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Learning Styles in Science Education a Decade of Research (2012-2022): A Literature Review

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Abstract

This study reviews 50 articles on learning styles in science education, focusing on approaches, media, and learning models from 2012-2022. Every single student with different intelligence certainly has a different learning style. Learning styles provide knowledge about various ways of student learning and important information about student preferences; consequently, they can be utilized to optimize student learning processes. Integrating learning styles in the learning process aims to facilitate students with certain learning styles; therefore, their achievements can be improved sharply. The method of this research is SLR (systematic literature review) with the following phases: (1) determining research questions; (2) determining criteria; (3) generating a framework for articles; (4) searching, filtering, and selecting the data; (5) analyzing and interpreting the content of each reviewed article. This study discusses the distribution of research focused on the attributes of the content, the topics covered in the implementation of learning styles in science education, and the characteristics of existing learning style-based learning media. In conclusion, a literature review has been carried out on learning styles in science education.

Keywords: learning style; literature review; science education; systematic review; teaching approaches

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INTRODUCTION

Students' learning experiences are directly influenced by their learning styles, among the most important individual differences. Students' varied learning preferences suggest different learning styles (Arthurs, 2007; Felder, 1996; Özgür, 2018). Each student's learning style is distinct from others (unique) (Willingham et al., 2015). The learning style combines cognitive, affective, and psychomotor factors,

which are relatively stable aspects of how individuals perceive the learning environment, interact with it, and respond to it (Keefe & Ferrell, 1990; Kanli & Ilican, 2020). The way students prepare to learn new and challenging information or recall it involves their unique ways of learning, which is known as their learning style (Dunn & Dunn, 1993; Kanli & Ilican, 2020; Pashler et al, 2008). Learning style is a student's individual learning preferences determined based on each individual's way of perceiving information. Determining the students' learning styles can help educators develop methods for creating learning and teaching environments designed for students (Altun & Serin, 2019; Akoyunlu, 1995; Moussa, 2014). There are several learning styles assessment models such as Kolb learning style inventory (Campos et al, 2022; Kolb, 1984; Manolis et al, 2013), Gregorc style delineator (Durukan & Arslan, 2022; Gregorc, 1985), Felder–Silverman Index of learning styles (Felder & Silverman, 1988; Marosan, et al., 2022; Zagulova, et al., 2019) and Fleming VAK model (Banas, 2018; Fleming, 2001; Sultana, Zamir, & Dad, 2021). The VAK learning style framework is the most popular and widely used classification of students' learning styles (Almasri, 2022; Deborah et al., 2014; Khodabakhshzadeh et al., 2017). The identification of a student's learning style that aligns with the pedagogical approach, offering the chance to engage in learning tasks, is acknowledged as a crucial factor in enhancing individual learning performance (Aguilar, et al., 2022; El-Sabagh, 2021; Panjaburee & Srisawasdi, 2016). Based on theoretical and empirical research findings, the educational field has been linked to student learning styles (Gajic et al, 2021; Olić & Adamov, 2016).

Extensive research has been conducted on learning styles and the instructional strategies that complement them. Scholars in this area emphasize the importance of matching students' learning styles with appropriate instructional actions to enhance the learning process. An education process that is carried out without taking the learning characteristics of students into account causes many students to be unsuccessful, so the educational and instructional processes should be structured based on student's learning styles and intelligence types (Ekici, 2003; Kaymakci & Can, 2021). Instruction that is tailored to individual differences provides various methods for students to comprehend and demonstrate their understanding of the material being learned (Demir, 2021; Heacox, 2002; Tomlinson, 2005). From the previous explanation, integrating learning styles in the learning process is very important, not least in science education. Literature studies related to this are very necessary to know the extent to which learning styles have been integrated into science learning and the benefits obtained by applying media, models, and assessments-based learning styles.

