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DEVELOPING AFFECTIVE LEARNING STRATEGIES FOR SCIENCE EDUCATION: A LITERATURE REVIEW

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Abstract: This study aims to identify innovative, effective learning strategies in science education through a comprehensive literature review. The research utilized trusted databases, WoS and Scopus, which resulted in 19 scholarly articles that met specific inclusion and exclusion criteria. A total of 509 articles were obtained through keyword identification, then through the screening and eligibility stages, and 19 articles that met the criteria were retrieved. The findings underscore the importance of practical assessment and profiling in gaining valuable insights into students' emotional states and competencies. Moreover, the student-centered approach enhances self-awareness and establishes a deep emotional connection with scientific principles. This study highlights the substantial impact of the educational environment and teacher effectiveness on students' affective experiences, emphasizing the importance of fostering a positive and supportive learning atmosphere. The practical learning strategies identified have the potential to contribute to the advancement of science education by promoting emotional engagement and enhancing students' overall learning experience.

Keywords: *Affective Learning, Science Education, Learning Strategies*

INTRODUCTION

The affective realm, which encompasses qualities such as objectivity, open-mindedness, inquisitiveness, respect for evidence, integrity, and critical thinking, represents essential dispositions that ought to be fostered among students in the realm of science education [1-3]. As we engage with the study of science, we witness that much emphasis is placed on the cognitive and psychomotor outcomes of science instruction, both of which are readily observable. Nevertheless, few would contend that cultivating affective traits during the investigative process is not a legitimate objective of science pedagogy [4-5]. Assuming that the development of affective processes constitutes the primary goal of science education, science educators should strive to identify situations that engender positive affective processes, especially in the context of science instruction. Regrettably, data about this matter remains scant.

The importance of the second aspect of affective outcomes in scientific education, the attitude towards science [6-7], is apparent when we understand that a student may have the cognitive and psychomotor skills to carry out a task. However, their emotions influence their willingness to do so [8]. Moreover, numerous studies have shown a strong link between students' attitudes towards science and academic achievements [9]. The practical outcomes of science education are predominantly reliant on endogenous variables subject to the influence of the schooling process [10]. While research has found a positive relationship between teacher endogenous variables and attitudes [11-12], there is a dearth of data concerning the impact of the primary endogenous variable, the learning environment, on affective outcomes. Student interaction is a crucial factor in the learning environment [13], as it is mainly responsible for creating the social atmosphere that shapes students' approach to their coursework and ultimately influences their behaviour [5]. Any attempt to comprehend student behavior must account for their experiences in interpersonal relationships.

The educational research results distinguish affective into several constructs, namely interest, attitude, and motivation [14]. Some researchers classify attitudes differently from motivation [15]. Attitude is more about liking and disliking a condition. At the same time, motivation is more about interest, curiosity, and anxiety [16]. One of the studies mentioned that young students have more positive affective when compared to teenage students [17]. This indicates that an approach is needed to maintain students' interest and curiosity in science for adolescent students.

The primary objective of this research is to identify and scrutinize efficacious approaches to enhance students' attitudes toward science and augment their academic achievements. The study will investigate various factors that impact the emotional results of science education, encompassing endogenous variables like the learning milieu, pupil-teacher interactions, and pupil-pupil interactions. Through a comprehensive analysis of existing literature, the study aims to formulate innovative, effective learning strategies that can be incorporated in science classrooms to augment pupils' involvement and inspiration towards learning science. Ultimately, this research intends to contribute towards ameliorating science education by providing

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empirical-based discernments into the significance of affective outcomes in endorsing prosperous learning in science.

RQ 1: What innovative, effective learning strategies can be formulated based on existing literature in science education?

