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Learning styles in science education at university level: A systematic review

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Abstract

In this systematic review study, it is aimed to summarize the findings and reach a conclusion about the role and importance of learning styles in science education at university level from 2007 to 2023. This paper analyzed the studies related to the learning styles in science education at university level. The original studies were extracted from Scopus database, and the review of the 21 selected journal articles revealed that the common feature of the studies in both groups was that learning styles in science education had a positive effect on both cognitive and affective factors. The relation between learning styles in science education at university level and some cognitive or affective factors was investigated. While some studies have found significant differences between these two variables, some studies have concluded that there is no significant relationship. According to the detailed analysis of each 21 articles, the content of the studies was coded as name of the author and year, profile of the participants, research type and major findings. The reviewed research has numerous implications for learning styles in science education at university level.

Keywords: learning style, science education, university level, systematic review

INTRODUCTION

Learning styles refer to the unique ways individuals best receive and process information. In science education, incorporating different learning styles can enhance students' understanding and engagement with various scientific concepts. Research studies have found that utilizing multiple teaching approaches catering to diverse learning styles can improve academic performance and lead to better retention of information.

Visual learners may take advantage from the use of diagrams, graphs, or animations, while auditory learners may prefer lectures, podcasts, or audio recordings. Kinesthetic learners may benefit from the use of experiments, simulations, and interactive activities requiring movement and hands-on activities. However, the implementation of multiple learning styles in science education is not without challenges. One of the significant challenges is catering to the diverse learning needs of students. Some students may have a dominant learning style; hence, they may struggle with learning materials that do not match their preferred learning style.

Most of the studies concluded the importance of understanding different learning styles in science education at the university level. For example, Felder and Silverman (2002) found that by identifying the preferred modes of learning such as visual, auditory, or kinesthetic, instructors can adjust their teaching styles to better match the needs of learners, leading to improved learning outcomes, engagement, and motivation.

The impact of different learning styles on science education are of great interest. Students with an active learning style fared better on science exams and had a more favorable attitude toward science courses, according to a research by Kolb et al. (2014). Students who learn reflectively, however, perform worse in scientific courses. Additionally, a research by Abrahams

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Contribution to the literature

- This systematic review may have the ability to pinpoint instructional approaches that are compatible with various learning styles.
- Which learning styles work best for university-level science instruction may be determined through this systematic review.
- The review might investigate the controversy around learning styles and determine if they are a true indicator of how people learn.

and Millar (2008) discovered a connection between students' science performance and their preferred learning style, which suggests that teachers should take this into consideration. It is critical to note, however, that there's a few controversy associated with the validity and reliability of learning style measures, as mentioned via way of means of Willingham et al. (2015). Despite this controversy, studies on learning styles keep telling science education, as evidenced via way of means of the research referenced here.

There have been several research looking into the connection between learning styles and academic achievement (Harahap et al., 2019; Jiraporncharoen et al., 2015; Sahin & Yilmaz (2020)) reflecting the long-standing interest in learning styles in the field of education. Understanding how various learning styles affect information acquisition and retention in the context of scientific education has significant ramifications for how science is taught and learnt. A growing amount of research studies how various learners perform in science classes and how pedagogical techniques might be modified to fit the requirements of varied pupils.

Much research have looked at the relationship between learning preferences and academic success, especially in the setting of scientific education. In one study, Stone (2021) investigated the connection between high school students' academic success in chemistry and their learning preferences. According to the findings, pupils who demonstrated a convergent learning style, which is defined by a concentration on structured and practical learning methods, performed better academically in chemistry. Students with a divergent-leaning style, on the other hand, had lesser academic success in chemistry. This style is characterized by a more intuitive and inventive approach. These findings imply that academic accomplishment in scientific education may be improved by adapting instructional strategies and resources to students' preferred learning preferences.

Overall, incorporating learning styles in science education is crucial for creating an inclusive learning environment supporting diverse student needs and preferences.

