Integrated Science Exploration in the Traditional Toy "Bamboo Cannon" as a Supplement for Local Wisdom-Based Science Learning

1st Dinar Maftukh Fajar
UIN Kiai Haji Achmad Siddiq Jember
Science Education
Jember, Indonesia
dinarmaftukh@uinkhas.ac.id

2nd Mohammad Achbatullahulhaq Mangku Negara
UIN Kiai Haji Achmad Siddiq Jember
Science Education
Jember, Indonesia
achbatullah01@gmail.com

Abstract— Local wisdom-based science learning is essential as it encourages students to comprehend and appreciate scientific knowledge within the context of their culture and local values, thereby fostering a deeper and more relevant engagement in the science learning process. Bamboo cannon is one of the traditional toys rich in integrated science aspects, and the tradition of playing it remains popular in rural communities in Indonesia. This study aims to explore the bamboo cannon toy's characteristics and combine science aspects to supplement local wisdom-based science learning. The study is expected to enrich students' knowledge and preserve local culture collectively.

To achieve this goal, this qualitative research was conducted where the tradition of playing bamboo cannons is still alive, namely in the Krajan Hamlet, Kasiyan Village, Puger District, Jember, East Java, Indonesia. The findings were further examined through an exploratory framework and analyzed with integrated science aspects as a learning supplement. The research subjects consisted of three residents: Ahmad Taufiq Haqiqi, a junior high school student; Iqbal Habibi, a college student; and Budi Suharto, a Hamlet leader. Data collection techniques included observation, interviews, and literature review. Data analysis methods encompassed Data Condensation, Data Display, and Verification.

The research results indicate that: 1) Exploratory findings are observed in the selection of bamboo type and age, cutting bamboo with a saw, cleaning the bamboo nodes using a crowbar, making holes in the bamboo, mixing calcium carbide and water as explosive materials, and igniting the bamboo cannon, which can produce explosions. 2) The analysis of integrated science aspects in the traditional bamboo cannon toy includes: Plant Scientific Classification, Plant Morphology, Inclined Plane, Friction and Heat, Momentum-Impulse, Material Classification and Chemical Bonds, Hydrolysis Reaction, Exothermic Reaction, Combustion Reaction, Newton's Third Law, Parabolic Trajectory, Inelastic Collision, Sound Waves, Wave Interference, Organ Pipe, and Sound Intensity.

Keywords— Science, Local Wisdom, Bamboo Cannon

I. INTRODUCTION

Indonesia possesses a diverse range of ethnic groups and cultural riches. These cultural facets are the outcomes of the sustained thoughts and actions of its people [1]. Culture is also vital in defining the identity of a region. If culture is not preserved, it can fade away or be claimed by other nations. [2] Due to the influence of foreign cultures on the local population and the neglect of indigenous traditions. This cultural tapestry encompasses traditional clothing, traditional weapons, customary practices, cuisine, advice, local games, and more [3], representing the nation's identity and local wisdom. One way to instill local wisdom in the younger generation is by connecting their education to local culture in their respective regions[4].

Local wisdom consists of traditions passed down from generation to generation, each with distinctive characteristics. However, local insight is only sometimes separate from scientific knowledge. Scientific knowledge can also be derived from concrete experiences and conceptualized into principles and theories through research and scientific thinking. Some aspects of local wisdom, such as traditional medicine, religious rituals, and local games, are often regarded as mere traditions without recognizing their underlying scientific concepts. Some local wisdom is related to nature, while science studies natural objects. Therefore, science and local wisdom are intertwined. For example, some societal beliefs that can now be explained scientifically, such as the concept of sleep paralysis [5] or the application of physics in traditional game "engklek" [6].

Natural Science (Ilmu Pengetahuan Alam or IPA) is a discipline that studies facts and events in nature, as well as the cause-and-effect relationships within it. Branches of natural science include Biology, Physics, Chemistry, Astronomy/Astrophysics, and Geology [7]. Natural science has been taught since early childhood education (PAUD) and is a subject at the junior high school (SMP/MTs) level. Science lessons can be linked to everyday occurrences that were initially just customs or traditions. With scientific knowledge, rules that were once beliefs and practices can be explained scientifically [4].

Local wisdom and traditional games in Indonesia are being abandoned by the younger generation, primarily due to their dependence on gadgets and online gaming [8]. According to a survey by APJII, 75.50% of Indonesia's 143.26 million internet users are teenagers aged 13-18 years

D. Pristine Adi et al. (eds.), *Proceedings of the 2nd Annual Conference of Islamic Education 2023 (ACIE 2023)*, Advances in Social Science, Education and Humanities Research 809,
https://doi.org/10.2991/978-2-38476-182-1_18

old [9]. However, traditional games have positive values such as unity, responsibility, social skills, patriotism, and solidarity [10]. Utilizing traditional games as a learning tool can make the learning process more enjoyable and enhance students' memory [11]. It can also serve as an alternative method to improve students' understanding of science learning [12].

