Vol 13(2) (2024): 123-136
DOI: http://dx.doi.org/10.24235/sc.educatia.v13i2.18509

SCIENTIAE EDUCATIA: JURNAL PENDIDIKAN SAINS

https://www.syekhnurjati.ac.id/jurnal/index.php/sceducatia

Integrating Local Wisdom of *Pesantren* into Physics Education: A Torque-Based Analysis of Daily Activities

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article info

Article history:
Received: 24 September 2024
Received in revised form: 24 December 2024
Accepted: 26 December 2024
Available online: 30 December 2024

Keywords:
Inventory
Torsion
Pesantren
Local wisdom

abstract

This study explored the integration of torque concepts into the local wisdom of Islamic boarding schools (*Pesantren*), emphasizing the application of these principles. The research aimed to connect abstract physics concepts with culturally relevant practices to enhance physics education. Field observations were conducted on 17 *Pesantren* activities using a descriptive qualitative method, with data collected from 10 students in Pamekasan. Direct observation and photography documented torque-related movements during prayer, ablution, and other daily tasks. The findings identified 29 torque-related movements, including actions like performing ablution and making adzan. These traditional practices were analyzed for their application of force, pivot points, and lever arms, demonstrating their alignment with the concept of torque in physics. The study concluded that integrating these cultural activities into physics education not only aids in understanding theoretical concepts but also enriches the learning experience by incorporating students' cultural backgrounds. This approach promotes a more meaningful and engaging physics education while respecting the cultural values of *Pesantren* students.

1. Introduction

Education is a conscious and structured process that aims to create a conducive learning environment to foster students' intellectual growth (Lathifah et al., 2022). It is pivotal in enhancing students' abilities to contribute to their personal and environmental development (Sukmawati et al., 2018). As a lifelong process, education involves all levels of society and continuously adapts to advances in science and technology. In Indonesia, the recently implemented *Merdeka* curriculum offers students the autonomy to manage their learning process, allowing teachers to design engaging learning environments while emphasizing the *Pancasila* graduate profile (Risdiany et al., 2021).

An essential aspect of implementing the *Merdeka* curriculum is integrating local wisdom, which serves as a strategic approach to foster *Pancasila* values (Kusnadi, 2022). Incorporating local cultural values into education enriches learning experiences and strengthens students' connection to their cultural identities and surroundings (Shufa, 2018). Physics education, in particular, benefits from integrating local wisdom, as many physics concepts are embedded in traditional practices (Setiadi, 2019). Previous research highlights the integration of local cultural

practices into physics education, such as identifying physics concepts in local traditions like the *Kayangan Api* fire ritual (Lestari et al., 2022), agro processing (Laos et al., 2019), traditional weaving (Husin et.al., 2019), and sea harvesting traditions (Safitri et al., 2023).

Despite these efforts, integrating local wisdom in physics education primarily focuses on cultural practices outside religious institutions. On the other hand, local wisdom in *pesantren* (Islamic boarding schools) is typically associated with religious education. Thus, there is a need to explore the potential of integrating *Pesantren* local wisdom into physics education, particularly in physics topics such as torque, where everyday practices in *Pesantren* can illustrate relevant concepts, such as in ablution, prayer, beating the drum, the call to prayer, and so on. This activity provides an example of an activity closely related to torque.

Integration of local wisdom in physics education has mainly been limited to cultural practices outside of religious institutions, with little attention paid to the unique traditions within Islamic boarding schools. Although Islamic boarding schools are renowned for emphasizing character building and moral education (Kahar et al., 2019), their potential to contribute to contextual physics education remains underexplored. This gap is particularly evident in torsion, where everyday practices in Islamic boarding schools, such as specific prayer movements and ablution rituals, demonstrate underlying physics principles. Addressing this gap is essential to making physics education more relevant and engaging for students in Islamic boarding schools. Integrating local wisdom rooted in pesantren traditions bridges theoretical physics concepts with culturally meaningful practices, enhancing understanding and appreciation of physics among Islamic boarding school students.

