TPACK in Blended Learning Media: Practice 4C Skills for Rotational Dynamics in Senior High School

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Abstract. In the 21st century, the fields of ICT and education are like two sides of a coin that cannot be separated. The skills of students must support the rapid development of science and technology. Workers in the 21st century have at least 4C competencies, namely: critical thinking, communication, collaboration, and creativity. The emergence of the Covid-19 in 2020 demands a blended learning model as an ideal learning process. This article describes research on website development as a blended learning medium for rotational dynamics in high school. The research method used is Research and Development with a Dick & Carey approach. Media has been produced in a website that combines technological knowledge, pedagogical knowledge, and physics content knowledge (TPACK) in multiple representations with stages to train students’ 4C skills. The stages of 4C skills on the website as a blended learning medium that developed were: (1) criticizing initial information; (2) developing and compiling arguments, reasons, assumptions, and evidence; (3) communicating arguments, reasons, assumptions, and evidence; (4) criticizing the quality of arguments, reasons, assumptions, and evidence; (5) open-minded; (6) seek new information; (7) conclude. Media also facilitates communication between users to build networks and improve collaboration capabilities. The results of this study have been tested for eligibility by material physicists, learning experts, and media experts. The eligibility test results of the website as a blended learning medium for rotational dynamical material in high school were declared eligible to practice 4C skills.

1. Introduction
The 21st-century learning process stimulates 4C skills: critical thinking, communication, collaboration, and creativity in problem-solving [1] [2]. Where the learning process, which still contains many misconceptions, interferes with the formation of 4C skills [3] [4] [5]. Learning physics that is not contextual will lead to misconceptions in students [6] [7] [8]. The use of technology in learning can minimize misconceptions in students [9] [10] [11] [12].

Blended learning is technology-based learning method [13] [14]. The blended learning model combines face-to-face learning with independent learning based on e-learning [15] [16] [17]. Blended learning materials utilize audio, visual, video, and animation to support online learning process activities [18]. Blended learning can be done in computer-based learning, web-based learning, virtual classrooms, and digital collaboration [19].

Learning during the Covid-19 pandemic separates students and teachers in different spaces [20] [21]. The blended learning model requires learning media to learn independently under teacher direction and supervision [22]. Physics blended learning media must be designed by utilizing technology for the delivery of physical concepts in contextual learning stages and multiple representations [23] [24] [25].
Exposure to contextual material will shape scientific literacy in students [26]. Website-based blended learning can display more scientific representations that support contextual learning [27].

The implementation of TPACK in physics blended learning media will make it easier for students to understand physics concepts independently [28]. TPACK in blended learning will integrate technology and pedagogical concepts at the stage of exposure to physics concepts in blended learning website media [29]. The basic steps in the Blended Learning model refer to TPACK-based learning, one of which is the Acquisition of Information model used in forming 4C skills [30].

Based on the description above, this article presents research on the development of a blended learning media website based on TPACK to train 4C skills in class XI SMA students with the rotational dynamic material.

2. Method

2.1. Research and Design

This article describes a website-based blended learning media resulting from research and development using the Dick and Carey approach. It can use this blended learning website media to practice 4C skills of class XI high school students on rotational dynamic material. An R&D process has been carried out according to Dick and Carey, which has staged:

1. Identify the objectives of learning physics in high school, referring to the Kementerian Pendidikan Dan Kebudayaan No. 21 of 2016 concerning the standard of content for primary and secondary education.

2. Conduct an analysis of learning physics in high school, which refers to content standards to produce basic competency indicators.

3. Analyze the learner and the context. Prepare material maps by the indicator formulation and determine prerequisite materials and materials relevant to basic competencies that will form according to learning objectives.

4. Formulate specific learning objectives. Formulate specific learning objectives according to learning indicators relevant to basic competencies and physics learning objectives in high school. Students’ specific learning objectives are learning objectives achieved by students using blended learning website media.

5. Develop assessment instruments for physics learning in a blended learning website media. Develop test items for measuring indicators of achievement of basic competencies in physics teaching in high school.

