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The Application of the Dimensional Analysis Approach in Understanding the Interrelationships Between Physical Quantities for Students

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Abstract

The main issue raised in this study is the tendency of students to rely on memorizing physics formulas without understanding the relationships between quantities and their dimensions. This study aims to explore the use of the dimensional analysis approach as a tool for understanding and deriving the relationships between physical quantities in various types of motion, including oscillatory motion, free fall motion, and parabolic motion. Exploratory and conceptual analysis methods were used in this study with a descriptive approach. In addition, an attitude scale instrument was used to measure students' perceptions, which has been shown to be valid (0.80–0.92) and reliable ($\alpha = 0.89$). The results show that the equations obtained through dimensional analysis are consistent with theoretical equations. This confirms that the approach is capable of correctly identifying the form of physical relationships, although it cannot yet determine the numerical constants precisely. In addition, student responses show a positive attitude towards the dimensional analysis approach, which is considered a new, useful, and efficient way of solving physics problems. However, students also recognized the limitations of this method in producing exact solutions due to the existence of arbitrary constants. These findings indicate that dimensional analysis is a scientifically robust and pedagogically valuable approach that can strengthen conceptual understanding. Thus, the application of the dimensional analysis approach in physics learning can help students find solutions logically and systematically.

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INTRODUCTION

One branch of natural science that attempts to explain phenomena based on the relationship between several physical quantities is dimensional analysis (Conejo, 2021). It is usually expressed in the form of a mathematical formula connecting one quantity with another. However, before they can have a thorough formula based on experiment or theoretical research, physicists frequently employ an easy but quite effective technique known as dimensional analysis. The idea of dimensional consistency, which states that all valid physical equations must have the same dimensions on both sides, forms the basis of dimensional analysis (Bhaskar & Nigam, 1990; Redish, 2021). Using this idea, we can estimate how several quantities are related simply by looking at their base units or dimensions, namely mass M, length L, and time T. In this way, we can obtain the general form of an equation without having to follow the entire mathematical procedure strictly.

Quantities, units, and dimensions in physics education are always taught to students, as they play an important role in understanding subsequent material (Gok, 2018). This is evidenced by the fact that quantities and units are taught from junior high school through college, particularly in reference to the curriculum applicable in Indonesia (Martin, 2019; Setiawan & Suwandi, 2022). In addition to serving as an approach for checking the consistency of the equations obtained, dimensional analysis also serves as a modeling approach for describing physical relationships when theoretical or experimental data still have limitations (Santiago, 2019). Before performing more complex quantitative calculations, this approach helps students understand the physical meaning of a quantity and how it relates to other quantities.

Although dimensional analysis has been introduced in physics education for a long time, several studies show that students' and university students' understanding of the application of this concept is still relatively low (Purnama et al., 2023; Purnomo et al., 2025). According to Gok (2018); Lassri and Lassri (2022); Purnomo et al. (2025); Reichelova and Teleki (2013), students only memorize symbols, units, and dimensional forms without understanding their conceptual relevance. This makes it difficult for them to use dimensional analysis to simplify the general form of physics equations or evaluate the suitability of calculation results (Yildiz, 2015). In addition, research by Lenz and Gire (2016); Yahaya et al. (2023) shows that in learning activities, dimensional analysis is often taught mechanically and is not related to the context of kinematics or dynamics, so its use as a scientific reasoning tool is under-explored. Other perspective problems from Schiering et al. (2023) presented the findings of their study on the delivery of content in physics classes, which frequently face challenges and necessitate multiple delivery methods beyond rote memorization of textbooks. This shows a mismatch between mastery of basic concepts and the ability to apply dimensional analysis in practice.

Therefore, this study aims to use dimensional analysis to identify and reexamine the relationships between physical quantities in several traditional motion situations, such as oscillatory motion, free fall motion, and parabolic motion. Through this application, this study intends to show that dimensional analysis is not merely a mathematical tool for verification; rather, it can be used in oscillatory motion, free fall motion, and parabolic motion. In addition, this study also observes students' responses to the application of dimensional analysis as an approach to solving physics problems.

METHODS

An analytical and conceptual analysis with a descriptive approach was used in this study (see. Amiruddin & Suliyanah, 2023; Sari et al., 2023). This method was chosen since the main objective of the research was to examine and use dimensionality analysis as a means of scientific reasoning to get the general form of the physical equation, not to examine numerical connections using lab experiments. Each dimensional analysis performed refers to the following steps: (i) Determine the quantity and unit, (ii) Determine the dimensions of each quantity, (iii) Compile the dimensional equation and equate the dimensions, (iv) Determine to obtain the general equation.

