



Identification of Science Concepts and Principles Based on Local Wisdom of Pacu Jalur to Develop Science Learning Materials

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Abstract. Local wisdom in Indonesia always considered mystical and taboo to be discussed, while this will be a great potential when viewed from the point of view of science which is then identified and interpreted in the form of a study of scientific treasures. The scientific treasures of course will also be useful if they are integrated in education and used as learning materials. This study aims to identify the science concepts and principles based on local wisdom of Pacu Jalur to develop science learning materials for junior or senior high school. This research used qualitative research with the descriptive analysis of Miles and Huberman model. The sampling techniques of this research were purposive and snowball sampling that collected through the observation, in depth interview, documentation, and literature review. The result of this study indicated that pacu jalur as local wisdom and indigenous knowledge contains many values, including aspects of science. This study should be able to further add to the value of wealth, re-introduce to many people, and enthusiasm to be inherited and preserved such as being a part of local education.

Keywords: Science Concepts and Principles, Local Wisdom, Pacu Jalur, Science Learning Materials

Introduction

The introduction must contain a complete description of the problem that is narrated in a clear and detailed manner and contains the urgency of research supported by authentic data and facts, and ends with a specific purpose. The contents of the introduction are written in the regular Verdana 10 font. It contains discussed background topics, general understanding of terms that are the subject of research, relevant research results that have already existed, research objectives, and reveal the novelty of the paper discussed. The length of the introduction text is at least one full page.

Culture has an important role in social life. A naturally exist culture becomes a representation the rich of pluralism of its value. Culture also becomes an underlying orientation and paradigm of guiding values. Consequently, culture becomes the center of civilization and encourages the influence in daily life. Culture also has the generous connotation meaning. Despite of commonly defined as a result of human thought that had been ingrained then become human habit, but in fact is the culture is not only fastened by the behavior elements but also includes the result of material elements of a more complex form of thought and the load value of it, such as science, language and tradition. Therefore each group of human can have their own culture (Putra, 2019).

Indonesia is a country and a nation which has variety of cultures and traditions. From Sabang to Merauke there are so many local wisdoms that represent the various deep values and meanings of each group of Indonesian society. Local wisdom that had been raised into a culture in society did not appear instantly, however it was a result of customary knowledge that gave the reference and legacy to be carried out traditionally. The customary knowledge is an experienced-based knowledge of life that considers certain cultures or customs by observing and adapting the environmental and natural situations (Gunara et al., 2019). Based on this customary knowledge, the local wisdom will be appeared in various type of culture that further become more specific as local potencies.

Indigenous knowledge and local wisdom are two elements that have strong bond. The indigenous knowledge can be defined as a main topic of cultural discussion while local wisdom is a part of indigenous knowledge itself. Local wisdom is the one of the simple cultural representations that can be interpreted as a culture that exist in certain areas (Ratminingsih et al., 2020). Local wisdom can be defined as a life value that inherited from a generation to generation, such as religion, culture or spoken value in a society's social system. The existence of local wisdom is the result of a lengthy process of adaptation in an environment that inhabited by a group of community which interact one to another (Andriana et al., 2017). Local wisdom is also a cultural value which associated with the society as a guide in thought, action, and behavior. Local wisdom consist of material type such as traditional houses and clothing, regional characteristics and etc. whereas in non-material type the local wisdom could be values and philosophy which strongly held by society as guidelines of life (Uge et al., 2019). Based on the explanation, it can be stated that local wisdom of a culture can't be taken of the identity and the essential elements in society live of a nation. It will be inherent and inherited constantly and it will be a major entity in life. Its status is important and ingrained, the local wisdom and all values will be a philosophy of life and can be represented through the culture that they believe.

Indonesia as an archipelagic state that made up by many islands and escorted by various ethnics, languages, and traditions are evidence that Indonesia is rich in culture. Cultures as virtuous values represent the characteristics and personalities of district and nation. The cultural position is required to be maintained and preserved by everyone since the existence of regional and national cultures will affect each other and give the significant impact on the entity of a country (Febra et al., 2018). Furthermore Febra et al. (2018) explained in the same journal that one of the many cultures in Indonesia, Kuantan Singingi the one of districts in the Riau Province, is a paradise which provides the rich knowledge of local wisdom and noble culture of cultural values. Kuantan Singingi also known as Kuansing or Rantau Kuantan which located in Southwest of Riau Province and the fractional district of Indragiri Hulu.

Kuantan Singingi has many cultures that ingrained and have been inherited from generation to generation either spoken or written. One of the cultures of local wisdom that has been ingrained by the tough customary knowledge and become the most well-known icon in Kuantan Singingi is *Pacu Jalur*. *Jalur* in dialect of Malay of Rantau Kuantan has a different meaning than Indonesian Dictionary. *Jalur* in Malay culture of Rantau Kuantan means *perahu panjang* (long boat) with 25 to 40 meters length (Putra, 2019). Therefore, *pacu jalur* can be defined as a cultural festival competition of traditional wooden paddle boat with its length 25 to 40 meters that called *jalur*. The *jalur* (long boat) has diameter 1 to 1.5 meters and fill by the total 40 to 50 athletes. *Pacu jalur* usually held in Kuantan River. Before the main held in the capital district, Taluk Kuantan, the *pacu jalur* competition firstly held on an area of each Sub-districts (Afrison & Masunah, 2021; Firmanyah & Masunah, 2019). Since the geographical condition of Kuantan Singingi which runs by Kuantan River, the society need transportation to make their activities become easier, therefore there was an initiation to make a boat from the certain timbers, carved beautifully and even there are some boats that decorated with umbrella, rope, shawl, and middle pole.

The type of this boat named *Gulang-gulang*. This boat also used by kings, noblemen, and the leaders of ethnics (group) as transportation in the past (Febra et al., 2018).

Pacu jalur firstly was held to commemorate and celebrate the special day in Islam, however when the Netherlands began to come to Rantau Kuantan, *pacu jalur* held in order to celebrate the birthday of Wihelmina Queen (Firmanyah & Masunah, 2019). Finally, after the independence of Indonesia, *pacu jalur* was set up as an annual festival to celebrate the Indonesia's Independence days in August each year. History has shown that the tradition of *pacu jalur* in Kuantan Singingi is a cultural tradition that has existed since the colonial era to this era. This culture will never be lost and it can always be maintained from generation to generation (Febra et al., 2018). For the society of Kuantan Singingi, Riau province, the tradition of *pacu jalur* is an annual event that has been awaited by kids, adolescence and adult which attract the animo and the enthusiasm of society and tourist (Venydhea & Rosaliza, 2020; Aslati & Silawati, 2017; Mahardi & Erlisnawati, 2019).

The reason of choosing this issue is because *pacu jalur* is a genuine culture of Kuantan Singingi, Riau that have been existed for centuries ago. The culture of indigenous community that has grown and ingrained as an embedded entity in society's life in Kuantan Singingi, a tradition contain the number of elements and interesting value, such as philosophy, history, social-cultural, mythological and magical elements. The mythology about *pacu jalur* has been a traditional story from a generation to the next generation. The mythology contains of many mystical elements as seasoning and attraction. However, it will be more interesting if those available elements and values are augmented and explained rationally and empirically through science. By using the scientific approach, we can find more about *pacu jalur* tradition through more logical and can be proven. Therefore, the philosophy, mythological elements and tradition stories that had been ingrained in community's life as a culture can be more attractive and the substance and its application as it is interpreted through the scientific become more explicit. It is also can give the number of values of *pacu jalur* that society of Kuantan Singingi need to know and understand. Therefore, it will make society become more proud, love and enthusiastic to maintain and preserve it.

In this research, the researcher will identify several basic concepts and principles in *pacu jalur*, for instance toward the perspective of science. The result of identify will be interpreted and explained descriptively in order to explain *pacu jalur* scientifically. Although previously there have been several journals that have researched *pacu jalur*, such as Firmanyah & Masunah (2019) which discusses *pacu jalur* in the artistic aspect, then there are articles by Febra et al. (2018) and Putra (2019) discussing about culture and traditions aspects. Furthermore, there are also articles from Afrison & Masunah (2021); Erlisnawati et al. (2019); Mahardi & Erlisnawati (2019); Supentri (2018) which have interpreted the discussion of the pacemaker in the study of social values and Pancasila, and the article Gazali et al., (2018) which also discusses *pacu jalur* as sports. And so far, publications related to *pacu jalur* are still dominated by discussions of mystical and magical aspects (Venydhea & Rosaliza, 2020; Aslati & Silawati, 2017; Audia & Arianto, 2020; Hasbullah, 2017; Sari, 2017; Supentri, 2018). So that the new idea about scientific studies on *pacu jalur* culture that the researchers did in this article is an update that has not been published so far.

