

The Impact of Physics Co-curricular Activities Based on the Local Wisdom of the Makassar Tribe on Students' Scientific Measurement Skills

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ABSTRACT

Measurements in physics are essential as they serve as the foundation for analyzing the applicability of physical theories and laws, as well as for developing technology and other physics-related solutions. This study aims to analyze the impact of physics co-curricular activities based on the local wisdom of the Makassar tribe on students' scientific measurement skills. The research employed a pre-experimental method with an intact group comparison design. The study involved 40 students: 25 who participated in physics co-curricular activities and 15 who did not. The results showed that the average score of students who participated was 75.77, while those who did not scored 69.62. However, the results of the independent T-test indicated that the significance value (Sig. 2-tailed) was greater than $\alpha = 0.05$, meaning there was no statistically significant difference between the two groups. Nonetheless, the higher average score among students who participated in the co-curricular activities suggests potential for improvement in measurement skills. Therefore, although not statistically significant, physics co-curricular activities based on the local wisdom of the Makassar tribe show promise in enhancing students' scientific measurement skills.

Keywords: Makassar Tribe, Physics Co-curricular, Measurement Skills, Local Wisdom

1. INTRODUCTION

As a scientific discipline, physics has an important role in explaining various natural phenomena through systematic and quantitative approaches (Coccia, 2020; Jusup et al., 2022). Measurements are the primary foundation for understanding and developing physical concepts (Banda & Nzabahimana, 2021; Smith et al., 2020). Making measurements scientifically is not just a technical skill but the ability to define and measure what is being studied (Flake & Fried, 2020). Measurements allow students to empirically test the applicability of theories or laws of physics through observation and experimentation (Carroll, 2021; Maudlin et al., 2020). This makes measurement skills an essential component of the scientific thinking process that underlies all physics research activities (Jamil et al., 2024; Pols et al., 2021). Without good measurement skills, students' understanding of physics concepts becomes shallow and tends to be memorized.

Measurement and analysis significantly contribute to technology development, although they have differences (Hartigh Den & Hill, 2022). Every technological innovation is based on quantitative data obtained through an accurate and precise measurement process (Manzoor et al., 2021). Measurement accuracy is key to ensuring product safety, efficiency,

and functionality (Augustine, 2016). Measurement is also the starting point in the process of solving physics problems. Therefore, the mastery of measurement skills cannot be separated from the formation of a complete scientific competence of students.

The reality in the field shows that many students have difficulty mastering scientific measurement skills. Previous studies have shown that students often mistake choosing the right measuring instrument, reading the scale correctly, and interpreting the measurement results logically (Fitri & Suhendar, 2023). One of the problems students face is that teachers still use a theoretical learning approach and do not provide space for students to experience the measurement process themselves in real situations (Hamilton et al., 2021; Morris, 2020). The lack of creativity of teachers makes students less interested and less interested in following the learning process. Existing practicum activities also tend to be procedurally oriented without arousing students' conceptual understanding of the essence of measurement in physics (Patandean, 2021). One of the methods that can improve students' understanding in the practicum learning process, especially in measurement, is applying local wisdom in learning.

Local wisdom can be a bridge to provide a more authentic, relevant, and contextual learning experience and can be a forum to instill cultural values in students (Suryawan et al., 2022; Wahidin, 2020). Local wisdom is something that a region has that can reflect the diversity, regional potential, regional characteristics, and environments that can be applied in educational units so that learning activities can meet educational goals (Pramesti et al., 2024; Sofyan et al., 2019). Local wisdom contains empirical knowledge and practice that has a complex structure to complement the formal curriculum (Olewnik et al., 2023). In the South Sulawesi region, especially in the culture of the Makassar Tribe, there are various traditional practices involving the principles of physics and measurement activities (Limpo et al., 2022; Nugroho et al., 2023). This approach aligns with the modern science education paradigm that encourages context- and culture-based learning, enabling students to construct scientific understanding through meaningful experiences (Sukadari & Huda, 2021; Sutarja et al., 2024). Instilling new knowledge, especially in the region's culture, certainly makes it easier for teachers to improve students' understanding, especially in measurement skills.