Jember is a region with a population comprising various ethnic groups, known as the Pendalungan region. Pendalungan combines Javanese and Madurese cultures, creating unique traditions in the area [13]. Immigrants from Java and Madura have merged in Jember, resulting in a diverse range of local wisdom. In the celebration of Indonesia's 74th Independence Day in 2019, the people of Jember, along with Bupati Jember Dr. Hj. Faida, conducted a bamboo cannon festival by igniting 1000 bamboo cannons [14]. Bamboo cannons are toys commonly used in major celebrations, especially during the holy month of Ramadan.

Bamboo cannons are a popular local tradition played by males of various ages. This game is believed to have been inspired by real cannons from the 16th century during the arrival of the Portuguese in Indonesia [15]. Playing it is similar to operating a real cannon, with a fire ignited at the base of the bamboo. Bamboo cannon toys are often found in rural areas and played during religious festivals, annual events, and customary ceremonies. Bamboo cannons produce loud explosions from the explosive materials used in them.

Bamboo cannon toys are crafted from natural bamboo materials and create explosive sounds using explosive materials. This game is linked to the science disciplines, including biology, chemistry, and physics. Bamboo cannons encompass elements of integrated scientific knowledge, as they produce explosions and thunderous sounds related to science curriculum materials taught in schools [16].

II. METHOD

A. Research Time and Location

This research was conducted on Saturday and Sunday, March 25-26, 2023, to accommodate the informants' free time. The research location was in Krajan Hamlet, Kasiyan Village, Puger District, Jember Regency. Kasiyan Village was chosen because it still preserves and maintains its local culture. A literature review was carried out from March 27 to May 29, 2023, to analyze integrated science concepts related to bamboo cannon toys.

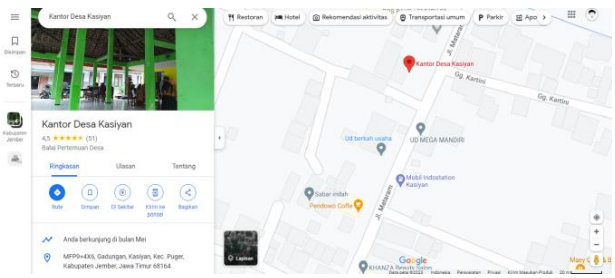

Figure 1. Location of Krajan Hamlet, Kasiyan Village, Puger District, Jember Regency
(Source: Google Maps)

B. Research Methodology

This research employed a qualitative research approach with an exploratory method to gain a better understanding of a specific phenomenon and provide an initial overview of the research topic, which can then be further investigated [17].

The purposive sampling method was employed in selecting research subjects because it was anticipated that all relevant informants in Krajan Hamlet, Kasiyan Village, had almost identical knowledge of bamboo cannons. This method was used to select a sample that represents the population while taking specific criteria into account.[18]

Informants were selected based on criteria such as educational background and age. The research subjects comprised three Krajan Hamlet and Kasiyan Village residents representing children, teenagers, and adults. The first informant is Ahmad Taufiq Haqiqi, a Sultan Agung Junior High School student, Kasiyan Village, Puger District, Jember Regency. The second informant is Iqbal Habibi, a student at the State Islamic University Kiai Haji Achmad Siddiq Jember. The third informant is Budi Suharto, the head of Krajan Hamlet, Kasiyan Village. These three informants represent the residents of Krajan Hamlet, Kasiyan Village..

The data analysis technique used in this research followed the data analysis process proposed by Miles, Huberman, and Saldana (2014) with the following components:

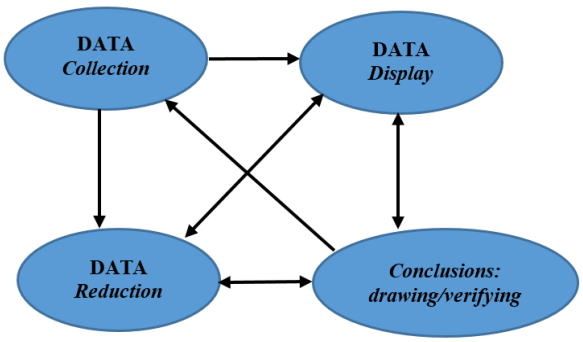

Figure 2. Components of Data Analysis
(Source: Miles, Huberman, and Saldana, 2014: 14)

In the initial stages of the research, the interview and observation methods were employed to collect data about the research subjects/objects. All data were meticulously recorded to avoid the loss of information from visual observations and auditory input. This method generated a diverse and abundant dataset, enhancing the diversity and completeness of information. The researcher understood the informants' responses by considering the interview context and grouped the understanding outcomes based on the same core questions. Relevant data were retained, while irrelevant data were disregarded. Data were presented in concise and narrative descriptions. The final stage involved the process of drawing conclusions and verification. Initial findings are tentative and subject to change if there is no strong evidence during subsequent data collection. However, if supported by valid and consistent evidence as the researcher collects additional data, these conclusions are considered credible[19].