This research also aims to raise and acquaint the native culture oh Kuantan Singingi regency, Riau to the public. Therefore, the research that focus to the culture can be a science and educational for Indonesian people generally and Kuantan Singingi, Riau particularly. Because towards this research, we will see and interpret the original culture from the different perspective, that is through the contextual and scientific approach. The

result of the interpretation can be a means of education for many people, and it can be used as reference of learning resources for teachers and students in learning science in Kuantan Singingi or Riau province. Therefore, This study aims to identify the science concepts and principles of Pacu Jalur to develop science learning materials for junior or senior highschool, which has always been more likely to adopt the western context can be enriched with the contextual material which convenient to the social life background of teachers and students. It can more meaningful and connect directly, since there is a correlation and relation between the science material which have been taught with the original culture and the local wisdom of local society. It will also the one of effort to not overlook the ancestral heritage, increase the understanding, love and pride to the culture that have been become their identity.

Methods

This study used qualitative research with the descriptive analysis. The data analysis used is the Miles and Huberman model which consists of several steps, namely, data collection, data reduction, data display, and conclusion. Miles and Huberman's model steps can be seen more clearly in the image below:

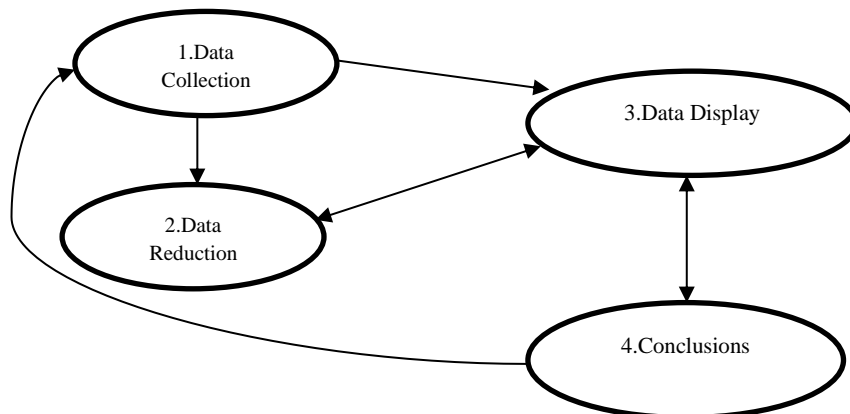


Figure 1. Miles and Huberman Data Analysis Model Stages (Sugiyono, 2019)

As the aim of this study is to identify the science concepts and principles of Pacu Jalur, the researchers need to carry out several stages of the analysis model above. Sugiyono (2019) states that in qualitative study, the data collection is done by natural setting or in actual natural circumstances. The primary data of this research collected through the observation, in depth interview and documentation. Whereas the secondary data is obtained throughout the literature review of some reading sources which discuss about the relevant topic. After it can be collected, then the next step is to reduce the data. Reducing data means summarizing, choosing the main things, and focusing on the important things. So that the data that has been reduced will provide a clearer picture and make it easier for researchers to collect further data. After the data is reduced, the next stage is data display. In qualitative research the data will be displayed in the form of descriptive or narrative text. After the data is reduced and displays, the data can be concluded in the form of descriptive findings that were previously still dim and become clearer. These findings can be in the form of concrete evidence, causal relationships, or theories. This finding will be the conclusion of the research that results in the identification of scientific concepts and principles in pacu jalur culture.

The sampling techniques of this research were purposive and snowball sampling. Purposive sampling is a technique which collects the sample of the data based on a specific consideration. While the snowball sampling is a technique that begins out small but gradually grew larger (Sugiyono, 2019). In this study, there were several considerations for the selection of the sample. For instance the knowledge and the involvement of sources as cultural actors such as the athletes, the managers, the shamans, the reporters and the cultural viewers, in addition to explain the aspect of science, the data collected through the interviews with science teachers (physics, chemistry and biology) and some master students who appropriate with the focus of their study.

After doing the observation, interview, documentation and literature review. The information data obtained is analyzed by triangulation to test the data accuracy. This research is expected to be able to present the result of study that could analyze and describe the elements of science in Pacu jalur tradition in Rantau Kuantan as the local heritage especially in the district of Kuantan Singingi.

Results and Discussion

The Process of Searching The Wood

The district of Kuantan Singingi is bordering on the West Sumatra Province which has a tropical climate with rainy season on September to February and dry season on March to August. The climate system is also affected by local life style. Kuantan Singingi has low land with about 400 meters above sea level. There are two major rivers that run through district those are Kuantan and Singingi River. These rivers have the important roles especially as the transportation means and public activities. Kuantan River run through ten sub-districts those are Hulu Kuantan, Kuantan Mudik, Gunung Toar, Kuantan Tengah, Benai, Pangean, Kuantan Hilir, Kuantan Hilir Seberang, Inuman and Cerenti (Febra et al., 2018). Because of this natural social background, the customary knowledge and local wisdom in Kuantan Singingi such as pacu jalur is dominated by farm-life aspect and Kuantan River.

Based on the results of interviews with cultural leaders who are also commentators on the event of *pacu jalur*, in the process of searching the wood, in ancient times the people of Kuantan Singingi district usually looked for wood to make *jalur* on the Batabuah hill which is a highland hilly area in the upper reaches of Rantau Kuantan and is still included to the Bukit Barisan of Sumatra island. Although wood to create the *jalur* can also be found in other forests or jungles, but at that time the majority of indigenous peoples preferred to take wood there. The process of looking for the wood of *jalur* in ancient times need longer time than now. Because at that time there were still many limitations of the tools or technology used, therefore the tools and facilities that operated were still many with traditional characteristics.

In the article (Aslati & Silawati, 2017; Hasbullah, 2017; Supentri, 2018) explained that to determine the seeking and retrieval of wood for the *jalur*, it usually begins with a conference in the village where the community intends to make the *jalur*. At the discussion several important roles were chosen, such as "parents" of *jalur* who later became elders in the village because of their experience on *jalur*. In addition, several important positions will also be selected for the needs of the administrative process and accommodation such as the committee of *jalur's* production. After the vote completed, the next steps is the discussion of the location of searching the wood, the time, and the mechanism of departure.

After got the decision, the villager society on the agreed day will go to the forest or in the Kuantan Singingi district also known as Rimbo Godang. Rimbo means forest and Godang means big. So, this term refers to the meaning of a large forest or wilderness that is rarely touched by humans.

The interview that the researcher conducted with one of the cultural leaders also revealed that when searching for the wood of *jalur* into the forest, a hundred of villager society joined together. The old, young, teenagers and even adults flocked together to go looking for the desired wood and bring the supply to eat together in the forest. This phenomenon is a reflection of the nuances of solidarity, kinship and brotherhood that are deeply rooted in society.

The timber trees that will be used for *jalur* are usually chosen based on the considerations of the *jalur* maker, lumberjack, and then will be consulted with the elders of the *jalur*. If the elders think the wood is appropriate and in convenient to the desire and needs, the wood will be marked. If it doesn't convenient, the society will look for another wood. Based on interviews with several sources including community leaders who are also connoisseurs of *jalur*, the shaman of *jalur*, the committee of *jalur*, athletes of *jalur*, artisans of *jalur*, and cultural actors such as commentators of *pacu jalur* and supported by relevant article references, according to Aslati & Silawati (2017) and Supentri (2018) the wood chosen for the *jalur* is wood that is tens or even hundreds of years old with a length of about 30-35/40 meters or more, and width 95/100-110 cm with a wood circumference of 4 fathoms an adult or 13 feet. The types of wood used are Mersawa, Meranti, Borneo, and Keruing. These four wooden trees of course also have different characteristics.

The tradition of *pacu jalur* as both indigenous knowledge and local wisdom is recognized as an outcome from the assimilation of art, sport and mentality mystical elements. The number of myths and magical elements that circulated among the local society such as *mambang* or the wooden guardian that resemble supernatural being, some people even said that the existence of the *mambang* affects the fortune of *jalur*. The shaman of *jalur* is believed has a great role and contribution in mystical elements. Its start from determine the timber, the time of *jalur's* departure to the location of competition and even during the competition it made the number of society of Kuantan Singingi believe that the victory of the *jalur* can be obtained and influenced by the shaman. Furthermore, when *jalur* will attend a competition, the shaman will do some rituals, spell (incantation) (Venydhea & Rosaliza, 2020; Aslati & Silawati, 2017; Audia & Arianto, 2020; Putra, 2019).