Scientific measurement skills in physics learning have been widely highlighted in various studies, but the approach used to develop these skills is still dominated by conventional learning models that are classical (Banda & Nzabahimana, 2021; Pollard et al., 2021; Pols et al., 2021). Measurement skills are often assumed to develop automatically as experiments are carried out in the classroom, whereas in practice, the development of these skills requires a more structured, contextual, and reflective pedagogical approach (Kulgemeyer et al., 2020; Stebner et al., 2022). Most previous research has focused on improving students' cognitive learning outcomes without paying enough attention to aspects of basic scientific skills, particularly measurement. Therefore, a culture-based approach is needed to improve the student learning process.

Learning approaches that utilize local wisdom have begun to gain attention in the science education literature. Many regions have begun to implement learning based on local wisdom to increase the relevance of the material to students' daily lives (Rizaldi et al., 2023). This approach is more widely used to build positive attitudes toward culture or to

improve conceptual understanding. At the same time, the potential of local wisdom as a medium for learning scientific skills has not been explored optimally (Lubis et al., 2022). In the context of the local culture of the Makassar Tribe, several studies have specifically linked traditional cultural practices to the training of scientific measurement skills in physics education (Octana, 2020). Thus, this research confirms the educational value of local wisdom and proves its effectiveness as a vehicle for building scientific skills relevant to the physics curriculum. To complement local wisdom as a learning medium, of course, an activity is needed that utilizes the culture in the region, one of which is implementing physics co-curricular activities based on local wisdom.

Integrating these values of local wisdom into physics co-curricular activities can increase students' motivation to learn, strengthen the relationship between science and culture, and train students' scientific skills in a context closer to their lives (Suwito, 2020). Local wisdom-based physics co-curricular activities combine contextual, cultural, and scientific practice learning principles that allow students to build scientific understanding through cognitive bridges between cultural experiences and physical concepts (Dewi et al., 2021; Hitchcock et al., 2024; Puddin et al., 2023). The co-curricular activities developed in this study do not just display culture as an illustration but make it as a structural foundation of the measurement skills learning process and also as a learning space or student activity (Buhari et al., 2021; Kelly, 2020; Munir & Zaheer, 2021; Poornima & Tadi, 2023). This enriches contextual learning models that have not fully utilized local potential as an educational resource in developing scientific skills (Asmayawati et al., 2024; Darling-Hammond et al., 2020). This approach combines contextual, cultural, and scientifically practice-based learning principles, allowing students to build scientific understanding through cognitive bridges between cultural experience and physical concepts (Goode et al., 2023; Zulkefli et al., 2022). Methodologically, this study also adopts an evaluative approach that focuses on science process skills, different from the declarative knowledge-based evaluation approach commonly used in similar studies.

The novelty of this research lies in the use of co-curricular activities as a vehicle for the development of scientific skills, especially in the measurement and development of scientific measurement skills (Alhadad et al., 2021). This research is expected to contribute theoretically and practically to developing culturally and contextually based science pedagogy. Research conducted by (Martawijaya et al., 2025) regarding physics co-curricular activities based on local wisdom of the Makassar tribe, there was a significant increase in the Pancasila Student Profile (P3) with a p-value of < 0.05 . The N-Gain result showed an increase of 48.39% in the low category and 51.61% in the medium category. All students responded positively to this learning activity, although some still faced challenges in certain aspects.

This study aims to empirically analyze the impact of implementing physics co-curricular activities based on the local wisdom of the Makassar Tribe on the development of scientific measurement skills of high school students. In particular, this study aims to identify the extent to which the integration of local cultural activities that contain traditional measurement practices into non-formal learning activities can improve students' ability to use measuring tools, choose appropriate measurement techniques, interpret measurement data, and understand the concepts of accuracy and uncertainty in the scientific process.

2. METHODS

This study uses a quantitative approach with a pre-experimental type to investigate the impact of physics co-curricular activities based on the local wisdom of the Makassar Tribe on students' scientific measurement skills. The design used in this study is *the Intact-Group Comparison Design* (Sugiyono, 2013), namely an experimental design in which two groups, namely the experimental group consists of students who have participated in physics co-curricular activities based on local wisdom, while the control group consists of students who have never been involved in these activities. Sampling in this study uses a non-probability method, namely by using *purposive sampling* with the criteria of respondents who have availability to participate in the research (*Incidental sampling*) (Fitriana et al., 2023). The sampling technique using the non-probability method does not use a random process in sample selection but looks at the availability of students. The subject of this study consisted of 40 students divided into two groups, namely the first group of 25 students who had participated in the co-curricular activity and the second group of 15 students who had never participated in co-curricular activities.

