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The Effective Ways to Affect Students' Motivation in Science Education: A Systematic Literature Review

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ABSTRACT This study addresses a critical gap in science education research, where existing studies on student motivation largely analyze singular learning methods in isolation, lacking comprehensive, comparative assessments of diverse approaches. This research reviewed Scopus-indexed articles with 5 inclusion and exclusion criterias published from 2015 to 2025 to characterize research trends and identify effective learning models and media affecting student motivation in science education. The research method used was a systematic literature review using PRISMA method. This study analyzes the characteristics of content, including publication year, publication type, countries where the research was conducted, research approach, educational level, and science content. The articles included in this study were chosen from international journals. The research approaches applied in the articles are quantitative, qualitative, mixed method, and research and development. Furthermore, this study found that students' motivation have been evaluated in various educational level (stage) for instance in elementary school, middle school, high school, and undergraduate. Moreover, the results of science content analysis showed that the evaluation of students' motivation was found in Science, Physics, Biology, Chemistry, and the integration of science with other subjects. Our findings reveal that while research spans various educational levels and science topics, flipped classroom and augmented reality (AR) are highly effective in fostering student motivation. This study offers valuable insights for educators and researchers on implementing impactful strategies.

Keywords Students' Motivation, Learning Model, Learning Media, Science Education

1. INTRODUCTION

Students' motivation is critical to their academic success at school. Motivation has been linked to the amount of intellectual energy typically used in learning activities, resulting in the view that motivation is equivalent to personality. Motivation is the driving force that compels an individual to seek knowledge, take action, comprehend, trust, or obtain specific skills, attitudes, or values (Filgona et al., 2020). Motivation refers to the reasons underlying behavior characterized by will and desire (Lai, 2011). Motivation can be categorized into two primary types: intrinsic and extrinsic motivation (Ryan & Deci, 2000) (Ryan & Deci, 2000). Intrinsic motivation refers to engaging in an activity for its own sake, driven by personal interest, enjoyment, or a sense of accomplishment. For instance, a student who reads a book because the subject matter is fascinating exemplifies intrinsic motivation. Conversely, extrinsic motivation is influenced by external factors, such as rewards or recognition. A student who studies hard to earn good grades or to gain praise from teachers and parents is motivated extrinsically. Externally motivated students are at higher risk of achieving lower academic performance than internally motivated students (Vero & Puka, 2017).

Likewise, learning motivation is the internal and external impetus that propels students to engage in learning, persist in their studies, and strive for academic achievement. Intrinsic motivation contrasts with internal motivation; it comes from the students themselves, while extrinsic motivation contrasts with external motivation, which comes from environmental factors. In education, lack of motivation can disrupt students' learning process (Vero & Puka, 2017). Conversely, students' motivation

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increases when factors relevant to those students are present (Williams & Williams, 2011). Additionally, learning motivation is primarily driven by psychological factors like emotions, attitudes, self-perception, and goal orientation. Social and environmental influences, particularly the significant roles of teachers and family, also play a crucial part, alongside demographic factors (age, socioeconomic status, gender) and cognitive abilities (including perceived competence), which further impact their motivation to learn (Ishida & Sekiyama, 2024). Students' motivation can be measured and quantified by questionnaires. For instance, SMTSL (Students' Motivation Towards Science Learning) developed by Tuan et al. (2005) consisting of six scales, including self-efficacy, active learning strategies, science learning value, performance goal, achievement goal, and learning environment stimulation.

Previous research on systematic literature reviews in students' motivation has been conducted. Byusa et al. (2022) conducted a study to investigate the educational games implemented and how these games have enhanced students' motivation and understanding of chemistry concepts. Additionally, Fitria (2023) employed gamification and analysed its positive influence on students' motivation. Similarly, Saadon et al. (2020), in their systematic review of augmented reality implementation, found that it improves students' motivation in the learning process at schools and universities. In another study by Ahmed et al. (2025), the researchers examined the impact of AI learning aids on ESL learners' motivation and academic performance. In addition, Azzahra et al. (2024) conducted a literature review of science learning motivation in elementary school and focused on the effectiveness of the Wordwall website. The utilization of virtual reality in mathematics lessons studied by Ahmad et al. (2024) focused on how virtual reality affects the learning environment and students' motivation. Furthermore, another study on digital learning media with preliminary strategy implementation and its relation to students' learning motivation was conducted by Faiqoh (2023). However, there is no literature review that examines the influence of different learning media and models on student motivation, particularly across different science disciplines.

