Identification of Physics Concepts in the Local Wisdom of *Cowek* Pottery Making in Gedangan, Lamongan

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ABSTRACT

Cultural heritage is an important part of shaping community identity because it reflects history, values, and unique ways of life. One example is the craft of *cowek* pottery. However, globalization has caused communities to slowly abandon local cultural values. Therefore, preserving local wisdom is necessary, one of which can be done through integration into school learning. Physics education has great potential to promote local wisdom because many physics concepts are directly related to traditional practices. This study aims to explore the physics concepts found in the process of making *cowek* pottery in Gedangan Village, Lamongan, and identify their potential as sources of contextual learning. The research uses a qualitative descriptive method with an ethnographic approach, involving two *cowek* craftsmen selected through purposive sampling. Data were collected through observation, interviews, documentation, and literature study. Data analysis employed the Miles and Huberman model, which includes data reduction, data presentation, and conclusion drawing. The study results show that each stage of *cowek* production involves physical concepts such as plasticity, pressure, friction, centripetal force, work and energy, changes in form, and heat transfer. The *cowek* making process also presents various physical phenomena that can help students understand concepts more concretely and meaningfully, making it highly potential as a contextual learning resource. These findings confirm that traditional activities are closely linked with the application of physics laws. Thus, local wisdom in *cowek* making can be utilized as a relevant and actual learning resource to support students' understanding of physics concepts in everyday life.

INTRODUCTION

The cultural heritage plays an important role in shaping the local identity of a community, as it reflects its history, cultural values, and unique way of life. Cultural heritage is not only in the form of physical relics such as buildings, artifacts, or works of art, but also includes intangible heritage such as traditional knowledge and cultural expressions. Traditional knowledge and cultural expressions refer to all forms of knowledge, skills, and works that originate from indigenous peoples or local communities and are passed down from generation to generation (Turnip & Senoper, 2022).

Every island has different traditions and cultural characteristics, reflecting the rich diversity of ethnic groups and races spread across the archipelago. This diversity is a hallmark of the Indonesian nation and forms a beautiful and valuable cultural mosaic. In addition, this abundant diversity makes Indonesia a fertile ground for understanding local identities and cultural values that have been passed down from generation to generation (Indrawati & Sari, 2024).

The values contained in culture cannot be measured materially, but rather become unwritten principles that guide people's behavior and outlook on life. Local wisdom in a culture reflects ways of thinking, interacting, and adapting to the environment and social norms that are upheld. However, due to the influence of globalization, society has slowly begun to abandon the noble values of the nation's culture (Turmuzi et al., 2022). Therefore, preserving local wisdom is essential for safeguarding cultural and national identity while also honoring Indonesia's rich diversity. (Indrawati & Sari, 2024).

One form of cultural product that is still widely found today is pottery. Pottery in Indonesia has existed since prehistoric times and has become part of universal culture, as almost every region in the world has a tradition of making pottery (Agustin et al., 2021). Pottery is the result of processing clay that is fired until it hardens and becomes brightly colored. One of the pottery centers is located in Gedangan, Lamongan, where the manufacturing process is still carried out traditionally using the spinning technique. The craftsmen in the village produce various types of pottery such as jugs, pans, barrels, pots, and especially *cowek* as their main product.

The *cowek* is a type of pottery that is still commonly used in everyday life. However, with the passage of time, the production of traditional *cowek* has declined because fewer young people are continuing the craft. In fact, the *cowek* is not only a household item, but also represents local wisdom that embodies cultural values and traditional knowledge. Therefore, the *cowek* as a cultural product needs to be preserved. One of the preservation efforts that can be made is to integrate it into the world of education so that the cultural values and knowledge contained within it remain known, understood, and passed on to the next generation.

One way to preserve and maintain local wisdom is through its integration into school learning. The integration of local wisdom into learning, especially physics learning, is very much needed because many physics concepts are directly related to these traditional practices (Damarsha et al., 2023). Physics is an effective means of introducing scientific concepts through local phenomena and practices in the surrounding environment as a concrete effort to preserve cultural heritage while creating more meaningful learning (Rohmah et al., 2024). In addition, physics also plays an important role in helping humans understand various natural phenomena systematically through observation, experimentation, and analysis (Liwun et al., 2025).

Physics education that integrates culture or local wisdom is also known as ethnophysics, which is an approach that links physics concepts with a particular culture (Nurmasyitah et al., 2022). Learning that utilizes local wisdom helps students understand the cultural values of their region and makes the learning process more contextual and meaningful (Hakim et al., 2023). Therefore, by linking lesson material to everyday life, students can see the real relationship between science and their culture. In addition, the purpose of integrating local wisdom into learning is for students to recognize and understand the strengths of their respective regions, so that they are able to manage resources, participate in various activities related to local potential, and help preserve and conserve the culture, traditions, and resources of their region (Hakim et al., 2023).

Without realizing it, pottery makers have applied various concepts of physics in the manufacturing process. In the clay forming stage, the concepts of centripetal force and rotation are applied when the clay is spun on a potter's wheel. The drying process involves heat transfer and water evaporation, while pottery firing involves heat conduction and changes in the state of matter. Therefore, pottery making not only reflects cultural values and traditional skills, but can also be used as a source of contextual physics learning in ethnophysics education in schools.