LITERATURE REVIEW

The role and significance of learning styles in science education at university level were emphasized by different researchers in the literature. According to Kubat's (2018) study, half of the science teachers stated that individual differences are important in determining students' learning styles. Again, half of the teachers emphasized that students recognize their individual differences through tests, homework, and teaching and learning activities. Teachers also explained that students should actively participate in class to plan the learning and teaching process according to students' individual differences, and that individual differences can be supported by increasing the number of experiments and class trips. Furthermore, Gabel et al. (1987) showed that five most important research interests of teachers were, in order of preference: practical experience, scientific content of the curriculum, cognitive development and learning styles, problem solving and learning strategies. The area of least interest was research into sex differences. Moreover, Pablico et al. (2017) suggested differentiated instruction strategies for science education in high schools that cater to auditory, visual, and kinesthetic learners.

Coma-Roselló et al. (2018) presents innovations aimed at stimulating the autonomy of engineering students by various active methods. Strategies designed to address this issue are based on an analysis of students' learning styles and integrate specific tools in the teaching practice, which aid in assessment and automatically respond to student-generated concept maps. Among the key findings, the student assessment of the "concept mapping" activity emerged as helpful but not easy. Despite the difficulty, or precisely for this reason, the experience helped to enhance their self-control and develop the skills to manifest the acquired knowledge. Moreover, Allers (2010) found that the students favored agreeable and dynamic teaching/learning encounters more than the teachers are utilizing them. The study emphasizes the significance of students being effectively included within the teaching-learning handle through agreeable strategies. This may improve their capacity to utilize cognitive abilities such as creative thinking, interpretation, critical thinking, and problem-solving. In addition, Thanyaphongphat and Panjaburee (2019) revealed that the decision model can advise appropriate learning material to the students individually based on their learning style and preferred type of technology and the learning support system showed a good performance related to the gain of knowledge and motivational learning. Furthermore, Alshammari and

Qtaish (2019) showed that adapting according to a combination of learning style and knowledge level leads to significantly better learning outcomes in both the short and medium term than adapting according to either characteristic alone. Likewise, Halloun (2007) concluded that significantly higher student performance is increasingly being demonstrated than in conventional lectures and demonstration classes, especially in physics classes at high schools and universities. Improved academic performance is reflected in a more meaningful understanding of course materials, better learning styles, higher success rates, lower dropout rates, and a narrowing of the gap between students from diverse backgrounds. In a similar way, Trindade et al. (2002) showed that 3D virtual environments could help students with high spatial skills to understand better conceptual concepts. However, only some parameters (interactivity, navigation, and 3D perception) turned out to be relevant and only for some topics. Whereas stereoscopic visualizations cannot seem to be relevant except for crystalline structures. Similarly, Paiboonsithiwong et al. (2016) found that learning styles significantly impact academic performance among health sciences students, indicating that educators should utilize varied teaching methods for optimal learning outcomes. Information technology can transform teaching and learning in the thermal physics classroom and challenge educators to tailor the course to meet the diverse needs of students. Specifically, students used five learning modes, including face-to-face learning, online learning, alternative blended learning, online learning, and flipped learning according to Hung and Young (2021).

Research related to learning styles has shown that learners have different preferences for receiving and processing information. Visual, auditory, and kinesthetic learning styles are the most common. Visual learners prefer to learn through seeing, auditory learners prefer to learn through listening, and kinesthetic learners prefer hands-on approaches. Incorporating diverse learning styles in science education provides opportunities for students to explore different teaching and learning methods that best suit their individual needs. The utilization of different learning styles in science education can enhance student engagement, improve understanding of complex concepts, and foster critical thinking.

