Utilising “Meriam Karbit” Indigenous Knowledge to Construct Alternative Physics Experiments Based Smartphone Camera

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Abstract. Many research proved that indigenous knowledge is closely related to the context of today's concept of science and the recent smartphone technology can be used to reveal it. The motivation of this research is to suggest alternative physics experiments that could be conducted by the teacher using relevant traditional technology and smartphone sensor. In order to find alternative experiments and to explore the physics concepts behind the use of paper projectile in real “Meriam Karbit” attractions, we used a modified Meriam Karbit into a miniature form and its projectile with two mass variations. Recorded videos of Meriam Karbit miniature explosion from smartphone camera were analysed using VidAnalysis applications. The study succeeded in revealed that the higher the mass ratio of the Meriam Karbit system to the mass of the projectile, the velocity ratio of the two systems was even higher, and vice versa. The mass difference between paper used with the mass of real Meriam Karbit made from very large wood is enormous, the paper gets a huge portion of the burst velocity of the explosion while the Meriam Karbit is apparently unmoved. This was a more rational explanation of the use of paper projectile and could be used to study the momentum conservation concepts.

1. Introduction
The problems of physics education in West Borneo that arise was standardised experimental physics apparatus that the number has not been met, and many teachers didn’t conduct alternative physics experiments. In many studies found that the real impact of learning physics without experiment activities was students become passive when learning physics [1]. On the other hand, many research at the global level has uncovered the benefits of smartphones and sensors integrated with it to overcome the limitations of conventional experimental apparatus and created an innovative and exciting atmosphere of physics learning [2-4]. However, the learning settings taken were not in accordance with Indonesian culture, this will lead to the phenomenon presented to be more imaginary and not touch the phenomenon that exists in the student’s life, whereas many local wisdom that can be utilised for the development of physics learning, as one example is traditional technology. Technology in an indigenous tribe containing the correct knowledge and logic when associated with the scientific context at present [5]. Specifically reviewing the potential of traditional technology in West Borneo was discovered a technology locally named as Meriam Karbit. Meriam Karbit famous because it could produce canon-like sound and explosion. At present many people at the school age
who held the celebration of incoming month Ramadhan using this Meriam Karbit didn’t know what is the physics concept behind the functional system of Meriam Karbit [6]. Correlated with the results of the gun analysis, Meriam Karbit technology showed the knowledge in processing sound concept, pressure due to gas expansion, and explosion [7]. Despite the loud burst of explosions, this Meriam Karbit end is only covered with newsprint. The paper mass used as the cover is much lighter when compared to the mass of iron balls on the guns and the proportions are not as proportional to the size of the wood. In addition to this, the indigenous community apparently has knowledge of setting this Merriam Karbit on the banks of the Kapuas river with good stabilization, especially when reviewing its dimensions. The use of thin paper as a projectile and the installation of Meriam Karbit in such a way on the banks of the river is closely related to the concept of momentum and the law of conservation of momentum [8-11]. The problem is how to package and explore this indigenous knowledge in a class scale through experimentation activities, easy to do and understood by learners.

2. Literature Review

The explosive phenomenon of a weapon is an interaction that conceptually opposite of the collision phenomenon [8]. In Indonesia, it was very difficult to find the reality of events where archers or hunters were on the ice and other slippery places when firing shots and also the space shuttle releases its cargo charge [9-11]. Most schools have no experimentation tools similar to tubes with a massless spring that can be compressed between the two balls [8]. This is not in line with evidence-based strategies whereas this topic is generally placed as an introduction to lead to the law of conservation of momentum, so this simple explosion becomes difficult to understand [12]. Reviewing the law of the momentum, it can be stated that the total momentum \( \vec{P} \) of an isolated system is constant. Interaction within the system does not change its total momentum. The law of conservation of momentum directly has the consequence that the interaction between an isolated system is a pair of actions-reactions [8]. It could be written as in equation (1), with \( \vec{P}_i \) is the total momentum before the interaction and \( \vec{P}_f \) the total momentum after the interaction.

\[
\vec{P}_f = \vec{P}_i
\]  

Since equation (1) is a vector equation, then when it described in its vector component for \( N \) the number of interacting particles, it can be expressed as in equation (2).

\[
(p_{fx})_1 + (p_{fx})_2 + (p_{fx})_3 + \cdots = (p_{ix})_1 + (p_{ix})_2 + (p_{ix})_3 + \cdots \\
(p_{fy})_1 + (p_{fy})_2 + (p_{fy})_3 + \cdots = (p_{iy})_1 + (p_{iy})_2 + (p_{iy})_3 + \cdots
\]  

If there are two objects A and B in a system. When these two objects interacting with each other can be regarded as an isolated form of a system, if the upward normal forces compensate for the force of gravity so that \( F_{netto} = 0 \), for example as in the case of two spheres placed on a tube with a massless spring compressed between the second ball. The total momentum of this system is conserved. The total system momentum before it is detonated is zero because the two objects are initially in an equilibrium state, as a consequence, the total momentum will also be zero [8]. After being detonated when reviewing the direction of \( x \), it can be expressed as in equation (3) and because the initial conditions of the velocities A and B are zero, the equation (4) can be obtained.

