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Analysis of Physics Learning Outcomes Based on High School Students' Learning Styles: A Meta-Analysis Study

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ABSTRACT. Learning physics in senior high school is often a challenge because the material requires theoretical and mathematical understanding, especially if the learning method does not pay attention to the learning style of students. This study aims to analyze articles related to physics learning outcomes based on the learning styles of high school students using a meta-analysis approach. This research is a meta-analysis of previous research published in the 2015-2024 timeframe. This research provides guidance for teachers in designing effective learning strategies according to the needs of students. The results showed that visual learning style is the most dominant in supporting physics concept understanding, followed by auditory style, and finally kinesthetic style. However, other factors such as motivation and teaching methods also affect learning outcomes. The conclusion of this study states that learning style is not the only factor that affects physics learning outcomes. A multimodel learning approach is important to improve learning outcomes effectively and inclusively.

1. Introduction

Learning is a behavioral change that occurs through experience and training. The purpose of learning is to change behavior, both in terms of knowledge, skills, attitudes, and all personal aspects (Khadijah, 2013).

Learning is a process of changing behavior to gain knowledge through a series of experiences with results in the form of mastery, use, and assessment of attitudes and values of knowledge, basic skills contained in various fields of study (Lubis, S, 2021). In the learning process, teachers or educators can assess the success of learning by observing the level of activeness of students during learning activities and seeing the learning outcomes achieved by students.

Learning outcomes can be influenced by various factors, both external and internal. External factors include environmental influences, while internal factors involve learner characteristics such as intelligence, motivation, attitude, and learning style (Damayanti, A, 2022). Additionally, learning outcomes are often expressed as numerical grades obtained by students after receiving instructional materials through tests or examinations. These outcomes reflect the learners' abilities following their learning experiences (Asriyanti, F.D. & Janah, L.A, 2018). Generally, learning outcomes represent specific competencies in the cognitive, affective, and psychomotor domains that students achieve after undergoing the learning process (Hamalik, Oemar, 2019).

Each student has a different learning style, which allows for differences in how they absorb information, both in terms of the amount of information and the speed at which it is received (Nurnaifah, I. I., Akhfar, M., & Nursyam, N, 2022). Learning style is an approach that explains how individuals learn, including how they concentrate on the learning process and master difficult information through different perceptions (Kurniati, A., Fransiska, F., & Sari, A.W, 2019). In addition, learning style can also be defined as the method that learners use in processing information during the learning process. In general, learning styles include how a person absorbs, organizes, and processes information (Marpaung, J, 2016). Therefore, each individual, including learners, has a different way of receiving, processing, and remembering the information obtained.

Students with an auditory learning style tend to understand information more easily through listening, while those with a kinesthetic learning style learn more effectively through hands-on practice or physical activities. Conversely, students with a visual learning style are better at receiving and processing information when it is presented in the form of images, charts, or diagrams. Nevertheless, learners with a dominant learning style still possess characteristics of the other styles (Yulianci, S., Nurjumiati, N., & Asriyadin, A, 2020). These three types of learning styles—visual, auditory, and kinesthetic—can influence students' behavior in carrying out their learning activities (Azis, F. R. N., Pamujo, P., & Yuwono, P.H, 2020). Therefore, the three main learning styles are visual, auditory, and kinesthetic.

Physics subjects at the Senior High School level are often considered difficult because they combine abstract and mathematical concepts. In addition, the lecture method that is still often used tends to make learning monotonous and student learning outcomes are less than satisfactory (Junita, Gusnaeni Novia et al, 2024). Many teachers pay less attention to the learning styles of students, so that the learning process becomes less optimal. As a result, many learners have not been able to recognize their dominant learning style, making it difficult to follow the learning process effectively. In fact, basically every learner has all three types of visual, auditory and kinesthetic learning styles, although one of them is more dominant. Therefore, learners need to be helped to recognize their learning style so that the learning process takes place effectively and learning objectives are achieved.