The results of previous research conducted by Liwun et al. (2025) examined the identification of physics concepts, particularly temperature and heat, in the process of making Kasongan Yogyakarta pottery. Meanwhile, Najib's (2018) research explored the concept of ethnoscience in the process of making roof tiles, which can be linked to the materials of temperature, expansion, heat, heat transfer, pressure, and the physical properties of traditional materials. However, this study does not explain in detail the physics concepts involved, as its main focus is only on identifying the relationship between the tile-making process and the learning objectives or basic competencies in the curriculum. In addition, studies on ethnophysics in the *cowek* pottery making process are still very limited.

Based on this description, *cowek* as a traditional pottery product has great potential as a source of physics learning based on ethnophysics. However, scientific studies that specifically address *cowek* in the context of preserving local wisdom through education are still limited. Therefore, this study was conducted to explore ethnophysics in the process of making *cowek* as a form of local wisdom. Through direct observation of each stage of the manufacturing process, this study aims to explore the concepts of physics involved in the process of making *cowek* pottery in Gedangan, Lamongan, and to identify the application of various principles of physics that arise in this activity. Thus, the results of this study are expected to provide a contextual understanding of the application of physics concepts in everyday life while introducing the cultural values contained in the tradition of *cowek* making.

Based on this background and objectives, the research questions in this study are as follows:

1. What are the physics concepts found in the local wisdom of the *cowek* making process?
2. What is the potential of the local wisdom of *cowek* making as a source of contextual learning in physics education?

RESEARCH METHOD

This study is a qualitative descriptive study using an ethnographic approach. The ethnographic approach in this study is used to understand the relationship between the cultural activities of the community and the scientific concepts contained therein (Sari et al., 2023). Through this approach, researchers can explore the meanings, customs, and traditional practices of the Gedangan community in making *cowek* pottery, which reflects the application of physics concepts in everyday life.

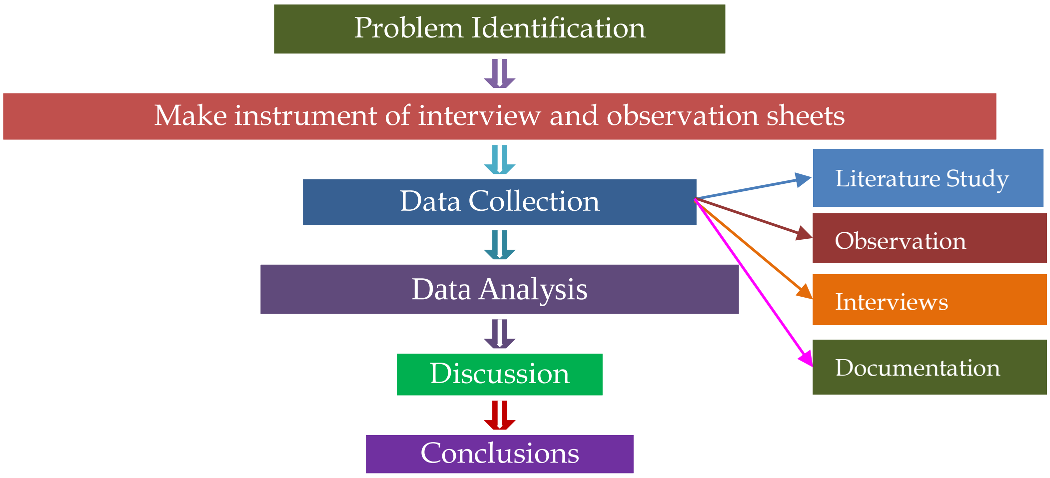

Figure 1. Research Flow

Figure 1 illustrates the research design flow used in this study (adapted from Rohmah et al., 2024). The research procedure consisted of several stages: (1) a preparation stage, which included problem identification, determination of the research location, and a preliminary literature review; (2) an instrument development stage, which included the preparation of interview and observation sheets; (3) a field data collection stage through observation, interviews, and documentation; (4) a data analysis stage, which involved analyzing the results of interviews and observations and then presenting them in descriptive form; (5) discussion, which involved linking the findings with the results of literature studies to strengthen data interpretation; (6) a conclusion stage as the final step of the research.

The sampling technique used was purposive sampling, which is a technique for determining samples based on specific considerations (Sugiyono, 2022). The research location was in Gedangan Village, Lamongan. The criteria for sample selection were individuals who understood the *cowek* making process, so the subjects and main sources of data in this study were two *cowek* craftsmen. In addition, additional data was obtained from documents, related literature, and direct observations in the field.