Although the existing literature provides valuable insights into student motivation, most studies analyze the impact of a single type of learning media—such as augmented reality—in isolation. This approach limits our understanding of how different instructional media and models collectively influence student motivation. This study offers a broader perspective by examining multiple learning media and instructional models in the context of science education. Furthermore, previous research often focuses narrowly on specific science subjects, whereas this study explores differences in student motivation across various science disciplines. By filling these gaps, this research aims to provide comprehensive insights that can assist science educators in selecting and applying more effective pedagogical approaches. Understanding how diverse learning tools impact motivation across science topics is crucial for enhancing teaching strategies and fostering long-term student interest in science.

This research analyzes the characteristics of the content, including publication year, publication type, countries where the research was conducted, research approach, educational level (stage), and science content. In addition, we investigated learning models and media that have been applied to affect students' motivation in science education. The result of this study can provide stakeholders in the field of science education, including teachers, researchers, and others, with an overview of effective ways to improve students' motivation. The aim of this study was to review articles on students' motivation in science education published from 2015 to 2025. There are two research questions used to guide the process of this study:

1. How is the distribution of research based on the characteristics of content, including publication year, publication type, country, research approach, educational level (stage), and science content?
2. What is the effective learning model and learning media to improve students' motivation in science learning?

2. METHOD

2.1 Research Design

This research employed a systematic literature review method following PRISMA guidelines. A systematic literature review (SLR) offers a structured approach to identifying, screening, and including studies related to a specific question or topic (Pati & Lorusso, 2018). A systematic literature review provides a way to evaluate the strength and extent of current evidence regarding a particular question or topic. In this research, articles were selected from highly reputable journals indexed in Scopus and ranked Q1-Q3 to ensure research quality. The articles chosen were published from 2015 to 2025. This study reviews 40 articles on students' motivation in science education identified through a search using two queries. The first query "science motivation" OR "student* motivation" and the second query "science education" OR "biology education" OR "chemistry education" OR "physics education" that suits the inclusion and exclusion criteria.

2.2 Research Procedure

Establishing clear inclusion and exclusion criteria in a systematic literature review (SLR) helps identify a manageable, relevant set of studies directly relevant to the research question (Xiao & Watson, 2019). The inclusion and exclusion criteria for the chosen article are shown in Table 1.