This research is a meta-analysis that analyzes articles related to physics learning outcomes in terms of learning styles of high school students. The analysis was carried out descriptively-qualitatively using the content analysis method which was adjusted to the research objectives. Meta-analysis in this study aims to review, evaluate, and interpret several studies that are relevant to the needs or topics desired by the researcher. Basically, meta-analysis is a statistical procedure used to identify trends in the magnitude of effects observed in a series of quantitative studies that address the same research problem (Hasana, 2016).

Previous research shows various results related to the relationship between learning styles and physics learning outcomes. Research shows that there is no significant relationship between learning styles and student learning outcomes (Susilawati, Ma'ruf, and Yani, 2019). Similar findings were also obtained which concluded that there was no effect of students' learning styles on their learning outcomes (Nurnaifah, Akhfar, and Nursyam, 2022). In contrast, research shows that visual learning styles tend to provide better physics learning outcomes than other learning styles, with visual learners more effectively learning through media

such as pictures, diagrams, and graphs (Mudah, 2023). In addition, it was found that visual learning style is dominant in learners, followed by kinesthetic, which has a positive relationship with their physics learning outcomes (Anggrasari, 2018).

This research uses a more in-depth meta-analysis approach, which not only evaluates the results of one or two studies, but also reviews several articles to get a broader picture of the analysis of physics learning outcomes in terms of physics learning styles at the senior high school level. Previous studies tend to use ex-post facto, correlational, descriptive, and quantitative descriptive research methods in analyzing learning outcomes based on the learning styles of high school students.

Based on the explanation described above, researchers want to conduct research on "Analysis of physics learning outcomes in terms of learning styles of high school students: A Meta-Analysis Study".

2. Methode

This study uses the meta-analysis method to analyze the results of previous studies that discuss similar issues. The articles analyzed in this study include 16 relevant articles that discuss the analysis of physics learning outcomes in terms of learning styles of high school students. The articles were obtained from various platforms such as Google Scholar, Semantic Scholar, Open Knowledge Maps, and Connected Papers, with a publication range of 2015-2024.

The data collection process in this study was carried out using the documentation method, namely by selecting, collecting, and analyzing articles that fit the inclusion criteria. These criteria include articles that discuss physics learning outcomes at the high school level, use the Visual, Auditory and Kinesthetic learning styles model, and are published within a predetermined time period. While articles that did not meet these criteria, such as articles that did not discuss Visual, Auditory and Kinesthetic learning styles or that focused on students outside the high school level were not continued in the analysis process.

The data analysis stage was carried out by examining the content of each article to identify how physics learning outcomes when viewed from the learning styles of high school students. This process ends with drawing conclusions based on the findings.

3. Results and Discussion

The results of research obtained from several sources are 16 studies. The selection of 16 studies in this meta-analysis was based on relevance to the topic of physics learning outcomes in terms of learning styles of high school students, publication range 2015-2024, and availability of sufficient data for analysis. Articles were obtained from platforms such as Google Scholar, Semantic Scholar, Open Knowledge Maps, and Connected Papers, with quality criteria including the presentation of relevant data. This research comes from articles that have been researched previously.

Tabel 1. Data Analysis of Physics Learning Outcomes in terms of Students' Learning Style

No	References	Research Title	Research Results
1	Ihfa Indira Nurnaifah	The influence of learning styles on student physics learning outcomes	The learning style of Class XI students of SMAN 9 Pinrang is dominated by visual learning style at 44%, followed by kinesthetic at 36%, and auditory at 20%. Analysis using Microsoft Excel resulted in a regression equation Y=86.92998-0.10133XY, with a negative coefficient indicating a negative influence of learning styles on learning outcomes. The linear regression test using SPSS 21 shows a significance value of 0.263 (> 0.05), so it is concluded that learning styles do not affect student learning outcomes.