The researcher utilized source triangulation and member-checking strategies to validate the data. Source triangulation involves verifying data from multiple different sources. Member checking was performed by reviewing the data analyzed by the researcher with the data providers. The aim was to evaluate the extent to which the obtained data corresponded to the information provided by the data providers. If the providers approved the data, it was deemed valid and trustworthy. Member checking aimed to ensure that the information used aligned with the intent of the data source or informant [20].

III. Results and Discussion

A. Overview of Research Object

Bamboo cannon is a traditional toy in Indonesia that goes by various names in different regions. Children play it during the holy month of Ramadan to break their fast and wake up those observing the pre-dawn meal (sahur). However, its existence has been eroded by technological advancements in the millennial era. This toy takes the form of a "cannon" made from bamboo, and how it is played is similar to a real cannon by igniting a fire at the base of the bamboo. Bamboo cannons are extremely popular among children and teenagers in Indonesia and use kerosene or carbide mixed with water as fuel.

Bamboo cannon toys encompass integrated science concepts, including biology, chemistry, and physics, making them more than just entertainment. In their construction, bamboo morphology involves physics concepts like friction and the biology concept of bamboo morphology. This toy teaches physics concepts related to motion and energy and chemistry regarding fuel reactions with air. Thus, bamboo cannons become an effective educational tool for children to develop creativity and skills in utilizing natural resources. This research object is located in Krajan Hamlet, Kasiyan Village, Puger District, Jember Regency.

Table 1. Components of Bamboo Cannon

Components of Bamboo Cannon	Documentation of the Object	Description
Bamboo Cannon Body		The size of the bamboo cannon created by the researcher is approximately 2 bamboo joints in length. The type of bamboo used is known as "bambu duri" or locally referred to by residents as "pring ori." Taking 2 bamboo joints to make 1 bamboo cannon is the minimal size, as using only 1 bamboo joint would pose a danger to the person playing it.
Inner Bamboo Joint Hole		The inner sections of the bamboo are perforated/cleaned until only one bottom section of the bamboo is left. The purpose of cleaning the inner chambers of the bamboo is to serve as a pathway for inserting chunks of carbide and for the exit of acetylene gas produced from the reaction of carbide with water. If the inner sections are not perforated, the bamboo could break and harm the person playing it.
Small Hole on the Bottom Joint		Holes are made on the body/stem of the bottom joint. These holes serve as a place for adding water and igniting the fire when playing with the bamboo cannon toy. Acetylene gas will emerge from the small holes and is ignited with fire as a trigger for the explosion.
Section for Containing Explosive Material		The bottommost section of the bamboo joint is where the explosive material for the bamboo cannon is placed. The explosive material and water will be contained in this section.
scaffolding		The bamboo cannon, with chunks of carbide inside, is placed on a support structure in a tilted position. Positioning the bamboo cannon at an angle ensures that the pieces of carbide and water are located precisely at the bottom corner. This is because water naturally flows to lower areas, facilitating the carbide's reaction with water.

Components of Bamboo Cannon	Documentation of the Object	Description
Wooden Fire Ignition Stick		This wooden stick serves as a fire ignition tool for the bamboo cannon. At the end of the post, a highly flammable material like rubber, tissue, or cloth is wrapped around it. This stick can be made from bamboo or tree branches and typically measures 1-2 meters long. Igniting the fire using a regular matchstick without maintaining a safe distance can be hazardous and even result in burns.

Table 2. Bamboo Cannon Manufacturing Process and How to Play

Stages	Documentation	Description
Bamboo Cutting		The first step in making a bamboo cannon is to cut the bamboo, using 2-5 joints to create one bamboo cannon toy. Bamboo is cut using a saw.
Cleaning the Bamboo Joint Section		The inner section of the bamboo joint is cleaned using a crowbar. Leave one joint at the very bottom of the bamboo to contain the explosive material. The bamboo joints that have been damaged are then discarded by turning the bamboo upside down.
Creating Holes in the Bottommost Joint Section		The bamboo joints are then perforated. Position the holes close to the bottom joint so they are not destroyed. The tool used to perforate the bamboo joints typically has a sharp or pointed end, such as a screwdriver or the tip of a knife.
Igniting the Fire on the Bamboo Cannon		The bamboo cannon is taken to a safe location for playing. In this experiment, we brought it to a spacious area safe from crowds. The bamboo cannon is filled with several small chunks of carbide. Then, the bamboo is leaned against a support structure with a tilted position and the perforated section at the bottom. A small amount of water is poured into the small hole. The cavity at the end of the bamboo is covered with the hand for about 10 seconds while waiting for the carbide and water to start reacting. When the bamboo begins to heat up and emit smoke, ignite the fire on the prepared long wooden stick. Direct the fire into the small hole or the fuel chamber.
Bamboo Cannon Explosion		The gas produced from the mixture of carbide chunks and water will explode when ignited by the fire. The hotter the bamboo becomes, the louder the resulting sound.

B. Results of Integrated Science Exploration

Based on the observations conducted on the object, integrated science aspects in the bamboo cannon toy can be found in Table 3. The table shows the integrated science aspects that occur in the bamboo cannon toy, from the manufacturing process to how it is played.