\[
m_A(v_{fx})_A + m_B(v_{fx})_B = m_A(v_{ix})_A + m_B(v_{ix})_B = 0
\]  

\[
m_A = \frac{m_A(v_{fx})_B}{m_B(v_{fx})_A}
\]

Equation (3) and equation (4) show that the total momentum of the system is zero, but the momentum of each object is not zero [8]. Object A must have the same momentum as the magnitude of the momentum of object B, but with a negative sign indicating that the object will move in the opposite direction. Phenomena in mechanics with real-world condition settings can be easily
displayed and analysed using computers, tablets, and smartphones [13-16]. Momentum and collisions conventionally used wireless cart experiments that the velocity can be visualised to a computer or PC. Cart equipped with this wireless device when used for very frequent experimentation intensity and rough handling were susceptible to damage and costs predicted to be much more expensive when compared to using video analysis especially using a device to mirror the smartphone screen to projectors [17]. Technology is now available, although there was a few research that uses it primarily to explore the concept of the explosion.

3. Material & Methodology
In the preliminary of this study, we reviewed various ethnographic documents that describe the traditional technologies in West Borneo. Information relating to physical form including the selection of materials and functional were matched with the structure of physics concepts based smartphone experimental activities. This study used projectors, Dongles and WiFi connections to clarify visualisation in class scale settings as shown in Figure 1. Explosive forces and smoke effects such as Meriam Karbit were obtained from gas expansion coming out of the butane fill cans which are often used for gas lighter fillers, associated with Meriam Karbit miniature used elastic capillary pipes.

The projectile used two variations, in the first variation used a projectile that was not given additional mass so that was lighter and on the second variation used projectile was given thin metal as additional mass so that was heavier. The focus of the study was on the effect of the mass ratio of the system on the use of the projectile before and after adding the mass to the velocity ratio of Meriam Karbit and cart system after the explosion. From equation (4) it could be counting that higher the mass ratio of the Meriam Karbit system to the mass of the projectile, the velocity ratio of the two systems is even higher, this is in line with the first variation when used projectile without additional mass [8,10]. Conversely, lower the mass ratio of the Meriam Karbit systems to the mass of the projectile, the velocity ratio of these two systems is even lower, and this is in line with the second variation. The obtained video frame first was in trim or cut, so positioning from frame to frame becomes easier using VidAnalysis App.[15]. If the time and position of the moving object were known, then it can be determined its velocity with the equation (5).

\[ \vec{v}_{\text{average}} = \frac{\Delta \vec{r}}{\Delta t} \]  

In equation (5) \( \vec{v}_{\text{average}} \) is the average velocity vector of an object during the time interval (\( \Delta t \)) in which the object undergoes a displacement (\( \Delta \vec{r} \)).

4. Results and Discussion
Figure 1 shows the experiments using the Meriam Karbit experimental system with the projectile without additional mass, Figure 2 and Figure 3 show the using of the VidAnalysis application on the Android smartphone that was generated the analytical output.

![Figure 1. The experimental set up with Meriam Karbit Miniature and cameras is configured with the Dongle or AnyCast to be displayed in front of the class and real-time manner.](image-url)
Figure 2. The output of VidAnalysis App. of the Meriam Karbit miniature motion without an additional mass on the projectile.

Both figures were produced from a recorded video at the same time, despite the focus of the frame to frame analysis was different. Figure 2 shows that the object to which the observation focuses was the Meriam Karbit on the dynamics cart and precision rails (on projectile without additional mass variations setting). While in Figure 3 shows the object that became the focus of observation is the Meriam Karbit projectile (on projectile without additional mass variations setting). The VidAnalysis application could analyse the position of the object according to the cartesian coordinates in the x and y directions, so to begin analysing after determining which video recording to analyse, would be asked to set the center of the motion coordinate axis and calibrate how many meters the actual distance from the two reference points calibration on video. The use of precision rails that have been equipped with a measuring scale facilitates the calibration process performed. The motion of the Meriam Karbit and the projectile were fixed in the x-axis direction. Figure 2 shows that the Meriam Karbit on cart motion toward the positive x-axis and its opposite with projectile motion toward the negative x-axis. This opposite direction of motion was clearly in line with the concepts presented earlier, which has consequences for the occurrence of action-reaction pairs. The graph of the projectile motion in Figure 3 was steeper than the Meriam Karbit motion graph in Figure 2, which indicates that the projectile moved faster than the Meriam Karbit on cart motion. The data points on the graph that were marked with the ellipse line correspond to the position and time values in the table marked with the square line on the right. The unmarked dot was a condition before the explosion, so close to constant indicated there was no movement. Non-zero value because the screen size of the smartphone is smaller than the tablet, we found the positions determined in the frame-by-frame on VidAnalysis become more difficult to precise. However, when the object velocity calculated using equation (5), this inaccuracy can be further eliminated. Figure 4 shows Meriam Karbit on the dynamics cart and the precision rail system with projectile weighted (used additional mass). Figure 5 shows that the focus of observation was Meriam Karbit projectile. The video trim process in Figure 4 and Figure 5 produces data that was very close to the event of the explosion, so the unimportant motion data of the object at rest before the explosion wouldn’t be raised too much.
The output of the VidAnalysis App. of the Meriam Karbit miniature motion with the projectile was weighted.