Dincol-Ozgur (2018) indicated that most of prospective chemistry and science teachers had a visual learning style, followed by a moving or kinesthetic learning style and an auditory learning style. In addition, statistically significant differences were found in missing self-adjusted scores for prospective chemistry and science teachers. Besides this, Arslan et al. (2009) showed that there was a significant relation between science and mathematics reasoning for participants having converger and diverger learning style at mathematics education. Similarly, Ucar and Yilmaz (2023) stated that participants received points for e-learning style in general on the positive side. Regarding the variables gender, learning level, and duration of social media use, statistically significant differences were found in terms of e-learning style. Moreover, Almasri (2022) found that participants demonstrated a very high level of engagement and satisfaction with using simulations to learn scientific concepts in physics, chemistry, and biology subjects. Their confidence and visual/auditory/kinesthetic (VAK) learning style, especially locomotor style, were important predictors of their participation and satisfaction with the learning process. According to McMahon (2010), tracking and survey results showed a dramatic increase in both student retention and their enthusiasm for course content and pursuing earth sciences. Likewise, Yang et al. (2016) emphasized the experimental effects of confidence and retention of learning are appreciably higher than the ones of the control group. The findings propose that the effects of pair programming activities may be leveraged primarily based totally on an understanding of students' motivation for and retention of learning.

On the other hand, Farkas et al. (2016) examined the relationships between course performance and visual/aural/read-write/kinesthetic (VARK) learning preference, study duration, and career plan among undergraduate students enrolled in an undergraduate anatomy and physiology course at a metropolitan university. There was no significant difference between the students grouped according to their learning styles. Time spent working was not significantly associated with either learning style or career choice. In a similar way, Van Petegem et al. (2023) concluded that the framework also reveals which aspects of programming skills practice facilitate or inhibit learning or have little or no impact on the learning process. It was shown that student success could be predicted.

Some of the studies were about review of the literature and presenting a model or framework. For example, Coffield et al. (2010) conducted a systematic review on learning styles and pedagogy in post-16 learning, emphasizing the importance of accommodating learners' varying preferences. Singh-Pillay and Naidoo (2020) presented a model and showed that educators complement the use of Moodle and Zoom with WhatsApp, the factor that enabled online learning, was the data availability for educators and students. In contrast, factors limiting online teaching and learning were the technical training received for online learning, a discrepancy between pedagogy and student learning style. Furthermore, Virkus (2019) stated that multiple learning paths within the course offered students the opportunity to choose their own personal learning path according to their personal learning goals, learning style, interests, and other preferences. Open badges also