Table 3. Results of Integrated Science Exploration in the Bamboo Cannon Toy

Activities	Integrated Science Concepts
Selection of Bamboo Type	Scientific Classification of Plants, Plant Morphology
Bamboo Cutting	Inclined Plane, Friction, and Heat
Cleaning the Bamboo Joint Sections	Inclined Plane, Impulse Momentum
Hole Drilling	Inclined Plane, Impulse Momentum
Explosive Material	Material Classification and Chemical Bonding
Mixing the Explosive Material	Hydrolysis Reaction, Exothermic Reaction
Igniting the Bamboo Cannon	Combustion Reaction
Bamboo Cannon Explosion	Newton's Third Law, Parabolic Trajectory, Inelastic Collision, Sound Waves, Wave Interference, Organ Pipe, Sound Intensity

Biological Aspects in the Bamboo Cannon Toy

The types of bamboo commonly used to make bamboo cannon toys are as follows:

Table 4. Types of Bamboo Commonly Used to Make Bamboo Cannon Toys

Types of Bamboo (Scientific Names)	Thorny Bamboo (*Bambusa Blumeana*)	Black Bamboo (*Gigantochloa atroviolacea*)
Scientific Classification	Kingdom : Plantae Division : Magnoliophyta Class : Liliopsida Order : Poales Family : Poaceae Genus : Bambusa Species : Bambusa blumeana	Kingdom : Plantae Division : Magnoliophyta Class : Liliopsida Order : Poales Family : Poaceae Genus : Gigantochloa Species : Gigantochloa atroviolacea
Morphology	Thorny Bamboo (Bambusa Blumeana), also known as "spring ori" in the Javanese language, is a tall plant (10-20 meters) with cylindrical and rough stems covered in sharp thorns. The stems are solid and hollow with a layer of fibers that provide strength and flexibility. Its leaves are lance-shaped and densely arranged in a lush green cluster. The root system consists of primary roots that grow from the base of the stem and fibrous roots that absorb water and nutrients from the soil. Thorny bamboo produces small flowers in grain-like clusters that hang from its branches. This plant has various uses, such as construction materials, crafts, and the furniture industry[21].	Bamboo is clumping, dense, and erect, with dark green culms and orange tips. It can reach a height of 15 meters, with a culm diameter of about 6-8 cm and internodes measuring 40-50 cm in length. The culm walls are approximately 8 mm thick and undergo color changes from dark green to purplish-green or dark brown. The nodes have pale or whitish rings, close to the ground, and few aerial roots. Branching occurs around 2-3 m above the ground, often with many branches, including one more giant branch. The sheaths of the culms easily fall off, except for the lower ones. The sheath leaves are oval or triangular, with a length of about 4-9 cm, and are recurved. The ligule is irregularly toothed and about 2 mm tall. The leaves on the branches are lanceolate, with a length of back 20-28 × 2-5 cm, and the sheath of the leaf is covered with whitish hairs when young. This bamboo flowers in panicles on branches with leaves, with groups of up to 18 spikelets on each panicle. Each spikelet contains 4 perfect florets and one imperfect terminal floret. [22].

When selecting bamboo species to make bamboo cannons, it is important to consider the strength, size, and age of the bamboo. Although there are many bamboo species in Java, residents of Dusun Krajan, Kasiyan Village, mention only two types of bamboo that are considered strong and safe to be used as materials for bamboo cannons. Thus, the making of bamboo cannons involves aspects of plant biology in scientific classification and plant morphology.

The Physics Aspects of Bamboo Cannon Toys

The Physics Aspects That Occur When Bamboo Is Cut

1. Bevel on a Saw:

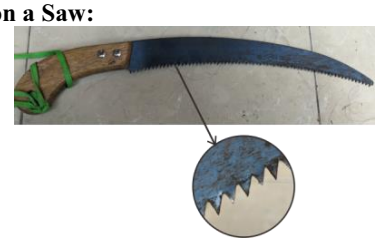

Figure 3: Saw Blade

On the teeth of the saw blade, it can be seen that the sides are pointed and angled. The concept of angle on the teeth of a saw blade is used to be able to damage and cut wood.

2. "Heat and Frictional Force"

Figure 2. Saw Friction on Wood

When wood is being sawed, the saw continuously rubs against the wood. The friction between the saw and the wood generates heat in both objects. This indicates the presence of heat produced by the frictional force between the saw and the wood.

The Physics Aspects That Occur When Drilling/Cleaning Bamboo Joints

1. Bevel on a Crowbar

Figure 3. Beveled Surface of the Crowbar

As depicted in the provided image, the crowbar's tip has been tapered using the principle of a beveled surface. This design enables the crowbar's tip to effectively cause harm or damage to an object when it is forcefully inserted.

2. Momentum and Impulse

Figure 4. Cleaning Bamboo Joints with a Crowbar

During cleaning bamboo joints, a crowbar possesses momentum contingent upon its mass and velocity. As the crowbar makes contact with the wood, its rate undergoes alteration due to shifts in both speed and direction. This alteration in rate can generate an impulse force that is applied to fracture the bamboo joints.