2	Fitriani Kadir, Imam Permana, and Nurul Qalby	The Effect of Student Learning Style on Physics Learning Outcomes of PGRI MAROS High School	Students with kinesthetic learning style obtained good physics learning outcomes when utilizing physical activities, with a contribution of 7.31% at PGRI Maros High School. Auditory learning style contributed 44.34%, with students more easily understanding physics lessons through listening to explanations from teachers or friends. Visual learning style also contributed 44.34%, where students tend to achieve good results when learning in a quiet environment. All these learning styles show that the higher the tendency of a particular learning style, the better the physics learning outcomes of students.
3	Nurdiana	The Relationship between Critical Thinking Skills and Physics Learning Outcomes Based on Learning Styles of Xi Mia Class Students at Sma Negeri 2 PANGKEP	Learners with kinesthetic learning styles obtained the highest physics learning outcomes score, namely 58.57%. Followed by students with an auditorial learning style who obtained a score of 53.65%, while students with a visual learning style obtained a score of 49.52%. However, the three learning styles of auditorial, visual, and kinesthetic have a positive relationship with the physics learning outcomes of students in class XI MIA SMA Negeri 2 Pangkep.
4	Fifi Angrasari	Relationship between Learning Style and Physics Learning Outcomes of Class X MIA Students at SMA Negeri 2 Takalar	The physics learning outcomes of class X MIA students at SMA Negeri 2 Takalar show a significant positive relationship with their learning style. In other words, the more appropriate the learning style applied, the better the physics learning outcomes achieved by students.
5	Hesti Diana Putri, Baiq Septia Azizati, Nurul Aini, and Joni Rokhmat	Analysis of Learning Styles and Student Learning Outcomes on Newton's Law Material	The results showed that the kinesthetic learning style has an average percentage of 40%, more effective than the auditory and visual learning styles which each have 30%. Changes in students' learning styles can occur as they make the most of the teacher's teaching style, which affects learning outcomes. Therefore, it is important for teachers to recognize students' learning styles and adjust learning to make it more comfortable and effective.
6	Sri Nur Susilawati, Ma'ruf, and Ahmad Yani	Science Process Skills, Learning Styles, and Physics Learning Outcomes	Based on the results of this study, it was found that there was no significant relationship between learning styles and learning outcomes of students in class XI MIPA at SMA Negeri 08 Gowa. This shows that learning style factors do not significantly affect the achievement of student learning outcomes at the school.

7	Novia Junita, Desnita, Asrizal, and Gusnedi	Analysis of the relationship between learning styles and creativity with high school physics learning outcomes	Physics learning outcomes show a positive relationship with learning styles. This means that the more appropriate the learning style applied, the better the physics learning outcomes achieved by students. In other words, learning style has a significant influence on the achievement of student learning outcomes in physics.
8	Yolanda Dhea Afelia, and Agus Prasetyo Utomo	Analysis of Learning Styles of Class X Students of SMAN 1 Bangorejo in the Implementation of Differentiated Learning on Independent Curriculum	In this study, it was found that students' learning styles were not limited to one type of style. The learning style tendencies of grade X students are divided as follows: 64% are more likely to use visual and auditory learning styles, while 36% prefer kinesthetic learning styles. This result shows that most learners understand the material more easily with the support of visual and audio objects.
9	Siska Widiawati, Hikmawati, and Wahyudi	The Effect of *Group Investigation* (GI) Cooperative Learning Model on Physics Learning Outcomes in Response to Student Learning Styles	The physics learning results of students on static fluid material show that learning styles affect the results achieved. Visual learning style gave the best results, followed by auditory learning style, and kinesthetic learning style came last. This indicates that students' learning styles can affect their understanding of physics materials.
10	Suci Febriani, Muhammad Taufik, and Ni Nyoman Sri Putu Verawati	The Effect of *Guided Discovery Learning* Model with Experiment Method on Physics Learning Outcomes of MAN 1 Mataram Students in View of VAK Learning Style	The results showed that there was no significant influence between VAK (Visual, Auditory, Kinesthetic) learning styles and students' physics learning outcomes. This means that the learning style applied by students is not directly related to their achievement in physics lessons.
11	Gunawan, A. Harjono, and Imran	The Effect of Interactive Multimedia and Learning Style on Students' Mastery of the Concept of Heat	The results showed that learning styles have a significant influence on student learning outcomes. This means that the learning style that students apply can affect their achievement in the learning process.
12	Syahriani Yulianci, Gunawan, Aris Doyan, and Fenny Febriyanti	The Effect of Learning Style on Students' Mastery of Physics Concepts on the Material of Magnitude and Measurement	The statistical test results show that there is no significant influence between learning styles and students' mastery of physics concepts. In other words, the learning style applied by students does not significantly affect the extent to which they master physics concepts.
13	Erniyanti, Zulkarnaen, and Didik Supriyadi	Analysis of the Effect of Learning Style on Physics Learning Activity of Class X-9 Students of SMA Negeri 1 Samarinda	The results showed that students in class X-9 tend to have a more dominant visual learning style. The learning activeness of students in this class is classified as very good. This activeness can be influenced by various factors,

