



EFEKTIVITAS MEDIA PEMBELAJARAN DENGAN SIMULASI PHET DAN OLABS PADA MATERI MASSA DAN PEGAS KELAS X DI SMA NEGERI 1 SEI. AMBAWANG

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Abstrak

Penelitian ini bertujuan untuk mengetahui efektivitas penggunaan media pembelajaran berbasis simulasi PhET dan OLabs pada materi massa dan pegas di kelas X SMA Negeri 1 Sei. Ambawang. Latar belakang penelitian ini berawal dari keterbatasan fasilitas laboratorium di sekolah yang menghambat pelaksanaan praktikum fisika, sehingga diperlukan alternatif media berbasis digital untuk mendukung proses pembelajaran. Metode penelitian yang digunakan adalah kuasi eksperimen dengan desain pretest-posttest kontrol group. Sampel penelitian diambil dengan teknik random sampling dari siswa kelas X. Instrumen penelitian berupa tes pilihan ganda digunakan untuk mengukur hasil belajar siswa sebelum dan sesudah perlakuan. Hasil penelitian menunjukkan adanya peningkatan signifikan pada hasil belajar siswa setelah mengikuti pembelajaran menggunakan simulasi PhET maupun OLabs. Perbandingan nilai pretest dan posttest mengindikasikan bahwa kedua media tersebut efektif membantu siswa memahami konsep massa dan pegas. Selain itu, pembelajaran dengan simulasi juga mampu menciptakan suasana belajar yang lebih interaktif dan memotivasi siswa untuk aktif dalam kegiatan belajar. Dengan demikian, dapat disimpulkan bahwa penggunaan media pembelajaran PhET dan OLabs terbukti efektif dalam meningkatkan pemahaman konsep fisika siswa, serta dapat menjadi solusi inovatif untuk mengatasi keterbatasan sarana laboratorium dalam pembelajaran fisika.

Keywords : Efektivitas, Media Pembelajaran, PhET, OLabs, Massa dan Pegas

cial status of the palace relatives. This began when Mataram was led by Sultan Hamengku Buwono VII, around the early 19th century. At that time, commoners were not allowed to use andong. People were only allowed to use ox carts. During the reign of Sultan Hamengku Buwono VIII, andong gradually began to be used by the general public, although it was still limited to businessmen and traders (Pratama, 2016) .

In cities like Yogyakarta, andong is an important part of social and cultural life, and continues to be maintained today even though it has been largely replaced by motorized vehicles. Andong remains a cultural symbol that is closely associated with the identity of the city of Yogyakarta. (Dian Deliana & Prajnanta Final, 2023) . Although motorized vehicles have dominated the modern transportation system, andongs remain as one of the tourist attractions. Tourists often use andongs to get around the city or enjoy the traditional atmosphere, such as going around the Yogyakarta Palace or the famous Malioboro area. (Hadi, 2019) .

In recent years, andong is not only considered as a means of transportation, but also as an important cultural heritage, reflecting the pride and local wisdom of the Javanese people. In fact, andong has become part of the cultural preservation effort, where the government and local communities work together to maintain its existence as a symbol of tradition. However, on the other hand, andong also faces the challenges of modernization, with the emergence of issues related to safety, animal welfare, and impacts on the environment. (Rakhmad, 2021) . Nevertheless, the andong phenomenon currently continues to attract interest, both as a tourist attraction, a cultural symbol, and a lesson on the application of the principles of physics underlying motion and energy in traditional transportation systems.

Physics is a branch of science that studies various phenomena in human life, both on the smallest and largest scales. For example, the study of the smallest unit of atoms to discuss celestial bodies. This complex study of physics is interesting to discuss so that it can become useful knowledge for life. In the

current educational scope, physics has become a bugbear for students. (Harikrishnaprabu & Annapooranam, 2019) . In addition, physics is a science that studies the nature and symptoms of nature or natural phenomena in terms of matter and energy and all the interactions that occur in it. Physics is basically a fun and interesting material to learn. This is because everyday life is much related to the concept of physics. (Kristiyanto, 2022) . However, in reality, many students think that physics is difficult, scary, unrelated to everyday life and monotonous because textbooks are limited and less interesting for students to read or study. (Komalasari, 2014). One real picture in the concept of physics can be presented in a contextual form that can be done in the physics learning process.