Further in (Audia & Arianto, 2020) also stated that in the ritual of *pacu jalur* there are some objects that shaman used, such as the black chicken which used to ask permission of the forest guardian and *mambang*, boiled egg and yellow rice (*beras kuning*) as sacrifices, *tepung tawar* that sown around the tree, myrrh (*kemenyan*) to deport the supernatural creature (ghost, evil) that exist around the timber and *jeruk purut* (kind of lime) to the ritual before the competition. Each ritual is related one to another and if there is one ritual is not performed properly, the society assumed that there will be unbalance (Venydhea & Rosaliza, 2020).

When the tree has been selected and determined, before the tree is cut down, the elders of *jalur* will do a special ritual by bringing incense as a request for permission to cut down and bring the tree to the village. It is suitable to the mythology in society of the Kuantan Singingi, there are some large trees that "*berisi*" or have a guardian and some are empty or there is no guardian. According to one the elders or the shaman of *jalur* who was interviewed by the researcher, because of the needs of the trees used for the wood of *jalur*, usually the wood which "*berisi*" or there is a guardian. The magical things like this

only can be seen by the elders of *jalur*. "berisi" or "berpenunggu" means that there is a supernatural being that occupies the tree, so it is necessary for us to ask for permission if we want to cut it down. This supernatural creature is also commonly referred to "mambang". It stated that the mambang of *jalur* sometimes will come to the village when taking the tree. The myth is the mambang of *jalur* that is on the wooden tree will give luck or good fortune and success to the *jalur*. Besides there is or not the factor of "mambang" on the timber of *jalur*, according to the interview that researcher do with an experienced artisan of *jalur*, the characteristics of a good wood tree that can be used as a *jalur* are its presence is close to spring, and the number of tree buttresses (*banir*) is odd. It also refers and suitable to the stories of ancient people. Hasbullah (2017) also adds the characteristics of good and lucky wood are having a *selendang akar*, which is a small wood that grows near a tree and is wrapped around it. The type of *selendang akar* is also considered either hard or soft if the *selendang akar* is hard it is the right decision. In addition, also see the distance of the position of falling trees from the stump, and there is also the opinion that a good wood will fall across the river. Local people also believe that a good wood will also be seized by venomous animals such as scorpions, snakes, and etc.

All interviewees who were interviewed and supported by the researchers' observations all this time explained that the felling of timber trees usually uses a chainsaw, or the Kuantan Singingi community prefers to call it "Sinso" as a term that refers to its original name in English but has become an absorption term in the local language. If we look to the history, before using a chainsaw at the time, in fact in the past, people were more likely to use traditional tools such as axes known as "baliuang". Hasbullah (2017) explained that according to the mythology that believed by the people, the trees will be cut down are cultivated and expected to fall towards the rising sun or east, it symbolizes light and strength so it will give positive energy, optimism, a sign of life, strength, and enthusiasm. So, knocking down a tree on the west side is something that is avoided because it means death and weakness.

After the tree cave in and falls, cutting the tip of the wood as well as cleaning around it will facilitate the process of making a rough *jalur* there. There are two options for the mechanism of this stage after the wood is felled. There are those who immediately return to the village without bringing the wood and there are also those who immediately bring the wood to the village. This mechanism depends on the result of the previous meeting.

According to a leader of community who is also a connoisseur of *pacu jalur* explained that if the decision at the previous meeting was to take it directly to the village, then the fallen tree would be pulled together out of the forest or carried with heavy equipment. The construction of *jalur* on this mechanism will be fully carried out in the village later. Meanwhile, if it is not brought to the village immediately, then the decision on when to bring the wood to the village will be decided on the next meeting. While waiting for the pick-up time by the community, usually the *jalur* builder has started to work by forming the construction of the *jalur* roughly, it aims if later when the wood will be brought to the village it will be easier.

An artisan of *jalur* explained that during this work, the craftsman firstly would start splitting the wood into two parts, the upper and lower by using a chainsaw, this process is called *pendadoan*. Then the craftsman will do *mencaghuak kayu* (wood) which is the process of removing the volumes of the wood by using the "baliuang". This process can take a relatively long time depending on the situation, but ideally this process will take 1-2 weeks. Besides splitting and *mancaghuak kayu* (wood), several other rough constructions will also be carried out by craftsmen while waiting for the community to pick them up. After

the rough construction is completed and *jalur* is ready to be brought to the village, the time of departure and the technical aspects must also be decided.

The process of bringing *jalur's* wood to this village is commonly called "Maelo Jalur". When the day of *Maelo Jalur* come, the community will revert together, from various ages, ranging from young people, adults, to old people will go to location in the forest once again. The process *maelo jalur* from the forest also takes a relatively long time, sometimes it can take months to a year, but sometimes in certain cases it is shorter than that, such as a week or a day. This can depend on the situation and conditions in the field as well as the solidarity of the community.

Maelo jalur process also has a variety of ways and techniques. According to one cultural figure that the researcher interviewed, in the ancient times the society do the activity of *Maelo jalur* by pulling a kind of rattan rope which is usually called *manau*. *Manau* is installed in such a way on the front, body, and back of the *jalur's* wood which has been equipped with safety and bottom base. This is to prevent the wood of *jalur* from colliding or potentially being damaged when pulled. This front guard in terms of the local community is called *Juluang-juluang*. *Juluang-juluang* is made and shaped from several woods that are put together in such a way as to be attached to the *jalur's* wood. Then after it feels ready and safe, the *jalur's* wood will be pulled out to be taken out from the forest.

He further explained that the community still did not use heavy equipment in the *maelo jalur* process therefore this process could take a very long time because it was still pulled manually and several times of intensity because it was not possible to pull it on one occasion. This is because the distance from the forest to the village is quite far however in order to save energy and time, there are also some other techniques in *maelo jalur*. Because of the distance is far, the wood of *jalur* that was pulled from the forest subsequently taken to the Kuantan river in order to be flowed to the edge of the village or it could be by using a speedboat or boat that was intentionally equipped with an engine. However, as the passage of time, the development of tools and technology is increasingly, therefore the process of *maelo jalur* is facilitated adequately and easily, such as by using heavy equipment and large-sized transportation to bring it to the village. Thus the time that takes in process of *maelo jalur* is faster than in the past. If in the past this process could take a total of months or even years, now it can be a week, a few days, even a day. After the wood of *jalur* reaches the village, then the comprehensive process of making *jalur* will be carried out.

The Process of Making Jalur

This process consists of several steps that are complex and detailed to support the quality of *jalur*. The tools used when making *jalur* are *baliuang*, drills, chainsaws, planes, chisels, grinders, and others. Based on the observations and research results obtained by researchers through interviews with the artisan of *jalur*, the shaman of *jalur*, and the culture actors, and supported by literature references such as Aslati & Silawati (2017) and Supentri (2018) explained that the process of making *jalur* has a systematic and structured step. For the details, it will be explained as follows:

The wood of *jalur* which is brought in whole to the village, the first stage of construction is to make *pendadoan* by measuring certain parts with thread. As explained before, this *Pendadoan* is a stage of splitting the wood into two parts and then forming the back and sides of the *jalur* in general. When making *pendadoan* there are usually some parts of the *jalur* that are cut or reduced in size as needed. The process of *pendadoan* usually takes approximately 3 days. After finishing making *pendadoan*, the volumes of the

jalur's wood are removed by using *baliuang*, a traditional axe tool of the Kuantan Singingi community.

After the *pendadoan* is made, it will be continued with *mancaghuak*. *Mancaghuak* is dredging the inside of the wood that has been leveled before. The outcome part of *mancaghuak* will be used as a seat for the athletes during *pacu jalur*. In clearing the width of the contents of the *jalur*, firstly, it is made into approximately 50 cm with a depth of 30-50 cm in the middle. The inside of *jalur* will be fitted with "*panggagh*" and "*ulagh-ulaghan*" as a seat for the people or athletes in the *jalur* race later. This construction stage will last for 1-3 weeks.