			including the learning style applied by students.
14	Syahriani Yulianci, Nurjumiati, and Asriyadin	Analysis of VAK (Visual, Auditory, Kinesthetic) Learning Style Characteristics of Students in Physics Learning	The results showed that grade X students who participated in physics learning were more likely to rely on auditory learning styles. This means that they more easily understand the material by listening to explanations from teachers or other audio sources.
15	Junierissa Marpaung	The Effect of Learning Style on Student Achievement	The results show that learning styles are strongly related to the way students transfer the knowledge gained, both during the learning process in class and when studying at home. By understanding their learning styles, students can develop more effective strategies to improve their learning achievement.
16	Muhamad Sahri and Zulkarnaen	Identifying the Characteristics of Learners as a Reference for Learning Planning Physics at SMA Negeri 2 Samarinda	The data obtained shows that the most dominant learning style among students is visual learning style. Kinesthetic learning style came second, while auditory learning style came last.

Table 1 shows the results of a search related to the physics learning outcomes of high school students based on learning styles. The data presented includes the references, research title, and research results.

Based on the data in Table 1, there are differences in the results of studies that discuss physics learning outcomes in terms of students' learning styles. Learners' learning styles can be divided into three types, namely visual, auditory, and kinesthetic. The results of the analysis of 16 articles show the variation of results obtained from previous studies.

Visual learning style involves a student's ability to understand information through vision, such as reading, looking at pictures, graphs, or diagrams (Rusman, 2017). Visual learning style is the most dominant style in influencing learning outcomes. Fifi Anggrasari's research (2018) shows a significant relationship between visual learning styles and physics learning outcomes, where students with this style achieve better results through media such as diagrams, graphs, and images. Research by Novia Junita et al. (2017) and Gunawan et al. (2017) supports this finding by showing that visual learning style gives the best results when teachers use interactive media. In addition, research by Erniyanti et al. (2022) found that 64% of grade X students of SMA Negeri 1 Samarinda tended to adopt a visual learning style, which helped improve their learning activeness. Research by Muhammad Sahri and Zulkarnaen (2022) also reported that visual learning style is the most dominant among students, although its success is highly dependent on the availability of adequate learning media. However, some studies show different results. Ihfa Indira Nurnaifah (2022) found that although the visual learning style is dominant (44%), its contribution to learning outcomes can be negative, especially if the visual media used is not optimal. Research by Sri Nur Susilawati et al. (2020) and Suci Febriani et al. (2019) also showed that visual learning style has no significant effect on physics learning outcomes, which may be influenced by the lack of adjustment of learning methods to students' learning styles.