Contextual physics learning is a more interesting learning alternative for students. Contextual learning in practice connects conceptual domains that contain theories which are then linked to the more realistic and real everyday world (Wahyuni, 2023) . By applying the principles of contextual physics learning, learning will be more meaningful for students, because students will work scientifically and experience it themselves, not just channeling educator knowledge to students (Milanto et al., 2023) . Therefore, contextual physics learning can help convey physics and surrounding phenomena to students, one of which is through traditional andong transportation.

In the context of physics, andong can be analyzed through various basic concepts such as force, motion, energy, and Newton's laws. The existence of this analysis can be a special attraction in physics that is contextual to the local heritage, namely andong. In the simple motion of andong, various physics concepts of Newton's law principles are stored. Newton's laws have three basic principles in physics that explain the relationship between the force acting on an object and the motion it causes. These laws were formulated by Sir Isaac Newton in the 17th century and became the foundation for classical mechanics that can be associated with andong motion. (Muhamad Taufiq & Ida Kaniawati, 2023) . For example, when the andong is moving, the force applied by the horse to pull the cart will produce an acceleration that can be calculated based on the mass of the andong and the horse and the force applied. In addition, in terms of motion, the

application of Newton's law is very visible, where the total force acting on the andong must be proportional to the acceleration produced (Santos & Silva, 2021) . In addition, the attractive design of the andong in terms of the shape of the carriage, the arrangement of the seats, and the shape of the wheels are also related to physics. Of course, in all aspects of objects in everyday life, the application of physics can be found, such as andong. Thus, andong is not only a traditional means of transportation, but also a relevant object to be studied through the perspective of physics, which provides a deeper understanding of the principles of physics that are contextual and make it easier.

tive research, the aim is to obtain subjective meaning, social context from research participants, in accordance with the context understood in order to become more clear and clear findings (Fossey et al., 2002). In addition, through an ethnographic approach, the im is to describe and analyze culture based on intensive field research (Bungin, 2012). The ethnographic approach in this study is used to describe, explain and analyze the physics concepts contained in the traditional andong transportation tool. The research process is carried out in five stages, namely problem identification, data collection, data analysis, discussion, and conclusion. These stages are shown in Figure 1. The research stages are as follows.

Figure 1. Research Stages

Andong is a means of transportation in the form of a horse-drawn carriage that has historical and cultural value attached to Yogyakarta. Andong, which was originally only used by nobles, has now become a means of transportation for the general public. Andong can be found in tourist attractions such as Malioboro. The existence of andong attracts the attention of tourists so that it becomes a means of preserving culture and plays a role in the community's economy.

The research based on the identification of the andong problem uses observation and documentation in data collection. The first stage of data

collection is observation. In the direct observation activity of the andong working method carried out in Malioboro, the area around Bringharjo Market, and Point 0 km. Then the documentation of the andong is in the form of photos and videos. The next stage of research analyzes the data obtained to sort the data needed. The data analysis required is in the form of physical phenomena, physical concepts, descriptions and documentation on andong.

The observation data will be analyzed in four steps; (1) Writing the observation data and documentation in the form of descriptive text, (2) Discussing the physics concept of the traditional andong transportation tool, (3) Revising if there are misconceptions, (4) Drawing conclusions.

In the data analysis process, the observation data is described in writing. The physics concept from the observation of the andong obtained is the physics of the rotating wheel movement and when the andong is pulled by a horse. The first step is to write down the observation data and documentation in the form of descriptive text, where all information obtained during the observation is recorded in detail. This descriptive text covers aspects of physics related to the traditional andong transportation tool, such as the principles of motion, force, and energy working on the vehicle. Not only that, this process also includes documentation in the form of photos to examine the physics concept and then describe the directions of the forces that occur in the andong. Furthermore, the second step is to discuss physics concepts that are relevant to the andong, where various basic physics concepts are applied to explain the phenomena that occur during observation, such as friction, speed, and acceleration of the andong movement. Routine discussions are held once a week to ensure that the physics concepts written and described are interrelated.