RESEARCH METHODS

To identify effective learning strategies, including models and assessments in science education, a review was conducted instead of a systematic review or meta-analysis due to the complexity and length of the literature. Rapid reviews have a similar methodology to systematic reviews but are designed to provide answers in a shorter timeframe, typically within six months, and with fewer resources. Decision-makers in America and Europe use them, often producing consistent results with traditional systematic reviews. The two most comprehensive scientific databases, Web of Science (WoS) and Scopus were used for the review. The search used a combination of keywords, including "affective learning strategies AND “science education," and was conducted across all fields without any time restrictions.

The search was conducted on April 08, resulting in 213 documents found in WoS and 296 documents in Scopus. The RefWorks® bibliographic manager eliminated duplicate articles, leaving 111 articles. After applying the scientific article filter, the inclusion and exclusion criteria stated in Table 1, and the relevance of the works for this rapid review, a total of 19 scientific articles were selected.

Inclusion Criteria

a) Scientific papers were published in the form of peer-reviewed scientific articles.
b) Research of any kind (experimental, reviews, descriptive.).
c) The research was on science education.
d) Publications indexed in Web of Science or Scopus provided they were in English, at least in their title, abstract, and keywords.

Exclusion Criteria

a) Publications that did not have access to at least the abstract.
b) Practical strategies and Science education were not part of the study.
c) Documents were not published as peer-reviewed scientific articles, such as theses, conferences, editorials, or opinion articles.
d) Duplicate items

The researchers participating in the search identified the most crucial information relevant to this work from these studies. The essential aspects of each approach's development, primary objectives, and configuration elements were highlighted. Articles that confirmed the positive effects of each approach on specific teaching-learning process variables were selected, prioritizing systematic review, meta-analysis, or literature review articles.

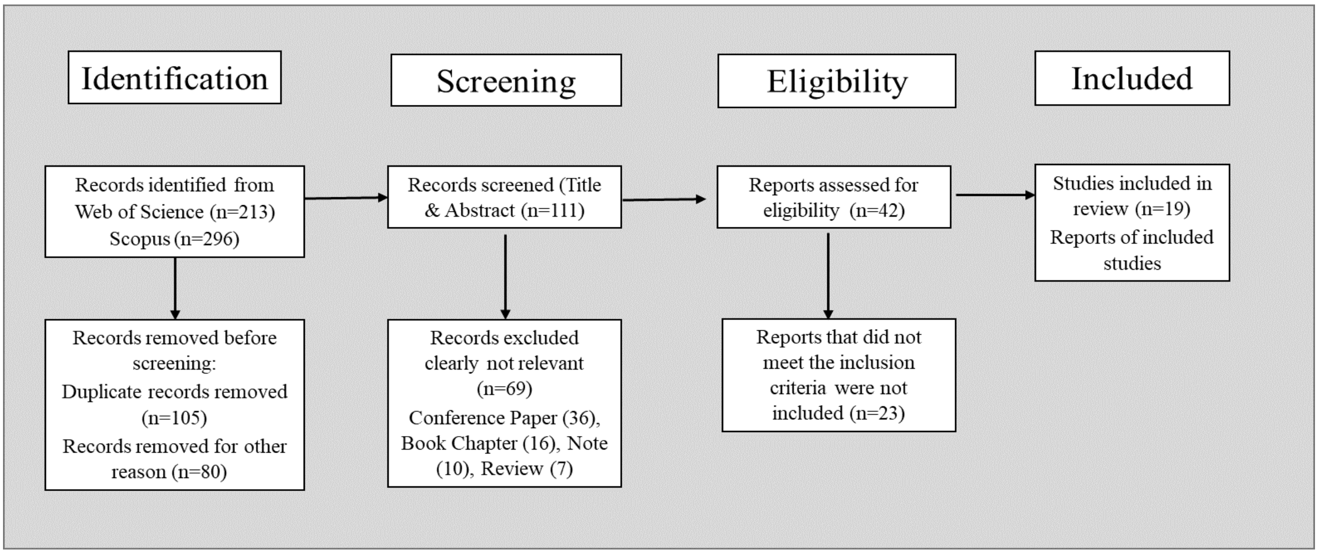

Figure 1. Treads to conducted a systematic review

RESULTS AND DISCUSSION

This rapid review aimed to identify and examine effective strategies for improving students' affective towards science. Nineteen literature-related strategies related to affective learning strategies, including models and assessments in science education. The focus was on documenting the strategies studied rather than analyzing their effectiveness.