The next process will be continued by grinding which aims to smooth the outside or the edges of the *jalur's* wood. This is done to make the body of *jalur* to be more proportional. After that, the *jalur* will be inverted in order to form the lower curvature which called the *perut jalur* (the main center of *jalur*). This process is very complicated because the size of the curved inside must have a proportional and precise size since it will affect the buoyancy of *jalur* on the surface of the water. This process will also be continued with the manufacture of *kakok* holes (*lubang kakok*) which functioned as a mark on the *jalur* in order that the manufacturing process remains precise and suitable to the predetermined size. *Kakok* holes (*lubang kakok*) are made by using a drill in the inside of the *jalur* lengthwise with space 50 cm and 15 cm transversely. The hole will be covered with hard wood and the convenient size for each hole. Afterwards the *jalur* is reversed in order to make lumps which become the foundation of *panggar* or *ulagh-ulaghan* which called *timbuku*. *Timbuku* is made in parallel between the two sides of the body of the *jalur* with space approximately 60 cm for each it.

The next stage is the manufacture of the head or prow of the *jalur* and the rudder or the rear of *jalur*. The manufacture of this section also uses *baliuang* for the first step of the construction stage and uses chisels and grinders at the end to refine and sharpen the aesthetical value of its shape. The prow is made like a boat in general however it is more pointed with a triangular shape measuring 20-35 cm on each of the two sharp sides. The prow of the *jalur* is made with 60 cm to 1 or 1.5 m to the "ear" of the *jalur*. The "ears" of *jalur* are part of the art elements on the left and right sides of the front prow of the *jalur*, usually used as a footstool for the athlete who is sit behind the dancers. While the rear or the rudder with length 2 m.

The height of the prow of the *jalur* is designed and made with a height of 25 cm from the main center of the body of the *jalur* or also commonly called the *perut jalur*. The size is equal to half of the depth of the *perut jalur*. The *perut* of *jalur* or lower body of *jalur* must also be shaped with a proportional curve while the rear of *jalur*, the place of *tukang onjai* will be made about 65 cm taller when it is not loaded and it will be 15 cm from the water surface when it is filled or has a load therefore the *jalur* will be curvy when viewed from front to back. On the rear where the *tukang onjai* stands, there is also an interesting ornament called *sepatuang inggok*, the function of this ornament is to adorn and distinguish the shape of the *jalur* from most ordinary boats.

After the *jalur* have been completely formed, each part, then the next step before the *jalur* will be heated the *jalur* will be re-smoothed, trimmed, as well as repairs to perfect its shape. After that the *jalur* will be heated. This step is a process to develop the main centre of *jalur* or *perut jalur* by burning the top and bottom. Therefore, the contents or the main center of *jalur* where the athletes sit, which initially only measures approximately 50 cm, expands to 90-110 cm. When the heating process, the *jalur* will be raised to the top of the *rampaian* or the place of heating, the height of this place is about 1.20 meters.

The process of heating the *jalur* will spend a few hours approximately 6 hours to all night long it depends on the needs and the circumstances. After the heating process, *jalur* cannot be directly used for *pacu jalur* in the river. However, it must be left approximately 15 days. After 15 days, *jalur* can be used to the *pacu jalur*. In order to enhance the artistic value of *jalur*, it also decorated with motifs, painted, and named according to the identity and expectations of the village from which the *jalur* came. Hasbullah (2017) stated that usually the motif of *jalur* that used is the typical Malay carvings such as flowers, leaves, animals, ferns, and caladium. Supentri (2018) explained that each *jalur* that have been finished will consist of certain parts such as the prow or head (the front of the *jalur*), the "ears" of the *jalur* on the front and back, *Panggar* as a seat for the athletes, the hull of the *jalur*, *Ulagh- Ulaghan* as a place for rowers, *Pandaro* (*jalur's* seeds), and *Candiak-Candiak* or also known as *Salembayung*, which is a unique ornament located at the back of the *jalur* as a handle of *Tukang Onjai*.

Before being competed, the *jalur* will be given a name as an identity and easily recognizable by the community. The *jalur* usually will be named for several considerations such as based on the results of the meeting, the recommendation of the shaman, and some are also adapted from the legends of the community. It can be believed that the name *jalur* is a semiotic theory that has a certain meaning, and it is expected to bring good luck according to the name given. The variations of *jalur's* names are usually adapted the names of animals, plants, mythology, customary terms, names of figures and places, to modern terms (Hasbullah, 2017). These are the names of some famous *jalurs*, such as *Siposan Rimbo* (from *Pauh Angit*, *Pangean* subdistrict), *Limbago Sati Rantau Kuantan* (from *Kopah*, *Kuantan Tengah* subdistrict), *Linta Jalang* (from *Petapahan*, *Gunung Toar* subdistrict), *Palimo Olang Putie* (from *Sungai Alah*, *Hulu Kuantan* subdistrict), *Delima Indah Permata Kuantan* (from *Saik*, *Kuantan Mudik* Subdistrict).

Pacu jalur

Based on interviews that conducted by researchers with one of the most famous commentators, he explained that every position in the *jalur* has a certain philosophical meaning. Like a dancer is the position that is at the very front above the prow of the *jalur* and serves as a marker of the path that is leading or winning. This position is always taken by a kid or little boy around 8-11 years old., which means that the generation of rantau Kuantan which must be able to stand and exist in the midst of the shaking of the waves and always try to stand on the waves. is a position in the middle of the *jalur's* body, which functions as a person who give signals and commands to all athletes during the race. *Timbo Ruang* usually carries *upia pinang* or frond of betel palm which is usually thrown into the water as a sign or signal and gives encouragement to the racing to the athletes. *Timbo ruang* symbolizes a leader in the Kuantan Singingi community. While the *tukang onjai* is the position that is at the rear and the task is *mengonjai* and giving the rhythm to the track and directions to the athletes who positioned in the rudder of *jalur*. *Tukang onjai* in this position are usually taken from the elder people, which have a philosophical meaning as a representation of indigenous people who always provide views, advice, and guidance in social life. The *anak pacu* (athlete) is the main position, consists of several more specific positions such as the rudder who responsible to navigate and direct the *jalur*, the *kabigh* as the one who responsible to assisting the rudder, *luan* and *gandiang* athletes as a consistent position for rowing according to the command of the *timbo ruang*. This is a symbol of the community itself which strives to always maintain solidarity and create the unity (Supentri, 2018). While the position of *Pacu Jalur* potraits can be seen in figure below:



Figure 2. Pacu Jalur in Kuantan River (acaraevent.com, 2018)

According to the data obtained by the researcher, through interviews with several sources and direct observation, it was shown that each *jalur* had various contents of the athletes, however commonly the minimum athletes of a *jalur* approximately 49-50 people and maximum of 60-63 people. Each athlete will be equipped with several important attributes that they will use during this *pacu jalur*, including headbands, Malay clothes for dancers, *timbo ruang*, and *tukang onjai*. The costume for the athlete, water buckets and midrib or commonly called *upiah* from betel palm for *timbo ruang*, a ponytail of various ornaments such as *setawar sedingin*, which is tied in one hand dancer and *tukang onjai*, and paddle which will become an important equipment in *pacu jalur*.

Like most fast racing competitions, the *pacu jalur* also begins the race from the Start. The arena of *pacu jalur* has various routes and track forms, because the shape of the track or racetrack on each bank of the Kuantan river is not always straight, sometimes there are several banks that are designed not to be straight from start to finish. The racetrack is also equipped with *pancang* (stakes). *Pancang* is a start and finish line that functioned to separate and restrict two prows of *jalur* which positioned in left or right and as the guidance that designed aesthetically by giving flags and numbers. In the *pacu jalur* event, there are 6 stakes spread from the start to the finish of the track (Supentri, 2018). The track distances of the *pacu jalur* also varied, but the common length of the track from the start to the finish is approximately 1 KM. *Jalur* that is declared first to reach the finish line or the last stake will be the winner. Due to the increasing excitement of this cultural event, the total number of participants who participate can reach hundreds each year, and adopts a competition format with a knockout, semi-final, and final system which is held for 3-4 days.

Identification of Science Concepts and Principle of Pacu Jalur

Biodiversity Aspect

One aspect of scientific studies contained in the *pacu jalur* culture is the study of biodiversity. In this context, of course, it is about the types of wood used. In the interviews conducted by the researchers, the selection of the type of wood used in making the *jalur* by the community, actually indirectly the people of Kuantan Singingi have studied and applied the concept of plant classification. As previously explained, the selection of this wood is not arbitrary and can use all types of trees. But the choice of wood tree species is used based on many considerations and characteristics that are observed such as type, size, texture, age, and other wood morphology which are a theory and concept of plant biology. This consideration is carried out to support the quality of the *jalur* that will be produced later.