In the third step, revisions are made to identify and correct possible misconceptions in the understanding of physics concepts applied to andong. This is important to ensure that the analysis is accurate and in accordance with correct physics principles. Finally, the fourth step is to draw conclusions based on the results of the analysis that has been carried out. This conclusion will provide a clearer picture of the application of physics concepts in traditional vehicles such

as andong, as well as provide a deeper understanding of how the means of transportation works from a physics perspective.

eserved to this day. Andong is one of the tourism icons in Yogyakarta. In 2019, andong Yogyakarta was named an Intangible Cultural Heritage of Indonesia by the Ministry of Education and Culture (District of Yogyakarta Cultural Service, 2019 ; Pangestuti et al., 2023) . The existence of andong in Yogyakarta is not only one of the local wisdoms of traditional transportation, but andong is also a famous mode of transportation to this day. (Deskarina & Atiqah, n.d.; Octanisa, 2023) . Unlike current public transportation , andong has a distinctive design, namely four wheels and pulled by one or two horses. Andong can be found in the Malioboro and Kraton areas, making it a tourist attraction in Yogyakarta. In the context of physics, andong can be analyzed through various basic concepts such as force, motion, energy, and Newton's laws. The various uniqueness and simplicity of andong apply physics concepts that can be contextual physics learners (Venerus & Öttinger, 2018) . Learning that links real-life phenomena with physics concepts. Contextual learning in practice connects between concept domains that contain theories that are then linked to the more realistic and real everyday world (Hudson & Whisler, 2007; Jensen, 2005).

Traditional transportation such as andong is very close to physics phenomena (Alfiany & Novrianti, 2022) . Thus, this study aims to analyze the concept of physics in traditional transportation, andong, especially the concept of motion and force . The first stage of data collection is observation. In the observation activity, observations were made on how to move the andong while analyzing related physics concepts. Based on the results of the research that has been carried out, there is a physics concept that can be an alternative to contextual physics learning. The results of the study can be written in tabel The following .

Table 2. Physics Concepts in Andong

Physics Pheno menon	Physics Concep t	Description/E xplanation of Physics Concepts
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Rotating wheel movement	Moment of Inertia	A wheel that rotates around its axis has a moment of inertia that tends to maintain the rotational state of the wheel so that it is stable when moving.
The role of the axle	Torque	The axle acts as a fulcrum for the wheel, where the force applied is transmitted to the wheel through the axle, thereby creating torque.
Movement when running the andong	Newton's Second Law	The use of horses to drive andongs provides a pulling force. produces acceleration

		according to the mass of the object.
Wheel friction while driving	Newton's Third Law	The interaction of the wheels with the road will cause frictional force in the opposite direction of the force. In addition, it causes action and reaction.

Andong as a traditional means of transportation has its own characteristics and deep historical value. Some of the characteristics of andong that distinguish it from other transportation are that it has four spoked wheels, where the two front wheels are smaller than the rear wheels. (Juno, 2021) . In addition, the way the andong works is with a horse pulling the andong carriage. This simple transportation concept contains physics concepts as in Table 2.

Moment of Inertia

The aim of physics is to study the motion of objects , whether they are objects or living things. (Chusni et al., 2018) . Moving objects can be particles and each part moves in the same direction and speed (Muirhead, 1887; Ramadhanti et al., 2021) . Likewise, andong as a means of transportation has translational motion and rotational motion on its wheels. The application of this motion can be reviewed when the wheels are rolling. Motion is divided into two based on the speed that occurs in the object, namely rotational motion and translational motion (Chusni et al., 2018; Mingqi Kong & Ghosh, 1999) . Both of these motions cannot be separated from the moment of inertia. This is because the moment of inertia is a derived quantity that is influenced by the radius of an object (Chusni et al., 2018) . If an object has a radius, the object will have an angular velocity and make

it rotate (Ayu et al., 2022 ; Riswanto, 2014) . The andong wheel that rotates around the axis has a moment of inertia that tends to maintain the rotation of the wheel so that it is stable when moving. This is shown in Figure 2. The following