6. Develop instructional strategy, physics learning in blended learning website media. The physics learning strategy in the blended learning website media is designed to train 4C skills. The learning component of the blended learning website media consists of an introduction, material description, illustrations, sample questions, conclusions, and self-evaluation.

7. Develop and select instructional materials. The introductory part consists of perception which displays animations, linking students’ prior knowledge with the material to be studied. Discussion activities to train students’ critical thinking, creative and communication skills about the perception displayed. In the material description section, the essential materials of rotational dynamics are presented contextually and with multiple representations. Illustrations and sample questions support the description of the material. In the end, there is a conclusion of essential concepts and self-evaluation.

8. Design and conduct a formative evaluation of instructions. Conduct a formative assessment to determine the appropriate blended learning website media used in physics learning to train students’ 4C skills. Evaluation of material feasibility, media feasibility, and pedagogical feasibility was measured using instruments on a continuous scale of 1 – 4. A formative assessment was carried out by material physicists, blended learning media experts, and physics learning experts.

9. Revise blended learning physics website media. The physics blended learning website media that is not feasible according to the informative expert evaluation is revised, and re-formative assessment is carried out by the expert declares it possible.
2.2. Instrumentation research

Research and development of blended learning website media test for eligibility by using an instrument in the form of a questionnaire. There are three questionnaires developed, namely a questionnaire to test the eligibility of the material, a questionnaire to test the eligibility of the media, and a questionnaire to test the feasibility of pedagogy.

2.2.1. The Physics Concepts Eligibility on the Blended Learning Website Media

The physics concepts eligibility on the blended learning website media is assessed in three parts, which has staged:

2.2.1.1 Part of presentation of physics concepts on the blended learning website media, with assessment indicators, including: (a) The sequence of physics, material presented; (b) Accuracy of scientific representation in formulating physics concepts; (c) Video illustrations on blended learning media websites are relevant to the physics concepts discussed; (d) Animated examples on blended learning media websites are relevant to the physics concepts discussed; (e) The illustrations on the blended learning website media are relevant to the physics concepts discussed; (f) The graphic picture on the blended learning website media is relevant to the physics concept being discussed; (g) The table illustrations on the blended learning website media are accurate and relevant to the physics concepts discussed; (h) The mathematical equations presented are relevant to the physics concepts discussed; (i) Ease of understanding the presentation of physics material exposure; (j) The integrity of the meaning of the physics material is shown; Dan (k) Exposure to physics material is free from SARA, gender bias, pornography, and bullying.

2.2.1.2 Part of science representation on blended learning website media, with assessment indicators, including: (a) Effective Indonesian sentences support verbal representation; (b) The symbolic representation of mathematical equations is presented in a precise, easy, and sequential manner; (c) The animate representation of science supports the understanding of the physics concepts presented; (d) The visual representation of the images and graphs shown is relevant to the physics concepts presented; (e) The use of language in the preparation of physics, material is precise, straightforward, and clear; (f) Non-verbal illustrations by the concepts of the physics material shown; (g) The order of presentation of communicative and easy-to-understand physics concepts; (h) The order in which facts, data, and illustrations are presented contextually; Dan (i) The suitability of the preparation of physics material with language rules.

2.2.1.3 Part of blended learning website media, with assessment indicators, including: (a) Illustrations from videos on blended learning media websites relevant to the physics concepts presented; (b) Illustrations of animations on blended learning media websites relevant to the physics concepts presented; (c) Placement of blended learning website media supports the process of understanding the physics concepts being studied; and (d) The blended learning website media that is presented is appropriate and not excessive.

2.2.2. The Eligibility of the Blended Learning Website Media

The eligibility of the blended learning website media is assessed in two parts, which has staged:

2.2.2.1. Part of the performance of blended learning website media, with assessment indicators including: (a) Domain name; (b) Login to website system; (c) Speed of page access; (d) The process of downloading materials; (e) Task file upload process; (f) Video upload process; (g) Functioning of discussion forums; (h) The functioning of the message forum among users; and (i) Self-evaluation.

2.2.2.2. Part of the media design of the blended learning website, with assessment indicators including: (a) Quality of media banners; (b) The quality of the background display; (c) Quality of graphic display; (d) Header font size; (e) Material font size; (f) Header font color; (g) Material font color; (h) Font type alignment; (i) Functionality of the navigation buttons; (j) Image quality; and (k) Video quality.