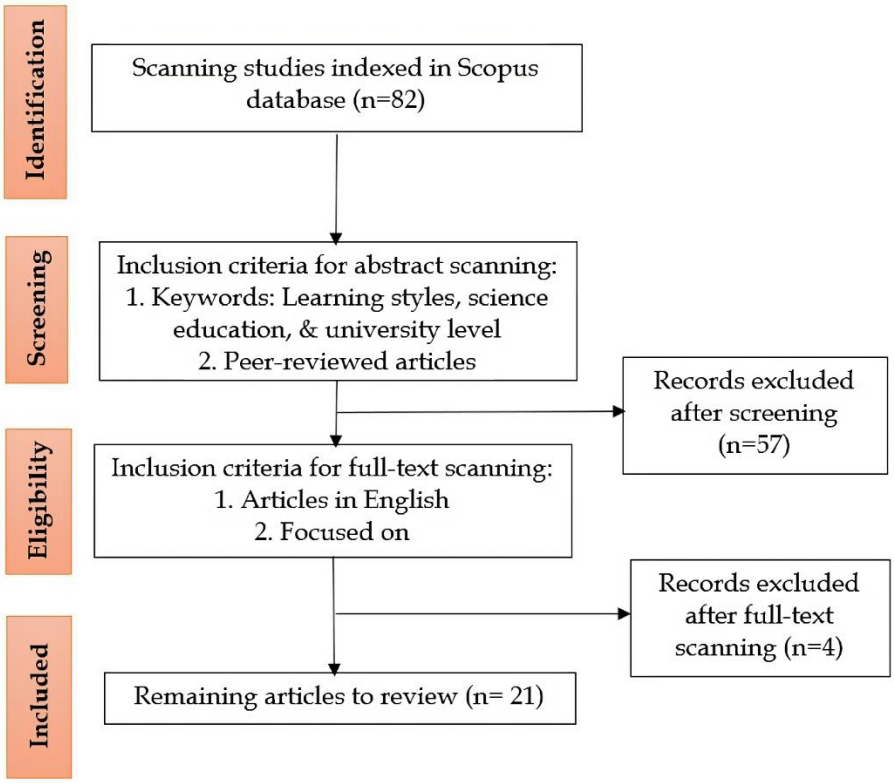

Figure 1. PRISMA flow diagram describing article selection process (Source: Authors' own elaboration)

allowed recognition of "soft skills" or literacy. Open Badges can also be a useful tool for assessing students' information literacy in a variety of contexts. Besides this, Riggs (2005) presented an analysis of common field elements to shed light on local earth science education and provided a field learning research-based explanation for the success of this design. Markowitz and DuPre (2007) summarized graduate experience in science education (GESE) course and data on the effectiveness of this course in providing graduate students with teaching and learning information that they will use throughout their careers in another study.

METHOD

Data Collection Process

This study is a literature review related to the learning styles in science education at university level in Scopus database. Learning styles, science education, university level and systematic review were used as keywords through Scopus database. It was found 82 publications in the first scan and 25 of the publications were articles. For the next phase, educational journals were selected. As a result, this search included a literature review of 21 articles indexed in Scopus database.

Figure 1 describes the article selection process according to priority reporting items of systematic reviews and meta-analyses (PRISMA) guidelines (Moher et al., 2015). A qualitative thematic review was used in this study. The themes were decided as "effects of learning style on some variables" and "correlation between learning styles and the other variables". Keywords ("learning styles" AND "science education" OR "physics education" OR "chemistry education" OR "biology education" AND "university") were included in the word and phrase combinations used to search for articles in Scopus database.

Inclusion criteria were publications in English-language journals with a focus on learning styles in science education at university level. Other types of documents such as unpublished studies, conference abstracts/posters, literature reviews, editorials, letters, and concept articles were excluded.

Data Analysis

According to the detailed analysis of each 21 articles, the content of the studies was coded as name of the author and year, profile of the participants, research type and major findings (**Appendix A**). The main purpose of this review was to analyze learning styles in science education at university level in terms of the effects of learning styles on cognitive and affective factors and relationship between learning styles and other variables as themes. Scopus database analysis tools were used to analyze the data and create maps on important variables. In the study, statistical analysis was also done to look for trends and patterns in the data. Descriptive statistics were used to analyze the distribution of publishing output across author name and publication year, profile of participants, research design and main results. To determine whether there were any notable differences in