This study aims to inventory the concept of torque as it is embedded in the daily activities of *pesantren*, offering a novel approach to physics education that aligns with students' cultural and religious contexts. By documenting these practices, we aim to bridge the gap between physics education and local wisdom in *pesantren*, enhancing students' understanding of their religious practices and the underlying physics concepts.

2. Method

This study employed a qualitative descriptive approach with a field observation design. The qualitative method was chosen because it allowed for an in-depth exploration of the daily activities and practices of the students (*santri*) in the pesantren, aligning with the research's focus on capturing the local wisdom related to torque concepts (Creswell, 2014). The participants in this study were ten *santri* from a pesantren in Pamekasan, selected using purposive sampling to ensure that they were actively engaged in daily activities relevant to the concept of torque (Sugiyono, 2016) with a research flow as shown in Figure 1.

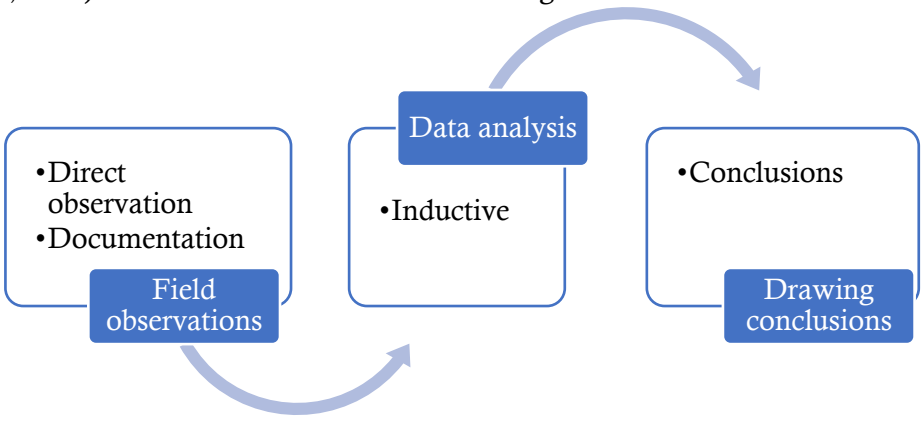


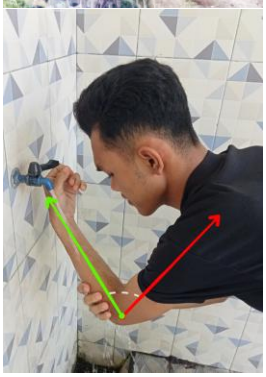
Figure 1. The research flow

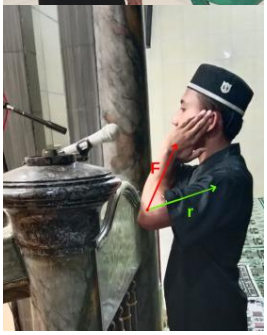
Figure 1 shows that the research flow begins with data collection including direct observation, where researchers observe physical actions of students such as praying, sweeping, and other routine tasks that reflect the application of torsion in real life. Observations are supported by documentation using a camera to capture important moments and activities for further analysis (Moleong, 2017). By combining observation and visual documentation, this study ensures a rich and detailed data set that comprehensively understands how torsion is applied in daily activities in Islamic boarding schools. Data analysis followed an inductive process, where patterns and themes related to torque were identified from observed activities and documentation (Miles & Huberman, 1994).

3. Result and Discussion

The study identified 17 daily activities in the *pesantren* that were classified under torque based on local wisdom. These activities consisted of 29 distinct movements, each demonstrating the practical application of torque in everyday life. Examples of these activities included physical actions such as performing ablution (*wudhu*), striking the *beduk*, and bowing during prayer. Each movement involved the rotation of limbs or body parts, illustrating how torque was applied in various religious and routine practices. Integrating these movements into physics education gave students a contextual and culturally relevant learning experience. To illustrate these findings, Table 1 presents a series of images depicting the activities, descriptions of the movements, and explanations of how torque was applied in each activity.