The Physics Aspects That Occur When a Bamboo Cannon Explodes During Play

1. Newton's Third Law

Newton's Third Law elucidates the principle of actions and reactions being equal and opposite in response to an event. In the case of a bamboo cannon detonation, when the explosion transpires, the smoke emanating from the hole in the bamboo joint is propelled outward, while, simultaneously, the bamboo cannon experiences a recoil force pushing it backward.

2. Inelastic Collision

An inelastic collision is a physics concept used to describe a situation where two objects collide directly, and there is no loss of kinetic energy due to deformation or braking during the collision. In the context of bamboo cannons, this concept explains how a bamboo cannon can generate a powerful explosive force without experiencing significant damage or deformation after firing a projectile.

A bamboo cannon is a traditional toy made from bamboo pieces that launch projectiles. The basic principle of a bamboo cannon involves converting chemical energy into kinetic energy that propels the rocket out of the cannon barrel. When the bamboo cannon is ignited, the explosive material inside it detonates, producing high-pressure gas.

During the collision, the projectile inside the cannon barrel directly collides with the high-pressure gas generated by the explosive material. Because bamboo cannons are made of flexible materials, they can flex slightly during the collision, reducing the impact of the pressure generated by the crash. Additionally, releasing high-pressure gas after the collision imparts an impulse to the projectile, propelling it out of the barrel at high speed. Before the cannon is fired (the 'event'), its total momentum is zero [23].

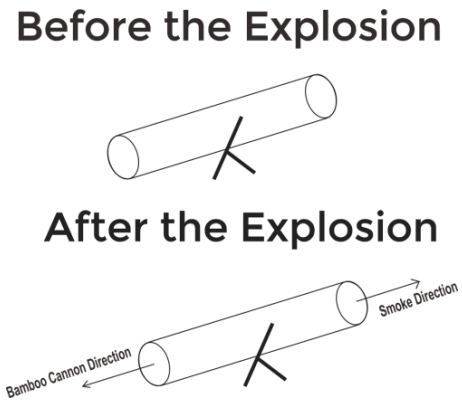

Figure 5. The Concept of Momentum in Bamboo Cannons

3. Parabolic Trajectory

During a bamboo cannon explosion, powerful energy and high-pressure gas are released. When the gas is released at high speed, it forms a parabolic trajectory due to the projectile's motion (the bamboo leaf fibers used as cannonballs). The concept of a curved trajectory in a bamboo cannon explosion can be explained using the basic principles of projectile motion.

Projectile motion materializes when an object is thrust into the air at initial horizontal and vertical speeds. In a bamboo cannon detonation context, the gas released assumes a specific direction and velocity, thereby imparting impetus to the projectile. Subsequently, the rocket propelled from the bamboo cannon explosion adheres to a curved path defined by a parabolic trajectory. This trajectory results from the concurrent effects of gravitational acceleration acting in the vertical direction and a consistent initial horizontal velocity. Consequently, the projectile traces a curved course resembling the shape of a parabola.

The course of this parabolic trajectory is subject to influence from several determinants, including the angle at which the bamboo cannon is oriented, the projectile's initial velocity, and the explosion's force. The launch angle significantly impacts the configuration and distance the parabolic path covers. At the same time, the projectile's initial velocity plays a pivotal role in determining the maximum elevation achieved by the rocket in its flight..

4. Sound Waves

The volume and intensity of a sound are contingent upon the proximity to the source of the sound. Close to the source, the sound is perceptibly louder, while at a greater distance, it becomes notably quieter. When a bamboo cannon detonates, there is an abrupt alteration in air pressure within its immediate vicinity. The high-pressure conditions resulting from the explosion induce rapid air movement, thereby generating sound waves characterized by frequencies spanning the range of 20 Hz to 20,000 Hz, often denoted as the audio-sonic frequency range [24].

5. Wave Interference

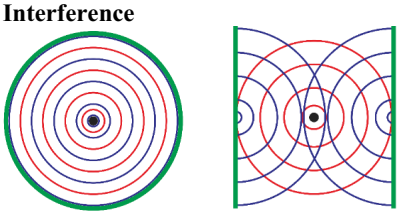

Figure 6. Wave Interference

In the event of an explosion, sound waves emanating from the point of origin, the bamboo cannon explosion, propagate outward in all directions. These sound waves propagate through the medium, and as they travel, they encounter various surfaces and objects. When these sound waves interact with obstacles or characters, they undergo reflection and diffraction, giving rise to wave collisions and interactions between the waves themselves.

6. Organa Pipe

The principle underlying the presence of an organa pipe within a bamboo cannon centers on the physics phenomenon of sound vibrations engendered by the movement of air within the pipe. Sound, characterized as a longitudinal wave, arises from the oscillations of particles within a medium, such as air. As air courses through the pipe, the vibrations stemming from the explosion within the bamboo cannon set the air particles into motion, thereby generating sound waves. When this vibrational air traverses a particular length of the organa pipe, it engenders a phenomenon known as resonance. Resonance manifests when the frequency of the air's oscillation aligns with the pipe's resonant frequency, culminating in the production of a resounding and vibrant sound [25].