The data collection techniques in this study included observation, interviews, documentation, and literature study. Observations were conducted directly to observe all stages of the *cowek* forming process, from clay processing to the firing stage, using an observation sheet containing a grid of activities to be observed. In-depth interviews were conducted with *cowek* craftsmen to obtain detailed information about their techniques, experiences, and understanding of the *cowek* manufacturing process. The interview process used interview guidelines that had been compiled in the form of a structured list of questions. Documentation was carried out simultaneously with observation and interviews, in the form of photos and videos as visual data to support the research findings. In addition, literature studies were also carried out by reviewing journals, books, and previous studies relevant to ethnophysics, pottery, and local wisdom, as reinforcement and comparison of research data.

The data analysis technique in this study refers to the Miles and Huberman (1992) model, which includes three stages of activity, namely: (1) data reduction, (2) data presentation, and (3) drawing conclusions or verification. In the data reduction stage, researchers select, sort, and focus on data obtained from observations, interviews, documentation, and literature studies. Data that is not relevant to the research objectives is set aside, while data related to the *cowek* making process and emerging physics concepts is analyzed further. The next stage is data presentation, which involves compiling the reduced data into a narrative description and a table categorizing physics concepts based on the stages of *cowek* production. At this stage, the researcher presents the relationship between the findings. The final stage is drawing conclusions or verification. The researcher interpreted all the data to identify the physics concepts that emerged in each stage of *cowek* production and assessed the potential of this activity as a source of contextual learning. The conclusions were then verified by comparing the observation data, interview results, documentation, and literature study to ensure the validity and consistency of the research findings. field with physics theory and other references, thereby facilitating the interpretation process.

RESULTS AND DISCUSSION

1. Local Wisdom of *Cowek* Pottery

Local wisdom is a potential resource that includes traditional knowledge, cultural values, customs, and various other forms of knowledge that have been passed down from one generation to the next (Ni'mah et al., 2024). Traditional crafts are one form of local wisdom. Traditional crafts are works made manually using simple tools and natural materials. Pottery is one example of traditional crafts that is still preserved and can be found in Indonesian society. In addition to serving as household items, pottery also embodies cultural values that reflect the identity and character of a region, giving it a meaning that goes beyond that of a mere object (Izah et al., 2025).

Pottery is a craft product made from clay that is shaped using specific techniques and serves as household items and tools to support daily activities. One of the most familiar pottery products is the mortar. In general, a mortar is a flat, round kitchen utensil used to grind or mash cooking spices. In addition, the mortar is one of the most common forms of pottery found in various regions of Indonesia. The mortar is very popular in the archipelago because Indonesian cuisine is known for its rich spices and herbs, which require a tool that can help grind these ingredients optimally. Therefore, the mortar has various local names, such as *cowek, layah, lemper, batu penumbuk, ulegan,* and other terms, depending on the local dialect and culture.

The main raw material for making mortars is clay, or what the local community calls *lemah*. Scientifically, soil is a material composed of aggregates of solid minerals that are not cemented (chemically bound) to each other and organic materials that have decayed (solid particles) accompanied by liquids and gases that fill the empty spaces between the solid particles (Najib, 2018). Pottery crafts generally use two types of clay, namely primary clay, which is white to dull white in color and has a coarse texture, and secondary clay or sedimentary clay, which is gray in color, has a smoother texture, and is more plastic (Alfazri et al., 2016). The clay used in making mortars has a microporous, non-porous, and dense structure. These characteristics make it difficult for air to enter but easy for water to seep in, resulting in a sticky and plastic texture. These conditions allow the clay to follow the movements of the hands, making it easy to shape into *cowek* (Handayani et al., 2024).

The village of Gedangan, Maduran District, Lamongan Regency, is an area located in the northern part of Lamongan Regency and is known as one of the centers of pottery crafts. Gedangan Village has the potential for family businesses and micro, small, and medium enterprises that have been developing for a long time, especially in the manufacture of various pottery products (Amri et al., 2024). These activities have earned Gedangan the nickname of pottery craftsmen's area, and its products are even marketed outside Java Island. The local community has a special name for mortar products, namely *cowek*, and the *cowek* craftsman in this village are known as *Anjun*.

The main material used to make *cowek* and pestles comes from clay, which is generally obtained from the banks of the Bengawan Solo River. The location of the village, which is close to the river, has made the use of clay a common practice since long ago. Bengawan Solo clay is dark brown to almost black in color, indicating that it is more plastic and stronger, making it very suitable for use as a base material for pottery (Salsabiila et al., 2025). In the past, the *Anjun* collected and processed the clay themselves. However, with the passage of time and the increasing age of the craftsman, most of whom are now 40 years old or older, the work of collecting and mixing the clay is now done by skilled workers, so that the *Anjun* now only need to purchase the finished clay before moving on to the forming stage.

2. The Process of Making *Cowek*

The process of making *cowek* pottery in Gedangan Village, Lamongan, is still carried out traditionally using techniques and terms that have been passed down from generation to generation. The initial stage begins with collecting clay from the Bengawan Solo River, then mixing it with rice field soil to reduce the mud content. The mixture is then processed with water and sand so that it is not too hard and easy to shape. The mixture of clay, rice field soil, sand, and water is processed through a process called *diidek-idek*. *Diidek-idek* is the process of mixing clay with rice field soil, sand, and water by stomping on it with your feet until the mixture becomes soft and easy to shape. This process aims to even out the mixture, remove large lumps, and adjust the water content so that the soil is not too hard or too soft, as shown in Figure 2.