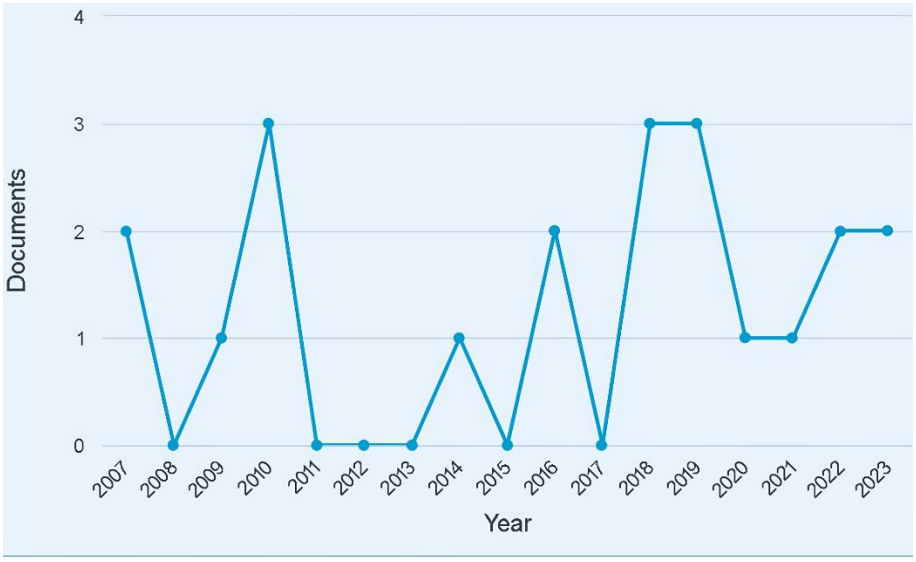

Figure 2. Distribution of number of articles by years (Source: Authors' own elaboration)

publishing output between different factors, inferential statistics were also used. The search's parameters incorporated publications indexed in Scopus database, placed restrictions on the study.

Annual Accounts of the Articles

The distribution of articles related to learning styles in science education at university level by years is shown in **Figure 2**. The first article was published in 2007 and articles on the learning styles in science education at university level showed a fluctuating distribution until 2018 with 2019 being the year in which the most articles on this topic were published.

FINDINGS

Effects of Learning Styles on Some Variables

The effect of learning styles on many different variables at the university level in science education has been the subject of many studies in the literature. Some of these variables are cognitive factors such as academic achievement, creative thinking, critical thinking, and problem-solving skills, while others are affective factors such as motivation and satisfaction.

Effects of Learning Styles on Cognitive Factors

First, research on the effect of learning styles on cognitive factors in science education of university students was examined. In one of these studies, Coma-Rosella et al. (2018) found that the concept mapping learning style increased engineering students' self-control and improved their ability to demonstrate their knowledge. Similarly, Allers (2010) identified the learning style preferences of dental students as collaborative active learning style and found that this learning style enriches students' cognitive skills, creative thinking, interpretation, critical thinking, and problem-solving skills. In another study, Alshammari and Qtaish (2019) revealed that learning styles to which e-learning is adapted provided a better learning outcome and increased the level of knowledge. Likewise, Hung and Young (2021) showed that different learning styles supported by e-learning can positively transform the learning and teaching process. In a study examining the effect of learning styles on academic achievement, Halloun (2007) found that enhanced learning styles increased students' academic achievement. In the same way, Riggs (2005) demonstrated that domain-based learning styles positively affected academic achievement in earth science teaching. Moreover, Trindade et al. (2002) stated that the learning style appropriate for the three-dimensional virtual learning environment helped students with three-dimensional learning skills to grasp the learning outcomes more easily. Virkus (2019) concluded that multiple learning paths within the course provided students with the opportunity to choose personal learning paths based on their personal learning goals, learning styles, interests, and other preferences.

Effects of Learning Styles on Affective Factors

In a study conducted by Thanyaphongphat and Panjaburee (2019), which examined the effect of learning styles on affective factors, it was concluded that technology-supported learning styles positively affected the motivation of university students. In another study, Almasri (2022) emphasized that the kinesthetic learning style has an important role in the engagement and satisfaction of university students in the learning process, especially with the support of simulation in learning science concepts in the study in which the participants were university students. Likewise, Yang et al. (2016) emphasized that students in the experimental group equipped with learning styles were better than students in the control group in terms of confidence and learning retention.

Relationship Between Learning Styles and Other Variables

Some of the studies in the literature investigated relationship between learning styles and the other variables. For example, Arslan et al. (2009) found a significant difference between the science and mathematical thinking skills of participants with convergent and divergent learning styles. Similarly, Ucar and Yilmaz (2023) concluded that there are significant differences in terms of students' gender, learning level and media usage time by using e-learning style. Furthermore, Van Petegem et al. (2023) stated that there was a significant relationship between students' learning styles and their future success. In another study, Kubat (2018) suggested that learning-teaching processes should be planned according to individual differences, considering that there is a significant relationship between science teachers' learning styles and individual differences. Moreover, McMahon (2010) emphasized that there is a significant relationship between learning styles and students' attendance to earth science course. According to Markowitz and DuPre (2007) it was shown that the graduate experience course in science education played an important role in determining the learning style that students would use throughout their careers. In addition, science, mathematics and technology educators' views on online education were evaluated in the context of learning styles, and it was suggested that the WhatsApp application be accepted as the official platform according to the study conducted by Singh-Pillay and Naidoo (2020). In addition, Dincol-Ozgur (2018) found that there was a statistically significant difference between learning styles of prospective chemistry and science teachers' lack of self-directedness scores.