The instrument used in this study is a non-test instrument. Non-test instruments can be measured using a direct assessment rubric sheet when students perform measurement activities. To ensure the instrument's validity, this test has been validated by experts in scientific measurement. This instrument is ensured to have good validity, allowing for the objective and accurate measurement of students' scientific skills (Arikunto, 2013). This test was administered to all students in two groups (experimental group and control group) before and after participating in physics co-curricular activities based on local wisdom to measure changes in scientific measurement skills during the research period. The data collection process is carried out after the co-curricular activities are completed, where students will be tested independently to learn the students' measurement skills from both groups.

The data analysis in this study was carried out in two stages: descriptive analysis and inferential analysis (Zwillinger, 2000). In the first stage, data from the scientific measurement skills test were analyzed descriptively to obtain an overview of the difference in average scores between the two groups. In the second stage, a parametric test, namely the Independent T-test, was used to test the significance of the difference in measurement skills between the two groups.

3. RESULTS AND DISCUSSION

In this section, an overview of the results of students' measurement skills is presented, which includes:

3.1 Descriptive Statistical Analysis

Table 1. Statistics on The Value of Skills Measurement of Learners

Statistics	Group	
	Co-curricular Activities	Not a Co-Curricular Activity

	M	MC	S/B	T	M	MC	S/B	T
Sum	25				15			
Smallest Value	5	6	8	7	5	4	6	5
Greatest Value	12	11	15	12	11	10	15	12
Standard Deviation	1.91	1.53	2.17	1.72	1.75	1.85	2.61	2.39
Variance	3.64	2.33	4.71	2.97	3.07	3.41	6.83	5.70
Average	9.68	7.92	11.96	9.84	8.73	7.53	11.40	8.53

Information:

M : Mistar

MC : Measuring Cups

S/B : Scales/Balance Sheet

T :Thermometer

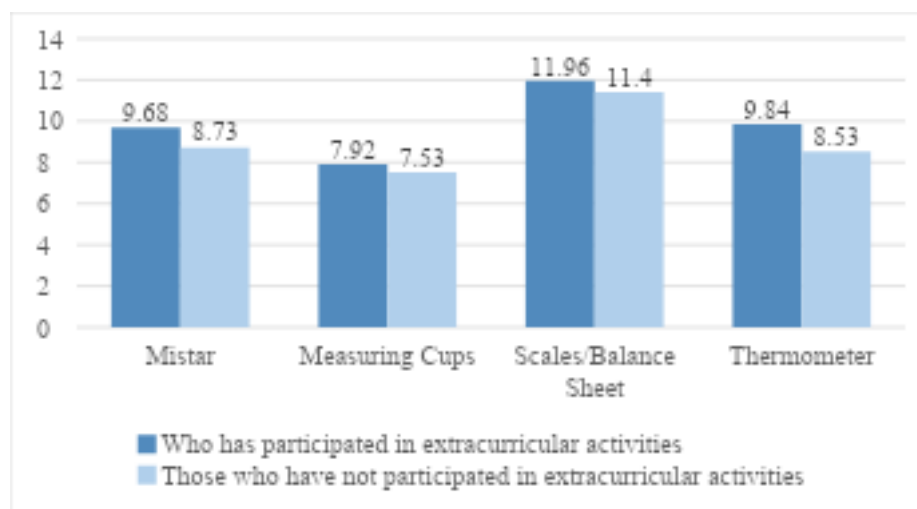


Figure 1. Average Bar Chart Values of Both Groups

3.2 Normality Test Results

The normality test determines whether the data comes from a normally distributed population. This test was carried out on the results of the measurement skill assessment in both groups. The Liliefors test was used in this study because the data obtained was <30. The normality test results in this study are presented in Table 2 and Table 3.