Figure 2. Soil results after the trampled process *(diidek-idek)*

Once the texture is right, the clay is shaped using a traditional spinning tool called a *perbot*. A *perbot* is a tool used to spin lumps of clay so that they can be shaped as needed into a mortar (Wahyuningsih, 2023). The *perbot* tool is shown in Figure 3(a). Then, an appropriate amount of clay is taken and pressed. It is then placed in the center of the *perbot* and rotated until a symmetrical circle is formed. The process of forming a mortar is shown in Figure 3(b).

(a)

(b)

Figure 3. (a) The *perbot* tool; **(b)** The *cowek* formatting process

After the forming process, the *cowek* is dried in the sun until it is half dry, as shown in Figure 4(a). The drying process takes 6 hours, after which the bottom is smoothed. The next process is to add feet to the bottom of the *cowek* by adding clay, then drying it again until it is dry. After that, the process is *Ndalimi*, which is the process of applying water to a cloth and then rubbing it on the surface of the *cowek* to make it smoother and neater as shown in Figure 4(b). Next, the edges or rim of the mortar are coated with red clay mixed with kerosene, then rubbed with a stone until the surface appears shiny. After that, the mortar is dried again until completely dry before entering the firing stage as shown in Figure 4(c).

(a)

(b)

(c)

Figure 4. (a) Drying process; (b) *Ndalimi* process (smoothing) after adding feet the bottom of *cowek*; (c) Drying process after being colored red with red soil until completely dry.

Once the *cowek* have been collected and are completely dry, the next stage is burning, as shown in Figure 5(a). The burning stage takes approximately 18 hours. This process is carried out after the *cowek* are completely dry. The *cowek* are then arranged in layers, with corn husks filling the inside of the stack, followed by firewood and another stack of *cowek* on top. This arrangement is made up to three layers, then the top is covered again with wood, *damen* (dry rice straw), and ash from the previous burning. The arrangement is arranged in a circle so that the heat is evenly distributed during the burning process.

After the firing process is complete, the *cowek* pottery are left to cool before being removed and inspected. Each *cowek* is carefully checked to ensure that there are no cracks or defects. *Cowek* that are in good condition, with a smooth surface and no cracks, are sorted for sale to the market or to customers. Meanwhile, *cowek* that are cracked or defective cannot be used and are usually set aside. The remaining ash from the firing process is collected for use in the next firing process, as a coating or cover to distribute the heat evenly. Figure 5(b) shows a well-fired *cowek* with an even reddish color and a smooth surface.

(a) **(b)**

Figure 5. (a) The burning stage; (b) Final result of the Cowek making process

3. Analysis of Physics Concepts in *Cowek* Pottery Making

The making of *cowek* as a traditional pottery craft not only represents local cultural wealth, but also involves various physics concepts in each stage of the process. Starting from the selection and processing of clay, shaping techniques using a spinning potter's wheel, to the drying and firing processes, all stages are closely related to physics principles such as force and motion. From the selection and processing of clay, the shaping technique using a spinning potter's wheel, to the drying and firing processes, all of these stages are closely related to physical principles such as force and motion, elasticity, and temperature and heat (Lumbangaol et al., 2024). The following are the results of identifying physics concepts in the stages of making a *cowek*, including:

3.1 The processing of mixing clay (*diidek-idek* process)

In the idek-idek stage, clay from Bengawan Solo is mixed with rice field soil, water, and sand using foot pressure. This process applies the principles of elasticity, force, and pressure in traditional practice. The clay mixture is trampled repeatedly to make the dough smooth and easy to shape. This is done because the quality of the soil used will greatly determine the final result of the pottery, such as the strength and smoothness of the surface formed (Liwun et al., 2025).

a) Pressure

Figure 6. Illustration of force diagram in the clay mixing process

The concepts of force and pressure play an important role, especially when craftsmen step on the soil mixture using their entire soles, as shown in Figure 6. Pressure in physics is defined as the ratio between the force exerted and the surface area of the pressure field (Abdullah, 2016), which is formulated as:

$$P = \frac{F}{A} \quad (1)$$

Notation:
P = Pressure (N/m^2 or Pa)
F = Force of press (N)
A = Area of cross section (m^2)

In the *idek-idek* process (step on the soil mixture using their entire soles), the force (F) comes from the weight of the craftsman, while the area of the pressing surface (A) is the area of the sole of the foot. When the craftsman uses the entire sole of their foot, the pressure area becomes large, so the pressure exerted on the soil mixture becomes smaller. As a result, the craftsman's foot does not sink too deeply into the soil, but the pressure generated is sufficient to help mix the soil evenly.