Table 1. Literature of effective strategies for improving students' affective towards science

No	First Author	Tahun	Approach of research	Affective Strategies	Country	Field
1.	Melissa Joy Wolfe	2022	Qualitative	STEM Expansion via Exchange Program	Australia	STEM
2.	Karolina Broman	2020	Mixed Methods	Context-based learning	Sweden	Chemistry
3.	Elisa Vilhunen	2022	Qualitative	Predict-observe-explain (POE)	Finlandia	Physics
4.	L Lufri	2021	Quantitative	Scientific approach with the assistance of student worksheets based on PBL	Indonesia	Biology
5.	I M Astra	2021	Quantitative	Think Pair Share	Indonesia	Physics
6.	Jeong et al.	2021	Qualitative	Keeping a journal related to science	Korea	Science
7.	Murat Bursal	2020	Mixed Methods	Graphing skills and affective states	Turkey	Science
8.	Wan Ng	2019	Quantitative	Affective profiles of Year 9/10 students in science/science learning	Seven SE Asian countries and Australia	STEM Education
9.	Cory Hensen	2019	Quantitative	General chemistry laboratory studies	USA	Chemistry
10.	Kory M. Enneking	2019	Quantitative	Alternating face-to-face and virtual experiments	USA	Chemistry
11.	Sarah Frencha	2019	Qualitative	Embodied modes of performance	Australia	Science
12.	Sündüs Yerdelen	2019	Quantitative	Classroom learning environment perceptions and teacher effectiveness	Turkey	Science
13.	Rabiudin	2018	Qualitative	Authentic Affective Assessment	Indonesia	Physics
14.	Harkirat S.	2015	Quantitative	Single-sex versus coeducation school	Brunei	Science
15.	Lacy M. Cleveland	2017	Quantitative	Active-Learning Strategies		Biology
16.	Abdul Halim Abdullah	2017	Quantitative	STEM Education	Malaysia	Science, Technology, Engineering and Mathematics
17.	Barend Vlaardingerbroek	2016	Quantitative	Linking the experiential, affective, and cognitive	Australia	Biology
18.	Julia Y. K. Chana	2016	Mixed Methods	At-home study strategies or in-class learning	USA	Chemistry
19.	Kelli R. Galloway	2016	Qualitative	Affective chemistry laboratory experiences	USA	Chemistry

Table 1 shows those studies focus on the affective characteristics and learning strategies used in science, particularly in science and chemistry. These studies were conducted using quantitative and qualitative methods, literature reviews, and adaptations of existing affective scales.

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In a study, research was conducted on the influence of student exchange programs in rural areas on students' STEM (Science, Technology, Engineering, and Mathematics) learning. The method collected data from 10th-grade students who reported their affective responses to exchange program experiences [17]. This is supported by the results of another study, which found that STEM successfully improved students' affective in science learning [10], [18], [19]. The learning strategy employed was expanding students' STEM experiences through exchange programs. This study was conducted without specifying a country or particular field of study—another study on contextual learning in chemistry education in Swedish high schools. The method used was qualitative interviews and quantitative surveys. The learning strategy used was context-based learning. This study was conducted in Sweden in chemistry [14]. The method used was latent class growth analysis to identify student groups with different emotional trajectories. The learning strategy used was prediction-observation-explanation (POE) in high school physics education. This study was conducted without specifying a particular country [20]. Another study was conducted on the influence of the scientific approach with the help of PBL-based student worksheets on students' affective competencies in biology. The method used was quasi-experimental with a randomized control posted-only design. The learning strategy used was the scientific approach with the help of PBL-based student worksheets [21].