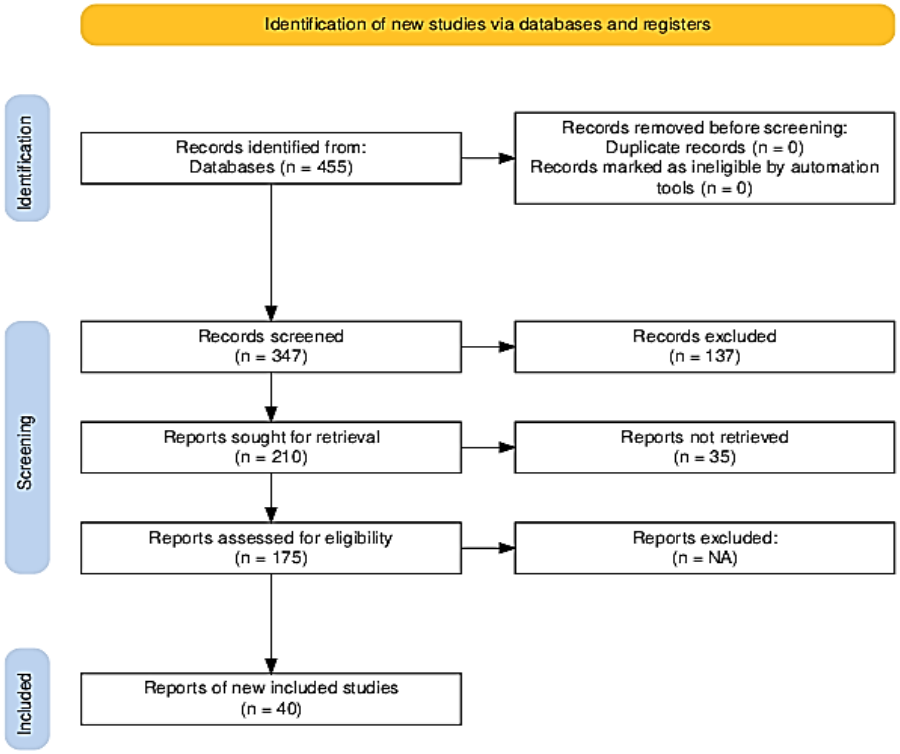

Figure 1. Flow Diagram for the Present Systematic Literature Review using PRISMA

Table 1. Inclusion and Exclusion Criteria

No	Categories	Inclusion Criteria	Exclusion Criteria
1	Subject area	Science education	Non-science education
2	Publication year	Published within 2015 to 2025	Published earlier than 2015
3	Language	English	Non English
4	Publication type	Journal	Proceedings and thesis
5	Journal specification	Indexed by Scopus	Not indexed by Scopus

In carrying out this study, there are three stages of the review steps: (1) identification of the content of the articles; (2) screening the articles against the determined criteria; and (3) the suitable articles being included in this study. The flow diagram of the present is shown in Figure 1.

2.3 Data Collection

The articles chosen for review were published from 2015 to 2025. The data collection for this systematic review encompassed multiple journal sources, as detailed in Table 2, which presents the distribution of articles across journals.

Table 2 indicates that 25 international journals reviewed in this study are indexed by Scopus. The number of articles is symbolized by the letter "f" in the table. All journals included in this study are listed in the Scimago Journal & Country Rank (Scimagojr.com), further supporting their standing. Consequently, the chosen articles are considered to be of good quality. Articles indexed in Scopus are used because Scopus maintains high-quality standards, covers many academic subjects, provides useful research tools, and is well-known around the world. Using sources from Scopus helps ensure that the research is trustworthy, easy to trace, and widely accepted in academic and professional fields.

3. RESULT AND DISCUSSION

3.1 Research Question 1: How is the distribution of research based on the characteristics of the content?

The distribution of research was analyzed in the following characteristics: publication year, publication type, countries where the research was conducted, research approach, educational level, and science content.

The Distribution of Research Based on Publication Year

The publication years of the articles in this research ranged from 2015 to 2025. The completed data is presented in Figure 2. Based on Figure 2, it can be observed that student motivation in science has been investigated and evaluated throughout the years. This shows that researchers are continually trying to improve students' motivation, especially in science. According to the data in Figure 2, the most articles were published in 2023, and the fewest were published in 2020.

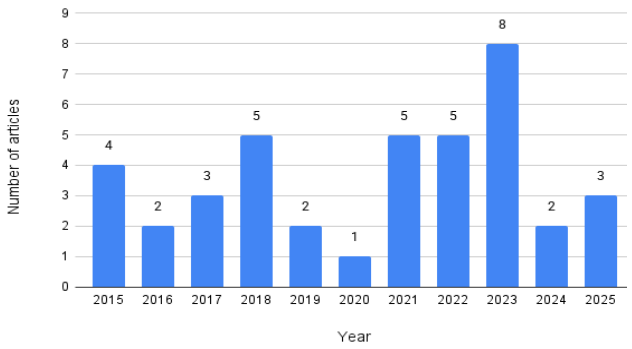

Figure 2. The Distribution of Research Based on Publication Year

The Distribution of the Research Based on Publication Type

Table 3 presents the distribution of research studies included in this systematic review, categorized by publication type to demonstrate the diversity of source materials examined. The publications included in this study are divided into journals, proceedings, and theses. Table 3 shows that all the articles reviewed in this research were selected from 40 international journals (100%). Even though students' motivation is also to be studied in proceedings and theses, we did not select articles from those sources. We aimed to maintain research quality and minimize the risk of bias by selecting international journals rather than proceedings and theses (Shirvani et al., 2024).

Table 3. The Distribution of Research Based on Type of Publication

No	Type of Publication	f	%
1	Journal	40	100
2	Proceedings	0	0
3	Thesis	0	0
Total		40	100

Distribution of Research Based on Country

The information about countries was determined from the location of each research in each article. The completed data are shown in Figure 3. Figure 3 represents the countries and regions (continents) that evaluate and analyze the students' motivation in science. Data on countries and regions (continents) were obtained from the samples used in each study. Based on Figure 3, 22 countries and 1 region (continent) are involved in the research. The data sources used in this study are detailed in Table 4, which includes the country of origin, number of articles, and the primary authors.