7. Sound Intensity

Sound intensity signifies the magnitude or vigor of sound as perceived by an observer. During a bamboo cannon explosion, the sound intensity is very high due to releasing significant energy. Sound intensity is measured in units called decibels (dB), and a bamboo cannon explosion can produce sound with intensity far above the threshold of human hearing [26].

Sound intensity is a quantity carried by sound waves (per unit area) perpendicular to the direction of wave propagation. The sound intensity heard, measured in decibels (dB), is called the Sound Intensity Level. The sound intensity level is the logarithmic value of the ratio between sound intensity and the hearing threshold. In everyday life, the sound intensity level indicates loudness produced by a sound source.

Here is the equation for the Sound Intensity Level:

$$TI = 10\log(\frac{I}{I^0})$$

$\boldsymbol{TI}$ **:** Sound Intensity Level (dB)
$\boldsymbol{I}$ **:** Sound Intensity (W/m^2)

When the smallest audible sound intensity, also known as the threshold of hearing intensity, is equal to:

$$I_0 = 10^{-12} W/m^2$$

If the source of the sound being heard increases, the intensity of the sound heard will change logarithmically.

$$TI_n = TI_1 + 10\log n$$

TIn **:** The intensity level n of a sound source
TI_1 **:** The intensity level 1 of a sound source at position
$\boldsymbol{n}$ **:** The number of sound sources

When the listener changes position relative to the sound source, either moving farther away or closer.

$$TI_2 = TI_1 + 20\log(\frac{r_2}{r_1})$$

TI_1 **:** The intensity level at position 1
TI_2 **:** The intensity level at position 2
r_1 **:** The distance from position 1 to the sound source
r_2 **:** The distance from position 2 to the sound source

Chemical Aspects in Bamboo Cannon Toys

1. Classification of Matter and Chemical Bonds

CARBIDE (Calcium Carbide)

$$[:C\equiv C:]^{2-}$$
$$Ca^{2+}$$

Chemical Formula : CaC2
Molar Mass : 64.099 g/mol
Melting Point : 2,160°C
Boiling Point : 2,300°C

Calcium carbide is one of the explosive materials used in playing with bamboo cannons. This substance is a solid-state material. Calcium carbide consists of carbon and calcium atoms that form a compound molecule. The carbon atoms in calcium carbide are bound by two types of chemical bonds: covalent bonds (between carbon atoms) and ionic bonds (between calcium atoms and [C2]2- molecules) [27].

WATER (Dihydrogen Monoxide)

$$H-O-H$$

Chemical Formula : H2O
Molar Mass : 18.0153 g/mol
Freezing Point : 0°C
Boiling Point : 100°C

Water is a liquid compound comprised of hydrogen and oxygen atoms that are chemically bonded together through covalent interactions[28]. This compound, water, assumes significance as an essential component in the operation of bamboo cannons utilizing the explosive substance known as calcium carbide. Acetylene gas is produced as a result of the reaction between calcium carbide and water.

2. Hydrolysis Reaction

The reaction between carbide (calcium carbide, CaC_2) and water produces acetylene gas (ethyne, C_2H_2) and calcium hydroxide ($Ca(OH)_2$). This process is known as carbide hydrolysis. Here is the chemical reaction equation that describes this reaction:

$$CaC_{2(s)} + 2H_2O_{(l)} \rightarrow C_2H_{2(g)} + Ca(OH)_{2(aq)}$$

In this reaction, carbide reacts with water molecules to form acetylene and calcium hydroxide. The resulting acetylene is a highly flammable gas used in various industrial applications such as welding, metal cutting, and producing organic compounds. The reaction described above is referred to as Carbide Hydrolysis [29].

The results of the calculations from the observations are as follows

128 grams are placed into the bamboo cannon. Then, 36 ml of water is added. The acetylene gas that forms... If there is any carbide left, the mass of the remaining carbide...

(1 ml water = 1 gram water)

It is known that:

m CaC_2 : 128 grams	Air : 36 grams
Mm CaC_2 : 64gr/mol	Mm H_2O : 18gr/mol
n CaC_2 = 12,8/64	n H_2O = 3,6/18
= 2 mol	= 2 mol
Mm C_2H_2 : 26	

Reaction	$CaC_{2(s)} + 2H_2O_{(l)} \rightarrow C_2H_{2(g)} + Ca(OH)_{2(aq)}$			
n Initial	2	2	-	-
n Reaction	1	2	1	1
Final	1	-	1	1

The mass of acetylene gas formed = mol × Relative molecular mass
= 1 × 26
= 26 gram

Unreacted carbide remaining = mol × Relative molecular mass
= 1 × 64
= 64 gram

The reaction from a chunk of carbide with water produces 64 grams of acetylene gas. The greater the mass of the substances reacting, the more significant the acetylene gas produced. If the group of acetylene gas increases, the explosion will be more meaningful and louder.