On the other hand, Gabel et al. (1987) emphasized that one of the most important educational types of research is learning styles and since there is no significant relationship between gender and learning styles, the least attention is paid to gender differences research. Likewise, Farkas et al. (2016) revealed that there was no significant difference between the students grouped according to their learning styles and time spent working was not significantly associated with either learning style or career choice.

DISCUSSION

In this systematic review study, it is aimed to summarize the findings and reach a conclusion about the role and importance of learning styles in science education at university level from 2007 to 2023.

When the studies in the literature are summarized, it is seen that learning styles influence various variables in science education at university level. These variables were classified as cognitive and affective factors and the effects of learning styles on these variables were examined separately. Some of the studies were related to the effects of learning styles in science education on cognitive factors such as academic achievement, creative thinking, interpretation, critical thinking, and problem-solving skills (Allers, 2010; Alshammari & Qtaish, 2019; Coma-Rosella et al., 2018; Halloun, 2007; Hung & Young, 2021; Riggs, 2005; Trindade et al., 2002; Virkus, 2019). Whereas the other studies were related to the effects of learning styles in science education on affective factors such as motivation, attitudes toward something and satisfaction (Almasri, 2022; Thanyaphongphat & Panjaburee, 2019; Yang et al., 2016). The common feature of the studies in both groups is that learning models in science education have a positive effect on both cognitive and affective factors.

When the relationship between learning styles and some variables in the literature is examined, it is seen that there is a significant difference between the control group and the experimental group in terms of those variables in most of the studies (Arslan et al., 2009; Dincol-Ozgur, 2018; Kubat, 2018; Markowitz & DuPre, 2007; McMahon, 2010; Ucar & Yilmaz, 2023; Van Petegem et al., 2023). On the other hand, some studies such as Farkas et al. (2016) and Gabel et al. (1987) concluded that there was no significant difference between learning styles and some variables between control and experimental groups.

CONCLUSIONS

Recent studies have provided evidence that the concept of learning styles may not even be valid. Participants classified as visual or auditory learners did not perform better when the instructional material matched their hypothetical learning styles according to Rogowsky et al. (2015). Similarly, Kirschner and van Merriënboer (2013) argued that the concept of learning styles was a myth that should be eliminated. Instead, they suggested that teachers should focus on the content of instruction and not on the students' assumed learning styles. In addition, some of the studies in the literature help the concept that there may be no clean proof that teaching in step with studying patterns is greater powerful than teaching the usage of different methods. For example, Coffield (2004) carried out a scientific evaluate of seventy-one research on learning styles and discovered no clean proof that teaching in step with learning styles progressed educational performance. Similarly, Pashler et al. (2009) reviewed 10 research on learning styles and discovered no proof that teaching to particular studying patterns improves educational performance.

Implications and Recommendations

The reviewed research has numerous implications for teaching and learning in science education at the university level. Firstly, educators need to purpose to

contain a whole lot of teaching techniques to accommodate one of a kind gaining knowledge of patterns. For instance, visible aids, interactive activities, and peer discussions might be used to attain university students with one of a kind gaining knowledge of patterns. Secondly, teachers need to be aware about the effect of gaining knowledge of patterns on university students' attitudes closer to gaining knowledge of, that may result in an extra nice gaining knowledge of experience. Thirdly, university students need to be advocated to become aware of their gaining knowledge of alternatives and expand powerful observe techniques that align with their gaining knowledge of style. By adopting those techniques, university students can take possession in their gaining knowledge of process, that may result in higher instructional overall performance and accelerated motivation.