Table 2. Normality Test Results in Groups That Have Participated in Co-curricular Activities

Tests of Normality	
Kolmogorov-Smirnova	Shapiro-Wilk

	Statistics	Df	Sig.	Statistics	Df	Sig.
VALUE	.158	25	.110	.958	25	.379
a. Lilliefors Significance Correction						

Table 3. Normality Test Results in Groups That Have Not Participated in Co-curricular Activities

Tests of Normality						
	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistics	Df	Sig.	Statistics	Df	Sig.
VALUE	.157	15	.200	.949	15	.514
a. Lilliefors Significance Correction						

3.3 Hypothesis Test Results

The statistical analysis prerequisite test results showed that the measurement skill values in both groups were normally distributed. The homogeneity test showed that both groups' measurement skill value data was homogeneous. Therefore, the hypothesis test will be carried out using *the Parametric test* with further analysis using the *Independent T-test* to see the impact of physics co-curricular activities based on local wisdom on students' measurement skills and also to find out the difference between groups who have participated in co-curricular activities and those who have not participated in co-curricular activities. The results of the hypothesis testing are presented in the following table.

Table 4. Hypothesis Test Results Measurement Skills Test Results in Both Groups

Independent Samples Test						
		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	Df	Sig. (2-tailed)
Measurement Skills Results	Equal variances assumed	1.168	.287	1.675	38	.102
	Equal variances not assumed			1.557	23.421	.133

Based on Table 4, the value of each asymp is obtained. Sig. (2-tailed) is greater than the significant level where the significant value is $\alpha = 0.05$. This shows that H_0 is accepted and H_1 is rejected. These results show that physics co-curricular activities based on local wisdom do not impact students' measurement skills. This also means that there is no difference between students who have participated in physics co-curricular activities based on local wisdom and those who have not participated in co-curricular activities.

The descriptive statistical analysis results revealed a consistent pattern of student measurement skills between the two research groups. Groups of students who had participated in physics co-curricular activities tended to have higher average scores on all types of measuring instruments used in the research. Using the bar, the co-curricular group obtained an average of 9.68 compared to the control group, which obtained 8.73, indicating a difference of 0.95 scores. For measuring cups, the co-curricular group reached an average of 7.92 while the control group reached 7.53, with a relatively small difference of 0.39

scores. The use of scales/balance shows the most striking differences, with the co-curricular group obtaining an average of 11.96 and the control group 11.40, with a difference of 0.56 scores. Meanwhile, in using thermometers, the co-curricular group achieved an average of 9.84 compared to the control group, which obtained 8.53, showing the most significant difference of 1.31 scores.

This pattern of difference in average scores indicates that the physics co-curricular make a positive, albeit varied, contribution to students' ability to use various measuring instruments. The variability between the measuring instruments suggests that the effectiveness of co-curricular activities may differ depending on the type of measurement skills taught. Thermometers show the most significant difference, indicating that the concepts of temperature and thermal measurement in the context of local wisdom are easier for students to understand and apply. In contrast, measuring cups showed the most minor differences, which may indicate that volume measurement skills require a more intensive or different approach in the context of local wisdom-based learning.

The normality test results using the Kolmogorov-Smirnov and Shapiro-Wilk tests showed different findings from the previous analysis, where the measurement skills data in both groups showed a normal distribution. In the group that had participated in extracurricular activities, the significance values of Kolmogorov-Smirnov were 0.110, and Shapiro-Wilk were 0.379, both greater than $\alpha = 0.05$. Similarly, in the control group, the significance values of Kolmogorov-Smirnov of 0.200 and Shapiro-Wilk of 0.514 also showed a normal distribution. This normal data distribution provides a solid basis for using parametric tests in further analysis, specifically independent t-tests, to compare the two groups. The normality of this data distribution indicates that students' measurement skills in both groups are evenly distributed around mean scores, with statistically predictable variations. This shows that the sample used in this study is representative and does not show extreme bias in one particular direction. This condition confirms that the measurement instruments can produce consistent and reliable data.

The hypothesis test results using the independent t-test revealed interesting findings regarding the impact of physics co-curricular activities based on the local wisdom of the Makassar Tribe on students' measurement skills. Assuming equal variances, a t-value of 1.675 with a degree of freedom of 38 and a significance value (2-tailed) of 0.102 was obtained. This significance value is greater than the significance level $\alpha = 0.05$, which indicates that H_0 is accepted and H_1 is rejected. These findings suggest that although there are differences in average scores in favor of co-curricular groups, these differences are not statistically significant enough to be declared as a meaningful impact.

The analysis of the results of this study reveals several contextual factors that may affect the effectiveness of physics co-curricular activities based on the local wisdom of the Makassar Tribe. The first factor is the program's duration and intensity, which may not be optimal for a significant measurable impact (Nuzalfa et al., 2025). Measurement skills are psychomotor competencies that require repeated practice and enough time to be well internalized in students' cognition. Co-curricular activities that are temporal may not be able to provide enough exposure to produce substantial changes in students' abilities.