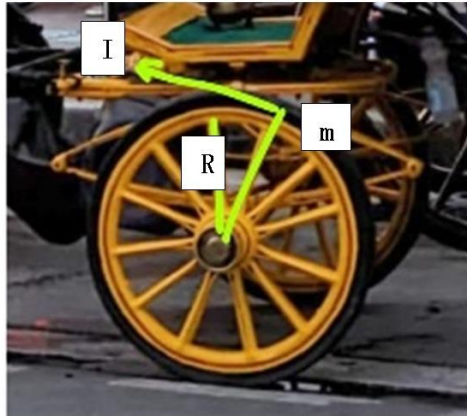


Figure 2. Moment of Inertia on the andong

Every rigid object moves in a circle at each point of its motion particle, this is a certain reference that can be determined by the moment of inertia (Radomirovic & Kovacic, 2011; Sirajuddin & Rustang, 2021) . The magnitude of the moment of inertia on a solid cylinder can be found by equation 1:

$$I = mr^2 \dots (1)$$

Where: I is the moment of inertia ($kg.m^2$), m is the mass of the object (kg) And r is the square of the radius of the object . The moment of inertia is influenced by the value of the radius (the distance of the object from the axis . In the context of andong, a rotating wheel can be analyzed to understand how the moment of inertia affects the movement and stability of the andong as it moves. The greater the distance of the wheel mass from the axis of rotation, the greater the moment of inertia, which means more torque is needed to accelerate or decelerate the movement of the wheel . The factors that influence the moment of inertia are as follows:

1. The moment of inertia is influenced by the mass of an object or particle.
2. The moment of inertia is influenced by the geometry of an object (shape)
3. The moment of inertia is influenced by the position of the axis of rotation of an object.
4. The moment of inertia is affected by the distance to the axis of rotation of an object or the moment arm.

The implementation of the concept of moment of inertia on the andong can be an alternative for learning physics. Using andong as an example in learning physics provides a closer understanding to the students' experience. This not only makes the material more interesting, but also allows students to see the real application of physics concepts. For example, they can make direct measurements on the andong wheel and calculate the moment of inertia based on the mass and radius of the wheel. This activity can help students understand the concept of moment of inertia in real terms. By integrating physics learning into local wisdom such as andong, students not only learn about physics but also appreciate their cultural heritage. This can create awareness of the importance of preserving tradition. This contextual learning can increase students' pride in their culture and strengthen local identity amidst the current of modernization (Trisnawati, 2014).

Torque

The andong wheel has an axle that will produce torque. Torque is a rotating force produced by a force on an axis of rotation. In the andong wheel, the axle plays an important role in producing torque, which is a rotating force produced by a force applied at a certain distance from the axis of rotation. Torque can be understood as the force that causes an object to rotate, and in the context of a horse-drawn carriage, this torque is crucial to ensure that the wheels can rotate efficiently (Venerus & Öttinger, 2018). When a horse pulls a horse-drawn carriage, the force applied to the wheel creates a torque that rotates the wheel, allowing the horse-drawn carriage to move forward. Simply put, torque is the force that causes an object to rotate. Based on the results of the analysis of the physics concept of horse-drawn carriage torque, the following torque physics equation is obtained.

$$\tau = F \times d \dots (2)$$

The Greek letter Tau (τ) represents torque. The SI (metric) unit of force is *the newton*, and the unit of distance is *the meter*. Since torque is the product of force times distance, the unit of torque is the Newton-meter

The factors that cause torque based on observations are that the greater the force given, the greater the torque produced. Torque will be maximum when the force works perpendicular to the arm of the force. This can be observed in the picture of the cart wheel below this.

Figure 3. Torque on the andong.

Based on observations of the andong wheel, the spokes of the wheel are the arms of the force that are pulled from the pivot point until they intersect perpendicularly with the line of action of the force. As for calculating the moment of force of an object, the tendency of the wheel to rotate must be considered. So in this torque concept, it is necessary to pay attention to several provisions of the moment of force, namely the following moment of force signs.