After learning about quantities, units, and dimensions, the researcher used an attitude scale sheet given to 10 students to find out their responses to the dimensional analysis approach in the context of physics. The attitude scale instrument was created using a four-point Likert scale to assess students' views on physics learning using the dimensional analysis approach, consisting of “strongly disagree = 1”, “disagree = 2”, “agree = 3”, and “strongly agree = 4” (Alan & Kabasakal, 2020). The attitude scale instrument has been declared valid in terms of content validity through a process of expert judgment by three physics education experts, which was then analyzed using Aiken's V test. The Aiken's V value obtained was in the range of 0.80-0.92, which is in the high category and meets the criteria for content validity (Aiken, 1985). Then, the reliability of the instrument was analyzed using Cronbach's Alpha, which produced a value of $\alpha = 0.89$ and fell into the very good category (Cronbach, 1951).The selection of a four-point scale was intended to encourage respondents to give more decisive answers by not including neutral options, thereby producing data that more accurately reflected students' attitude tendencies.

RESULTS AND DISCUSSION

Oscillatory Motion (period)

Context of the problem

Oscillatory motion is a type of periodic motion that occurs when an object moves back and forth through its equilibrium position under the influence of a restoring force. A simple example of oscillatory motion is a mass suspended on a spring. When an object of mass m is suspended on a spring with spring constant k, and the system is given a small displacement from its equilibrium position, the object will oscillate in simple harmonic motion. One important quantity that we want to know is the period of oscillation T, which is the time required for one complete oscillation. Thus, the relationship between T, mass m, and spring constant k can be obtained as follows.

a. Quantities, units, and dimensions involved

A summary of the quantities, symbols, standard international units, and dimensions used in oscillatory motion is presented in Table 1.

Table 1. Summary of quantities and dimensions in oscillatory motion

Quantity	Symbol	SI unit	Dimension
Mass	M	Kilogram (kg)	[M]
Period	T	Second (s)	[T]
Spring constant	k	Newton per meter (N/m)	$[MT^{-2}]$

In general, the relationship is assumed to be:

$$T \propto C\, m^a k^b \tag{1}$$

where C is a dimensionless constant.

b. Dimensional Analysis

$$[T] = [m]^a\, [k]^b \tag{2}$$

Substitution to dimensional form:

$$T = [M]^a\, [MT^{-2}]^b \tag{3}$$

Simplify:

$$T = [M]^{a+b}\, T^{-2b} \tag{4}$$

c. Aligning Dimensions

For the equation to be dimensionally homogeneous, the exponents of each dimension on the left and right must be the same. On the left side, there is only the time dimension [T], so

$$M: a + b = 0 \tag{5}$$

$$T: -2b = 1 \tag{6}$$

So that it is obtained:

$$b = -\frac{1}{2},\ \ a = \frac{1}{2} \tag{7}$$

d. Final Equation

By substituting the exponent value:

$$T = C\, m^{1/2} k^{-1/2} \tag{8}$$

or can be written as follows:

$$T = C\sqrt{\frac{m}{k}} \tag{9}$$

e. Compare with theoretical/experimental results

Based on the simple harmonic motion theory, the period of motion of a mass-spring system is:

$$T = 2\pi\sqrt{\frac{m}{k}} \tag{10}$$

Thus, the results of the dimensional analysis provide the correct form of the relationship, while the empirical constant value is obtained from theory or experimental results, namely, C = 2π

Free Fall Motion (for time t from a height h)

Context of the problem

In free fall (without air resistance), an object is released from rest at a height h above the ground and experiences constant acceleration due to gravity *g*. We want to determine the time *t* it takes for the object to reach the ground, expressed through known quantities: height *h* and acceleration due to gravity *g*.

a. Quantities, units, and dimensions involved

A summary of the quantities, symbols, standards, international units, and dimensions used in free-fall motion is presented in Table 2.