Through in-depth interviews with experts in the world of pacu jalur such as shamans, track makers, athletes, to senior cultural observers, the majority of the wood used in making the track comes from the order of Malvales and the family of Dipterocarpaceae. Classification of this type of wood family is classified as hard and heavy wood trees with a large distribution in Sumatra as many as 111 species or 31.9% (Prasetyo, 2013). This characteristic is also a consideration for this type of wood family, which is often used as a material for making jalur. The types of meranti families used were Mersawa (*Anisoptera marginata* Korth), Meranti (*Shorea* Spp.), Borneo (*Dryobalanops camphora*), and Keruing (*Dipterocarpus*). The characteristics of the wood are explained more fully and in detail through data from interviews with jalur makers and cultural observers as follows:

- 1) Mersawa has a dense wood grain, is durable, does not lose weight quickly when used, and a medium texture, so it is often used as the main choice in making jalur because it is easier to shape. For the Kuansing people, Mersawa trees are also divided into two types, namely those with "alui" and "lowe" leaves. The explanation of these characteristics is further clarified through the data obtained and published on the official website of the Barito Watershed Management Agency (BPDAS) under the auspices of the Ministry of Environment and Forestry in 2020 which noted that in general this tree can reach a height of 45 m with a diameter of 150 cm. The shape of the stem is cylindrical with variants of gray, gray-yellow, gray-brown, and brown colors. Mersawa trees usually have a buttress height of 1.5-3 m and are included in the strength category II-III, durability IV with a specific gravity of 0.64. For more details, the Mersawa taxonomy can be seen as follows:

Kingdom : Plantae
Order : Malvales
Family : Dipterocarpaceae
Genus : *Anisoptera*
Species : *Anisoptera Marginata* Korth

- 2) Meranti (*Shorea* spp.) This tree has a height of 60 m with a trunk diameter of up to 1 m (Patabang, 2013). According to data from DISPERKIMTAN Palangkaraya 2021 through its official website (disperkimtan.palangkaraya.go.id) it is stated that meranti trees have a specific gravity of 0.3-0.86 and include trees with strong categories II-IV and class III-IV durability. The following are more detailed details regarding your meranti classification:

Kingdom : Plantae
Order : Malvales
Family : Dipterocarpaceae
Genus : *Shorea*
Species : *Shorea* Spp.

Based on the results of interviews with researchers with jalur makers and experienced jalur observers, they explained that in the manufacture of track wood, the types of meranti used are usually white and red meranti. According to them, the difference can be seen from the color of the wood flesh. So far, they have also explained that red meranti is more widely used than white meranti because the resistance and weight factors do not change much. Meranti is also classified as a light wood with wood fibers that are not too tight. This breed can be said to be gentler than Mersawa. One of the most noteworthy differences between meranti and mersawa is the meranti's better buoyancy, which affects the ability of the jalur on the river.

- 3) Borneo is the wood name for the Kuantan Singingi community. Actually, the type of Borneo wood has the Latin name *Dryobalanops camphora*. The official length of the BPDDAS Barito (2020) was explained that this type of wood has the characteristics of a height of 35-45 m and a diameter of 80-100 cm with a buttress length of up to

2 m. According to one shaman and a commentator who interviewed the researcher, the characteristics of this type of wood are hard but more durable and are the highest level of wood species used in making jalur. Unlike Mersawa and Meranti, this type of wood has a denser and heavier wood flesh construction. According to the International Union for the Conservation of Nature and Natural Resources (IUCN), this type of wood is included in the red list of the highest rarity category (Prasetyo, 2013). The following is the taxonomy of Borneo tree classification:

Kingdom : Plantae
Order : Malvales
Family : Dipterocarpaceae
Genus : *Dryobalanops*
Species : *Dryobalanops camphora*

- 4) Keruing is also one of the wood trees that is used as a material for making jalur. According to the official website of BPDDAS Barito (2020), this tree is a medium to large tree with alternating leaves and varying sizes. Taxonomically this tree can be classified as follows:

Kingdom : Plantae
Order : Malvales
Family : Dipterocarpaceae
Genus : *Dipterocarpus*
Species : *Dipterocarpus Sp*

Jalur wood usually comes from trees that are categorized as an Angiospermae Spermatophyta plant classification. The obvious characteristics of this plant are having an ovary or seeds protected by two fruits, large and tall trunk, the sporophyte form has roots, stems, flowers, and leaves. The roots of this plant have two types, namely fibers and taproots. The stem is mostly cambium for dicots and not cambium for monocots. In this case, usually the jalur wood tree is a dicotyledonous type with two institutional leaves, finger bones, and carrier bundles in a circle and reproduces generatively or mating (Irnaningtyas, 2013; Widodo et al., 2016).

Scientifically, the factors that influence the characteristics of the wood chosen to be used as jalur such as the size and shape of the tree can be caused by internal and external factors of the plant itself. According to one of the biologists interviewed, the internal factors are hormones and the tree's genetics. This is relevant to Campbell et al., (2012) who also explained the influence of the auxin, cytokines, and gibberellins hormones on plant size. So that a tree that has good genetics and active hormones will have the potential to make the tree bigger and taller.

Biologically, this wood is suitable to be used as a jalur because it is easy to shape and soft or durable. This is due to the fact that the tree in this jalur is a dicotyledonous species, so the large and tall stems are theoretically due to the activity of meristem tissue whose cells are always actively dividing by mitosis. This meristem consists of two kinds, namely primary meristems at the tips of roots and stems which have an influence on the length or height of roots and stems. Meanwhile, secondary meristems which are mature cells with meristematic ability that can again divide like cambium which is located between xylem and phloem cause this tree to be large (Zubaidah et al., 2017)

External factors also greatly affect the characteristics of trees such as the environment and adaptation to their habitat. So that this factor will also indirectly form a tree structure from the outside. Because by adjusting to their habitat, the majority of Kuantan Singingi people look for trees as the basis for wood raw materials for jalur to

tropical rain forests with their distinctive characteristics which will be explained in more detail next.

According to the story of the ancients, in addition to considering the size and type of wood, in choosing wood trees to be used for the jalur, they must prioritize choosing trees that are close to springs. Scientifically this is certainly rational and logical, because environmental factors like that are very supportive and influential on the tree. A plant that is near a spring such as a river will make the plant rich in minerals and get a very sufficient supply of nutrients. Because through this condition the plants will absorb a lot of nutrients that are good for tree growth, so the lignification process on the stems will be better than plants that are far from water sources. Therefore, trees in forests that tend to be near water sources will have the ideal size to be used as wood for making jalur.

The facts about the influence of butchers are also in line with the above theories and concepts. Buttresses will make a tree stronger. The robustness of a tree is indispensable in the wood of jalur. It is natural according to the mythological story of the local community, to choose a good wood tree, one must also consider the presence of buttresses. Although for the problem of a little or a lot and an odd or even number, it can't be fully proven scientifically. But this could be a meaning of the philosophical value of the wood tree itself for the local community.

Science Concepts and Principles of *Maelo Jalur*

Force

In principle, to be able to pull the logs that have been cut down, of course, the community will pull together using a rattan rope called manau as described above. In this process, when viewed from the point of view of science, there are many concepts and principles of science that are used during this process. Like the general concept of force, momentum, and work and energy.

Force can simply be interpreted as a pull or push that can change the shape, direction, and speed of a material (Tipler, 1998; Zubaidah et al., 2017). This concept and applied directly in the *maelo jalur* as the main solution to be able to take the route outside the forest or to the village. In this pulling process, of course, the community will apply a pulling force on the wood to be able to move it, the jalur that was originally stationary or not moving will begin to change position when the community is given a pulling force in a certain direction.

When the wood of this jalur moves, naturally there will be friction between the bottom surface of the track and the ground. This frictional force is a physical and direct contact force between two surface objects which is microscopically caused by the binding force between the molecules (Hardiansyah, 2021; Kanginan, 2013; Tipler, 1998; Zubaidah et al., 2017). The direction of this frictional force will always be opposite to the direction of motion of the object in this context is the jalur that is drawn. When the wooden track is pulled with a certain force, in this case we assume the magnitude of the force is \mathbf{F} , then when the force is applied to the track wood, the objects at that time will also have a frictional force. As long as the track wood has not moved, the frictional force that applies is called static friction. The value of static friction will increase from 0 to the maximum value of the friction force. But when the wooden track starts to move because it is pulled, the value of the friction force will drop to a constant value, and this frictional force is called kinetic friction (Kanginan, 2013).