A literature review is the foundation of academic research (Xiao & Watson, 2019). An integrated literature review provides an opportunity to assess future policy direction and catalyze further research (Torraco, 2016). A literature review focusing on the application of learning styles in science education in one decade (2012-2022) has not been conducted. Learning media that facilitates learning for each student with different learning styles and intelligence has yet to be widely developed. In fact, it is necessary to develop learning media that are in sync with student characteristics and are directed at changes in student behaviour and learning outcomes (Broto & Irianto, 2017). Consequently, reviewing literature focusing on learning styles in science education is crucial. The findings

of this review are anticipated to be valuable as a point of reference for all parties involved in science education, particularly educators, instructors, and prospective researchers. Furthermore, the use of the learning styles approach in science education holds potential as an alternative method of instruction. This research aimed to review 50 articles related to science education learning styles published between 2012 and 2022. The following is a learning style framework in science education, a learning style approach that can be used in learning activities, and the development of media and learning style-based assessment. Figure 1 shows a chart of learning style approaches that can be integrated into media, assessment, and science learning.

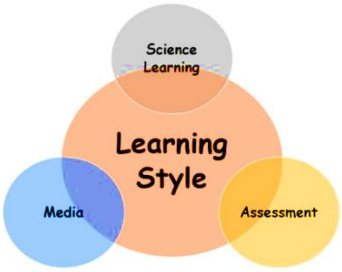

Figure 1 Learning style in science education

Learning approach by utilizing student learning style preferences can be done by developing learning style-based media to optimize student potential (Shamsuddin & Kaur, 2020; Soflano et a., 2015), or inserting appropriate activities for each student with different learning styles to increase student's performance and motivation (Al-Azawei, Ciampa, 2014; Parslow, & Lundqvist, 2017), can also by developing learning style-based assessments. Through these ways, it is hoped that all students with different learning styles can be facilitated equally. Three research questions guided the study:

1. How is the distribution of research based on the article's characteristics?
2. What topics are discussed in the implementation of learning styles in science education?
3. What are the characteristics of existing learning style-based learning media?

METHOD

This article reviews 50 articles about learning styles in science education. The sources of the reviewed articles can be seen in Table 1. Based on Table 1, all articles reviewed were selected from international journals. Although there are many articles related to learning styles in science education in proceedings and theses, we should have included articles from these sources. The selection of articles from journals indexed by Scopus (Q1, Q2, Q3, & Q4) and ERIC. We choose articles from journals indexed by Scopus and Eric. Journal indexation is the easiest design as a point of search for a reference. Some indexers provide a list of journal titles, links, and categorizations. We use the PRISMA procedure, which consists of four steps: (1) Identify the journals that will be included in the meta-analysis; (2) Screening, filtering or selecting data; (3) Eligibility, determining the article to be used as material for literature assessment; and (4) Inclusion, combining and reporting results. With this procedure, we selected 50 articles from a total of 1811 articles.

Table 1 The sources of the reviewed article

No	Journal	Indexed	Description	f	%
1	Journal of Baltic Science Education	Scopus Q2	SJR 2021: 0.48 H-Index: 20	5	10
2	Journal of Educational Computing Research	Scopus Q1	SJR 2021:1.28 H-Index: 64	3	6

