Developing physics test instrument in the context of ocean literacy

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Abstract. Ocean literacy is an understanding that should be integrated into physics learning for the coastal area. Ocean issues will help students understanding physics concepts. Indonesian government through Kemendikbud and Kemenko Maritim have been developing ocean-relate learning. To support government effort improving ocean literate-education system, it needs a sustainable process. Author choose to develop physics test instrument as one step which addresses the ocean literacy to the Indonesian curriculum. This article presents task analysis of kinematics and dynamics concepts to the 7 essential principles and 24 fundamental concepts of ocean literacy. The results will be described with the matrices relating those. It will be a framework aligning 2013 curriculum to the principles of ocean literacy. Some developed item tests with ocean issues will be described in the end of section.

1. Introduction
Physics learning in the context of ocean literacy is relatively new. Even though West Sulawesi (Sulbar) geographically is one of maritime province in Indonesia. It was found that teacher and students still have poor understanding of ocean sciences [1]. Most of public services are located near the sea. Yet, this maritime potential of Sulbar have not been explored by teacher while they are discussing physics content in their class. Arief Rachman on LIPI said that ocean literacy has a strong relation especially with physics [2]. Therefore, student should study linear motion by means of ocean issues like tides, wind, and surface current.

LIPI argues that ocean-oriented learning should be focused for school in coastal area [2]. This idea is contradicted with the circumstances that maritime education hasn’t been applied to the learning process in there nowadays [3]. On the other hand, physics teacher in Sulbar have satisfied the requirements to execute this idea obviously. They should have integrated ocean literacy in their class.

The future goal of nowadays government is establishing Indonesia as Global Maritime Axis [4]. Responsible institutions must take cooperative strategy to realize this dream. Initially, it may start with enhancing the education quality by policy makers like ministry, university, and schools. They must promote ocean literacy to all of educational faculty members. This vision will be achieved if each of them support each other improving the effective ocean-literate education.

Creating physics learning in the context of ocean literacy is the teacher duty. They should infuse this context into physics problems. It doesn’t mean that teacher must make a curriculum document separately. They just engage the essential concept of ocean literacy in their physics instruction. Ocean issues can be a scaffolding for student to understand physics concepts [2].
Since 2004, Center of Ocean Sciences Education Excellence (COSSEE) with another education communities have carried out workshop to identify essential principles of ocean literacy. The event produces a framework as teachers guide applying ocean literacy to be implemented in every school. They are motivated to do this grassroots effort to create ocean-literate society. They have been presented their discussion to align physics concepts to the seven essential principles of ocean literacy [5] The essential principles have also been fit to the Next Generation Science Standards (NGSS). It is the existing science standard that guide science teacher to achieve their learning expectation [6].

Furthermore, ocean-literate learning has also been taught in other countries, such as Chile, Japan, Portugal, and Spain [5]. Since 2017, Indonesia has also been establishing policy to implement the ocean-literate curriculum. The Ministry of Education and Culture of Republic of Indonesia (Kemendikbud) and The Coordinating Ministry of Maritime Affairs (Kemenko Maritim) has been administering this project. It is not an effort to make ocean literacy as a single subject taught by a single teacher like religious education or citizenship education. Yet, they want the science concepts can be taught through the ocean issues [2]. In 2018, a year trial has been held in 48 schools spread across 12 provinces in Indonesia. They began to implement in early childhood until high school education. The forty-eight schools are distributed including 12 early childhood schools, 12 elementary schools, 12 secondary schools, and 12 high schools. Learning material is developed and evaluated simultaneously. According to the Monitoring Team of Kemenko Maritim, this implementation has not had a good quality equally [7] It needs further assessment to benchmark the implementation quality of ocean learning.

Aligning physics learning in the context of ocean literacy must be matched with the 2013 curriculum. We know that it doesn’t take a short time to gain the best quality implementation. Strang [8] affirm that this implementation must align science concepts with curriculum, analyze science concepts to the ocean literacy, redesign teachers guide to make ocean-literate learning, construct standardized assessment in each grade, and develop curricular material. Until now, there is no standard document that can be used as a guide to implement ocean literacy in Indonesia. It causes there is no valid and reliable instrument to measure ocean understanding for Indonesian citizen. This research is considered to develop physics test instrument in the context of ocean literacy. The whole of article will illustrate our initial stage doing some matrix aligning the essential principles to the 2013 curriculum. This matrix will guide us to construct physics item test for further research steps.