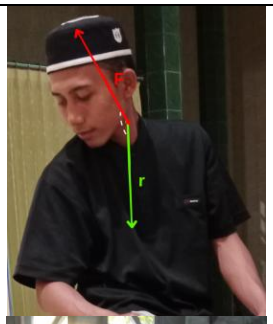
Table 1. Daily activities in *Pesantren* and their relation to the concept of torque

No	Picture	Activities	Description of Motion in the Concept of Torque
1	 	*Wudhu*	During the activity of ablution, when the students washed their faces, the movement of their arms involved the concept of torque. The force (F) was applied by the hand while washing the face, and the arm from the elbow to the hand acted as the point where the force was exerted. Meanwhile, the upper arm, from the elbow to the shoulder, served as the lever arm or distance (r) over which the torque was produced. The rotation around the elbow joint demonstrates the concept of torque, as the force applied causes a rotational movement of the arm. During the activity of wudhu, when the students washed their hands, the application of torque was evident. The force (F) was applied by the hand as it moved to wash. The segment of the arm from the elbow to the hand exerted the force, while the segment from the elbow to the shoulder served as the lever arm or distance (r) over which the torque was generated. This setup demonstrated how the force applied produced rotational movement around the elbow joint, illustrating the concept of torque.

No	Picture	Activities	Description of Motion in the Concept of Torque
			During the activity of wudhu, when the students wiped part of their heads, the concept of torque was observed. The force (F) was applied by the hand as it reached to wipe the head. The segment from the elbow to the hand carried the applied force, while the segment from the elbow to the shoulder represented the lever arm or distance (r) over which the torque was exerted. This movement illustrated how the force caused a rotational effect around the elbow joint, demonstrating the application of torque in this specific activity.
			During the activity of wudhu, when the students wiped their ears, the concept of torque was evident. The force (F) was applied by the hand as it moved to clean the ears. The segment of the arm from the elbow to the hand transmitted the applied force, while the segment from the elbow to the shoulder represented the lever arm or distance (r) over which the torque was generated. This action demonstrated how the force created rotational movement around the elbow joint, illustrating the application of torque in this specific task.
			During the activity of wudhu, when the students washed their feet, the concept of torque was observed. The force (F) was applied by the foot as it interacted with the water. The segment from the knee to the foot transmitted the applied force, while the segment from the knee to the thigh represented the lever arm or distance (r) over which the torque was produced. This movement illustrated how the force caused a rotational effect around the knee joint, demonstrating the application of torque in this particular activity.
2		Beating the *beduk*	During the activity of striking the *beduk*, the concept of torque was clearly demonstrated. The force (F) was applied by the hand when it hit the drum. The segment of the arm from the elbow to the hand transmitted this force, while the segment from the elbow to the shoulder served as the lever arm or distance (r) over which the torque was generated. This action illustrated how the applied force produced a rotational effect on the drum, showcasing the application of torque in this specific activity.
3		*Adhan*	During the activity of preparing for the *adhan*, the concept of torque was evident. The force (F) was applied by the hand when it was positioned to call out the *adhan*. The segment of the arm from the elbow to the hand transmitted this force, while the segment from the elbow to the shoulder represented the lever arm or distance (r) over which the torque was produced. This position demonstrated how the force created a rotational effect around the elbow joint, illustrating the application of torque in this specific activity.

No	Picture	Activities	Description of Motion in the Concept of Torque
			During the activity of praying when the students performed the *takbir*, the concept of torque was apparent. The force (F) was applied by the hands as they were raised during the *takbir*. The segment of the arm from the elbow to the hand transmitted this force, while the segment from the elbow to the shoulder served as the lever arm or distance (r) over which the torque was generated. This action demonstrated how the force produced a rotational effect around the elbow joint, illustrating the application of torque in this specific ritual movement.
			During the activity of praying when the students performed the *sitting posture* (or *tasleem*), the concept of torque was observed. The force (F) was applied by the hands as they were placed on the chest. The segment of the arm from the elbow to the hand transmitted this force, while the segment from the elbow to the shoulder represented the lever arm or distance (r) over which the torque was exerted. This posture illustrated how the applied force generated a rotational effect around the elbow joint, demonstrating the application of torque in this specific ritual movement.
4		Praying	During the activity of praying when the students performed the *rukuk* (bowing), the concept of torque was evident in two distinct aspects. (a) On the back, the force (F) was applied while the students were bowing. The segment from the waist to the feet served as the lever arm or distance (r) over which the torque was produced. This configuration demonstrated how the force generated a rotational effect around the waist. (b) Additionally, the force (F) was applied by the hands as they were positioned on the knees. The segment from the shoulders to the hands transmitted this force, while the segment from the back represented the lever arm or distance (r) over which the torque was exerted. This setup illustrated how the force caused a rotational effect around the shoulder joints, demonstrating the application of torque in this specific posture.
			