No	Journal	Indexed	Description	f	%
3	International Journal of Instruction	Scopus Q2	SJR 2021: 0.5 H-Index: 26	2	4
4	Cypriot Journal of Educational Sciences	Scopus Q3	SJR 2021: 0.22 H-Index: 8	2	4
5	Eurasia Journal of Mathematics, Science & Technology Education	Scopus Q2	SJR 2021: 0.57 H-Index: 44	2	4
6	International Journal of Mobile Learning and Organisation	Scopus Q1	SJR 2021: 0.88 H-Index: 26	1	2
7	Jurnal Pendidikan IPA Indonesia	Scopus Q2	SJR 2021: 0.46 H-Index: 20	1	2
8	Education and Information Technologies	Scopus Q1	SJR 2021: 1.06 H-Index: 48	1	2
9	Journal of Computers in Education	Scopus Q1	SJR 2021: 1.04 H-Index: 11	1	2
10	Journal of Turkish Science Education	Scopus Q2	SJR 2021: 0.5 H-Index: 19	1	2
11	Asian Journal of University Education	Scopus Q3	SJR 2021: 0.37 H-Index: 7	1	2
12	Journal of Technology and Science Education	Scopus Q2	SJR 2021: 0.45 H-Index: 13	1	2
13	Simulation & Gaming	Scopus Q1	SJR 2021: 0.55 H-Index: 64	1	2
14	Asia-Pacific Forum on Science Learning and Teaching	Scopus Q4	SJR 2021: 0.14 H-Index: 16	1	2
15	GEMA Online Journal of Language Studies	Scopus Q1	SJR 2021: 0.29 H-Index: 16	1	2
16	Journal of Developmental and Physical Disabilities	Scopus Q2	SJR 2021: 0.51 H-Index: 47	1	2
17	Contemporary Educational Technology	Scopus Q1	SJR 2021: 0.72 H-Index: 10	1	2
18	Computers and Education	Scopus Q1	SJR 2021: 3.68 H-Index: 197	1	2
19	Sustainability	Scopus Q1	SJR 2021: 0.66 H-Index: 109	1	2
20	Anatomical Sciences Education	Scopus Q1	SJR 2021: 1.04 H-Index: 58	1	2
21	Journal of Geoscience Education	Scopus Q2	SJR 2021: 0.44 H-Index: 37	1	2
22	Orbital: The Electronic Journal of Chemistry	Scopus Q4	SJR 2021: 0.17 H-Index: 7	1	2
23	Macedonian Journal of Chemistry and Chemical Engineering	Scopus Q4	SJR 2021: 0.14 H-Index: 18	1	2
24	International Journal of Emerging Technologies in Learning	Scopus Q1	SJR 2021: 0.63 H-Index: 30	1	2
25	Journal of allied health	Scopus Q3	SJR 2021: 0.26 H-Index: 38	1	2
26	European Journal of Educational Research	Scopus Q3	SJR 2021: 0.31 H-Index: 13	1	2
27	Eurasian Journal of Educational Research	Scopus Q3	SJR 2021: 0.28 H-Index: 19	1	2
28	European Journal of Physics Education	ERIC	-	2	4
29	I-Manager's Journal on School Educational Technology	ERIC	-	1	2

No	Journal	Indexed	Description	f	%
30	International Education Studies	ERIC	-	1	2
31	Universal Journal of Educational Research	ERIC	-	1	2
32	African Educational Research Journal	ERIC	-	1	2
33	International Journal of Educational Methodology	ERIC	-	1	2
34	International Journal of Contemporary Educational Research	ERIC	-	1	2
35	Shanlax International Journal of Education	ERIC	-	1	2
36	Educational Research and Reviews	ERIC	-	1	2
37	Journal Of Educational Issues	ERIC	-	1	2
38	Educational Policy Analysis and Strategic Research	ERIC	-	1	2
39	Journal of Science Learning	ERIC	-	1	2
40	International Journal of Environmental & Science Education	ERIC	-	1	2
	Total			50	100

ERIC indexes various journal sources. The scope of approved journal sources is determined by reviewing 3-5 current issues during the source review process but may be updated at any time. Scopus has extensive scientific data, literature, and analytical tools to stay ahead of the competition. New discoveries advance scientific research. And when the latest research disappears, you lose the opportunity to rely on it for improvement. In addition, knowing the latest trends can influence and drive decision-making. Therefore, the articles selected for this study are of good quality.

We use the systematic literature review (SLR) method in this research (Petticrew & Roberts, 2008; Xiao & Watson, 2019; Winarno, et.al, 2020) with the steps: determining research questions, determining criteria, generating a framework for articles, searching, filtering, and selecting, analyzing and interpreting the content of each reviewed article (Borrego, Foster, & Froyd, 2014; Pati & Lorusso, 2018; Winarno, et.al, 2020). The first step is determining research questions, in which the authors discuss questions based on the research theme raised. Subsequent, we determine the criteria for articles to be reviewed. After defining the search strategy, it is necessary to analyze the discarding of unrelated works. Elimination is the initial screening process relies on evaluating the title, abstract, and conclusion together, as the title alone often lacks the necessary information for a thorough assessment. Due to the subjective nature of the elimination phase, specific exclusion and quality criteria were established to guide this process. Articles must be related to learning styles in learning processes or activities, we limited the articles to those published from 2012-2022 (within a 10-year period), and the article is written in English. Figure 2 shows the distribution of 1809 articles exploring learning styles in science, physics, chemistry, and biology through the past years.