1. Moment of style τ given a negative sign if it tends to rotate the object clockwise.
2. Moment of style τ given a positive sign if it tends to rotate the object counterclockwise.

In addition, the further the force is applied from the axis of rotation (pivot), the greater the torque produced. This explains why wheel design and axle position are very important in increasing the efficiency of the andong movement.

Based on the results of the analysis of the physics concept on the torque of the andong wheels, we can see that understanding torque is not only relevant in the context of classical mechanics, but also has practical applications in the design and operation of traditional vehicles. By understanding how torque works on the andong wheels, we can optimize the performance and efficiency of the andong in various road conditions and loads carried (Halliday et al., 2010). This shows that basic physics principles have a direct impact on the transportation technology we use every day.

Newton's Second Law

The phenomenon of the movement of the andong is related to Newton's law. Newton stated that every object has a cause that makes the object remain still or move, which can be interpreted as an object will move if it is subjected to force (Cox et al., 2011). Likewise, the andong can move when pulled by a horse. This is related to the concept of Newton's second law. Newton's second law is the law of motion of an object that connects force, mass, and acceleration. The acceleration of an object is directly proportional to the total force acting on it and inversely proportional to its mass. The direction of acceleration is the same as the direction of the total force acting on it (Hessel et al., 2013).

The phenomenon of the movement of the andong is closely related to Newton's laws, especially the second law which states that every object will remain at rest or move in a straight line at a constant speed unless subjected to an external force (Cox et al., 2011). In the context of the andong, this movement can be explained in a simple but profound way. When the horse pulls the andong, the force generated by the horse acts as the main driver. This force overcomes the

friction between the wheels of the andong and the road surface, allowing the andong to move forward.



Figure 4. Andong Moving Accelerated

The image above shows the forces acting on the horse-drawn carriage. Force is described as a pull or push that causes an object to move or change shape. The force shown in the image is acceleration. When the horse-drawn carriage is pulled by a horse, the force exerted by the horse acts as an external force that causes the carriage to move. This force must be large enough to overcome the friction between the carriage wheels and the road surface. In this case, the mass of the carriage (including the load) affects how much force is needed to achieve a certain acceleration.

The acceleration that arises is influenced by the mass of the object and the pulling force of the horse. Based on these conditions, mathematically Newton's second law can be formulated as follows.

$$F = m \cdot a \dots (3)$$

With

F = force acting on the object (N)

m = mass of the object on which the force is applied (kg)

a = acceleration of an object subjected to force (km/s^2)

Furthermore, Newton's second law also explains the relationship between force, mass, and acceleration. In this case, the large mass of the andong affects how much force is needed to start its movement. The heavier the load carried by the andong, the greater the force needed to pull it. This provides a deeper understanding of the dynamics of the andong's movement and how physical factors play a role in its operation.

By understanding Newton's law in the context of andong, students can see firsthand the application of physics theory in everyday life. (Wibowo, 2016). For example, if the andong is empty, then the mass that must be pulled is smaller, so the force required is also less, and the acceleration of the andong will be greater. Conversely, if the andong is carrying a heavy load, the force required to pull it will be greater, and as a result the acceleration of the andong will be smaller.

Thus, Newton's Second Law not only explains the physical phenomena behind the movement of the andong, but also provides insight into how the design and operation of the andong can be optimized for efficiency. Through this understanding, students can see the relevance of physics in local wisdom and traditional transportation such as andong.

Newton's Third Law

Newton's Third Law states that if an object exerts a force on another object, it will cause a reaction action. If an object exerts a force on another object, the object affected by the force will exert a force that is the same magnitude as the force received from the first object, but in the opposite direction (Lámer, 2017) . Mathematically, Newton's Third Law can be written as follows:

$$F_{action} = - F_{reaction}...(4)$$

with:

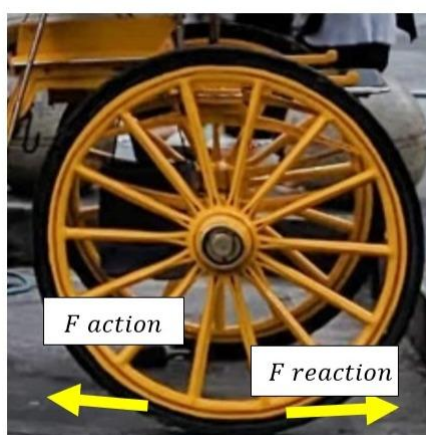
F_{action} = The force exerted by the object performing the action.