Meanwhile, auditory learning style involves learning through hearing, such as listening to teacher explanations, group discussions, or audio recordings (Rusman, 2017). Auditory learning style shows varied results. Nurdiana (2020) reported that students with auditory style recorded a learning outcome score of 53.65%, higher than students with visual style (49.52%) but lower than students with kinesthetic style (58.57%). Research by Fitriani Kadir et al. (2020) showed that auditory learning style made a significant

contribution, amounting to 44.34%, to physics learning outcomes, especially when discussion-based learning methods were applied. Syahriani Yulianci et al. (2020) also reported that grade X students are more likely to rely on auditory style in physics learning, which makes it easier for them to understand the material through oral explanation or discussion. However, research by Suci Febriani et al. (2019) did not find a significant effect of auditory style on physics learning outcomes, this could be due to the lack of variation in auditory-based teaching methods applied.

Kinesthetic learning styles tend to be more effective in practice-based learning or experiments. Research by Hesti Diana Putri et al. (2023) showed that kinesthetic style has an effectiveness of 40% in learning Newton's law, where students better understand the material through direct experimentation. This is supported by research by Siska Widiawati et al. (2017), which shows that students with kinesthetic style are superior in experiment-based learning on static fluid material. However, kinesthetic style has a lower contribution in learning abstract material. Research by Fitriani Kadir et al. (2020) reported that the contribution of kinesthetic style was only 7.31% in learning more theoretical material. Research by Yolanda Dhea Afelia et al. (2024) shows that only 36% of students predominantly use kinesthetic style, while the majority of students (64%) prefer a combination of visual and auditory learning styles.

The results of the analysis indicate differences in the contribution of each learning style to physics learning outcomes. Research that shows a significant relationship between learning styles and learning outcomes tends to involve learning methods tailored to students' learning styles. For example, research by Fifi Anggrasari (2018), Novia Junita et al. (2017), and Gunawan et al. (2017) showed that the use of appropriate visual media improved the learning outcomes of students with visual learning styles. Similar results were found for auditory styles, where group discussion or lecture approaches, as reported by Nurdiana (2020) and Fitriani Kadir et al. (2020), supported students' understanding. On the other hand, research by Hesti Diana Putri et al. (2023) and Siska Widiawati et al. (2017) showed that experiments or hands-on practice strongly support students with kinesthetic style. However, studies that did not find a significant effect, such as Sri Nur Susilawati et al. (2020) and Suci Febriani et al. (2019), indicate that the mismatch between learning methods and student learning styles is a contributing factor. Other factors, such as student motivation, student learning activeness, teacher creativity, availability of learning media, and learning environment, also affect physics learning outcomes.

Overall, the difference between research results that show significant and insignificant relationships in physics learning outcomes in terms of learning styles of high school students can be caused by various factors. These factors include the adjustment of learning methods to students' learning styles, the availability of supporting media, the level of student motivation, student learning activeness, teacher creativity in developing learning strategies, the complexity of the material taught, the tendency of a combination of student learning styles, learning environment conditions, and individual student characteristics.

4. Conclusion

A meta-analysis of 16 articles showed that learning styles have varying effects on physics learning outcomes. Students with visual learning styles are more effective at absorbing information through media such as diagrams, graphs and pictures, while students with auditory styles are helped more through discussions and oral explanations. Students with kinesthetic style show excellence in experiment-based or hands-on learning. However, learning success is not only determined by learning styles, but also influenced by other factors, such as teacher creativity, student motivation, student learning activeness, availability of learning media, and learning environment. Physics teachers are advised to adopt flexible and multi-model learning approaches to meet the needs of students with various learning styles. For example, teachers can use visual aids such as interactive diagrams and learning videos for visual students, implement group discussions or interactive lectures for auditory students, and design laboratory experiments or activity-based physics simulations for kinesthetic students. These approaches can also be combined, such as starting learning with oral explanations (auditory), continuing with graphics or simulations (visual), and ending with hands-on experiments (kinesthetic). This integrated learning strategy not only improves student learning outcomes but also creates an inclusive learning environment, so that the needs and characteristics of each student can be optimally accommodated.

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Author Involvement

SS made the research design and data collection, MJ guided and revised things in the research that were deemed inappropriate.

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