As in the previous variations, the graphs in Figure 4 and Figure 5 show that the Meriam Karbit on cart motion toward the positive x-axis and its projectile motion was aimed toward the negative x-axis. The projectile still moves faster than the Meriam Karbit motion. Table 1 presents the average velocity of each system that was calculated as the results in order to compare easily the difference in the results of the analysis between two variations of the projectile.

Table 1. The Meriam Karbit (MK) miniature and projectile velocity calculated from VidAnalysis.

| Projectile Variation | Object of VidAnalysis | \( x_i \) (m) | \( x_f \) (m) | \( \Delta \vec{r} \) (m) | \( t_i \) (s) | \( t_f \) (s) | \( \Delta t \) (s) | \( \vec{v}_{\text{average}} \) (ms\(^{-1}\)) |
|----------------------|----------------------|---------------|---------------|-----------------|-------------|-------------|----------------|-----------------|
| Light Projectile     | MK                   | 0.026         | 0.268         | 0.242           | 0.435       | 0.904       | 0.469          | 0.515            |
|                      | Projectile           | -0.095        | -0.430        | 0.335           | 0.368       | 0.435       | 0.067          | 5.000            |
| Heavy Projectile     | MK                   | 0.021         | 0.307         | 0.286           | 0.000       | 0.368       | 0.368          | 0.777            |
|                      | Projectile           | -0.060        | -0.331        | 0.271           | 0.000       | 0.067       | 0.067          | 4.044            |

The calculation results that the average velocity of each projectile variation and the system in Table 1 shows that in the second variation the Meriam Karbit system moved faster when firing the projectile with additional mass, but the projectile with additional mass became slower than the first variation. The experimental results using Meriam Karbit miniatures and the underlying basis revealed by Indigenous knowledge show clearly and in accordance with the concepts presented, that the higher the ratio or mass ratio of the Meriam Karbit system to the mass of the projectile system, the velocity ratio of the two systems even higher, and vice versa for mass ratio of Meriam Karbit system with the mass of the projectile system getting lower. This is a more rationale of the use of paper projectiles at the attractions of Meriam Karbit. The mass difference between newsprint used with the mass of Meriam Karbit is enormous. The paper gets a huge portion of the burst velocity of the explosion and can be ripped instantly, while the Meriam Karbit is apparently unmovable. Meriam Karbit mooring in such way with Gertak on river banks more related to equilibrium concepts especially related to stability and balance because the size of the Meriam Karbit used. This, of course, will be much different if the projectile used has a larger mass, so the explosion will result in a larger Meriam Karbit velocity in the opposite direction from the direction of the projectile motion and it is definitely necessary to structure the Meriam Karbit more forcefully. In the context of everyday life in West Borneo the experimental system used was predicted to be more contextual and reasoned by students than by using two ball systems that is detonated using a spring compression in a tube, or an athlete with an arrow and a hunter with a gun that stands up on the skis above slippery ice.
floors, and space shuttles that release cargo in the deep space. In the broader context, the method used in this study is in line with the research paradigm related to traditional technological analysis. Indigenous knowledge can be introduced in physics learning using an advanced organizer because the cognitive load related to learning content increased. The advance organizer can also be presented using a smartphone and to clarify the visualization in front of the classroom can be used also Dongle and Anycast, so it can go hand in hand with real-time experimentation.

5. Conclusion
This study has succeeded in getting alternative physics experiment related to the reason of the use of thin paper as a projectile on the Meriam Karbit attractions. In the class scale to be easy to do and understood by learners, we used the modified Meriam Karbit into the form of a miniature. The projectile used two mass variations. Although in miniature form, the explosion event still occurs very fast when viewed with the eyes. The effect of this variation on the motion of the projectile and the miniature system can be recorded using a smartphone camera and VidAnalysis application used to get the position data versus time so that the average velocity can be calculated easily. Meriam Karbit miniature system moved slower when firing the lighter projectile or without additional mass, but the projectile velocity became faster. This results have a good agreement with momentum conservation and the real Meriam Karbit attractions, the paper gets a huge portion of the burst velocity of the explosion while the Meriam Karbit is apparently unmoved. This study has the potential to create an enjoyable learning and showed the contribution to the efforts of indigenous knowledge preservation.

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