$F_{reaction}$ = The force exerted by the object that is reacting.

Based on the results of the research that has been conducted, the concept of Newton's Third Law in andongs lies in the movement of the andong wheels as shown in the following image.

Figure 4. Force on the Andong Wheel

The image above shows Newton's third law on the andong wheel. The wheel that moves forward shows the force as an action due to the pull of the



horse. Conversely, the response of the force causes a reaction in the form of frictional force in the opposite direction to the action force. When the horse pulls the andong, the andong wheel moves forward as a result of the action force provided by the horse. This force pushes the wheel forward, allowing the andong

to move smoothly along the road. However, behind this movement, there is a reaction force that occurs simultaneously.

The friction force between the wheels and the road surface functions as a reaction force that is opposite to the action force of the horse's pull. This friction force is very important because without sufficient friction, the wheels will not be able to rotate effectively and the horse-drawn carriage will not be able to move forward. In addition, friction also helps maintain the stability and control of the horse-drawn carriage when moving. (Ford, 1972) . Thus, the use of horse-drawn carriage wheels in contextual physics learning about torque, momentum, and Newton's laws not only makes the lesson more interesting but also more effective in improving students' understanding of physics material.

Based on the analysis of physics concepts in the andong above, it shows that the role of andong in contextual physics learning can be applied through understanding the concept of motion and force that occurs in an object. In andong, it is known that the moment of inertia, torque, friction and acceleration that arise are produced by the movement of the andong wheels and the pull of the horse. Therefore, it can be integrated between understanding the concept of physics in andong with learning that presents real examples around students as an alternative to contextual physics learning. So that this research can connect local wisdom knowledge such as andong with science, especially in physics. In addition, the existence of contextual learning can provide a positive impact on physics learning and local wisdom such as facilitating the delivery of learning about moments of inertia, torque, and Newton's laws (Ford, 1972) . Thus, the analysis carried out is a form of preserving local wisdom with wider promotion of andong in contextual physics learning.

CONCLUSION

The results of this study show that in the traditional andong transportation tool there are physics concepts in the form of moments of inertia, torque, and Newton's laws. By identifying physics concepts such as moment of inertia, torque, and Newton's laws in the use of andong, this study not only enriches students' understanding of physics principles, but also emphasizes the importance of andong as a symbol of Yogyakarta's local wisdom. This encourages efforts to preserve andong as part of a valuable cultural heritage, while making it a relevant object of study for contextual physics learning in the modern era.

The role of physics in the existence of andong contributes to cultural sustainability through several aspects. First, understanding physics about energy and torque can improve the efficiency of design and use of andong, making it more environmentally friendly and attractive to tourists. Second, the integration of physics concepts in education can raise awareness among the younger generation

about the importance of preserving this traditional means of transportation as part of cultural heritage. Third, by promoting andong as an object of physics study, the public can appreciate its cultural and functional value, thus encouraging stronger preservation efforts amidst modernization.

Andong as a traditional means of transportation in Yogyakarta needs to be preserved and maintained. In addition to being one of the local wisdoms that has been a means of transportation since ancient times, andong is also a mode of transportation that can be a relevant object to be studied through the perspective of physics. Thus providing a better understanding of the principles of physics in contextual physics learning. Therefore, the findings of this study have significant meaning in the context of education and cultural preservation.

The suggestions that can be submitted for further research are that it is hoped that this research will discuss andong in more detail and be associated with more relevant physics concepts. In addition, there needs to be a deeper analysis to examine the concept of physics so that it can provide an understanding for alternative physics learning to be better.

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