Table 2. Summary of quantities and dimensions in free fall motion (for time *t*)

Quantity	Symbol	SI unit	Dimension
Time of fall	t	Second (s)	[T]
Height	h	Meter (m)	[L]
Acceleration due to gravity	g	Meter per second squared (m/s^2)	[LT^{-2}]

In general, the relationship is assumed to be:

$$t = C\, h^a\, g^b \tag{11}$$

where C is a dimensionless constant.

b. Dimensional Analysis

Write down the dimensions on both sides:

$$[T] = [L]^a\, [LT^{-2}]^b \tag{12}$$

$$[T] = L^{a+b}\, T^{-2b} \tag{13}$$

c. Aligning Dimensions

$$L:\ a + b = 0 \tag{14}$$

$$T:\ -2b = 1 \tag{15}$$

From -2b=1, we obtain

$$b = -\frac{1}{2},\ \ a = -b = \frac{1}{2} \tag{16}$$

d. Final Equation

$$t = C\, h^{1/2} g^{-1/2} \tag{17}$$

or

$$t = C\sqrt{\frac{h}{g}} \tag{18}$$

Dimensional analysis only determines the form of proportionality and does not provide a numerical value for the constant C.

e. Comparison with the results of the equation of motion (kinematics)

From the equation of uniform accelerated motion for constant acceleration and initial velocity zero:

$$h = \frac{1}{2} g t^2 \tag{19}$$

$$t = \sqrt{\frac{2h}{g}} \tag{20}$$

Thus, the dimensionless constant in the context of free fall is C = $\sqrt{2}$ and the equation for falling time from a height *h* becomes:

$$t = \sqrt{\frac{2h}{g}} \tag{21}$$

Free Fall Motion (velocity upon reaching the ground)

Context of the problem

An object is dropped from a height *h* with no initial velocity ($v_0 = 0$) and is only affected by gravitational acceleration g. What is the relationship between the velocity of the object when it hits the ground (v), the height (h), and gravitational acceleration?

a. Quantities, units, and dimensions involved

A summary of the quantities, symbols, standard international units, and dimensions used in free fall motion (velocity) is presented in Table 3.

Table 3. Summary of quantities and dimensions in free fall motion (velocity)

Quantity	Symbol	SI unit	Dimension
Final velocity	v	Meter per second (m/s)	[LT^{-1}]
Height	h	Meter (m)	[L]
Acceleration due to gravity	g	Meter per second squared (m/s^2)	[LT^{-2}]

b. Dimensional Analysis

Assume a general relationship:

$$v = C\, h^a g^b \tag{22}$$

We assume $v = C\, h^a g^b$, where *C* is a dimensionless constant. Then, the dimensions are as follows:

$$[LT^{-1}] = (L)^a\, (LT^{-2})^b \tag{23}$$

$$[LT^{-1}] = L^{a+b}\, T^{-2b} \tag{24}$$

c. Aligning Dimensions

Make the exponents of L and T equal so that

$$L:\ a + b = 1 \tag{25}$$

$$T:\ -2b = -1 \Rightarrow b = \frac{1}{2} \tag{26}$$

Then

$$a = 1 - b = 1 - \frac{1}{2} = \frac{1}{2} \quad (27)$$

d. Final Equation

$$v = C\, h^{1/2} g^{-1/2} \quad (28)$$

Equation of energy (or equation of motion); $v = \sqrt{2gh}$. So dimensional analysis correctly gives the form; the constant $\sqrt{2}$ comes from the law of conservation of energy (or integration a=g). Result:

$$v = \sqrt{2gh} \quad (29)$$

Parabolic Motion (object released from height with initial velocity)

Context of the problem

In parabolic motion, an object is thrown from an initial height *h* above the ground with an initial velocity v_0 at an elevation angle θ relative to the horizontal direction. The object moves in a curved path due to a combination of uniform horizontal motion and uniformly varying vertical motion due to gravitational acceleration *g*. We want to determine the total time t required for the object to reach the ground (vertical position y=0), expressed in known quantities: initial height *h*, initial velocity v_0, and gravitational acceleration *g*. The angle θ is a dimensionless quantity, so it does not affect the physical dimensions of the equation, and can be included in the dimensionless constant *C*.

a. Quantities, units, and dimensions involved

A summary of the quantities, symbols, standard international units, and dimensions used in parabolic motion is presented in Table 4.