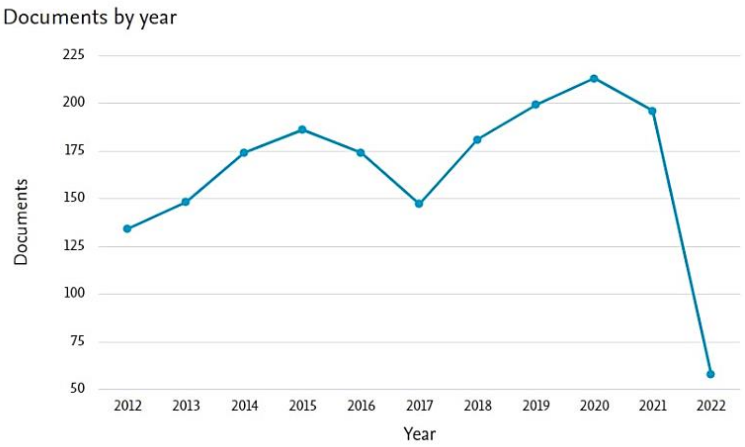

Figure 2 Documents by year

The academic community has shown considerable interest in this subject in recent years. It's important to note that the graph illustrates the frequency of works addressing learning styles across various paradigms and approaches. The number of publications steadily increases until the period spanning from 2017 to 2020, after which there is a decline in 2021 and 2022. The next step is creating a research framework from the title to the conclusion.

We selected 50 out of 1809 articles related to learning style in science education based on pre-determined criteria. We searched for articles by keywords: learning styles in physics, chemistry, biology and science education. The next step is to read and understand the contents of the selected articles and interpret them in tables and figures. Data analysis was carried out by creating a summary of articles in the form of a table in Microsoft Excel containing the title, author, year of publication, country, method, sample, subject, instrument, data analysis, results, and the journal where the article was published. Succeeding, we create a tally, group it by certain categories, and then create a new table or graph. For example, from 50 articles, we tally how many articles were published in 2012, 2013, 2014, etc., until 2022. Previously, we created a ***graph*** or ***table*** based on these results. This is also done for other categories such as source of article (name of journal), countries that implement learning styles approach, educational level of participants, subject, content discussed, and benefits.

RESULT AND DISCUSSION

RQ 1: How is the Distribution of Research Based on the Characteristics of the Article?

The distribution of research is categorized according to the year of publication, countries implementing the learning styles approach, educational level, and subject matter. The selected research for review spans from 2012 to 2022, and complete data can be found in Figure 3. Ultimately, the largest number of reviewed articles was published in 2018 (10 articles), and in 2012, 2014, and 2022 only one article reviewed.