In a study, research was conducted that the learning strategy was to make a journal three times a week for 12 weeks. The study was conducted in Korea at public schools and focused on science [22]. Another research investigated high school students' graphing skills and affective states related to graphs based on gender, grade level, and types commonly used in science courses. The study used quantitative and qualitative approaches, and the results showed that students prefer bar graphs and dislike pie charts [23]. The use of graphics in science learning exceptionally influences student affective; this has been researched and shows different results [24], [25]. A review of some of these studies found that using media such as graphs, pictures, and problem-solving greatly influenced students' affective behaviour in science learning.

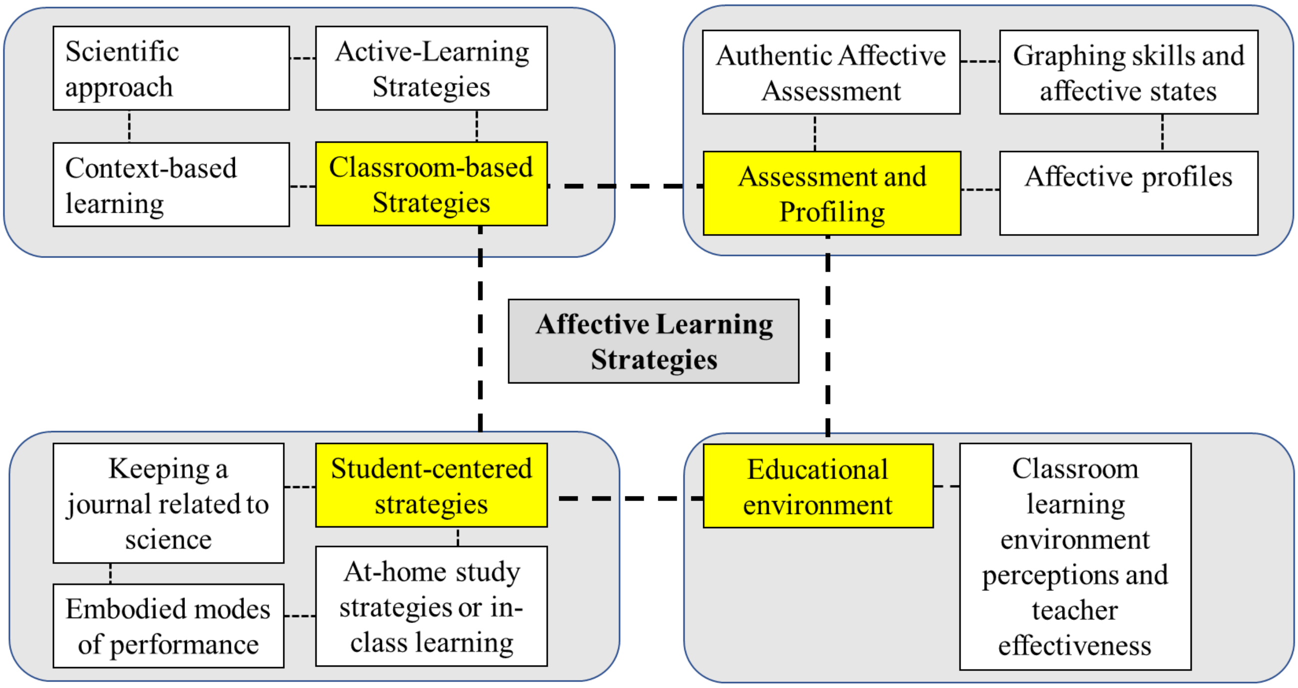

Figure 2. Affective strategies in Science Learning

A quantitative study that investigated the affective profile of year 9/10 students in science learning in seven Southeast Asian countries and Australia. The study aimed to understand the similarities and differences in students' attitudes and implications for STEM education development [26]—using existing affective scales in the general chemistry laboratory context. The study focused on using affective scales in the general chemistry laboratory environment [27]. The study was conducted in the United States using the Hybrid laboratory curriculum method, which consisted of alternating face-to-face and virtual laboratory experiments. The study aimed to enhance capacity in the general chemistry subject and evaluate the influence of the hybrid approach on cognitive, affective, and psychomotor learning. The results showed that students using the hybrid approach had similar cognitive and psychomotor abilities as those taught with traditional laboratory curricula. However, their compelling views towards

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chemistry were much lower [28]. It was found that science teaching models and methods affect students' affective. Choosing the suitable learning model will help teachers build students' affective.