The magnitude of the static frictional force between the wood surface and the ground can be formulated as $f_s \leq \mu_s N$. Where f_s is the static friction force, μ_s is the coefficient of static friction, and \mathbf{N} is the normal force. Meanwhile, the kinetic friction force is formulated as $f_k = \mu_k N$, where μ_k is the coefficient of kinetic friction. The value

of this coefficient depends on the nature of the two surfaces in contact (Kanginan, 2013; Tipler, 1998).

In addition to the tensile and frictional forces, there are actually other forces acting on the maelo process, including the tension force on the rope, gravity, and the normal force on the wood itself. In Kanginan (2013) explains that the rope tension force (**T**) is a tension force acting on the ends of the rope because the rope is tense. The tension in the rope in this context is caused by the pulling force on the rope when it is moving. Meanwhile, gravity is usually symbolized by **W**. This force is defined as the earth's gravitational force acting on an object. It is formulated as the product of an object's mass with its gravity. The direction of this force is always perpendicular to the earth's surface towards the center of the earth wherever the object is placed. While the normal force is defined as the force acting on the contact area between two touching surfaces whose direction is always perpendicular to the contact area. This force is symbolized by **N**. For more details, see what styles work when maelo this jalur can be seen in the image below:

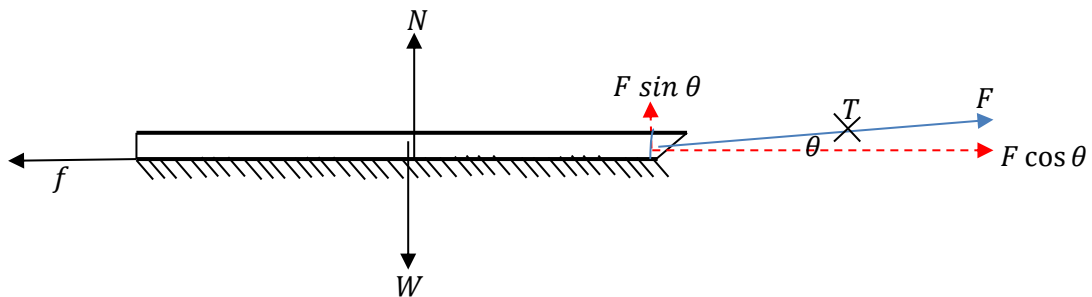


Figure 3. Force on *Maelo Jalur*

Description:

F = The applied pulling force

N = Normal force

W = Gravity

f = Frictional force

T = Tension force on the rope

θ = The angle of the force to the direction of displacement

Newton's 2nd Law

The concept of acceleration is studied in more detail in Newton's 2nd Law. Because when the wood is pulled, the wood will move and there will be acceleration from what was originally at rest. Mathematically Newton's 2nd law is usually written $a = \Sigma F/m$ and it is interpreted that the acceleration produced by the resultant force acting on an object is directly proportional to the resultant force; in the direction of the resultant force, and inversely proportional to the mass of the object. In this phenomenon, it is the increase in speed or acceleration that occurs when the track wood is pulled which was previously stationary or has a constant speed due to the force acting on the wood. If the force applied is greater, the acceleration of the wood when it is pulled will also be faster. It can be concluded that Newton's 2nd

law will occur on an object whose resultant force is not zero which causes the object's speed to always change or accelerate (Kanginan, 2013).

Through the diagram of the force in the image above we can calculate how much acceleration is given to the wood jalur so that it moves using the equations of Newton's 1st and 2nd laws. More details through mathematical work as follows:

$$\begin{aligned} \sum F_x &= ma & \sum F_y &= 0 \\ F \cos \theta - f &= ma & N + F \sin \theta - W &= 0 \\ F \cos \theta - (\mu k \cdot N) &= ma & N &= W - F \sin \theta \end{aligned} \quad (2)$$

$$a = \frac{F \cos \theta - \mu k(W - F \sin \theta)}{m} \quad (1)$$

So, to move the jalur when it is pulled, the people who participate in this jalur must provide a minimum acceleration of a value.

Work and Energy

As explained above that style can make a difference. If a force is applied to a stationary object, the force will gain speed, if it is applied to a moving object, it will get an acceleration or deceleration (Kanginan, 2013). In the study of dynamics of motion, a moving object is considered on the basis of a force as the cause. In this case of course there is effort given to the force. Work can be written mathematically in the form

$$W = F_x s = (F \cos \theta)s = F_s \cos \theta$$

where W is work, F is force, θ is the angle between F with to s , and s is displacement. Work can simply be summed up as the product of a component of a force that is parallel to its displacement and magnitude. The greater the applied force and the displacement that occurs, the greater the work value (Paul A. Tipler, 1998; Zubaidah et al., 2017). However, it should be observed more deeply that in the actual context, the size of the business is also influenced by the factor of the angle of the applied force F .

When a movement occurs, in the context of a *maelo jalur*, a displacement will be counted. As with the concept of work, an activity is said to be given work when the object given the force has a resultant direction of force $< 90^\circ$, because if it reaches 90° then the value of the work will be zero due to the formulation of $W = F_s \cos 90^\circ = 0$. If in the event of a wood displacement of this jalur the resultant direction of the force is $< 90^\circ$, then the wood of the jalur is declared to be given work. The smaller the angle, the greater the force exerted and vice versa. This is proven if the applied force (F) is in the direction of the displacement with an angle of 0° , the work will reach a maximum value. The value of work on the *maelo jalur* according to the picture above can also be calculated mathematically through the application of the business equation as follows:

Work by gravity (g):

$$\begin{aligned} W &= F_s \\ W &= mgs \end{aligned} \quad (3)$$

Work by F :

$$\begin{aligned} W &= F_s \\ W &= F \cos \theta \cdot s \end{aligned} \quad (4)$$

Work by f :

$$\begin{aligned} W &= F_s \\ W &= -f \cdot s \end{aligned}$$

$$W = -\mu k N \cdot s \quad (5)$$

The three works above when added together will result in the total works given by the community at the time of *maelo jalur* through the mathematical form $W_{total} = W_{gravity} + W_{force} + W_{friction}$.

In addition to affecting the displacement of the object's position, work is also related to its change in the velocity of the object. The work that affects the speed is called kinetic energy (Supiyanto, 2007). Energy which in principle is the ability to do work which can be valuable as potential energy on an object because of its position while it will have kinetic value when moving or changing positions (Widodo et al., 2016).

The kinetic energy in this maelo process arises because it is caused by the velocity of the force exerted on the jalur that makes it move. So mathematically when the mass of wood is multiplied by the speed squared it will produce kinetic energy in the jalur. The kinetic energy of the strip wood can be calculated by the formula $E_k = \frac{1}{2}mv^2$.

Momentum

A significant difference between kinetic energy and momentum is the type of magnitude. Although both of these quantities depend on the mass and velocity of an object, kinetic energy is a scalar quantity that does not accompany the direction of the object's motion. Meanwhile, momentum, which is a vector quantity, can provide a direction of motion which is seen as a measure of the difficulty of settling the particle (Tipler, 1998; Supiyanto, 2007). This process also contains the concept and principle of momentum. According to Einstein, an object is said to be in motion if it has momentum. The concept of momentum is formulated in the form $p = mv$, where p is momentum, m is mass, and v is velocity. An object is said to have momentum when an object or particle of that mass has a velocity value in a certain direction. In this process, the jalur which of course has mass is pulled so that it experiences a position shift, in that position shift the track wood has a velocity value that has a direction of motion, so in this process the jalur can be identified as having momentum.

Science Concepts and Principles of Mendiang Jalur

Temperature is the degree of hotness or coldness of an object, while heat is the transfer of energy from one substance to another due to a temperature difference (Kamajaya & Purnama, 2016; Kanginan, 2013, 2017; Widodo et al., 2016). In concept, the increase in temperature of an object depends on the type, because the greater the mass and the increase in temperature of an object, the heat required will also be greater (Widodo et al., 2016)

As previously explained, the *mendiang jalur* process of burning wood jalur that have been completed for the purpose of flexing and widening the "perut" or hull of the jalur. In the deceased line, the temperature of the fire must be considered, because the temperature must not be too hot or below the specified temperature. This means that the temperature must be right in order to be able to flex or expand the section of the jalur. The heated part of the track is the lower part of the track belly and the inside of the track belly. So that initially the belly of the track only has a width of 50 cm, it expands and widens by 90-110 cm.