### 2. Physics Instruction in the Context of Ocean Literacy

According to COSEE [5], ocean literacy is a knowledge about ocean influence towards mankind and how they influence ocean. This definition will be described into 7 essential principles in the table below. It was developed through community-wide consensus involving 100 members of those communities in USA. This most important ideas were derived and explained by 45 fundamental concepts of ocean literacy. They are described in Table 1 below.

| Essential Principle (P)                               | Fundamental Concepts (K)                   |
|-------------------------------------------------------|--------------------------------------------|
| 1. The earth has one big ocean with many features     | A. Physical feature of earth               |
|                                                       | B. Lithosphere                            |
|                                                       | C. Ocean circulation system                |
|                                                       | D. Sea level                               |
|                                                       | E. Physical feature of seawater            |
|                                                       | F. Water cycle                             |
|                                                       | G. Ocean as the estuary                    |
|                                                       | H. Limitation of ocean resources           |
| 2. The ocean and life in the ocean shape the features of earth | A. Earth material                          |
|                                                       | B. Tectonic plate                          |
|                                                       | C. Erosion                                 |
|                                                       | D. Carbon cycle                            |
3. The ocean is a major influence on weather and climate
   A. Weather and climate
   B. Solar radiation
   C. Ocean thermodynamics
   D. Hurricanes and cyclones
   E. Ocean absorption to carbon cycles
   F. Climate change
   G. Climate change impact

4. The ocean made earth habitable
   A. Oxygen cycle
   B. The earliest evidence of life
   C. Ocean for life

5. The ocean supports a great diversity of life and ecosystems
   A. Ocean life range
   B. Microbes
   C. Exclusive major groups
   D. Cycles, adaptations, and relationships among organisms
   E. Ocean living space
   F. Environmental factors
   G. Ocean energy
   H. Zonation patterns
   I. Estuaries

6. The ocean and humans are inextricably interconnected
   A. Human life
   B. Food, medicines, mineral, and energy
   C. Source of inspiration, recreation, rejuvenation, and discovery
   D. Pollution
   E. Extinction
   F. Natural hazards
   G. Ocean sustainability

7. The ocean is largely unexplored
   A. Discovery, innovation, and investigation opportunity
   B. Human curiosity of sea
   C. Ocean resources
   D. Technology in ocean life
   E. Mathematical models
   F. Interdisciplinary research

2.1. Alignment National Science Education Standards (NSES) to The Ocean Literacy
Concepts in the physical science must be in line with the essential principles. Bridging students with ocean problems in class is the first step to understanding physics with problem solving approach. However, each concept has a particular definition and example in the observed physical phenomena. It can’t be inferred that all of ocean literacy principles has been appropriate to it. One physical concept has been taught with some essential problems, it doesn’t mean that the concept can be aligned with another principles. Teacher must select the appropriate ocean problems which will be engaged into physics problems. Consensus results of some maritime institutions in United States have compared all of the physics concept with the possible principles of ocean literacy. The results shown in Table 2 below. It will describe how the physical concepts can be worked with the essential principles according to science education standards applied in there.

Table 2. Distribution of Physical Science Concepts in The Essential Principles [8]

| Physical Science | Essential Principle Ocean Literacy |
|------------------|------------------------------------|
|                  |                                    |
2.2. Alignment 2013 Curriculum to The Ocean Literacy

Content, teaching, dan assessment in ocean-literate physics learning should be aligned with the national curriculum [5,9]. According to Table 2, Motion and Forces concepts can be taught through essential principles code 1C, 1E, and 2E. This next analysis will make a match between basic competence in 2013 curriculum and those. Each of basic competence will derive indicators that should be achieved among the student after joining the class.

The description of the selected principles (P1.C, P1.E, P2.E) is shown below.

**P1.C** Throughout the ocean there is one interconnected circulation system powered by *wind, tides, the force of Earth’s rotation* (Coriolis effect), the Sun and water density differences. The *shape of ocean basins and adjacent land masses influence the path of circulation*. This “global ocean conveyor belt” *moves water* throughout all of the ocean basins, transporting energy (heat), matter, and organisms around the ocean. *Changes in ocean circulation* have a large impact on the climate and cause changes in ecosystems.

**P1.E** Most of Earth’s water (97%) is in the ocean. Seawater has unique properties. It is salty, its freezing point is slightly lower than fresh water, its density is slightly higher, its *electrical conductivity* is much higher, and it is slightly basic. Balance of *pH* is vital for the health of marine ecosystems, and important in controlling the rate at which the ocean will absorb and buffer changes in atmospheric carbon dioxide.

**P2.E** Tectonic activity, *sea level changes*, and the *force of waves* influence the physical structure and landforms of the coast.

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### Table 3. Alignment Basic Competence (KD) with The Principle P1.C, P1.E, P2.E

| Basic Competence (KD) | Indicator | Essential Principles |
|-----------------------|-----------|----------------------|
| 3.4 Analyzing physical quantities in linear motion with constant velocity and constant acceleration as well as its application in daily life | 1. Understanding the concept of linear motion. | P1.C |
| | 2. Understanding the concept of linear motion with constant acceleration. | P1.E, P2.E |
| | 3. Describing the difference between distance and displacement as well as between speed and velocity. | |
| | 4. Using the equation of linear motion with constant velocity and with constant acceleration correctly. | |
| | 5. Analyzing physical quantities through linear motion example in daily life. | P1.C, P1.E, P2.E |
| 3.5 Analyzing projectile motion using vectors, understanding the physical quantities, | 1. Explaining velocity and position vector of two-dimensional motion | P1.C |
| | 2. Analyzing position, velocity, and acceleration vector of an object. | P1.C, P1.E, P2.E |
Basic Competence (KD) and applying those in daily life

| Indicator                                                                 | Essential Principles |
|---------------------------------------------------------------------------|----------------------|
| 3. Analyzing position and velocity vector of projectile motion at time \( t \) | \( \sqrt{\text{P1.C}} \) |
| 4. Analyzing maximum height and maximum distance of projectile motion.      | \( \sqrt{\text{P2.E}} \) |