2.2.3. The Pedagogic Eligibility on the Blended Learning Website Media

The pedagogic eligibility on the blended learning website media is assessed in five parts, which has staged:

2.2.3.1. Part of presentation of physics concepts on blended learning website media, with assessment indicators, including: (a) The suitability of the material with the basic competencies of physics subjects in high school; (b) Coherence of presentation of physics, material; (c) The simplicity of presentation of
physics, material; (d) Contextual presentation of the material; (e) Ease of understanding physics, material; (f) Continuity in the presentation of physics, material; (g) Relevance of sample questions to indicators of achievement of basic competencies; (h) Relevance of sample questions to the material; and (i) the Sufficient number of questions for each indicator.

2.2.3.2. Part of use of science illustrations on blended learning website media, with assessment indicators, including: (a) Scientific illustrations are presented in multiple representations (verbal, symbolic, digital, and visual); (b) Illustrations on perception foster curiosity; (c) Illustration of apperception stimulates critical thinking ability; (d) A series of illustrations of physics concepts on blended learning media websites support the formation of scientific literacy skills; (e) Examples of problem-solving stimulate creativity; and (f) All illustrations are presented contextually.

2.2.3.3. Part of the components of blended learning website media, with assessment indicators, including: (a) The description of the material is presented contextually and multiple representations as independent study material; (b) Discussion forums as an indirect (asynchronous) component of learning media; (c) Virtual synchronous teachers in discussion forums; (d) discussion groups on live chat as a virtual synchronous learning medium; and (e) Virtual synchronous teachers in discussion groups on live chat.

2.2.3.4. Part of the 4C skills on blended learning website media, with assessment indicators, including: (a) perception as a stage of critiquing initial information to train critical thinking skills; (b) Discussion forum as a stage of developing and compiling arguments, reasons, assumptions, and evidence on a problem to exercise creativity; (c) Discussion forum as a stage for communicating arguments, reasons, assumptions, and evidence to practice communication skills; (d) Comment column in the discussion forum as a stage to criticize the quality of arguments, reasons, assumptions, and evidence to practice critical thinking skills; (e) Activities in discussion forums as an open-minded stage to train critical thinking skills and creativity; (f) There are stages of learning in finding new information to train creativity; (g) There are stages of learning in making conclusions to practice the ability to conclude; (h) Group creation facilities on discussion forums and live chats to practice networking skills in small groups; and (i) Formation of small groups in problem solving in discussion forums to practice collaboration skills.

2.2.3.5. Part of TPACK implementation on blended learning website media, with assessment indicators, including: (a) The material presentation fulfills the physics content knowledge aspect; (b) The material presentation fulfills the pedagogical knowledge aspect of physics; (c) The presentation of the material is supported by aspects of technological knowledge (technological knowledge); (d) The material presentation meets the technological knowledge aspect of the physics content being discussed; (e) The presentation of the material fulfills the aspect of material exposure that is by the students’ thinking processes (pedagogical content knowledge); (f) Material presentation using technological knowledge in the presentation (technological pedagogical knowledge) of the physics concepts discussed; and (g) The presentation of the material as a whole fulfills the relationship between knowledge of technology, pedagogy, and physics content (TPACK).

2.3. Analyze Data

The data processing of the eligibility test results in the form of a questionnaire by material experts, media experts, and pedagogical experts uses a continuous scale of 1 - 4 to get the results of the eligibility of blended learning website media which there are four categories of assessment based on interpretation criteria, which:

| No | Criteria | Score |
|----|----------|-------|
| 1. | Very bad | 1     |
| 2. | Bad      | 2     |
| 3. | Good     | 3     |
| 4. | Very good| 4     |

The interpretation of the score is calculated based on the acquisition score of each item, with the following equation.
Score Interpretation = $\frac{\sum \text{Acquisition Score}}{\sum \text{Maximum Score}}$