The function of the *mendiang jalur* is also to flex the jalur through being heated, where when heated in a certain temperature range on an object there will be calor released from the combustion activity. So that heat transfer occurs by radiation (Kanginan, 2013). Radiation is the transfer of heat without the need for a

medium through the emission of electromagnetic energy which is influenced by the hotter and surface area of the object, the greater the heat to be radiated, and the lower and darker an object is, the greater the heat received will also be (Kamajaya & Purnama, 2016; Kanginan, 2017; Widodo et al., 2016).

The influence of the activity of the *mendiang jalur* will also cause expansion. Expansion is the phenomenon of changing the shape and size of a material as a result of the impulse between the molecules that make up a substance when heated so that the distance between the molecules becomes larger and occupies a wider space (Kamajaya & Purnama, 2016; Kanginan, 2017; Widodo et al., 2016). The magnitude of this expansion will depend on the type of substance that makes up the object, the initial size, the magnitude of the increase in temperature, and the coefficient of expansion of an object. The coefficient of expansion is the ratio between the growth of stem length from its original length for every unit increase in temperature (Kamajaya & Purnama, 2016). Because the jalur is a three-dimensional object so it will apply the expansion of length, area, and volume.

This expansion will also cause a change in the density of the jalur. Because it is in accordance with the concept of density which is expressed mathematically through $\rho = \frac{m}{V}$. When the value of the jalur volume increases, so that through the mathematical relationship above, the value of as the density quantity will decrease. This is based on the inverse relationship between the two variables. This is what makes the jalur lighter than before after being killed.

Science Concepts and Principles of Pacu Jalur

Fluid Dynamics

When the jalur is able to float on the river, it does not mean it is due to the reduced mass of the jalur (Zubaidah et al., 2017). Because in principle, the pressure on a flowing fluid will depend on several variables such as density, fluid flow velocity, or depth (Kamajaya & Purnama, 2016). So, in the phenomenon of the floating of the jalur on the surface of the water, it proves that there are other physical factors working on the jalur at that time. This phenomenon can actually be explained through Archimedes' law. Mathematically this law can be formulated as follows $F_a = \rho g V$. Where, F_a is the floating force, ρ is the density, g is the gravity, and V is the volume of the object.

Archimedes' law is expressed as the buoyant force of an object when immersed in a fluid equal to the weight of the fluid displaced by the object (Kamajaya & Purnama, 2016; Kanginan, 2013, 2017; Tipler, 1998; Supiyanto, 2007; Zubaidah et al., 2017). The buoyant force here is meant to be an upward force exerted by a fluid substance on an object (Kanginan, 2013, 2017; Tipler, 1998). When the jalur is in the river, this buoyancy force is required given by the pressure of the river water. The jalur will float if the buoyant force is greater than the weight of the jalur. In addition, this buoyant force is also influenced by the influence of the density of objects and water, so that the density of the jalur must be smaller than the density of water. One solution to reduce this density has been carried out at the stage of the *mendiang jalur*. For more details, see the image below:

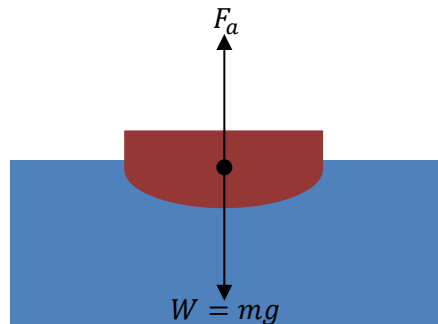


Figure 4. Buoyant Force of Jalur

When the race starts, all the racers must be ready and must not be careless. In the world of pacu jalur, there are two types of starting techniques, namely the usual start or start with a square off and a hanging start without a square off. Based on the results of the researcher's interview with a pacu jalur, he said that the starting technique used on a jalur depends on the jalur and the racers. Start with a square off or also commonly called Start "*lajak*" or "*Ujo*" usually use a heavy jalur, if the light jalur on average most usually prefer to use a hanging start in front of the stake because it is enough to quickly raise the bow of the jalur. This is of course relevant to the existing concepts and principles of physics, such as the principle of lift and thrust of the oars on the jalur which also depends on the pressure on the river water. The pressure exerted by the oar is of course also directly proportional to the applied force.

In principle, to be able to move the jalur is not just rowing. But there is a major factor called raising the "*stomach of jalur*". Raising the belly of the jalur is a way of pacu jalur, where when the jalur is stationary or not moving, 1/3 of the jalur floats on the surface of the water. When rowing, a force will be exerted on the jalur through the pressure of the cross-sectional area of the oar in the water, so that it will raise the "*stomach or body*" of the jalur until it becomes 2/3 of the floating part. When the belly of the jalur has gone up, the track will immediately slide quickly when rowed in a race. Actually, physically raising the belly of jalur means providing additional lift or buoyancy on the track by immersing the oar with a certain cross-sectional area so as to apply pressure and provide lift to the jalur. This phenomenon corresponds to and uses the concepts and principles of pressure in fluids and Archimedes' law.

As explained by one of the observers of the runway, to provide a stance on the jalur that takes the "*Lajak*" or "*Ujo*" Start Technique, it requires a jalur of 25 m before the start stake if it is converted into a calculation of the intensity of rowing frequency. The "*koghuak*" technique is 10-15 times rowing for wood. Temporary weight for light wood is enough only 4-5 times. However, the only drawback is the jalur with light wood, if the intensity of the rowing of the racers is unstable or loose it will cause the bow of the jalur to fall back down, in contrast to the jalur that tends to come from heavy wood, the position of the bow is more stable. although at some point in time when the race starts the position of the rising line's bow will be more constant. This can be proven by assuming that two pieces of wood consisting of 1 piece of wood that is a bit heavier and the other lighter we push together with the same force will make the wood that is a bit heavier slide more quickly and stably. This results in the majority if the jalur with a rather heavy mass has won or is leading in front of its opponent it will be difficult to catch, but if the jalur with a

lighter mass is doing rowing intensity that is always stable and constant then it will also be difficult to precede, this phenomenon is actually also depending on the construction and racing strategy that the track applies.

In the suspended start state, this situation will actually benefit the lighter route or the one that is easier to raise the jalur belly, while it will be more likely to be detrimental to the heavy mass line because it will be slow and require time to raise the jalur belly. Because on a light jalur, only a few forces from the paddles provided will provide and add lift to the jalur which makes the stomach of the track easy to rise and ready to slide. Meanwhile, on a heavier mass jalur, more rowing intensity will be required in terms of the force applied to provide additional lift to raise the belly of the jalur for direct gliding in the race.

Motion Dynamics

When moving, the jalur adopts the concept and principle of Newton's 3rd law, namely $F_{action} = -F_{reaction}$. The action force is given by pushing the paddle backwards so that it will provide a reaction force on the jalur to move forward, this principle is almost similar to how a rocket works. The action force given will produce the same value for the reaction force, so the greater the force given by the racers by rowing backwards together, the reaction force on the jalur to move forward will be faster, where the direction of the action-reaction force will always be opposite. directions, for more details can be seen in the illustration of the runway image below:

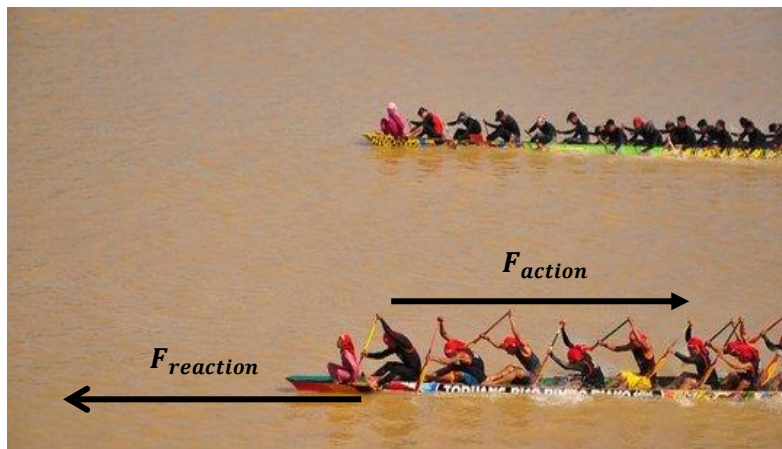


Figure 5. Newton's 3rd Law of Jalur (Merdeka.com, 2021)