Based on Table 4, Turkey has the highest number of articles, with 7 (17.5%). Moreover, the countries with the most articles reviewed in this study are from Asia. The data show that student motivation in science has been investigated and evaluated in many countries worldwide

Table 2. The Distribution of Research Based on Country that Evaluated Students' Motivation

No	Name of journal	f	(%)	Indexed by	H-Index 2024 (SJR)
1	Computers in Human Behavior	1	2.5%	Scopus (Q1)	275
2	Computers & Education	2	5.0%	Scopus (Q1)	253
3	Journal of Computer Assisted Learning	5	12.5%	Scopus (Q1)	121
4	Educational Psychology	1	2.5%	Scopus (Q1)	90
5	Journal of Science Education and Technology	5	12.5%	Scopus (Q1)	85
6	Quality & Quantity	1	2.5%	Scopus (Q1)	85
7	Thinking Skills and Creativity	1	2.5%	Scopus (Q1)	75
8	Research in Science Education	1	2.5%	Scopus (Q1)	72
9	Education Sciences	1	2.5%	Scopus (Q1)	68
10	Humanities and Social Sciences Communications	1	2.5%	Scopus (Q1)	64
11	Cultural Studies of Science Education	1	2.5%	Scopus (Q1)	44
12	Gifted Education International	1	2.5%	Scopus (Q1)	21
13	International Journal of Science Education	1	2.5%	Scopus (Q2)	132
14	Journal of Chemical Education	1	2.5%	Scopus (Q2)	109
15	Simulation & Gaming	1	2.5%	Scopus (Q2)	75
16	Eurasia Journal of Mathematics, Science and Technology Education	3	7.5%	Scopus (Q2)	63
17	FEBS Open Bio	1	2.5%	Scopus (Q2)	51
18	Computers	1	2.5%	Scopus (Q2)	50
19	Journal of Baltic Science Education	2	5.0%	Scopus (Q2)	29
20	Advances in Human-Computer Interaction	1	2.5%	Scopus (Q3)	32
21	Jurnal Pendidikan IPA Indonesia	3	7.5%	Scopus (Q3)	30
22	African Journal of Science, Technology and Mathematics Education	1	2.5%	Scopus (Q3)	22
23	International Journal of Information and Education Technology	1	2.5%	Scopus (Q3)	22
24	Participatory Educational Research	2	5.0%	Scopus (Q3)	16
25	Science Education International	1	2.5%	Scopus (Q3)	11
	Total	40	100%		

and has even spread across continents. This shows that researchers worldwide continue to test the most suitable methods teachers can apply to improve student motivation.

The Distribution of Research Based on the Research Approach

The research approach was determined in the research methods section of each article. Table 5 summarizes the research approaches employed in the reviewed articles, categorizing them into quantitative, qualitative, mixed-methods, and research and development.

Table 4. The Distribution of Research Based on Research Approach

No	Research Approach	f	%
1	Quantitative	25	62.5
2	Qualitative	2	5
3	Mixed Methods	12	30
4	R&D (Research and Development)	1	2.5
Total		40	100

Based on Table 5, the data reveal that the quantitative approach was the most used method, with 25 articles (62.5%), and research and development was the least used, with only 1 article (2.5%). This distribution shows a strong preference for statistical analysis alongside meaningful use of contextual and integrated methodologies.

The Distribution of Research Based on Educational Level (Stage)

The aim of analyzing the samples is to present a comprehensive overview of how previous research on students' motivation in science education is distributed across different educational levels. The completed data is apparent in Table 6.

Table 5. The Distribution of Research Based on Educational Level (Stage)

Participant/ Sample	Educational Level (Stage)	f	%	Total (%)
Student	Elementary	4	10	38 (95)
	Middle School	11	27.5	
	High School	12	30	
	Undergraduate	10	25	
	Middle and High School	1	2.5	
Other	Middle School	1	2.5	2 (5)
	High School	1	2.5	
Total		40	100	40 (100)

Based on Table 6, the sample of participants in articles is divided into two categories: students with 38 articles (95%) and others (students and teachers) with 2 articles (5%). From the Table 6, we found that high school students has the highest number of articles with 12 articles (30%) and the lowest number of articles came from combination of middle and high school students, combination of teacher and students in middle school, and combination of teacher and students in high school, with only one article (2.5%) for each.