The second factor that is no less important is the period between the implementation of co-curricular activities and the collection of research data. Temporal distances that are too far can cause the learning effect to fade, especially if there is no reinforcement or repetition of the material in the context of regular learning. This indicates the importance of closer integration between co-curricular activities and the regular curriculum so that learning based on local wisdom does not stand alone but becomes an integral part of the physics learning process. In addition, students who do not participate in extracurricular activities still have access to learning measurement skills through regular classes, which can reduce differences between groups.

This research has several limitations that must be recognized and considered for future research. A significant limitation is the relatively small sample size (25 students for the co-curricular group and 15 students for the control group), which can affect the statistical power of detecting possible differences. A larger sample size will increase the sensitivity of the statistical analysis and provide more representative results. In addition, a quasi-experimental research design with an inequivalent control group can give rise to selection biases that affect the study's internal validity.

When compared to previous studies, such as the research conducted by Sahabuddin et al. (2024), which also evaluated the influence of local wisdom-based activities on students' scientific skills, similar results were found when equal variances were not assumed, with a t -value of 1.557 and a significance level of 0.133. Their study revealed a significant improvement in aspects of observation and measurement. However, the study involved a more intensive and structured intervention and employed a quasi-experimental design with better control over external variables. These differences in findings indicate that the success of co-curricular activity implementation is highly influenced by the quality of execution, learning context, and methodological control.

Thus, although the present study did not yield statistically significant results, the findings remain relevant as an initial indication that physics co-curricular activities based on local wisdom have the potential to enhance students' scientific measurement skills. This highlights the need for further research with more rigorous methodology and deeper investigation.

4. CONCLUSION

This research makes an important contribution in understanding the role of physics co-curricular activities based on the local wisdom of the Makassar Tribe on students' measurement skills. Although statistically no significant difference was shown, the positive trends shown by co-curricular groups indicated that this approach had the potential to be developed. These results show that integrating local wisdom in physics learning requires careful planning, consistent implementation, and continuous evaluation to be able to have an optimal impact on students' skills. Future research is recommended to involve a larger sample size and to employ an experimental or quasi-experimental design to strengthen the statistical validity of the results. The duration of the activities should also be extended to observe their long-term impact. Additionally, qualitative analysis such as interviews or observations can be used to gain a deeper understanding of students' experiences.

REFERENCES

- Agustina, S. (2016). Analisis Keterampilan Generik Sains Siswa Pada Praktikum Besaran Dan Pengukuran Kelas X Di Sma Muhammadiyah 1 Palembang. *Jurnal Inovasi Dan Pembelajaran Fisika*, 3(1), 100–110.
- Alhadad, S. S. J., Vasco, D., Williams, J. C., Dizon, P., Kapnias, R. L., Khan, S. B., Payne, H., Simpson, B. C., & Warren, C. D. (2021). Learning, unlearning, and relearning together: Unmasking power in a students as partners program using collaborative autoethnography. *Student Success*, 12(2), 38–50. <https://doi.org/10.5204/ssj.1934>
- Arikunto, S. (2013). *Prosedur Penelitian: Suatu Pendekatan Praktik*. Jakarta: Rineka Cipta.
- Asmayawati, Yufiarti, & Yetti, E. (2024). Pedagogical innovation and curricular adaptation in enhancing digital literacy: A local wisdom approach for sustainable development in Indonesia context. *Journal of Open Innovation: Technology, Market, and Complexity*, 10(1), 100233. <https://doi.org/10.1016/j.joitmc.2024.100233>
- Banda, H. J., & Nzabahimana, J. (2021). Effect of integrating physics education technology simulations on students' conceptual understanding in physics: A review of literature. *Physical Review Physics Education Research*, 17(2), 23108. <https://doi.org/10.1103/PhysRevPhysEducRes.17.023108>
- Buhari, S. M., Suganya, R., & Rajaram, S. (2021). Effective Mechanism of Graduate Attributes distribution in Engineering Education Curriculum. In *Journal of Engineering Education Transformations* (Vol. 34).
- Carroll, S. (2021). Consciousness and the laws of physics. *Journal of Consciousness Studies*, 28(9–10), 16–31. <https://doi.org/10.53765/20512201.28.9.016>
- Coccia, M. (2020). The evolution of scientific disciplines in applied sciences: dynamics and empirical properties of experimental physics. In *Scientometrics* (Vol. 124, Issue 1). Springer International Publishing. <https://doi.org/10.1007/s11192-020-03464-y>
- Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, 24(2), 97–140. <https://doi.org/10.1080/10888691.2018.1537791>
- Dewi, C. A., Erna, M., Martini, Haris, I., & Kundera, I. N. (2021). Effect of Contextual Collaborative Learning Based Ethnoscience to Increase Student's Scientific Literacy Ability. *Journal of Turkish Science Education*, 18(3), 525–541. <https://doi.org/10.36681/tused.2021.88>
- Fitri, U. R., & Suhendar, H. (2023). Pembelajaran Keterampilan Pengukuran Di Man 2 Ciracas. *Jurnal Pengabdian Masyarakat Sains Dan Aplikasinya (JPMSA)*, 3, 2809–8153. <https://doi.org/10.21009/jpmsa.v3i1.34797>
- Fitriana, Sitompul, S. S., & H, M. M. S. (2023). *Jurnal dunia pendidikan. Jurnal Dunia Pendidikan*, 3(November), 67–78. <http://jurnal.stokbinaguna.ac.id/index.php/JURDIP/article/view/2083>