Based on the interview results, the craftsman also mentioned that when mixing soil, it is more comfortable to use the entire sole of the foot rather than standing on tiptoes, because this method makes the work less tiring and speeds up the mixing process. The physics behind this can be explained as when standing on tiptoes, the pressure area is reduced because only a small part of the sole of the foot is pressing on the ground, thereby increasing the pressure exerted. This high pressure causes some of the pressure to be concentrated in a small area, making the leg muscles work harder to maintain balance and press the mixture efficiently. Conversely, when craftsman use their entire soles, the body's weight is distributed evenly, resulting in less pressure and the leg muscles not having to work as hard as when standing on tiptoes. Additionally, the even pressure helps the mixture of soil, sand, and water become more homogeneous and cohesive.

b) Plasticity

Every solid material such as ceramics, semiconductors, metals, polymers, and superconductors has different mechanical properties, making them widely used in various fields (Baruqi et al., 2009). One solid material that is often used in everyday life is clay, which belongs to the category of natural ceramic materials. Clay has mechanical properties, namely plasticity, which allows it to be shaped into various forms according to the craftman's wishes, as shown in Figure 7.

Figure 7. Clay being kneaded before the process of shaping the *cowek*

The plastic properties of clay mean that the material can change shape permanently when force is applied, and cannot return to its original shape after the force is removed. This occurs because of the shifting positions of the fine particles that make up clay, which rub against each other and move when pressure is applied (Baruqi et al., 2009). When clay is mixed with water, the water acts as a lubricant that allows the clay particles to move more easily, making the material more flexible and easier to shape. This plastic property is utilized by potters during the forming process, as shown in Figure 7. When clay is pressed, struck, or stepped on, it will take on the shape of the force applied and retain that shape after the force is removed.

The interviews also revealed that the craftsman intuitively know when the clay has the ideal level of flexibility. This experience enables them to assess the condition of the mixture simply by feeling its texture and elasticity when shaped. If the clay is too hard, more force is required to shape it because the applied force does not easily cause deformation. This condition makes the clay feel stiff and risks causing cracks or breaks in the pottery being formed. In other words, clay that is too hard has low elasticity, making it difficult to shape as desired.

On the other side, if the clay is too soft, the particle structure inside becomes too loose, making it unable to hold its shape well. As a result, the pottery is easily dented or bent when being shaped. Therefore, the ratio of clay, sand, and water must be just right to achieve the right consistency, which is a flexible, slightly sticky texture that is easy to shape without losing its strength. The results of Sese's (2023) research state that the main ingredient in pottery making is clay, which is often mixed with various other ingredients such as sand, local clay, kaolin, feldspar, and broken tiles or unused pottery in certain proportions as needed. The addition of these mixed materials aims to improve the properties of clay, especially to reduce the plasticity of the dough so that it is easier to shape and to improve heat conductivity during the firing process. In the pottery forming process, there are various chemical components that are greatly influenced by the raw materials used, both the main and additional materials. The composition of these raw materials affects the shrinkage rate of the pottery; the higher the content of non-plastic materials, the lower the shrinkage. However, too high a content of non-plastic materials can also make the forming process difficult because these materials are unable to bind other materials well (Sese et al., 2023).

3.2 The processing of forming a *cowek*

c) Centripetal Force and Friction Force

During the *cowek* forming stage, artisans use a potter's wheel or traditional turntable as a tool to shape the clay into a circular form. During the process, the artisan's feet continuously rotate the potter's wheel, while their hands press and shape the clay mixture on top of it. This rotating motion creates a centripetal force, which is a force directed toward the center of the circle and serves to keep the clay moving in a stable circular motion. The clay is placed on the potter's wheel in the center so that the *cowek* is formed symmetrically (Sari et al., 2025).

From the interviews, it was found that in order to make the surface of the *cowek* smooth, craftsmen use a cloth that has been moistened with water during the forming process. The wet cloth is rubbed slowly on the surface of the spinning clay. The use of a wet cloth serves to maintain the moisture of the clay, reduce excessive friction between the hands and the clay, and help produce a flat and smooth surface for the *cowek*. The following is an illustration of the centripetal force that occurs during the making of *cowek* with a turntable, as shown in Figure 8.

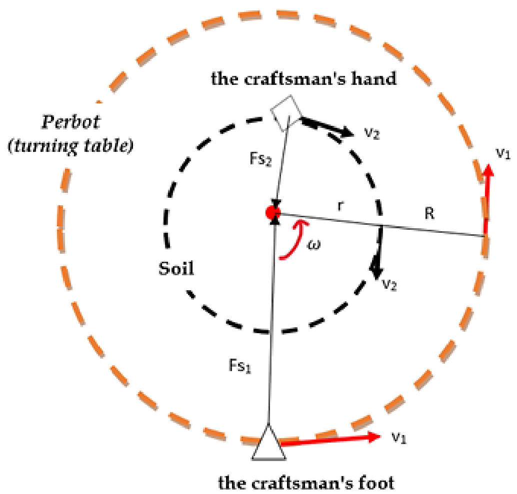

Figure 8. An Illustration of Centripetal Force in the Process of Making *cowek* with a Lathe (Turntable)

Description:

ω = Angular velocity of the potter's wheel (turning table)
r = Radius of the clay path from the center of rotation to the position of the craftsman's hand
R = Radius of the trajectory from the center of rotation to the edge of the potter's wheel
v_1 = Linear velocity of the point on the edge of potter's wheel rotated by the craftsman's foot
v_2 = Linear velocity of the point of clay formed by the artisan's hand.
Fs_1 = Centripetal force from the potter's wheel (turning wheel)
Fs_1 = Centripetal force from the potter's hands

Physically, this process involves two main forces, namely centripetal force and friction. When the potter's wheel is turned, each clay particle moves in a circle at a certain speed depending on its distance from the center of rotation. It is this circular motion that allows the clay to form a symmetrical pattern, while the artisan's hands provide friction to shape and curve the *cowek*.

