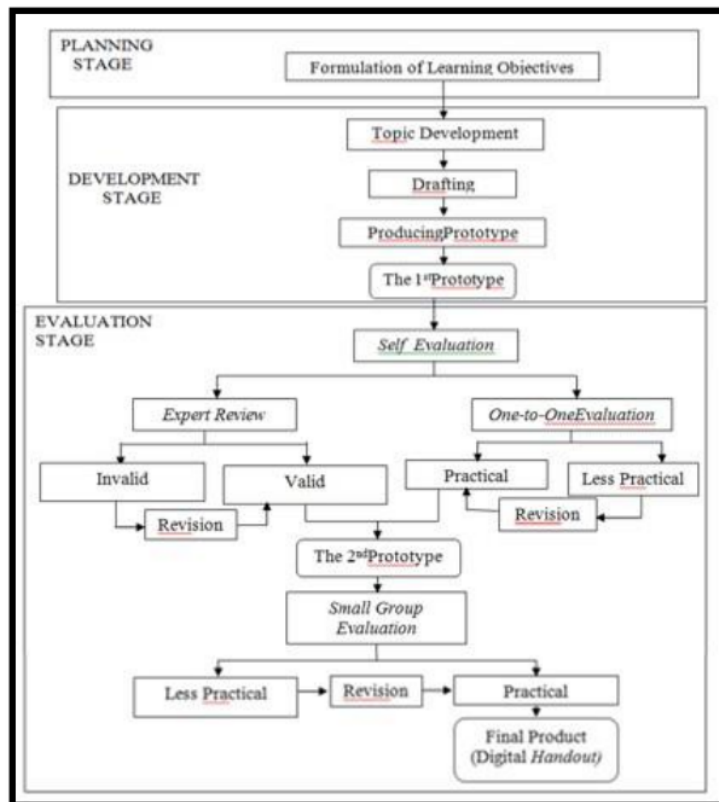


Figure 1. Digital handout on particle wave dualism development procedure (adopted from Rowntree and Tessmer)

## 3. Result and Discussion

### 3.1. Planning Stage

A needs analysis was carried out with the result 64.5% of the students expressed difficulty in learning the material, especially on the concept of particle wave dualism that has applications on technology due to the lack of reference. 80.6% stated the teaching material needed were in the form of digital handout. The formulation of learning objectives related to mastery of technology was carried out by analysing the semester program plan of Modern Physics courses by developing indicators of learning achievement and the ability to end a predetermined learning outcomes at the Physics Education Study Program, Sriwijaya University.

3.2. Development Stage

The development of the topic was done by creating an Outline of the Content of Digital Handout based on the description of the material obtained from the learning objectives that have been formulated before then used to construct a storyboard. The drafting was done by determining the components that will be included in the digital handout [13], [14].

Prototype production was done by making products in the form of digital handout on particle wave dualism material as a prototype-1 (the initial product). The application used is 3D Pageflip to convert existing pdf files, to obtain a digital display and add images, videos, audios, hyperlinks, flash, and the buttons and their functions [15], [16]. The digital handout produced is supplementary teaching material for other teaching materials because the materials presented focused on the application of the concept of particle wave dualism in the application on the technology. Several display digital handout pages presented in the form of images below start from cover and the contents [17].