In addition to the concepts and principles of Newton's 3rd law, when the jalur is accelerated, of course, it also adopts the concepts of work, energy, and momentum. In this study the force applied to the jalur to move with a certain displacement can be said to be a physical work. As previously explained, the concept of work will also be accompanied by kinetic energy because an object with mass in this context is a jalur moving with a certain speed. So, the value of the kinetic energy of the jalur is the product of the square of the jalur speed and its mass. The magnitude of the force, acceleration, and energy at the time of running this track can be calculated using the force diagram below:

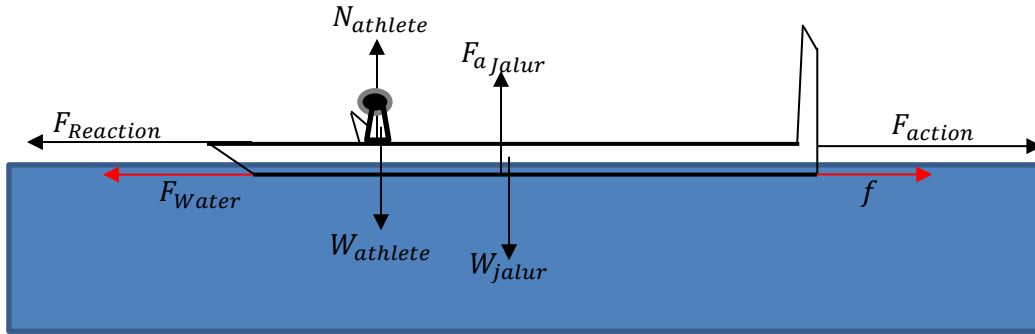


Figure 6. Motion Dynamics of Jalur

$$\begin{aligned}
 \Sigma F_y &= 0 \\
 N_{athlete} + F_{a_jalur} - W_{jalur} - W_{athlete} &= 0 \\
 N_{athlete} &= W_{jalur} + W_{athlete} - F_{a_jalur} \\
 N_{athlete} &= \rho_{jalur}gV_{jalur} + \rho_{athlete}gV_{athlete} - \rho_f gV_t \quad (6)
 \end{aligned}$$

$$\begin{aligned}
 \Sigma F_x &= ma \\
 F_{reaction} + F_{water} - F_{action} - f &= ma \\
 F_{reaction} + F_{water} - F_{action} - (\mu k \cdot N) &= ma \\
 F_{reaction} + F_{water} - F_{action} - (\mu k(\rho_{jalur}gV_{jalur} + \rho_{athlete}gV_{athlete} - \rho_f gV_t)) &= ma \\
 a &= \frac{F_{reaction} + F_{water} - F_{action} - (\mu k(\rho_{jalur}gV_{jalur} + \rho_{athlete}gV_{athlete} - \rho_f gV_t))}{m} \quad (7)
 \end{aligned}$$

Work by gravity:

$$\begin{aligned}
 W &= Fs \\
 W &= (W_{athlete} + W_{jalur})s \\
 W &= (m_{athlete}g + m_{jalur}g)s \\
 W &= (m_{athlete} + m_{jalur})gs \quad (8)
 \end{aligned}$$

Work by force:

$$\begin{aligned}
 W &= Fs \\
 W &= (F_{reaction} + F_{water} - F_{action})s \quad (9)
 \end{aligned}$$

Work by friction:

$$\begin{aligned}
 W &= Fs \\
 W &= -fs \quad (10)
 \end{aligned}$$

So that the total work done when the jalur is racing is the result of the accumulation of the 3 works above. The physics calculation simulation above is only

a mathematical approach by still ignoring many other variables in order to simplify and simplify equation simplification. Although in fact and in reality, there may be many other factors that influence and other unexpected events that the researchers have not specifically included.

In connection with the concept of work and energy, the jalur that is moving can also be viewed from its momentum. The momentum (p) of the jalur can be calculated by multiplying the mass of the jalur and the load (m) with the speed of the jalur (v) at the time of the race. An object with mass such as a jalur will have a large momentum if the action-reaction force gives a large push so that it increases the speed of the jalur, thus the momentum of the jalur will also be large. Vice versa if the action-reaction force is relatively small, so that the thrust is only able to provide a modest speed, this will result in a small momentum value. In accordance with the previous fact that since the jalur speed is not constant, we can use the instantaneous velocity to calculate the kinetic energy and momentum at a given time, and the average velocity if we want to know the kinetic energy and momentum of the jalur in the overall distance traveled during the race.

Newton’s Law of “Pancang”

The “Pancang” in the middle of the river as a reference for the barrier between the left and right bows of the racing jalur can be simulated in the form of a diagram of the working forces. “Pancang” that are designed in such a way have a ballast stone so that the “Pancang” remains in its position and is not carried away by water currents. In accordance with the concepts and principles described above, so that the “Pancang” does not move and is always in a predetermined position, it can be simplified through Newton’s law. A more in-depth explanation can be seen in the image below:

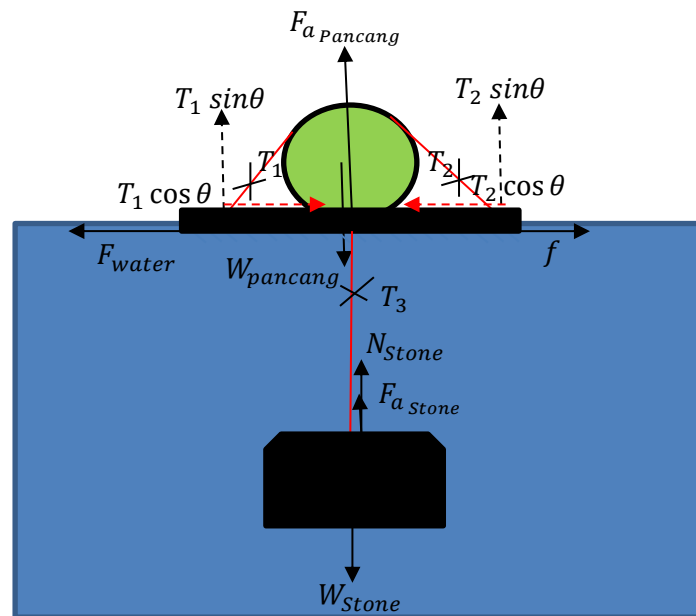


Figure 7. Newton’s Law of Pancang

Through the picture of the "panang" force diagram above, it can be calculated the value of the force acting so that the stake does not move as follows:

$$\begin{aligned} \sum F_y &= 0 \\ F_{a_{panjang}} + T_1 \sin \theta + T_2 \sin \theta + N_{stone} + F_{a_{stone}} - W_{pancang} - T_3 - W_{stone} &= 0 \\ N_{stone} &= W_{pancang} - W_{stone} - F_{a_{panjang}} - T_1 \sin \theta - T_2 \sin \theta - T_3 - F_{a_{stone}} \end{aligned} \quad (11)$$

$$\begin{aligned} \sum F_x &= 0 \\ F_{water} + T_2 \cos \theta - T_1 \cos \theta - f &= 0 \\ F_{water} + T_2 \cos \theta - T_1 \cos \theta - (\mu s \cdot N) &= 0 \\ F_{water} + T_2 \cos \theta - T_1 \cos \theta - (\mu s \cdot (W_{pancang} + W_{stone} - F_{a_{panjang}} - T_1 \sin \theta - T_2 \sin \theta - F_{a_{stone}})) &= 0 \end{aligned}$$

$$\mu s = \frac{F_{water} + T_2 \cos \theta - T_1 \cos \theta}{W_{pancang} + W_{stone} - F_{a_{panjang}} - T_1 \sin \theta - T_2 \sin \theta - T_3 - F_{a_{stone}}} \quad (12)$$

In the simplification of the above equation, it can be concluded that in order for the stake to remain stationary and in its original position, the coefficient of static friction is the resultant of the water force and the tension on the top of the pile divided by the resultant tension of the rope 3, the gravity of the "Pancang" and the ballast stones and subtracting the value of the rope tension. 1, 2, and rock pumice style. With the conclusion that the value of $w_{stone} > N_{stone}; F_{a_{stone}}; W_{pancang}; F_{a_{panjang}}$. The above simulation is just a mathematical approach by still ignoring many other variables in order to simplify and simplify equation simplification. Although in fact and in realit, there can be many other factors that influence and other unexpected events.

Conclusion

The result of this study indicated that pacu jalur as local wisdom and indigenous knowledge contains many values, including concepts and principles of science. Such as biodiversity, kinematics and dynamics of motion, fluid dynamics, and so on. This study should be able to further add to the value of wealth, re-introduce to many people, and enthusiasm to be inherited and preserved such as being a part of local education.

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