To establish a clearer connection between learning styles and academic accomplishment, more study is required. Incorporating cognitive and meta-cognitive tactics that can boost academic accomplishment regardless of learning style is one of several teaching strategies that go beyond learning style preferences that educators may find valuable. In order to assist students' learning and performance, educators may create more effective teaching practices by having a deeper grasp of the numerous aspects that affect academic attainment.

The implications of this systematic overview encompass the want for teachers to consider the range of mastering patterns among their students, and to create an extra inclusive and powerful mastering environment. However, it's far vital to be aware about the restrictions and gaps recognized withinside the literature, and similarly studies have to be performed at the best approaches to cope with extraordinary mastering patterns in technology training on the university level.

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APPENDIX A

Table A1. Variables of the selected papers

No.	Study	Participants profile	Research type	Major findings
1	Allers (2010)	35 dental students	Quantitative	Collaborative active learning style enriches students' cognitive skills, creative thinking, interpretation, critical thinking, & problem-solving skills.
2	Almasri (2022)	1,034 university students	Quantitative	Kinesthetic learning style has an important role in engagement & satisfaction of university students in learning process.
3	Alshammari and Qtaish (2019)	174 undergraduate students	Quantitative	Learning styles to which e-learning is adapted provided a better learning outcome & increased the level of knowledge.
4	Arslan et al. (2009)	463 preservice teachers	Quantitative	Significant relation between science & mathematics reasoning for participants having converger & diverger learning style at mathematics education.
5	Coma-Roselló et al. (2018)	Engineering students	Quantitative	Concept mapping learning style increased students' self-control & improved their ability to demonstrate their knowledge.
6	Dincol-Ozgur (2018)	Prospective chemistry & science teachers	Quantitative	Statistically significant difference between learning styles of prospective chemistry & science teachers' lack of self-directedness scores.
7	Farkas et al. (2016)	492 students	Quantitative	No significant difference between students grouped according to their learning styles. Time spent working was not significantly associated with either learning style or career choice.
8	Gabel et al. (1987)	553 elementary teachers	Quantitative	No significant relationship between gender & learning styles, least attention is paid to gender differences research.
9	Halloun (2007)	No participants	Qualitative	Enhanced learning styles increased students' academic achievement.
10	Hung and Young (2021)	89 students	Quantitative	Different learning styles supported by e-learning can positively transform learning & teaching process.
11	Kubat (2018)	14 science teachers	Qualitative	Significant relationship between science teachers' learning styles & individual differences.
12	McMahon (2010)	University students	Quantitative	A significant relationship between learning styles & students' attendance to earth science course.
13	Riggs (2005)	No participants	Quantitative	Domain-based learning styles positively affected academic achievement in earth science teaching.
14	Singh-Pillay and Naidoo (2020)	Science, technology, & mathematics education lecturers	Qualitative	Science, mathematics, & technology educators' views on online education were evaluated in context of learning styles.
15	Thanyaphongphat and Panjaburee (2019)	190 university students	Quantitative	Decision model advising appropriate learning material on their learning style.
16	Trindade et al. (2002)	21 university students	Quantitative	Learning style appropriate for 3D virtual learning environment helped students 3D learning skills to grasp learning outcomes more easily.
17	Ucar and Yilmaz (2023)	401 preservice teachers	Quantitative	Significant differences in terms of students' gender, learning level, & media usage time by using e-learning style.
18	Van Petegem et al. (2023)	2,080 university students	Quantitative	A significant relationship between students' learning styles & their future success.
19	Virkus (2019)	No participants	Qualitative	Multiple learning paths within course provided students with opportunity to choose personal learning paths on their personal learning goals, learning styles, interests, & other preferences.
20	Yang et al. (2016)	90 college students	Quantitative	Students in experimental group equipped with learning styles were better than students in control group in terms of confidence & learning retention.