- Flake, J. K., & Fried, E. I. (2020). Measurement Schmeasurement: Questionable Measurement Practices and How to Avoid Them. *Advances in Methods and Practices in Psychological Science*, 3(4), 456–465. <https://doi.org/10.1177/2515245920952393>
- Goode, H., Drysdale, L., & Gurr, D. (2023). What We Know about Successful School Leadership from Australian Cases and an Open Systems Model of School Leadership. *Education Sciences*, 13(11). <https://doi.org/10.3390/educsci13111142>
- Hamilton, D., McKechnie, J., Edgerton, E., & Wilson, C. (2021). Immersive virtual reality as a pedagogical tool in education: a systematic literature review of quantitative learning outcomes and experimental design. In *Journal of Computers in Education* (Vol. 8, Issue 1). Springer Berlin Heidelberg. <https://doi.org/10.1007/s40692-020-00169-2>
- Hartigh Den, R. J. R., & Hill, Y. (2022). Conceptualizing and measuring psychological resilience: What can we learn from physics? *New Ideas in Psychology*, 66, 100934. <https://doi.org/10.1016/j.newideapsych.2022.100934>
- Hitchcock, S., Seno-Alday, S., & Chandra, P. (2024). Missing the Mark: lessons From Failing to Foster Learner Engagement in a Co-Curricular Program. *Journal of Management Education*. <https://doi.org/10.1177/10525629241249764>
- Jamil, M., Hafeez, F. A., & Muhammad, N. (2024). Critical Thinking Development for 21st Century: Analysis of Physics Curriculum. *Journal of Social & Organizational Matters*, 3(1), 01–10. <https://doi.org/10.56976/jsom.v3i1.45>
- Jusup, M., Holme, P., Kanazawa, K., Takayasu, M., Romić, I., Wang, Z., Geček, S., Lipić, T., Podobnik, B., Wang, L., Luo, W., Klanjšček, T., Fan, J., Boccaletti, S., & Perc, M. (2022). Social physics. *Physics Reports*, 948, 1–148. <https://doi.org/10.1016/j.physrep.2021.10.005>
- Kelly, K. (2020). Collaborative and Co-curricular: Programming and Academic Library Impact.
- Kulgemeyer, C., Borowski, A., Buschhüter, D., Enkrott, P., Kempin, M., Reinhold, P., Riese, J., Schecker, H., Schröder, J., & Vogelsang, C. (2020). Professional knowledge affects action-related skills: The development of preservice physics teachers' explaining skills during a field experience. *Journal of Research in Science Teaching*, 57(10), 1554–1582. <https://doi.org/10.1002/tea.21632>
- Limpo, S. Y., Fahmid, I. M., Fattah, A., Rauf, A. W., Surmaini, E., Muslimin, Saptana, Syahbuddin, H., & Andri, K. B. (2022). Integrating Indigenous and Scientific Knowledge for Decision Making of Rice Farming in South Sulawesi, Indonesia. *Sustainability* (Switzerland), 14(5). <https://doi.org/10.3390/su14052952>
- Lubis, S. P. W., Suryadarma, I. G. P., Paidi, & Yanto, B. E. (2022). The Effectiveness of Problem-based learning with Local Wisdom oriented to Socio-Scientific Issues. *International Journal of Instruction*, 15(2), 455–472. <https://doi.org/10.29333/iji.2022.15225a>
- Manzoor, B., Othman, I., & Pomares, J. C. (2021). Digital technologies in the architecture, engineering and construction (Aec) industry—a bibliometric—qualitative literature