No	Picture	Activities	Description of Motion in the Concept of Torque
			During the activity of praying when the students performed the *i'tidal* (standing upright after bowing), the concept of torque was apparent. The force (F) was applied on the back as the students stood up from the bowing position. The segment from the thighs to the feet served as the lever arm or distance (r) over which the torque was generated. This configuration demonstrated how the force produced a rotational effect around the back, illustrating the application of torque in this specific posture.
			During the activity of praying when the students performed the *sujud* (prostration), the concept of torque was evident in two specific aspects: (a) On the back, the force (F) was applied while the students were in the prostration position. The segment from the thighs to the feet served as the lever arm or distance (r) over which the torque was generated. This setup demonstrated how the force created a rotational effect around the back, illustrating the application of torque in this posture. (b) Additionally, the force (F) was applied by the hands as they pressed against the ground. The segment from the elbows to the hands transmitted this force, while the segment from the elbows to the shoulders represented the lever arm or distance (r) over which the torque was exerted. This configuration illustrated how the force produced a rotational effect around the elbows, demonstrating the application of torque in this specific movement.
			
			During the activity of praying when the students performed the *iftirosy* and *tawarruk* sitting postures, the concept of torque was evident. The force (F) was applied on the back as the students sat in these positions. The segments from the thighs and calves served as the lever arm or distance (r) over which the torque was generated. This configuration demonstrated how the force produced a rotational effect around the back, illustrating the application of torque in these specific sitting postures.
			During the activity of praying when the students performed the *iftirosy* and *tawarruk* sitting positions, the concept of torque was demonstrated. The force (F) was applied to the back as they sat in these postures. The segments from the thighs and calves acted as the lever arm or distance (r) over which the torque was exerted. This setup illustrated how the force generated a rotational effect on the back, showing the application of torque in these seated positions.

No	Picture	Activities	Description of Motion in the Concept of Torque
			During the activity of praying when the students performed the *salam* (turning the head to the right and left), the concept of torque was evident. The force (F) was applied to the head as the students turned their heads to each side. The segment from the neck acted as the lever arm or distance (r) over which the torque was generated. This movement demonstrated how the force produced a rotational effect on the head, illustrating the application of torque during the *salam*.
5	 	Dzikir	During the activity of dzikir when the students moved their heads from side to side, the concept of torque was analyzed. The force (F) was applied to the head as they shook their heads to the right and left. The neck served as the lever arm or distance (r) over which the torque was exerted. This motion demonstrated how the force created a rotational effect on the head, illustrating the application of torque during the head movements in *dzikir*.
6		Raise both hands when praying	During the activity of praying when the students raised their hands for *dua* (prayer), the concept of torque was observed. The force (F) was applied from the elbows to the hands as they lifted their hands. The segment from the elbows to the shoulders acted as the lever arm or distance (r) over which the torque was exerted. This action demonstrated how the force generated a rotational effect on the arms, showing the application of torque during the act of *dua*.
7		Sit cross-legged	During the activity of sitting cross-legged, the concept of torque was identified in two aspects. (a) The force (F) was applied on the thighs, while the segment from the thighs to the back served as the lever arm or distance (r). (b) The force (F) was also applied from the elbows to the hands, with the segment from the shoulders to the elbows acting as the lever arm or distance (r). These two aspects demonstrated the application of torque in the sitting cross-legged posture.