In circular motion, even though the speed of an object can be constant, the direction of its velocity always changes because the velocity is always tangent to the trajectory. This change in the direction of velocity indicates acceleration. This acceleration does not change the magnitude of the speed, but changes the direction of motion so that it must be perpendicular to the velocity and always points toward the center of the circle (Abdullah, 2016). This acceleration is called centripetal acceleration, which etymologically means "towards the center" (Young & Freedman, 2012).

Figure 8 shows that the centripetal force of the spinning wheel Fs_1 keeps the clay spinning in a circular path. In addition, the craftsman's hand provides an additional centripetal force Fs_2 that also points towards the center of rotation. This force serves to prevent the clay from spreading outwards due to the apparent centrifugal force, while also keeping the *cowek* symmetrical during the forming process.

In addition to centripetal force, there is friction between the artisan's hands and the clay surface. This friction helps the artisan control the shape and thickness of the clay during the forming process. If the friction is too great, the surface of the clay becomes rough and difficult to shape. Conversely, if the friction is too small, it will be difficult for the artisan to control the shape of the mortar. The water used on the wet cloth acts as a lubricant that reduces the coefficient of friction, making the shaping process easier and resulting in a smoother *cowek* surface. After that, in the final stage, artisans usually use small stones or pieces of tin to create circular patterns on the inside of the mortar. These patterns are formed from a combination of circular movements of the clay and light pressure from these tools.

d) Work and Energy

In the stage of forming a *cowek* using a perbot, the concepts of work and energy are also applied. This activity can be observed when the craftsman rotates the perbot to form a *cowek* from clay. In general, work (W) is defined as the product of force (F) and displacement (s), or mathematically written as:

$$W = \mathrm{F}\,.\,\mathrm{s} \quad (2)$$

This equation applies to translational motion, which is when an object moves from one point to another in a straight line. However, in the process of making *cowek*, the potter's wheel does not experience linear displacement, but rather rotates around its central axis, so that the displacement that occurs is angular displacement (θ). Therefore, the concept of work in rotational motion is expressed in terms of torque (τ) and angular displacement, namely:

$$W = \tau\,.\,\theta \quad (3)$$

Torque itself is obtained from the product of the force applied by the craftsman on the pestle and the distance from the center of rotation (r), namely:

$$\tau = \mathrm{F}\,.\,\mathrm{r} \quad (4)$$

Thus, when the craftsman's foot rotates the pestle, the force applied at a certain distance from the center produces torque, which then causes the pestle to rotate. Therefore, the work done by the craftsman can be written as:

$$W = \mathrm{F}\,.\,\mathrm{r}\,.\,\theta \qquad (5)$$

In addition, when the craftsman's foot applies force to the potter's wheel, it exerts force on the turntable, producing rotational kinetic energy. This energy causes the clay to spin in a circle following the direction of the potter's wheel. The rotational kinetic energy produced can be expressed by the equation:

$$Ek = \frac{1}{2}\mathrm{I}\,.\,\omega^2 \qquad (6)$$

The process of making a *cowek* also involves the transformation of energy from the craftsman's body into kinetic energy. The energy source comes from chemical energy in the craftsman's body, which is the result of food metabolism. This chemical energy is converted into mechanical energy in the muscles, which is used to turn the potter's wheel with the feet and press the clay with the hands. Thus, overall, the energy conversion in this process takes place gradually, including:

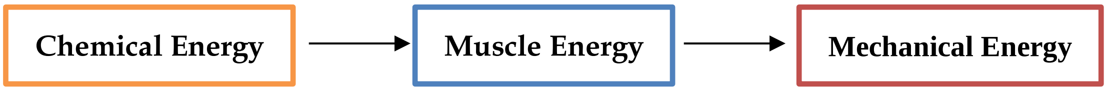

Figure 9. The Transformation of Energy in the *Cowek* Formation Process

3.3 Drying, Burning, and Cooling Processes

e) Temperature and Heat

(a) **(b)** **(c)**

Figure 10. (a) The Process of a *cowek* when aired; (b) The look of the *cowek* ready to be burned; (c) The look of the *cowek* after being burned

A *cowek* that has just been formed using a potter's wheel will have a surface that still looks very wet and shiny. This can happen because there is still a lot of water stored between the clay particles. The texture is easily deformed because the clay is still in a plastic state. Therefore, after the forming process, the *cowek* is aired first to reduce the surface water content and strengthen its initial structure so that it does not crack easily when dried. This initial drying process is important because clay that is still saturated with water is very plastic and prone to deformation. This is shown in Figure 10(a).