- review of research activities. *International Journal of Environmental Research and Public Health*, 18(11). <https://doi.org/10.3390/ijerph18116135>
- Martawijaya, M. A., Sujiono, E. H., Halim, A. D., Siew Wei, T., Mahir, M., Palloan, P., & Zharvan, V. (2025). The Impact of Physics Co-curricular Activities Based on Makassar Local Wisdom on Improving the Pancasila Student Profile and Learning Satisfaction. *Jurnal Pendidikan IPA Indonesia*, 14(1 SE-Articles). <https://doi.org/10.15294/jpii.v14i1.13178>
- Maudlin, T., Okon, E., & Sudarsky, D. (2020). On the status of conservation laws in physics: Implications for semiclassical gravity. *Studies in History and Philosophy of Science Part B - Studies in History and Philosophy of Modern Physics*, 69, 67–81. <https://doi.org/10.1016/j.shpsb.2019.10.004>
- Morris, T. H. (2020). Experiential learning—a systematic review and revision of Kolb’s model. *Interactive Learning Environments*, 28(8), 1064–1077. <https://doi.org/10.1080/10494820.2019.1570279>
- Munir, S., & Zaheer, M. (2021). The role of extra-curricular activities in increasing student engagement. *Asian Association of Open Universities Journal*, 16(3), 241–254. <https://doi.org/10.1108/AAOUJ-08-2021-0080>
- Nugroho, H. Y. S. H., Sallata, M. K., Allo, M. K., Wahyuningrum, N., Supangat, A. B., Setiawan, O., Njurumana, G. N., Isnain, W., Auliyani, D., Ansari, F., Hanindityasari, L., & Najib, N. N. (2023). Incorporating Traditional Knowledge into Science-Based Sociotechnical Measures in Upper Watershed Management: Theoretical Framework, Existing Practices and the Way Forward. *Sustainability (Switzerland)*, 15(4). <https://doi.org/10.3390/su15043502>
- Nuzalfa, S. N., Nurmeta, I. K., & Maula, L. H. (2025). *Jurnal Ilmiah Pendidikan Dasar*. *Jurnal Ilmiah Pendidikan Dasar*, 10(01), 112–137.
- Octana, I. N. (2020). Pengembangan modul pengayaan fisika sma bermuatan keterampilan abad 21 berbasis kearifan lokal pada etnis lampung (Doctoral dissertation, UIN Raden Intan Lampung).
- Olewnik, A., Chang, Y., & Su, M. (2023). Co-curricular engagement among engineering undergrads: do they have the time and motivation? *International Journal of STEM Education*, 10(1). <https://doi.org/10.1186/s40594-023-00410-1>
- Patandean, Y. R., & Indrajit, R. E. (2021). Flipped classroom: Membuat peserta didik berpikir kritis, kreatif, mandiri, dan mampu berkolaborasi dalam pembelajaran yang responsif. Penerbit Andi.
- Pollard, B., Hobbs, R., Henderson, R., Caballero, M. D., & Lewandowski, H. J. (2021). Introductory physics lab instructors’ perspectives on measurement uncertainty. *Physical Review Physics Education Research*, 17(1), 10133. <https://doi.org/10.1103/PhysRevPhysEducRes.17.010133>
- Pols, C. F. J., Dekkers, P. J. J. M., & de Vries, M. J. (2021). What do they know? Investigating students’ ability to analyse experimental data in secondary physics