This study uses a continuum scale range of 1 to 4 so that the maximum score is 4, the minimum score is 1, and the total capacity of scores is 4. So, it can be calculated:

$$\text{Score Range} = \frac{\text{Maximum Score} - \text{Minimum Score}}{\text{Number of Score Categories}}$$

$$SR = \frac{4 - 1}{4} = 0.75$$

Then the eligibility criteria were obtained with a difference of 0.75 with a very low interpretation starting from 1.00 – 4.00, as shown in the following table.

| Amount of Value | Percentage of Score Interpretation | Eligibility Category |
|----------------|-----------------------------------|----------------------|
| 1.00 ≤ Is < 1.75 | 25% ≤ IS < 43.75% | Not feasible |
| 1.75 ≤ Is < 2.50 | 43.75% ≤ IS < 62.50% | Quite decent |
| 2.50 ≤ Is < 3.25 | 62.50% ≤ IS < 81.25% | Worth it |
| 3.25 ≤ Is ≤ 4.00 | 81.25% ≤ IS ≤ 100% | So worth it |

3. Result and Discussions

3.1. Product

The research and development carried out have resulted in learning media in the form of blended learning website media based on TPACK with the advantages of training 4C skills. The stages of the 4C skills contained in the media are as follows.

1. The perception section is the stage of critiquing the initial information to link the knowledge to be learned by the knowledge and experience possessed by students (Figure 1).

2. Showing the discussion forum feature as a stage for developing and compiling students' arguments against a problem. The discussion forum also acts as a stage for communicating the student's arguments against the perceptions that have been displayed. Finally, there is a comment column on the discussion forum to criticize ideas between students to practice critical thinking skills.

![Figure 1. Apperception Section](image1.png)

![Figure 2. Softskill training activities](image2.png)
3. The description of the material consisting of essential materials, the remembering section as an answer to the problem in perception, the CATING section, and sample questions.

![Figure 3](image-url)

**Figure 3.** Stages of material presentation (a) essential concepts; (b) review phenomena; (c) postscript; and (d) sample questions.

4. The existence of group facilities in live chat to train the ability to create networks in small groups and group collaboration features between students.

5. The final section consists of conclusions and self-evaluation.

![Figure 4](image-url)

**Figure 4.** Collaboration skill (a) live chat; and (b) collaboration group

![Figure 5](image-url)

**Figure 5.** The final section (a) resume of material; and (b) self-evaluation

3.2. Description of Eligibility Test Results

The eligibility test results for the concept of physics of the blended learning website media by a physicist material expert received a very decent assessment in the three aspects assessed. The evaluation results are shown in Figure 6.

![The Physics Concepts Eligibility on the Blended Learning Website Media](image-url)

**Figure 6.** The Chart of Material Eligibility Test Results

The results of the blended learning website media eligibility test by media experts received a very decent assessment in the two aspects assessed. The evaluation results are shown in Figure 7.
The eligibility test results for learning physics about the blended learning website media by pedagogical experts get a very decent assessment in the five aspects assessed. The evaluation results are shown in Figure 8.

3.3. Discussions
The resulting TPACK-based physics blended learning website media is considered feasible in material, media and learning. Descriptions of essential material are presented contextually, and multiple representations are supported by tables, mathematical equations, sample questions, and self-evaluations [25]. Blended learning website media utilizes audio, visual, video, and animation to support synchronous and asynchronous online learning process activities [18]. Pedagogically, learning physics on the TPACK-based blended learning website media are declared feasible to train 4C skills [30]. The media displays perception in the form of scientific illustrations that can stimulate students' critical thinking skills. In the perception section, students are encouraged to develop and communicate arguments related to the problems presented. There is a discussion forum as a supporting facility so that students can practice 4C skills. Discussion forum activities remain under the direction and supervision of the teacher. This media can also train students' communication and collaboration skills displayed on discussion forums, live chat, and "HOPES" group [19].

4. Conclusions
TPACK-based physics blended learning website media has been produced on rotational dynamics. The stages of TPACK-based learning about the media are considered capable of training students' 4C skills. Based on the results of formative evaluations by material experts, media experts, and pedagogical experts, it can be concluded that the TPACK-based blended learning website media on the rotational dynamics produced is considered suitable to be used as a learning medium to train the 4C skills of high school students.
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