The next step is drying, which is done traditionally using direct sunlight. The drying time lasts for 1 to 2 days, depending on the intensity of the sunlight and weather conditions on that day. After 1–2 days of drying, the *cowek* begins to look dry on the surface. The color of the clay changes slightly to a lighter shade, but the inside still retains moisture. Then, legs and dye are added to the *cowek*. After that, it is dried again for about 3 weeks, as shown in Figure 10(b).

In physics, the drying process involves the transfer of heat from the sun to the *cowek*. The main heat transfer occurs through radiation, whereby heat energy from the sun is directly absorbed by the *cowek*, while the air around the *cowek* undergoes natural convection, which helps to remove water vapor from the surface of the clay. When the *cowek* absorbs heat energy, the temperature of the material increases and causes water to evaporate from the pores of the clay. This process is a combination of two mechanisms: (1) Heat transfer, where heat energy evaporates water from inside the material, (2) Mass transfer, where water vapor moves from the surface of the *cowek* into the free air (Handayani et al., 2024). Therefore, the system involved is an open system because the *cowek* releases mass and interacts fully with the surrounding air. The higher the ambient temperature, the faster the evaporation process occurs, significantly reducing the water content of the clay soil.

This reduction in water content causes the clay to harden and become stronger for the firing stage. In addition, drying is important to reduce the water content, because if the water content is not optimally reduced, the water remaining in the pores of the clay will suddenly turn into steam when heated (Wahyuningsih, 2023). This sudden evaporation process increases the internal pressure on the pottery structure, potentially causing cracks and even breakage during firing (Liwun et al., 2025).

Based on interviews with craftsmen, it was also stated that the firing process can only be carried out if the *cowek* has undergone a very optimal drying stage. This drying process lasts for 2 to 3 weeks, and the *cowek* is considered ready for firing when its color changes to a paler or whitish shade, indicating that its water content has been significantly reduced. Physics dictates that excessively high hydration levels will produce pressurized water vapor when heated, creating the risk of cracks due to internal pressure. Therefore, the drying stage is a critical requirement before burning.

In the burning process, the main source of heat is the fire produced from burning fuel such as wood or dry straw. The flame has a much higher temperature than the *cowek*, so heat flows spontaneously from the flame to the *cowek*, in accordance with the Second Law of Thermodynamics, which states that "Heat flows spontaneously from a high-temperature object to a low-temperature object and does not flow spontaneously in the opposite direction."

Additionally, the combustion process involves the transfer of heat through three mechanisms: radiation, convection, and conduction. Radiation occurs when the fire emits heat energy that is directly absorbed by the surface of the *cowek*. Convection occurs when hot air from combustion flows around the *cowek*, transferring heat energy through air movement. Subsequently, the heat absorbed on the outer part of the *cowek* spreads to the inner part through conduction, causing the entire *cowek* to increase in temperature.

The craftsmen say that the burning process needs to be done with the right duration and heat intensity to make a *cowek* like the one in Figure 10(c). If the fire gets too big too fast, the *cowek* tends to be “undercooked,” while burning it for too long can cause overheating, making the ceramic structure brittle. This is in line with the physical concept that the burning temperature affects the sintering process, which is a process of converting grains (ceramic material) into dense and strong ceramic material through heating (Rifai & Hartono, 2016). Suboptimal sintering will produce weaker ceramics, while excessive sintering can cause microstructural deformation.

Color changes in *cowek* during burning are also an important indicator. Based on interviews, excessively high fire temperatures can cause *cowek* to turn reddish, indicating excessive heat exposure. Conversely, *cowek* that is still blackish is usually not fully cooked and requires re-burning. These changes are related to mineral oxidation and thermal transformation in clay materials.

The craftsman also explained that the burning process must be monitored regularly every 3–4 hours to ensure that the fire temperature remains stable. In thermodynamics, the *cowek* burning system is considered an open system because there is an exchange of energy and matter between the fire, air, and *cowek*. Temperature stability is very important to keep the rate of heat transfer under control so that the *cowek* is heated evenly. This is also in line with the results of research conducted by Suroto (2017) that the quality of pottery is largely determined by the perfection of the burning process. Even firing produces strong, high-quality pottery, while imperfect firing tends to make pottery brittle, characterized by cracks in the walls and color differences in the cross-section due to uneven heat distribution. The quality of burning can also be tested by dipping the cooled pottery in water. If cracks appear, it means that the firing process was not optimal. Conversely, pottery that has undergone optimal firing to the oxidation and vitrification stages will show an even red color on both the inside and outside as an indicator of good burning quality (Suroto, 2017).

4. Analysis of the Local Wisdom Potential in *Cowek* Making as a Source of Contextual Learning

The process of making *cowek*, which is rich in physical phenomena, provides a great opportunity to be used as a source of learning that is contextual to students' lives. In the process of making *cowek*, there are a number of physical concepts that can be integrated into learning, including pressure, force and effort, energy, and temperature and heat. Based on the results of a literature review, it is known that pottery making has great potential for use in science and physics learning. Based on the results of the literature, it is known that the pottery making process has great potential for use in learning. The following are some of the results of a literature review on the potential of pottery making, as shown in Table 1.