- education. *International Journal of Science Education*, 43(2), 274–297. <https://doi.org/10.1080/09500693.2020.1865588>
- Poornima, C. S., & Tadi, M. (2023). Role of Co-curricular Activities in Enhancing Conceptual Learning of Anatomy – An Undergraduate Perspective. *International Journal of Anatomy and Research*, 11(4), 8729–8734. <https://doi.org/10.16965/ijar.2023.201>
- Pramesti, A. W., Winalda, T., Putri, N. D., Iswaningtias, A. D., Apriliana, E., Sukardi, R. R., & Yuniarti, Y. (2024). Analisis Konten Kearifan Lokal Karawitan sebagai Bahan Proyek Penguatan Profil Pelajar Pancasila. *Teaching, Learning and Development*, 1(2), 141–153. <https://doi.org/10.62672/telad.v1i2.15>
- Puddin, A., Ibrahim, B., & Ismail, M. F. (2023). Discovering Competency's Elements in the Affective Domain of a Sustainable Co-curricular Syllabus. *International Journal of Sustainable Construction Engineering and Technology*, 14(2), 223–231. <https://doi.org/10.30880/ijscet.2023.14.02.023>
- Rizaldi, M., Kurniansyah, D., & ... (2023). Kebijakan Penguatan Pendidikan Karakter Berbasis Kearifan Lokal Di Dinas Pendidikan Kabupaten Putwakarta. *JISIP (Jurnal Ilmu ...)*, 7(3), 2554–2562. <https://doi.org/10.58258/jisip.v7i1.5>
- Sahabuddin, E. S., Amrah, A., Syam, A. V., Bahar, B., Yusnadi, Y., Nurferiyani, A., & Arwien, R. T. (2024). Mengeksplorasi Dampak Resource Based Learning Pada Mata Pelajaran IPA, Literasi Lingkungan: Studi Kasus Kelas V Di UPT SPF SDN Mangkura V, Kota Makassar. *Publikasi Pendidikan*, 14(1), 21. <https://doi.org/10.26858/publikan.v14i1.59556>
- Smith, E. M., Stein, M. M., Walsh, C., & Holmes, N. G. (2020). Direct measurement of the impact of teaching experimentation in physics labs. *Physical Review X*, 10(1), 11029. <https://doi.org/10.1103/PhysRevX.10.011029>
- Sofyan et al. (2019). Development of E-Modules Based on Local Wisdom in Central Learning Model at Kindergartens in Jambi City. *European Journal of Educational Research*, 8(4), 1137–1143. <https://doi.org/10.12973/eu-jer.8.4.1137>
- Stebner, F., Schuster, C., Weber, X. L., Greiff, S., Leutner, D., & Wirth, J. (2022). Transfer of metacognitive skills in self-regulated learning: effects on strategy application and content knowledge acquisition. *Metacognition and Learning*, 17(3), 715–744. <https://doi.org/10.1007/s11409-022-09322-x>
- Sugiyono. (2013). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfabeta.
- Sukadari, S., & Huda, M. (2021). Culture sustainability through co-curricular learning program: Learning batik cross review. *Education Sciences*, 11(11). <https://doi.org/10.3390/educsci11110736>
- Suryawan, I. P., Pasek, I. M., & Sutajaya, I. W. S. (2022). Tri Hita Karana sebagai Kearifan Lokal dalam Pengembangan Pendidikan Karakter. *Jurnal Pendidikan Multikultural Indonesia*, 5(2), 50–65. <https://doi.org/10.23887/jpmu.v5i2.55555>
- Sutarja, Prayitno, H. J., Waston, Hidayat, S., Ali, M., & Sugiarto, F. (2024). Character Strengthening Model Of Religious Moderation Praxis Method To Improve And Develop

- Student Morale. *Revista de Gestao Social e Ambiental*, 18(2).
<https://doi.org/10.24857/RGSA.V18N2-076>
- Wahidin, D. (2020). Pendidikan Berbasis Kearifan Lokal Di Abad 21. *Ujmes*, 05(01), 1.
- Zulkefli, A. U., Abdullah, M. R. T. L., & Endut, M. N. A. A. (2022). Co-creation on Redefining Consumer Well-Being Needs Among Youth Through Self-Potential Development Model. *Frontiers in Psychology*, 13.
<https://doi.org/10.3389/fpsyg.2022.814757>
- Suwito., E., P., Eko, H., Munandar, M. A., & Maman, R. (2020). Local wisdom: Pillar development of multicultural nations and national education values. *Cypriot Journal of Educational Sciences*, 15(6), 1587–1598.
- Zwillinger, D.(2000). standard probability and Statistics tables and formulae. Chapman & Hall/Crc.