The Distribution of Research Based on Science Content

The science content discussed in this study was divided into five categories: science, physics, biology, chemistry, and the integration of science with other subjects. The aim of selecting articles that integrate science with other subjects is to identify and examine research in disciplines beyond pure science that incorporate a scientific topic. The completed data are shown in Table 7.

Table 6. The Distribution of Research Based on Science Content

Science Content	Information	f	%
Science	-	5	12.5
Physics	-	13	32.5
Biology	-	8	20
Chemistry	-	11	27.5
The integration of science with other subjects	Biology and Chemistry	1	2.5
	Science, Technology, Engineering, and Mathematics	1	2.5
	Earth and Life Science	1	2.5
Total		40	100

Based on Table 7, it is evident that research on improving students' motivation was mostly found in physics subjects, and the least in the integration of science with other subjects. From the data, it can be concluded that research on improving students' motivation has been conducted across all branches of science, including physics, biology, chemistry, and the integration of science with other subjects.

3.2 Research Question 2: What is the effective learning model and learning media to improve students' motivation in science education?

The collected data were analyzed into two categories: learning model and learning media. The data table was thoughtfully reviewed by two experts. Tables 8 and 9 contain information about the learning model and learning media applied to affect students' motivation, along with the science content, topic, author, and results. The data of the learning model and the effect on students' motivation are presented in Table 8.

Table 7. The Learning Model and the Effect on Students' Motivation in Science Education

No	Learning Model	Science Content — Topic	E.g., (only first author cited)	Instrument Used	Positive effect on students' motivation (Yes or No)
1	Flipped classroom	Chemistry — Oxidation and reduction, acid and base, neutralisation reaction	Lee (2021)	5-points likert scale type adapted from Glynn et al. (2011)	Yes
		Physics — Movement on Earth and work-energy	Aşıksoy (2015)	an SMQ (Science Motivation Questionnaire) developed by Glynn et al. (2009) and open-ended questions	Yes
		Biology — Human anatomy and physiology	Dixon (2021)	5-points likert scale type questionnaire adapted from Glynn et al. (2011)	Yes
		Physics — Magnetic force	Chang (2018)	5-points likert scale type questionnaire adapted from Keller (2010)	Yes
		Physics — Electromagnetism	Aşıksoy (2017)	5-points likert scale type questionnaire adapted from Glynn et al. (2009)	Yes
2	Inquiry-based learning	Biology	Ellwood (2018)	Researcher observation	Yes
		Chemistry — Ionizing radiation	Meulenbroeks (2024)	Questionnaire	Yes
		Integrated science — STEM	Teplá (2025)	7-points likert scale type questionnaire adapted from IMI	Yes
		Chemistry — Properties of liquid	Srisawasdi (2019)	5-points likert scale type questionnaire adapted from Glynn et al. (2011)	Yes
3	Active learning	Integrated science — Biomolecules structure and metabolism	Cicuto (2016)	7-points likert scale type questionnaire adapted from Science Education	Yes
		Biology	Corkin (2017)	7-points likert scale type questionnaire adapted from Pintrich et al. (1993) and Wolters (2004)	Yes
4	Blended learning	Physics — Direct current	Radulović (2023)	5-points likert scale type questionnaire adapted from Tuan et al., (2005)	Yes
		Physics	Shi (2021)	5-points slikert scale type questionnaire adapted from AMS, Utvær & Haugan (2016)	Yes
5	Agent-based learning	Physics — Force	Chen (2015)	5-points likert scale type questionnaire adapted from IMMS	Yes
6	Design thinking	Biology — Cell	Bawaneh (2023)	5-points likert scal type questionnaire developed y the author	Yes
7	POGIL (Process-Oriented Guided Inquiry Learning)	Chemistry — Electrolyte solution and redox reaction	Yuliastini (2018)	5-points likert scale type questionnaire adapted from Tuan et al. (2005)	Yes
8	Problem-based learning	Physics	Argaw (2017)	5-points likert scale type questionnaire adapted from Pintrich & DeGroot, (1990)	No

Table 8 represents eight learning models from 17 articles that have been implemented and evaluated for the students' motivation in science lessons. The data show that most learning models have had positive effects on students' motivation. The most effective learning model for improving students' motivation in science education is the flipped classroom, with 5 articles (12.5%). Meanwhile, only one learning model has no positive effect on students' motivation: problem-based learning. The problem used in the study is a quantitative problem-solving task that involves recalling formulas and solving the problem quantitatively.