The study was conducted in Australia using a performance-based pedagogical approach, which employed bodily performance to explain concepts or biochemical processes [29]. The study demonstrated that a multidisciplinary and creative approach can enhance students' motivation and engagement in science learning. The study was conducted in Turkey using Hierarchical Linear Modeling (HLM) analysis to evaluate the influence of students' perceptions of the classroom learning environment and teacher effectiveness on students' self-regulation in science class [3]. The study revealed that students' perceptions of the classroom learning environment were good predictors of students' self-regulation in science learning, and the task orientation variable was the strongest predictor. A study using a quasi-experimental design to compare the effects of two different active learning strategies on students' conceptual understanding, attitudes, and motivation in biology class. Data collection was done using quantitative methods in this study [30]. Abdul Halim Abdullah (2017) conducted a study in Malaysia to identify the readiness of teachers in the country to implement STEM education. The study used a survey method involving 190 teachers. Barend Vlaardingerbroek studied first-year college students' experiences, attitudes, and knowledge about microscopes. A study that partitioned students into three groups based on affective characteristics and compared home and classroom learning strategies between the three groups [31]. A study on students' affective experiences in the chemistry laboratory used a specific interview protocol to explore those experiences [32].

The research modeled the effects of selected affective factors on learning strategies and classroom activities in science education. This study showed that affective factors such as motivation and self-confidence can influence learning strategies and classroom activities [33]. An approach to elementary science education methods courses also focuses on the affective domain. This research emphasizes the importance of developing students' affective competencies, such as open-mindedness, interest, and enthusiasm for science, to help improve their learning outcomes in science. This is in line with the results of research, which states that enthusiasm [34], [35], openness, and interest [36]can improve science learning outcomes.

Affective learning strategies are crucial in promoting students' emotional engagement and overall learning experience [37][38]. Affective assessment and profiling provide insights into students' emotional states and graphing skills, helping educators tailor instruction to meet individual needs. Affective profiles comprehensively understand students' affective characteristics, enabling educators to provide personalized support. Affective laboratory experiences provide opportunities for students to explore and experiment, fostering a sense of curiosity and excitement. In student-centered strategies, keeping a journal related to science allows students to reflect on their learning and emotions, fostering self-awareness and metacognition. Embodied performance modes, such as role-playing or simulations, enable students to experience scientific concepts, enhancing their affective connection physically. At-home study strategies or in-class learning, depending on the educational context, create a flexible environment where students can engage with STEM materials in a way that suits their preferences [39]. Lastly, the educational environment and organization, including the classroom learning environment and teacher effectiveness, significantly impact students' affective experiences. A positive and supportive classroom environment [40], [41] and effective teaching practices can foster a conducive atmosphere for emotional engagement and academic success.

CONCLUSION

Affective learning strategies play a vital role in fostering emotional engagement and enhancing students' overall learning experience. Utilizing practical assessment and profiling offers valuable insights into students' emotional states and competencies, facilitating the provision of tailored instruction to meet individual requirements. Moreover, student-centered approaches, such as maintaining reflective journals and employing embodied modes of performance, contribute to developing self-awareness and establishing a profound emotional connection with scientific principles. The educational milieu, encompassing the classroom environment and the effectiveness of educators, exerts a profound influence on students' affective encounters, underscoring the significance of cultivating a positive and supportive atmosphere for learning.

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