No	Picture	Activities	Description of Motion in the Concept of Torque
8		Standing while reciting the sholawat	During the activity of standing while reciting sholawat, the concept of torque was observed. The force (F) was applied from the elbows to the hands as the students raised their arms. The segment from the elbows to the shoulders acted as the lever arm or distance (r) over which the torque was exerted. This movement demonstrated how the force produced a rotational effect on the arms, illustrating the application of torque during the recitation of *sholawat*.
9		Walking towards the astah for pilgrimage	During the activity of walking towards the astah for ziarah, the concept of torque was identified in two areas. (a) The force (F) was applied from the thighs to the feet, while the segment from the waist to the head acted as the lever arm or distance (r). (b) The force (F) was also applied from the shoulders to the hands, with the segment from the back to the waist serving as the lever arm or distance (r). These movements demonstrated how torque was generated during the walking posture in the *ziarah* activity.

No	Picture	Activities	Description of Motion in the Concept of Torque
10		Reading the Qur'an	During the activity of reading the Qur'an while raising both hands, the concept of torque was observed. The force (F) was applied from the elbows to the hands, while the segment from the elbows to the shoulders acted as the lever arm or distance (r). This movement demonstrated the application of torque as the arms were raised during the act of reading the Qur'an.
11		Sowan To The Teacher	During the activity of sowan to the teacher, the concept of torque was identified in two aspects. (a) The force (F) was applied from the back to the head, while the segment from the back to the thighs acted as the lever arm or distance (r). (b) The force (F) was also applied from the hands to the elbows, with the segment from the back to the thighs serving as the lever arm or distance (r). These movements illustrated the application of torque during the respectful bowing posture in the *sowan* activity.
12		Standing While Bowing The Head As The Teacher Passed By	During the activity of standing while bowing the head as the teacher passed by, the concept of torque was observed. The force (F) was applied from the neck to the head, while the entire body acted as the lever arm or distance (r). This posture demonstrated how the force generated a rotational effect around the neck, illustrating the application of torque during this respectful gesture.

No	Picture	Activities	Description of Motion in the Concept of Torque
13		Bending The Body While Passing In Front Of The Teacher	During the activity of bending the body while passing in front of the teacher, the concept of torque was examined. The force (F) was applied on the back, while the segment from the back to the thighs served as the lever arm or distance (r). This action illustrated how the force created a rotational effect around the back, demonstrating the application of torque during this respectful gesture.
14		Sweeping The Yard	During the activity of sweeping the yard, the concept of torque was analyzed. The force (F) was applied on the back, while the segment from the thighs to the feet acted as the lever arm or distance (r). This action demonstrated how the force produced a rotational effect around the back, illustrating the application of torque during the sweeping activity.
15		Reciting The Qur'an To The Pesantren's Administrators	During the activity of reciting the Qur'an to the pesantren's administrators, the concept of torque was examined. The force (F) was applied from the elbows to the hands, while the segment from the elbows to the shoulders served as the lever arm or distance (r). This posture demonstrated how the force created a rotational effect around the elbows, illustrating the application of torque during this activity.
16		Reciting The Nightly Religious Texts	During the activity of reciting the nightly religious texts, the concept of torque was analyzed. The force (F) was applied from the elbows to the hands, while the segment from the elbows to the shoulders acted as the lever arm or distance (r). This position demonstrated how the force generated a rotational effect around the elbows, illustrating the application of torque during this activity.

No	Picture	Activities	Description of Motion in the Concept of Torque
17		Sitting During A Meeting	During the activity of sitting during a meeting, the concept of torque was observed. The force (F) was applied on the back, while the segment from the thighs to the feet served as the lever arm or distance (r). This posture illustrated how the force created a rotational effect around the back, demonstrating the application of torque during the sitting position in the meeting.

In this study, the initial stage involved a comprehensive inventory of torque concepts associated with local wisdom in pesantren, achieved through meticulous observation and documentation of various traditional activities. The analysis uncovered 17 distinct activities comprising 29 different movements that illustrated the application of torque. These included movements during prayers, such as the Takbir, standing with hands folded, bowing, standing up, prostration, sitting in Iftirasy, sitting in Tawarruk, and concluding with Salam. Each of these movements demonstrates the interaction of forces and torques, thus providing a practical example of physics principles within a cultural context. The inclusion of ablution practices, such as washing the face, hands, wiping the head, cleaning the ears, and washing the feet, further illustrated the application of torque. Additionally, other activities like striking the drum, calling the adzan, reciting dhikr, praying, reading blessings, and visiting graves also incorporated elements of torque.