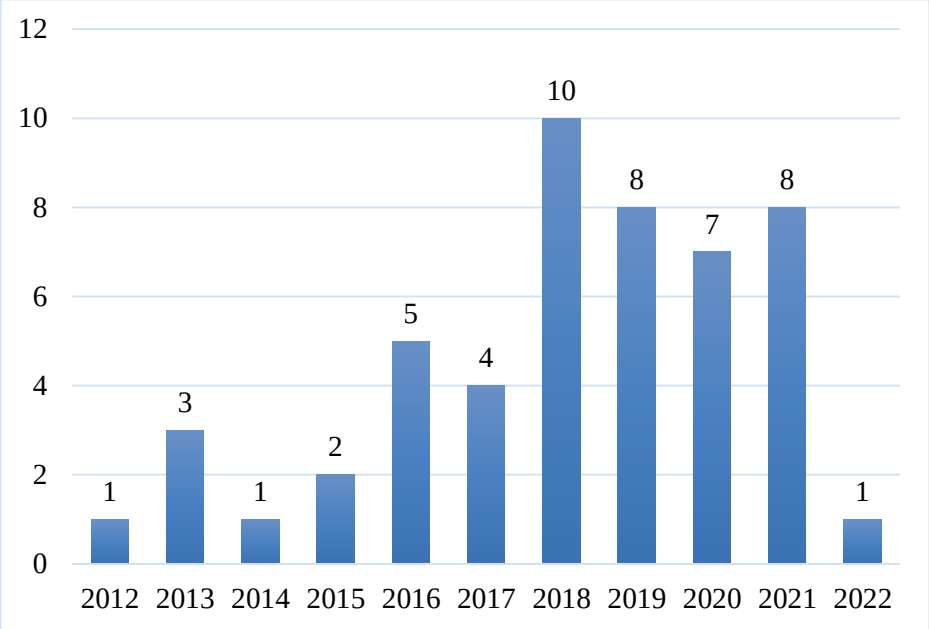

Figure 3 The distribution of research is based on the year of publication.

Research trends related to learning styles tended to increase from 2012 to 2018 but recently decreased. This decline can be caused by several factors, such as changing researcher interests, changes in the curriculum in force in a country, and socio-economic conditions in various countries. Changes in the curriculum in force in a country with each change of government also change the research direction in accordance with the new policy direction. Social conditions, such as the learning culture in force in a region, and economic conditions, such as limited funds to access appropriate learning media, also affect the research direction. In addition, research topic trends will also change periodically due to paradigm shifts and technological advances (Baydas et al, 2015). Meanwhile, in 2022, the number of studies is quite small, because the discussion of articles in this study is limited to 10 years, namely from 2012 to 2022, so the discussion is limited to 2022. The writer's affiliation provided the data on countries and regions implementing learning styles in science education, as shown in Table 2. Based on the table, the countries implementing learning styles in science education are Indonesia, Turkey, Kuwait, Thailand, Serbia, Philippines, Malaysia, Morocco, Colombia, Czech Republic, Taiwan, Yemen, USA, Nigeria, Scotland, Spain, Ukraine, Brazil, Saudi Arabia, and India.

Table 2 The distribution of research based on the countries

No	Country	f	%	Author
1	Turkey	14	28	Altun (2019); Ozgur (2018); Kanli (2020); Cakiroglu (2020); Arslan (2018); Önder (2016); Güneş (2018); Çelikler (2020); Akran (2018); Keskin (2021); Demir (2021); Kablan (2013); Hastürk (2021); Kaymakci (2021)
2	Indonesia	8	16	Zulfiani (2018); Zulfiani (2020); Laksana (2019); Sudria (2018); Zulfiani (2021); Kade (2019); Nugraha (2020); Habibi (2017)

No	Country	f	%	Author
3	Kuwait	1	2	Almasri (2022)
4	Thailand	2	4	Panjaburee (2016); Komalawardhana (2018)
5	Serbia	2	4	Gajić (2021); Olić (2018)
6	Philippines	2	4	Fetalvero (2017); Magulod Jr. (2019)
7	Malaysia	2	4	Halif (2020); Alias (2014)
8	Morocco	1	2	Hamdaoui (2018)
9	Colombia	1	2	Huertas (2017)
10	Czech Republic	1	2	Škoda (2016)
11	Taiwan	2	4	Huang (2020); Fan (2015)
12	Yemen	1	2	Abu-Asba (2012)
13	USA	4	8	Lynn (2016); Farkas (2016); Hall (2013); Good (2013)
14	Nigeria	2	4	Fakomogbon (2017); Nja (2019)
15	Scotland	1	2	Soflano (2015)
16	Spain	1	2	Sáiz-Manzanare (2021)
17	Ukraine	1	2	Derkach (2019)
18	Brazil	1	2	Caceffo (2019)
19	Saudi Arabia	1	2	Almomani (2019)
20	India	2	4	D'Souza (2018); Pradhan (2021)
	Total	50	100	

It can be seen that Turkey had the highest number of articles, with 14 articles. This is because, in that country, research on education (including learning styles) is widely studied and published in international journals (Gul & Sozbilir, 2015; Gülmez, Özteke, & Gümüş, 2021). Several countries had the lowest number of articles, each with only 1 article. From the data, it is evident that very few countries implement learning styles in science education.