Table 4. Summary of quantities and dimensions in parabolic motion

Quantity	**Symbol**	**SI unit**	**Dimension**
Time of fall	t	Second (s)	[T]
Initial height	h	Meter (m)	[L]
Initial velocity	v_0	Meter per second (m/s)	[LT^{-1}]
Acceleration due to gravity	g	Meter per second squared (m/s^2)	[LT^{-2}]

Therefore, it is assumed that:

$$t = C\, h^{a} v_0^{b} g^{c} \quad (30)$$

where *C* is a dimensionless constant that may depend on the angle θ

b. Dimensional Analysis

Dimensions on both sides:

$$[T] = L^{a}\,(LT^{-1})^{b}\,(LT^{-2})^{c} \quad (31)$$

$$[T] = L^{a+b+c}\, T^{-b-2c} \quad (32)$$

c. Aligning Dimensions

Equate the exponents for each dimension.

$$L: a+b+c = 0 \quad (33)$$

$$T: -b-2c = 1 \quad (34)$$

Then

$$b = -1-2c \quad (35)$$

Then substitute for the first one a+ (-1-2c) +c = 0 ⇒ a = 1+c. So that we obtain;

$$a = 1 + c, b = -1 - 2c, c \ \ is\ free \quad (36)$$

d. Final Equation

General form of dimensional analysis results

$$t = C\, h^{1+c/2} v_0^{-1-2c} g^{c} \quad (37)$$

The value of C cannot be determined solely from dimensional analysis—it requires a physical context.

Case 1, Object dropped (without initial vertical velocity)

Take

$$c = \frac{1}{2} \Rightarrow a = \frac{1}{2},\ b = 0 \quad (38)$$

$$t = C\sqrt{\frac{h}{g}} \quad (39)$$

From kinematics:

$$t = \frac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{2h}{g}} \quad (40)$$

Then C = $\sqrt{2}$

Case 2, Objects thrown from the ground (without initial height)

Take

$$c = -1 \Rightarrow a = 0,\ b = 1 \quad (41)$$

$$t = C\frac{v_0}{g} \quad (42)$$

From kinematics:

$$y = v_0 \sin\theta t - \frac{1}{2}gt^2 = 0 \quad (43)$$

$$t = \frac{2v_0 \sin\theta}{g} \quad (44)$$

Then C = 2 $Sin\ \theta$

Attitude towards the application of the dimensional analysis approach

Table 5 depicts students' responses after learning about quantities, units, and dimensions through the dimensional analysis approach using the Likert-scale (Gulya & Fehérvári, 2025). Most students agreed that this approach was new, useful, and efficient in solving physics problems. Students argued that it was easier to remember the dimensions of physical quantities than to memorize the related laws of physics. In addition, the majority of students believe that the dimensional analysis approach can shorten the time needed to solve physics problems.

Table 5. Aspects of attitudes assessed in the study

No	Statements	Strongly Agree	Agree	Disagree	Strongly Disagree
1	In my opinion, the dimensional analysis approach is a new approach to solving physics problems.	6	4	0	0
2	In my opinion, it is easier to remember the dimensions of the physical quantities involved in a problem than to remember the laws of physics related to the phenomena in the problem.	4	3	2	1
3	In my opinion, the use of the dimensional analysis approach is quite helpful in solving physics problems.	5	3	2	0

No	Statements	Strongly Agree	Agree	Disagree	Strongly Disagree
4	In my opinion, the use of the dimensional analysis approach can shorten the time needed to solve physics problems.	5	3	2	0
5	In my opinion, the dimensional analysis approach needs to be introduced to high school or college students as an alternative to the physics problem-solving approach.	6	4	0	0
6	In my opinion, the weakness of using the dimensional analysis approach is that it cannot produce exact solutions and still contains arbitrary constants.	5	5	0	0
7	In my opinion, an additional approach needs to be constructed that can be used to determine the arbitrary constants in order to obtain exact solutions.	6	4	0	0

In addition, despite their positive attitude, students also demonstrated a critical understanding of the limitations of the dimensional analysis approach. Students agreed that dimensional analysis cannot produce accurate solutions because it involves arbitrary constants, so an additional approach is needed to help determine these constants in order to achieve more accurate results. This shows that students not only appreciate the practicality of dimensional analysis but also understand the need to refine it so that it can be comprehensively applied in physics learning.

This study focuses on the application of the dimensional analysis approach in physics education for several cases of motion. The results of dimensional analysis on several physics motion topics, such as oscillatory motion, free fall motion, and parabolic motion, show internal consistency in the relationships between quantities obtained through dimensional analysis reasoning. In these three contexts, the derived equations successfully predict the correct functional relationship between mass, spring constant, height, velocity, and gravitational acceleration. This consistency confirms that dimensional analysis can serve as a powerful heuristic tool for deriving or verifying laws of physics, especially those related to motion, particularly when empirical data or complete theoretical models are not yet available (Bissell, 2012; Taylor et al., 2007). The proportional relationship obtained (e.g., $T = C\sqrt{\frac{m}{k}}$ and $t = \frac{2v_0 \sin\theta}{g}$) in line with the theoretical formulation of simple harmonic motion, free fall motion, and parabolic motion. This finding is in line with previous studies by Docktor and Mestre (2014); Redish (2021); Reichelova and Teleki (2013) which shows that dimensional reasoning helps students build conceptual coherence between physical quantities and improves their ability to generalize relationships between variables in various physics contexts, especially those related to motion.