3. Exothermic Reaction

An exothermic reaction is a reaction that releases energy, causing the system to give off heat to the surroundings, resulting in a decrease in enthalpy value. Carbide can react with water to form acetylene gas (ethyne) with the formula C2H2 and also produce calcium hydroxide with the formula Ca(OH)2, releasing heat to the environment [30].

The results of the observations' calculations

A chunk of carbide with a mass of 128 grams, mixed with 36 grams of water, initially at a temperature of 30°C, and after the reaction, it becomes 35°C, will result in the following enthalpy value:

It is known that:

CaC_2 : 128 grams	Water : 36 grams
Molecular mass CaC_2 : 64gr/mol	c Solvent : 4,2 J/gr
n CaC_2 = 128/64	ΔT = 35-30
= 2 mol	= 5
Q Reaction = m × c × ΔT	$\Delta H = -\frac{Q\ reaksi}{mol}$
= 36 × 4,2 × 5	$= -\frac{756\ Joule}{2\ mol}$
= 756 Joule	$= -378\ ^{Joule}/_{mol}$

Based on the reaction above, we can observe that a new compound is formed when CaC2 reacts with H2O. According to the principles of thermochemistry, the formation of a combination involves releasing heat from the system to the surroundings, resulting in a decrease in energy and a negative enthalpy value. An exothermic reaction occurs when a chunk of carbide reacts with water, causing the bamboo's surface to feel hot. Therefore, the response of carbide with water is exothermic.

4. Combustion Reaction

The result of the hydrolysis reaction of carbide with water, which forms acetylene gas (ethyne) with the formula C2H2, is an explosive gas compound that can burn completely when exposed to a spark or flame. Therefore,

when the bamboo cannon's hole is ignited, it will result in an explosion from a reaction between acetylene gas and the flame. The acetylene gas ignited by the flame will produce carbon dioxide and water vapor. Below is the equation for the complete combustion of acetylene gas [31].

$$2C_2H_{2\,(g)} + 5O_{2(g)} \Rightarrow 4CO_{2(g)} + 2H_2O_{(g)}$$

IV. Conclusion and Recommendations

Based on the literature review, a relationship was found between making and playing with bamboo cannons with integrated science aspects involving biology, physics, and chemistry. These include:

1. Selection of Bamboo Types: Scientific Classification of Plants, Plant Morphology.
2. Bamboo Cutting: Inclined Plane, Frictional Force, and Heat.
3. Cleaning Bamboo Joints: Inclined Plane, Impulse Momentum.
4. Creating Holes: Inclined Plane, Impulse Momentum.
5. Explosive Material: Classification of Matter and Chemical Bonds.
6. Mixing Explosive Materials: Hydrolysis Reaction, Exothermic Reaction.
7. Igniting the Bamboo Cannon: Combustion Reaction.
8. Bamboo Cannon Explosion: Newton's Third Law, Parabolic Trajectory, Inelastic Collision, Sound Waves, Wave Interference, Organ Pipe, Sound Intensity.

It is recommended that future researchers develop integrated instructional materials based on local wisdom. The goal is to provide additional knowledge to students so they can understand the concept of integrated science in the context of events. Through the analysis of integrated science aspects in bamboo cannon toys, teachers can connect community knowledge and other scientific concepts in the surrounding environment with the science concepts taught in school. Thus, the knowledge acquired by students will have a more significant meaning.

References

[1] L. Ralph, *The Cultural Background Of Personality*. New York: Appleton-Century-Crofts, 1947.

[2] "5 Budaya Indonesia yang Pernah Diklaim Negara Lain, Motif Batik Hingga Lagu Daerah," Tribunnews.com. Diakses: 10 Oktober 2022. [Daring]. Tersedia pada: https://www.tribunnews.com/nasional/2021/11/17/5-budaya-indonesia-yang-pernah-diklaim-negara-lain-motif-batik-hingga-lagu-daerah

[3] "25 Contoh Kearifan Lokal di Indonesia Beserta Penjelasannya - Sosiologi Info." Diakses: 10 Oktober 2022. [Daring]. Tersedia pada: https://www.sosiologi.info/2022/01/25-contoh-kearifan-lokal-di-indonesia-beserta-penjelasannya.html

[4] F. Jannah, "Kajian Etnosains Berbais Kearifan Lokal," Skripsi, Universitas Islam Negeri Kiai Haji Achmad Siddiq Jember, Jember, 2022.

[5] B. A. Sharpless dan K. Doghramji, *Sleep Paralysis: Historical, Psychological, and Medical Perspectives*. Oxford: Oxford University Press, 2015.

[6] I. A. Rizki, N. Suprapto, dan S. Admoko, "Exploration of physics concepts with traditional engklek (hopscotch) game: Is it potential in physics ethno-STEM learning?," *jipfalbiruni*, vol. 11, no. 1, hlm. 19–33, Apr 2022, doi: 10.24042/jipfalbiruni.v11i1.10900.

[7] A. W. Wisudawati dan E. Sulistyowati, *Metodologi Pembelajaran IPA*. Jakarta: Bumi Aksara, 2019.