The participants' sample in the articles was analyzed to determine the distribution of research based on the educational level. This analysis gives an overview of previous studies on learning styles in science education according to educational level. The elementary school level comprises students aged around 6-12 years. The junior high school level includes students who have completed elementary school and are around 12-15. The senior high school level encompasses students who have graduated from junior high school and are around 15-18. The undergraduate level includes students who have graduated from high school and are pursuing studies at the university, around 18-22 years old. On the other hand, graduate students are those who have completed university studies and are 22 years old or older. This comprehensive data is presented in Table 3.

Table 3 The distribution of research based on the educational level of participants

No	Educational Level	f	Percentage (%)
1	Elementary School	4	8
2	Junior High School	9	18
3	Senior High School	13	26
4	Undergraduate/Graduate Student	22	44
5	Teacher	2	4
	Total	50	100

Most research related to learning styles involves undergraduate/graduate students as participants. The application of learning style is seen in science education across different educational levels. Research at the elementary school level still needs to be improved in comparison to the levels of research carried out at junior high school and senior high school. According to Table 3, 22 articles included undergraduate/graduate students in their samples, whereas 2 articles featured teachers as participants. Research with teachers as participants is less because the aim is only to find out the teacher's understanding of the different learning styles of students. The main reason for researching learning styles using students as participants is that learning activities such as learning media, learning models, or assessments can identify students' preferred learning styles, allowing for the design of learning to improve student achievement and various skills. (Rayner & Riding, 1997; Akkoyunlu & Soylu, 2008; Uğur, Akkoyunlu, & Kurbanoğlu, 2011). Positive impacts on introductory physics courses also can be attributed to teaching approaches and learning techniques aligned with learning styles (Larkin & Dan, 2003; Önder & Silay, 2016).

The science content in this study is divided into five subjects: science, physics, chemistry, biology, and integrated science with other subjects (multiple subjects). The science content was categorized according to school subjects. The detailed information is visible in Figure 3. The incorporation of learning styles was predominantly observed in science, with the lowest occurrence in merging science with other subjects.

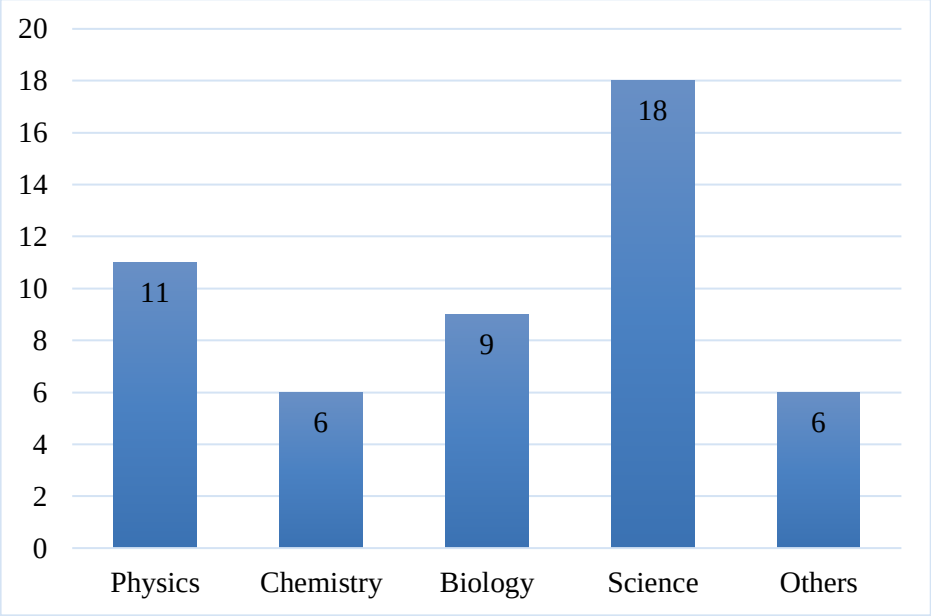

Figure 3 Based on the topic, research distribution varies.