In addition, the results of this study confirm the pedagogical value of applying dimensional analysis in physics learning, as obtained from student responses. Students' attitudes toward learning with a dimensional analysis approach show positive perceptions of the dimensional analysis approach, especially in terms of novelty, ease, and efficiency in solving physics problems. The majority of students believe that remembering the dimensions of physical quantities is easier than memorizing physics laws. This indicates that the dimensional analysis approach can strengthen conceptual understanding rather than just rote learning. Similar results were also found by Halliday et al. (2013); Sherin (2001); Singh (2006), who stated that when students are directed to reason based on quantities and units, they are able to develop a deeper understanding of the basic principles of physics.

Thus, the dimensional analysis approach can shift students' thinking patterns from algorithmic solutions to conceptual solutions in line with the main objectives of physics education research.

However, students also showed critical awareness of the limitations of the dimensional analysis approach, particularly regarding the existence of arbitrary constants that prevent the analysis results from providing definite numerical values. This awareness is in line with the findings of Cui et al. (2007); Van Heuvelen (1991), who emphasize that although dimensional analysis supports qualitative understanding, this approach needs to be combined with empirical or theoretical methods in order to produce complete quantitative solutions. Therefore, dimensional analysis should not be viewed as a substitute for formal methods but rather as a complementary strategy that strengthens understanding of the interrelationships between variables, prepares students for further modeling, and emphasizes the importance of physical consistency in every scientific formulation. Thus, the results of this study confirm that dimensional analysis produces relationships consistent with established physics theory. Furthermore, students expressed positive attitudes toward the use of dimensional analysis, suggesting that they perceive this approach as helpful for supporting their conceptual reasoning.

CONCLUSION

The effective dimensional analysis approach is useful in identifying and verifying proportional relationships between physical quantities in various motion contexts, such as oscillatory motion, free fall motion, and parabolic motion. This analysis produces relationships that are consistent with theoretical formulations and shows that this method can serve as a reliable tool for validating or deriving physics equations when empirical or theoretical models are incomplete. In addition, students showed a positive attitude towards the use of dimensional analysis, considering it a new, useful, and efficient approach to solving physics problems. This shows that dimensional analysis not only improves students' conceptual understanding but also encourages critical and reflective thinking about the structure of the laws of physics. However, this study also acknowledges several limitations, such as the fact that dimensional analysis cannot determine numerical constants, so it cannot produce exact solutions without the support of additional theory or empirical data. Thus, further research is recommended to integrate this approach with experiment-based or computational learning methods so that students gain a more comprehensive understanding that bridges conceptual reasoning and empirical verification.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, HRLS and ES; methodology, MZBA and IS; formal analysis, LNR and LS; writing—preparation of the original draft, HRLS and others.

AI DISCLOSURE STATEMENT

The author used DeepSeek (深度求索) during the preparation of this work for language refinement and grammar checking. After using DeepSeek, the author thoroughly reviewed and edited the content as needed and takes full responsibility for the publication's content. The authors declare that this research was prepared, researched, written, and edited without the aid of artificial intelligence (AI) techniques.

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REFERENCES

Aiken, L. R. (1985). Three coefficients for analyzing the reliability and validity of ratings. *Educational and Psychological Measurement*, *45*(1), 131–142.

Alan, Ü., & Kabasakal, K. A. (2020). Effect of number of response options on the psychometric properties of Likert-type scales used with children. *Studies in Educational Evaluation*, *66*, 100895.

Amiruddin, M. Z. Bin, & Suliyanah, S. (2023). Exploration physics concepts in local wisdom mappere bone south sulawesi as a source of physics learning: An analytical study. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *8*(1), 94–104.

Bhaskar, R., & Nigam, A. (1990). Qualitative physics using dimensional analysis. *Artificial Intelligence*, *45*(1–2), 73–111.

Bissell, J. (2012). Dimensional analysis and dimensional reasoning. In *Ways of Thinking, Ways of Seeing: Mathematical and other Modelling in Engineering and Technology* (pp. 29–45). Springer.