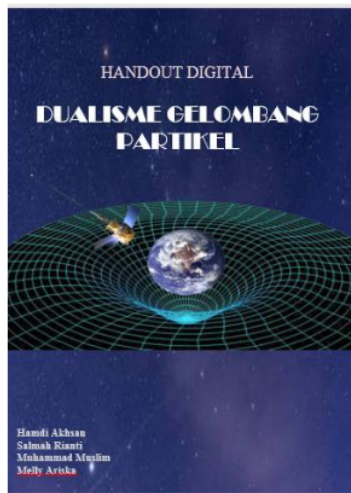


Figure 2. Digital handout cover



Figure 3. Home page display in every chapter

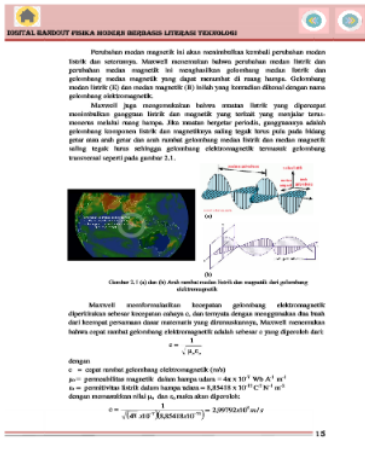


Figure 4. Content page display accompanied



Figure 5. Page display when video played

video and image

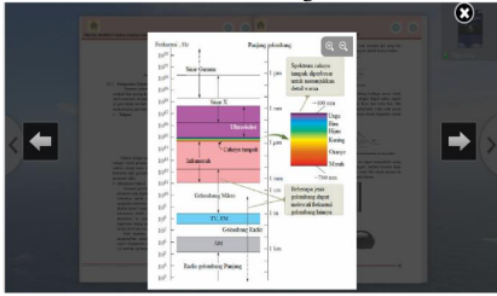


Figure 6. Page display when images clicked

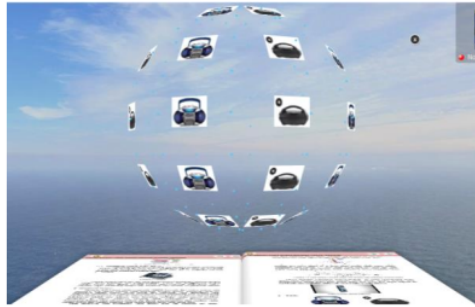


Figure 7. Page display when images more than one clicked



Figure 8. Page display with hyperlink

3.3. Evaluation Stage

The evaluation stage performed based on the stages of the Tessmer formative evaluation [17], [18]. The first stage is self-evaluation, self-evaluation of aspects of content, design, and linguistic prototype-1 conducted with the supervisor. Thus obtained some suggestions for improvements and prototype-1 has been fixed in part; 1) colour, text, and images cover; 2) margin and writing a page number in the list of images; 3) the colour on a part that can be clicked in the table of contents is the list of images.

The second stage of the expert review is conducted to evaluate and validate the three aspects of the design, content, and linguistic prototype-1 involving several experts. The result of the validation of design, content, and linguistic are presented in tabular form in Table 1.

Table 1. Summary of results of expert review stage assessment

Aspects validated	Validity value	Category
Design	4,04	Very Valid
Content	4,82	Very Valid
Linguistic	4,75	Very Valid

The resulting product had a very valid point aspects of the content or materials of the product developed is already relevant to the achievement of competency standards, aspects of the design are sufficient to facilitate the achievement of learning objectives, and the grammatical aspect is consistent.

Furthermore, the stage of one-to-one evaluation with testing of the product to students of Physics Education 2016 Indralaya class who had taken Modern Physics subject. The results of this test can be seen through the score questionnaire presented in tabular form in Table 2.

**Table 2** The results of one-to-one evaluation stage assessment

Indicator	Amount Scores of Subjects	Percentage (%)
1	12	80
2	12	80
3	12	80
4	12	80
5	24	80
6	21	70
7	21	70
8	37	82.2
9	24	80
10	23	76.67
11	146	81.11
<b>Average</b>	344	<b>79.08%</b>
<b>Category</b>		<b>Practical</b>

5 Based on the results, the prototype-1 produced has been practical. After going through the revision based on the results of consideration of the comments and suggestions of experts and the three of students produced prototype-2 that ready tested at the small group evaluation stage.

The small group evaluation stage is done by trying out the product to students who were divided into three small groups. This stage is carried out as a final evaluation stage of this study in an effort to produce a pototype-3 or the final product. The results of the assessment questionnaire responses from nine students presented in tabular form in Table 3.

**Table 3.** The results of small group evaluation stage assessment

Indi- cator	Subjects										Total Score	Percentage (%)
	AA	DN	EM	EW	HA	IH	KW	M	VN			
1	3	5	4	5	4	5	4	4	5	39	86,67	
2	4	5	4	5	4	4	5	4	5	40	88,89	
3	4	4	4	4	5	4	5	5	4	39	86,67	
4	5	5	5	4	4	4	5	4	4	40	88,89	
5	8	8	9	8	9	8	8	9	8	75	83,33	
6	6	9	8	10	9	10	8	8	8	76	84,44	
7	8	9	8	9	9	8	9	9	9	78	86,67	
8	10	14	11	11	13	11	13	12	14	109	80,74	
9	6	9	8	10	8	8	10	8	9	76	84,44	
10	7	9	8	10	9	8	10	8	9	78	86,67	
11	53	56	48	48	53	46	52	46	52	454	84,07	
	<b>Average</b>										1104	<b>84.59%</b>
	<b>Category</b>											<b>Practical</b>

Based on the results obtained in Table 3 is know that the prototype-2 produced was practical. Practical in the sense of language means “easy to use in practice”. This practical aspect can be assessed from the attractiveness, legibility, and advantages of the literacy base. Positive comments are given by students such as good, interesting, interactive, easy to use. Related to student retention of certain materials also increased. So, the prototype-3 (final product) has produced without many revisions.

Digital handout on particle wave dualism material has the advantage of presenting innovative print instructional materials are packaged in a digital form that can display videos, 3D images, hyperlinks, and other supporting things that cannot be displayed in the handout printed and is more efficient because it can be taken anywhere and can be stored in external memory, drives, or clouds so that it can be opened anytime and anywhere [8], [19]. As well as, the weakness that has not been observed because the effectiveness of the product has not been tested extensively (field test) and can only be opened via a desktop/PC because the file is an exe format that cannot be opened via the android/IOS. To be opened via the android/IOS then be shaped 3D file format that can be opened with a 3D application reader [9], [20], [21].

#### 4. Conclusion

A valid and practical digital handout on particle wave dualism material was produced in this study. The result showed the mean score for the validity of the digital handout was 4.53 for the design, content, and linguistic aspects with a highly valid category. The practicality average score in the one-to-one evaluation stage was 79.08% (practical) and in the small group evaluation stage was 84.59% (practical). Similar study still needs to be done to find out the effectiveness of product through the field test stage and the use of other applications that are easier to open on android/IOS.

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