[8] Husein, "Lunturnya Permainan Tradisional," *Aceh Anthropological Journal*, vol. 5, no. 1, hlm. 15, 2021.

[9] P. KOMINFO, "Kecanduan Gawai Ancam Anak-anak," Website Resmi Kementerian Komunikasi dan Informatika RI. Diakses: 4 Oktober 2022. [Daring]. Tersedia pada: http:///content/detail/13547/kecanduan-gawai-ancam-anak-anak/0/sorotan_media

[10] N. Mulyani, *Super asyik permainan tradisional anak Indonesia*. Yogyakarta: Diva Press, 2016.

[11] A. T. Damayanti, D. M. Fajar, dan M. Habibbulloh, "Monoicado: A Modification of the Monopoly Game for Science Learning for Light and Optical Instruments," *Science Education and Application Journal (SEAJ)*, vol. 3, no. 2, hlm. 89–101, 2021.

[12] D. Rohmawati, I. M. Ulfa, dan D. M. Fajar, "Penggunaan Metode Permainan Tradisional Patil Lele Dalam Memahami Konsep Gerak Parabola Pada Pembelajaran Kinematika," Jember: LP3DI Press, 2019.

[13] A. Ayu W, "Nama Diri Pendalungan Jember dalam Kebermaknaan Sosial Budaya," *Jantra*, vol. 13, no. 1, hlm. 25–42, 2018.

[14] E. : N. Indonesia, "Bupati Jember Apresiasi Festival Rakyat Rambipuji, Ada Penyulutan 1000 Meriam Bumbung » News Indonesia," News Indonesia. Diakses: 15 Desember 2022. [Daring]. Tersedia pada: https://newsindonesia.co.id/read/berita-jember/bupati-jember-apresiasi-festival-rakyat-rambipuji-ada-penyulutan-1000-meriam-bumbung/

[15] D. Rusyad, *Kompilasi Permainan Rakyat: Menggali Nilai-nilai Budaya pada Khazanah Folklor Indonesia*. ABQARIE BOOKS, 2020.

[16] R. Hudan Ramadhan, L. Ratnaningtyas, H. Kuswanto, dan R. Wardani, "Analysis of Physics Aspects of Local Wisdom: Long Bumbung (Bamboo Cannon) in Media Development for Android-Based Physics Comics in Sound Wave Chapter," *J. Phys.: Conf. Ser.*, vol. 1397, no. 1, hlm. 012016, Des 2019, doi: 10.1088/1742-6596/1397/1/012016.

[17] Morissan, *Metode Penelitian Survei*. Jakarta: Kencana, 2017.

[18] Urip Sulistiyo, *METODE PENELITIAN KUALITATIF*. Jambi: PT Salim Media Indonesia, 2023.

[19] M. B. Miles, A. M. Huberman, dan J. Saldana, *Qualitative Data Analysis*. New York: SAGE Publications, 2014.

[20] Sugiono, *Metode Penelitian Kualitatif, Kuantitatif, dan R&D*. Bandung: Alfabeta, 2019.

[21] G. C. Marano, A. V. Rahul, J. Antony, G. U. Kartha, P. E. Kavitha, dan M. Preethi, *Proceedings of SECON'22: Structural Engineering and Construction Management*. Springer Nature, 2022.

[22] E. A. Wijaya, *Indentikit jenis-jenis bambu di Jawa*. Puslitbang Biologi, LIPI, 2001.

[23] J. D. Cutnell, K. W. Johnson, D. Young, dan S. Stadler, *Physics*. New York: John Wiley & Sons, 2021.

[24] D. Halliday, R. Resnick, dan J. Walker, *Fundamentals of Physics, Volume 1*. John Wiley & Sons, 2017.

[25] N. H. Fletcher dan S. Thwaites, "The physics of organ pipes," *Scientific American*, vol. 248, no. 1, hlm. 94–103, 1983.

[26] H. A. Radi dan J. O. Rasmussen, *Principles of Physics: For Scientists and Engineers*. Springer Berlin Heidelberg, 2012.

[27] N. N. Greenwood dan A. Earnshaw, *Chemistry of the Elements*. Oxford: Pergamon Press, 1984.

[28] D. Eisenberg dan W. Kauzmann, *The Structure and Properties of Water*. OUP Oxford, 2005.

[29] K. Rodygin, G. Werner, F. Kucherov, dan V. Ananikov, "Calcium Carbide: A Unique Reagent for Organic Synthesis and Nanotechnology," *Chemistry - An Asian Journal*, vol. 11, hlm. 965–976, Feb 2016, doi: 10.1002/asia.201501323.

[30] K. S. Rodygin, K. A. Lotsman, K. S. Erokhin, V. A. Korabelnikova, dan V. P. Ananikov, "Thermal Mapping of Self-Promoted Calcium Carbide Reactions for Performing Energy-Economic Processes," *International Journal of Molecular Sciences*, vol. 23, no. 5, hlm. 2763, 2022.

[31] A. Williams dan D. B. Smith, "Combustion and oxidation of acetylene," *Chemical Reviews*, vol. 70, no. 2, hlm. 267–293, 1970.