3.6 Analyzing physical quantities of angular motion with constant velocity and its application in daily life

| Indicator                                                                 | Essential Principles |
|---------------------------------------------------------------------------|----------------------|
| 1. Explaining quantities on circular motion                               | \( \sqrt{\text{P1.C}} \) |
| 2. Explaining the equation of circular motion with constant velocity.    | \( \sqrt{\text{P1.E}} \) |
| 3. Applying the equations to solve problems related circular motion.     | \( \sqrt{\text{P2.E}} \) |
| 4. Explaining the system of wheels.                                      | \( \sqrt{\text{P2.E}} \) |

3.7 Analyzing force interaction and the relationship between force, mass, and linear motion, as well as the application into daily life

| Indicator                                                                 | Essential Principles |
|---------------------------------------------------------------------------|----------------------|
| 1. Explaining Newton’s First Law.                                          | \( \sqrt{\text{P1.C}} \) |
| 2. Explaining Newton’s Second Law about the relationship between force, mass, and acceleration. | \( \sqrt{\text{P1.E}} \) |
| 3. Explaining Newton’s Third Law about action and reaction.               | \( \sqrt{\text{P2.E}} \) |
| 4. Analyzing forces acting on an object.                                  | \( \sqrt{\text{P2.E}} \) |
| 5. Analyzing frictional force.                                            | \( \sqrt{\text{P2.E}} \) |
| 6. Analyzing dynamics problems through applying Newton’s Laws to determine certain quantity. | \( \sqrt{\text{P2.E}} \) |

3. Physics Test Instrument in the Context of Ocean Literacy

Table 3 becomes a framework for teachers to design the learning outcome and to construct test items. Test items in Table 4 must obey this guideline if it is developed to benchmark the ocean-relate physics learning. Several examples of them have been developed. It can be represented below in the Table 4. This research remains some items that must be developed in the further agenda. It is distributed into 30 kinematics (KD 3.4 and 3.5) dan 30 dynamics problems (KD 3.6 and 3.7).

**Table 4. The Example of Physics Item Test in the Context of Ocean Literacy**

| Indicator | Essential Principles | Problem |
|-----------|----------------------|---------|
| 3.4.1 P1.C |                      |         |

1. Wind will move surface waters when it blows over the sea. The surface current speed is typically about 3% of the wind speed. A fisherman will measure the wind speed blowing there. He found that his boat moves 18 meters in a minute. The measured wind speed is ...

A. 0.3 m/s  
B. 1 m/s  
C. 3 m/s  
D. 10 m/s  
E. 18 m/s

**Solution:**

Surface current speed  

\[ v_{\text{surface}} = \frac{s}{t} = \frac{18}{60} = 0,3 \, \text{m/s} \]

Wind speed  

\[ v_{\text{surface}} = 3\%v_{\text{wind}} \]
2. Wind is able to move the bouyant body in the sea. It will affect surface waters and cause some areas have different current speed in the sea. Keramba uses this phenomena to cultivate fishes. This method must be placed in proper conditions. The surface waters may not greater than 100 cm/s. A floating object is being observed. The displacement at time \( t \) is summarized below.

| time (s) | displacement (cm) |
|---------|------------------|
| 1       | 5                |
| 2       | 20               |
| 3       | 45               |

According to this data, the kind of motion and the possibility to put karamba in there is….

A. Linear motion with constant velocity, possible
B. Linear motion with constant velocity, impossible
C. Linear motion with constant acceleration, possible
D. Linear motion with constant acceleration, impossible
E. It can’t be determined the motion and the opportunity to cultivate fish

**Solution:**
The motion type can be determined by calculating the speed. We know, speed can be calculated with this equation:

\[
\nu = \frac{s}{t}
\]

and the result listed in the table below:

| time (s) | displacement (cm) | speed (cm/s) |
|---------|------------------|--------------|
| 1       | 5                | 5            |
| 2       | 20               | 10           |
| 3       | 45               | 15           |

We see that speed changes uniformly and the magnitude is less than 100 cm/s. Therefore, the surface waters move with constant velocity and it is likely to make keramba in this area.

**Answer: C**

4. Conclusion
Ocean literacy is an appropriate context for physics learning in the coastal area. Student is engaged to recognize ocean life during studying physics. This article has explained how 2013 curriculum in Indonesia aligned with essential principles of ocean literacy. Some ocean problems will be discussed in development process of item test. They will be constructed that satisfied with the analysis before. Furthermore, empirical study must be executed to check the validity and reliability of the test.
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