We can infer from the data that science, physics, chemistry, biology, and the integration of science with other subjects (multiple subject) all take learning styles into account. Research related to learning styles in science (including physics, chemistry, and biology) is mostly done on science subjects (18 out of 50) because the sample coverage is wider, which can involve elementary and junior high school students and college students.

This is because in elementary and junior high school, science learning is still integrated, not separated (Hennessy et al., 2007; Winarno et al., 2020; Simanjuntak et al., 2022).

RQ 2: What topics are discussed in the implementation of learning styles in science education?

The reviewed articles address the identification of students' learning styles and the development of methods, media, and assessments for science education that take learning styles into account. The content discussed in the articles can be seen in Table 4.

Table 4 The distribution of research based on the content discussed

No	Content	f	Percentage (%)
1	Students' learning styles	19	38
2	Learning style-based media	14	28
3	Learning style-based science learning	15	30
4	Learning style-based assessment	2	4
	Total	50	100

Most reviewed articles (19 articles) discussed the relationship between learning styles and various variables such as academic achievement, self-regulated learning skills, student engagement, students' performance, problem-solving skills, science process skills, and scientific attitude. The results of previous research regarding the identification of learning styles show that several factors influence learning styles. The average physics course achievement of students with an assimilator learning style is higher than that of other learning styles (Altun & Serin, 2019). The most common learning style of prospective chemistry and science teachers is visual learning style (Özgür, 2019). This study also discusses how the learning styles of individuals influence their self-regulation skills.

The creation of learning style-based assessments and their advantages were covered in two articles. The possibility of measuring HOTS with Adaptive Assessment System (AAS), which gives measurement opportunities more than factual knowledge, but problem-solving and reasoning strategies. Even though there was, on average, very little correlation between the type of learning styles and the achievement of the HOTS score, it was still influenced (Saul & Wuttke, 2011; Zulfiani, Suwarna, & Sumantri, 2020). When the students' achievement in light and shadow concepts was evaluated using different formats, there were statistically significant differences (girls performed better in structured communication grid tests, whereas boys performed better in open-ended tests). Additionally, the student's learning styles differed significantly (the mean scores of converger and accommodator students in open-ended tests were significantly different from those of diverger students) (Kanli & Ilican, 2020).

However, other articles covered incorporating learning style into educational activities. According to earlier studies, participants in the physics, chemistry, and biology courses demonstrated high engagement and satisfaction with using simulations to teach scientific concepts. Therefore, this finding has implications for researchers and educators interested in using computer simulations as an effective pedagogical approach in science education (Almasri, 2022). Compared to students with high physics learning performance, those with low performance viewed the value of scientific investigation-based web learning and integrated learning styles

more highly (Panjaburee & Srisawasdi, 2016). The scientific method, which includes inquiry-based or discovery-based science education, is a pedagogical approach used to present material to students at various stages of their learning. Therefore, it is reasonable to conclude that the proposed approach was more advantageous to low-performing students who prefer to learn by specific learning material presentation with appropriate scientific investigation than low-performing students who prefer to learn by general learning material presentation without appropriate learning process from conventional web-based learning. This is because the proposed approach allows students to reflect on their learning style and experience and receive the personal learning presentation with appropriate scientific investigation from the web-based learning environment.

When biology was taught to students according to their learning styles, they performed better academically. This finding had implications for inquiry-based learning and the training of future biology teachers (Gajic et al, 2021). Since consensus-based education fairly addresses issues of gender and learning styles, it may be a viable substitute for traditional biology education. Students' ability to reason and their understanding of democratic classroom practices have improved as a result. Consensus-based education's transparent, democratic, affirming, and cooperative atmosphere allows for accommodating each student's unique learning style without sacrificing academic success (Fetalvero, 2017). Regarding students' conceptual understanding, there is substantial interaction between various learning strategies (such as inquiry-based learning and direct instruction) and their visual-verbal learning styles (Laksana, Dasna, & Degeng, 2019). The only way learning styles affected performance was in the Convergers' superiority over the accommodators. However, all learners of all learning styles benefited from the inductive guided-inquiry learning of chemical topics, which involves concrete evidence through laboratory work (Sudria et al, 2018). Students who were more visual in the classroom engaged more than those who were auditory or kinesthetic. Additionally, it was noted that the relationship between learning styles and student engagement was significantly moderated by all components of student motivation, including achievement, recognition, relationships with peers, and relationships with lecturers (Halif et al, 2020). Significant relationships existed between learning styles, study habits and students' academic performance in applied science courses (Magulod Jr, 2019).