The observation of prayer movements such as the Takbir and standing with hands folded demonstrated the balance of forces and torques. Suhadi et al. (2020) had noted that during these actions, the forces and torques are distributed in such a way that the overall system remains in static equilibrium, with the total force and torque on the body balancing out to zero. the importance of force and pressure in physiotherapy, emphasizing their role in maintaining stability during therapeutic exercise (Vrdoljak & Šipraga, 2024). This finding aligns with our observations that these prayer positions require a careful balance of applied forces and lever arms to maintain stability. The results from our study reinforce this concept by showing how traditional practices in pesantren involve similar principles of force and torque as those described in the literature.

In the analysis of prostration, Mabruroh and Oviyanti (2023) demonstrated that the movement involves vector components of forces and torques, which vary depending on the reference point chosen for analysis. Their study found that different initial positions, such as the head and chest, produced varying resultant vectors, yet the equilibrium was maintained. Movements, including forces and torques, emphasizing that different reference points in motion analysis can lead to varying resultant vectors while maintaining balance (Bartlett, 2014). Our findings are consistent with this observation, showing that during prostration, the forces and torques involved can be analyzed using different reference points, yet the overall equilibrium is achieved, which underscores the practical application of torque concepts in religious practices. The activities related to ablution, including washing the face, hands, and feet, also involved torque principles. Each of these movements requires a specific application of force and lever arm, which were documented and analyzed. This finding supports the notion that everyday activities in pesantren, including those related to hygiene, incorporate physical principles akin to those studied in physics. By documenting these practices, this study contributes to a deeper understanding of how

traditional activities embody scientific concepts, making them more accessible for educational purposes.

Further, the study included activities such as reading the Qur'an, managing pesantren administration, reading nightly texts, and sitting during meetings, all of which also involved torque concepts. For instance, the act of raising both hands to read the Qur'an involves applying force and managing the lever arm in a manner consistent with torque principles. Wulansari et al. (2020) had explored similar concepts in the context of dance, noting how dancers manage torque through muscle strength and balance techniques to maintain stability. This study extends those findings by applying the same principles to various traditional activities in pesantren. The differences between this study and previous research are notable in terms of incorporating local wisdom into the analysis of torque. Previous studies by Suhadi et al. (2020), Rachmat et al. (2020), and Utsman (2018) primarily focused on general physics concepts without considering cultural contexts. Our study introduces a unique perspective by examining how local wisdom and daily practices in pesantren align with scientific principles, thus bridging the gap between traditional knowledge and modern physics education.

By inventorying daily activities in pesantren and analyzing them through the lens of torque, this study provides a practical context for understanding the application of physics concepts in everyday life. This approach not only enhances the relevance of physics education but also fosters a deeper connection between scientific principles and cultural practices. The integration of local wisdom into the study of physics makes the subject more relatable and accessible to students, particularly in regions with strong cultural traditions. Overall, the findings of this study underscore the significance of local wisdom in educational contexts and offer a model for integrating cultural practices into science education. Future research could further explore how other cultural practices align with scientific principles and contribute to a more comprehensive understanding of physics in diverse contexts.

4. Conclusion

Based on the inventory results, it was concluded that the study identified 17 activities involving 29 movements relevant to the concept of torque. The findings demonstrated that daily activities in *Pesantren*, including religious rituals such as prayers and ablutions as well as other activities like reading the Quran, praying, and visiting graves, involved fundamental principles of physics. Each analyzed movement in this study exhibited the application of force, pivot points, and lever arms in accordance with torque theory. The research highlighted that *Pesantren*'s local wisdom not only possesses cultural value but also illustrates relevant physics concepts. This finding provided new insights into how physical principles are applied within cultural contexts, offering a novel approach to teaching torque by using examples from students' everyday activities. Thus, the study contributed to the development of more contextual and relevant physics teaching methods. These results also opened avenues for further research on integrating physics concepts into various cultural and traditional practices.

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