Conejo, A. N. (2021). *Fundamentals of dimensional analysis*. Springer.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, *16*(3), 297–334.

Cui, L., Rebello, N. S., & Bennett, A. G. (2007). Assessing college students' transfer of learning from calculus to physics using non-traditional problems. *Proceedings of the NARST 2007 Annual Meeting*.

Docktor, J. L., & Mestre, J. P. (2014). Synthesis of discipline-based education research in physics. *Physical Review Special Topics-Physics Education Research*, *10*(2), 20119.

Gok, T. (2018). Investigation of students' knowledge of physical quantities' symbol, unit and formula. *Asia-Pacific Forum on Science Learning & Teaching*, *19*(2).

Gulya, N. M., & Fehérvári, A. (2025). The extent and change of attitudes towards students with disabilities: A Meta-analysis of results measured with the chedoke-mcmaster attitudes towards children with handicaps scale. *Educational Research Review*, 100738. https://doi.org/10.1016/j.edurev.2025.100738

Halliday, D., Resnick, R., & Walker, J. (2013). *Fundamentals of physics*. John Wiley & Sons.

Lassri, M., & Lassri, H. (2022). Dimensional analysis and its role in the learning of physical sciences in secondary qualifying school. *Universal Journal of Educational Research*, *10*(1), 571–578.

Lenz, M., & Gire, E. (2016). Faculty views of and expectations for dimensional analysis. *PER Conference*, 196–199.

Martin, S. N. (2019). Science education in Indonesia: Past, present, and future. *Asia-Pacific Science Education*, *5*(1), 1–29. https://doi.org/10.1186/s41029-019-0032-0

Purnama, D., Tanwiruddin, T., Fatina, G. H., & Rokhmat, J. (2023). Pengaruh motivasi belajar terhadap hasil belajar kognitif siswa pada materi besaran dan satuan. *Contextual Natural Science Education Journal*, *1*(1), 38–45.

Purnomo, D., Vebrianto, R., & Yuliastrin, A. (2025). Analisis pembelajaran fisika: Dari sudut pandang guru dan siswa. *Lamda: Jurnal Ilmiah Pendidikan MIPA Dan Aplikasinya*, *5*(1), 39–47.

Redish, E. F. (2021). Using math in physics: 1. Dimensional analysis. *The Physics Teacher*, *59*(6), 397–400.

Reichelova, M., & Teleki, A. (2013). The role of dimensional analysis in teaching physics.

ArXiv Preprint ArXiv:1308.6164.

Santiago, J. G. (2019). *A first course in dimensional analysis: Simplifying complex phenomena using physical insight*. Mit Press.

Sari, E. P. D. N., Amiruddin, M. Z. Bin, Admoko, S., Suprapto, N., & Suliyanah, S. (2023). Exploration concept of physics on local wisdom in traditional game angkle (Engklek) as student teaching material. *Berkala Ilmiah Pendidikan Fisika*, *11*(1), 40–50.

Schiering, D., Sorge, S., Tröbst, S., & Neumann, K. (2023). Course quality in higher education teacher training: What matters for pre-service physics teachers' content knowledge development? *Studies in Educational Evaluation*, *78*(May). https://doi.org/10.1016/j.stueduc.2023.101275

Setiawan, B., & Suwandi, E. (2022). The development of Indonesia national curriculum and its changes: The integrated science curriculum development in Indonesia. *Journal of Innovation in Educational and Cultural Research*, *3*(4), 528–535.

Sherin, B. L. (2001). How students understand physics equations. *Cognition and Instruction*, *19*(4), 479–541.

Singh, C. (2006). Student understanding of symmetry and Gauss's law of electricity. *American Journal of Physics*, *74*(10), 923–936.

Taylor, M., Diaz, A. I., Jodar-Sanchez, L. A., & Villanueva-Mico, R. J. (2007). 100 Years of dimensional analysis: new steps toward empirical law deduction. *ArXiv Preprint ArXiv:0709.3584*.

Van Heuvelen, A. (1991). Learning to think like a physicist: A review of research-based instructional strategies. *American Journal of Physics*, *59*(10), 891–897.

Yahaya, W., Oladimeji, A. A., & Enuwa, M. R. (2023). Measuring students' dimensional analysis knowledge of mechanics concepts of physical quantities in Kwara State, Nigeria. *Archives of Educational Studies (ARES)*, *3*(1), 24–34.

Yildiz, A. (2015). A discussion on an expression written about dimensional analysis in a physics textbook. *European Journal of Physics Education*, *6*(3), 1–7.

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