RQ 3: What are the characteristics of existing learning style-based learning media?

The integration of learning styles in science learning provides many benefits, which can be seen in **Table 5**. Teachers and researchers can consider these various advantages when integrating learning styles in learning activities at schools.

Table 5. The benefits of learning style integration in science education

No	Content	Benefit
1	Type of learning style	Achievements of talented students; Self-regulated learning skills; Student engagement; Inquiry-based science education effectivity; Academic success; Form more successful cooperative groups; Students' performance; Academic achievement; Academic performance; Problem-solving skills, Science process skills; Students' scientific attitude

No	Content	Benefit
2	Learning style-based science learning	Students' engagement, self-confidence, satisfaction; Learning outcomes; Conceptual understanding; Social skills; Attitudes; Teaching skills
3	Learning style-based assessment	Higher order thinking skill level; Student achievement
4	Learning style-based media	Conceptual learning achievements and perception; Conceptual understanding; Academic achievement; Performance of students; Motivation and opinions of students

Learning style-based media has been developed and proven to improve conceptual learning achievements and perception; conceptual understanding; academic achievement; performance of students; motivation and opinions of students. Several types of learning style-based media have been developed**,** such as computer-based science learning media. In line with Zulfiani, Suwarna, & Miranto (2018), the Science Education Adaptive Learning System has been deemed appropriate with its computer-based science learning media. Its features include integrated learning for students with various visual, auditory, read/write, and kinesthetic learning styles. The kinesthetic learning component of ScEd-ALS is highly effective in enhancing students' mastery of the material. Two components are mentioned in the ScEd-ALS concept design development (display and content). The designed display comprises the homepage, conversational apperception, texts accompanied by images, animations, videos, item examples, and item practice. It is anticipated that the researchers' content will enhance students' learning outcomes for remedial instruction by taking into account differences in learning styles. As a result, the information on computer-assisted media is delivered using four pedagogical strategies that are suitable for the VARK learning styles. Based on the percentage of students who met the mastery level, the efficacy of using ScEd-ALS in this study was evaluated. In contrast to aural and read/write learning methods, ScEd-ALS Android is the most effective medium because it caters to visual and kinesthetic learning styles (Zulfiani, Suwarna, & Miranto, 2021).

CONCLUSION

This study examined the features of the articles according to the subject, educational level, learning styles, approach-implementing countries, year of publication, and sources of the reviewed articles. According to the study's findings, 50 publications from 2012 to 2022 were selected for review. Because Scopus has indexed all of the selected articles, they are all of high quality. Indonesia, Turkey, Kuwait, Thailand, Serbia, Philippines, Malaysia, Morocco, Colombia, Czech Republic, Taiwan, Yemen, USA, Nigeria, Scotland, Spain, Ukraine, Brazil, Saudi Arabia, and India are the nations that use learning styles in science education. Moreover, science education at different educational levels incorporates learning styles. It was discovered that science, physics, chemistry, biology, and integrating science with other subjects (multiple subjects) all used the learning styles approach.

The reviewed articles address the identification of students' learning styles and how learning styles can be integrated into science education through media, approaches, assessments, and learning style-based learning models. The findings of earlier studies on integrating learning styles in science education demonstrate that a number of factors influence and are influenced by learning

styles. There are numerous benefits to incorporating learning style into science instruction. On the other hand, several types of learning style-based learning media have been developed, and they have certain characteristics in terms of display and content. In conclusion, a literature review has been carried out on learning styles in science education. Based on the findings in this research, further research can discuss the integration of learning styles in science education by incorporating modern learning technology, such as animation and simulations of various scientific phenomena, to improve students' understanding and achievement further.

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