Table 1. Literature Review on the Potential of Pottery Making in Learning

Number	Authors	Research Title	Main Findings
1	Reka Nurjanah, Shinta Purnamasari, & Andinisa Rahmaniar (2024)	Analysis of the Implementation of Local Potential in Science Education	Local potential can be implemented in modules, e-modules, learning tools, encyclopedias, learning media, and e-learning
2	Daimul Hasanah & Yuli Prihatni (2016)	Development of Physics Modules Based on Local Potential of Kasongan Pottery Crafts in Yogyakarta on Work and Energy	Successfully developed physics modules that integrate the concepts of work and energy with the local potential of Kasongan pottery.
3	Utari Nurfadhilah, Kartimi, & Novianti Muspiroh (2018)	Application of Local Pottery Potential-Based Learning in Sitiwinangun to Improve Critical Thinking Skills	Improved student learning activities and critical thinking skills on the concept of environmental change, as well as positive responses from students with a percentage of receiving 71%, responding 77%, and valuing 79%.
4	Aries Anisa (2017)	Improving Students' Critical Thinking Skills through Science Learning Based on Local Potentials in Jepara	Learning using the local potentials of pottery and furniture in Jepara effectively improved critical thinking skills (sig. 0.000).
5	Valasari Valendra & Suprayitno (2020)	Pottery from Rendeng Village, Bojonegoro, as a Source of Ethnopedagogical-Based Learning in Elementary Schools	Pottery encompasses various scientific aspects such as mathematics, science, social, religion, Indonesian language, and civic.

Table 1 shows that pottery making has strong potential to be used as a source of contextual learning. Research conducted by Hasanah and Prihatni (2016) proves that the pottery process can be integrated into physics material, particularly work and energy, through the development of modules based on local potential. These results show that local wisdom containing physical phenomena can help students understand concepts more concretely. This finding is in line with the research conducted, because the process of making *cowek* also involves various physics concepts such as pressure, force, work, energy, temperature, and heat.

Furthermore, research by Nurfadhilah et al. (2018) and Anisa (2017) also shows that learning based on local wisdom of pottery has the potential to increase student learning activities and critical thinking skills. Students responded positively because the learning felt closer to their daily lives. This is relevant to the use of mortar making as a learning context, as students can directly observe the process, making the understanding of physics concepts easier and more meaningful.

The research by Valendra and Suprayitno (2020) also confirms that the process of making pottery involves various scientific aspects and can be integrated into several subjects through various learning models. These findings reinforce that making *cowek* is not only relevant to physics learning but can also support a broader learning approach connected to the local cultural context.

In addition, a study conducted by Nurjanah et al. (2024) shows that local potential can be applied in various forms of teaching materials such as modules, e-modules, and other learning media. This opens up opportunities for the development of learning tools based on the *cowek*-making process to be more interesting and in line with current learning needs.

Based on the results of the literature review that has been conducted, it shows that local potential such as *cowek* making has a strong basis for use in contextual learning. The manufacturing process contains many physical phenomena that can help students understand the material more concretely, supported by previous research stating that learning based on local potential can increase student motivation, activity, and critical thinking skills.

CONCLUSION

Based on the results and discussion, it can be concluded that: 1) the process of making *cowek* as a form of local wisdom of the community contains various physics concepts that are highly relevant and applicable. Each stage, from clay processing, shaping on the potter's wheel, drying, to burning, incorporates physical principles such as plasticity, pressure, friction, centripetal force, work and energy, changes in form, and heat transfer. These concepts are clearly involved in the way *Anjun* (pottery craftsman) processes clay into strong, hard, and stable *cowek*. 2) Local wisdom such as *cowek* making has a strong foundation to be used as a source of contextual learning because it involves various physical phenomena that can help students understand concepts more concretely and meaningfully. The results of this study have important implications in the field of physics education, particularly in learning based on local wisdom. The identification of physics concepts in the process of making *cowek* shows that traditional activities can be a source of learning that is contextual, concrete, and close to the lives of students. Teachers can use the practice of making *cowek* as a real-life example to explain physics concepts so that learning becomes more meaningful and easier to understand. In addition, integrating local wisdom into learning can help students appreciate regional culture, recognize local potential, and foster a sense of pride in community traditions. Further research can expand the study by analyzing other traditional crafts to add to the variety of contextual physics learning resources based on local wisdom. Researchers can also develop teaching modules, student worksheets, or learning media based on the *cowek*-making process and test them in classroom learning to see their effectiveness in students' understanding of the concepts.

AUTHOR CONTRIBUTIONS

Azizatul Nur Rohmah: Conceptualization, Methodology, Formal Analysis, Investigation, Writing – Original Draft; **Adrian Bagas Damarsha**: Validation, Writing – Review & Editing; **Kifle Kassaw Mulatu**: Validation, Writing – Review & Editing; and **Oka Saputra:** Validation, Writing – Review & Editing

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