The data on the learning media and the effect on students' motivation are presented in Table 9.

Table 8. The Learning Media and the Effect on Students' Motivation in Science Education

No	Learning Media	Science Content — Topic	E.g., (only first author cited)	Instrument Used	Positive effect on students' motivation (Yes or No)
1	Augmented Reality (AR)	Biology — Human digestive system	Ziden (2022)	Likert-scale type questionnaire adapted from IMMS	Yes
		Biology — Cell	Erbas (2019)	5-points likert scale type questionnaire adapted from Pintrich et al. (1993)	Yes
		Biology — Anatomy	Khan (2019)	5-points likert scale type questionnaire adapteed from the IMMS and open ended question	Yes
		Chemistry — Atomic structure	Liu (2023)	Questionnaire	Yes
		Biology — Human body organs	Ciloglu (2023)	Motivation scale questionnaire	No
2	Gamification	Chemistry	Chans (2021)	Assessment survey developed by the author	Yes
		Physics — Introductory physics for engineering course	Okariz (2023)	5-points likert scale type questionnaire developed by the author	Yes
		Science — Understanding of insects	Su (2015)	5- points likert scale type questionnaire developed by the author	Yes
		Chemistry	Nkereuwem (2023)	4-points likert scale type questionnaire adapted from 'Artificial Intelligence And Student Motivation Questionnaire' (AISMQ)	Yes
3	Interactive simulations	Science	Banda (2023)	Questionnaire	Yes
		Physics	Alnaser (2024)	5-points likert scale type questionnaire adapted from the IM inventory	Yes
		Physics — Ohm's Law	Chen (2025)	5-points likert scale type questionnaire adapted from Chen et al. (2024)	Yes
		Chemistry — Electrolysis	Ahmad (2021)	5-points likert scale type questionnaire adapted from Song and Keller (2001)	Yes
4	Educational games	Integrated science — Climate change	Besalti (2024)	Interview developed by the author	Yes
		Physics	Hariyono (2023)	5-points likert scale type questionnaire adapted from Tuan et al. (2005)	Yes
5	Immersive and virtual reality	Science	Liu (2022)	Questionnaire	Yes
		Biology — Gene	Tsirulnikov (2023)	Feedback questionnaire developed by the author	Yes
6	Mobile learning tools	Physics — Electric field and currents	Nikou (2018)	7-points likert scale type questionnaire adapted from McAuley et al. (1989)	Yes

Table 9. The Learning Media and the Effect on Students' Motivation in Science Education (*continued*)

No	Learning Media	Science Content — Topic	E.g., (only first author cited)	Instrument Used	Positive effect on students' motivation (Yes or No)
7	Digital content	Science	Basar (2022)	3-points likert scale type questionnaire adapted from Uyanık (2014)	Yes
8	Self-assessment	Physics — Electromagnetism	Nikou (2015)	5-points likert scale type questionnaire adapted from Glynn and Koballa (2006)	Yes (PBA no)
9	Out of school environments	Science	Yildirim (2020)	5-points likert scale type questionnaire adapted from Dede and Yaman (2008)	Yes
10	Ethno-Vlab	Physics — Dynamics of force and motion	Rizki (2025)	5-points likert scale type questionnaire adapted from Tuan et al. (2005)	Yes
11	Project-based media	Biology	Özarslan (2018)	Motivation towards Learning Biology Questionnaire	No

Table 9 shows that 11 types of learning media from 23 articles have been implemented and evaluated for students' motivation in science education, including science, physics, biology, chemistry, and the integration of science with other subjects. The data show that most learning media have had a positive effect on students' motivation. The most effective learning media for enhancing students' motivation towards science education is Augmented Reality (AR), with 5 articles (12.5%) stating the positive effect. Although four other articles reported a positive effect, one article found that mobile augmented reality in the context of human body organs had no significant effect, resulting in a negative effect on students' motivation. Besides that, there are two more learning media that do not give a positive effect to students' motivation, such as the biology project and paper-based assessment.

3.3 Discussion

This study reviews 40 articles from reputable international journals on students' motivation in science learning. This study examines how research is distributed based on the characteristics of content and the effectiveness of learning models and media used in science learning. Content analysis was chosen because it aligns with several previous studies that explored publication year (Alonso et al., 2025; Ashraf et al., 2021; Ilma et al., 2023), publication type (Alizkan et al., 2021), country (Alonso et al., 2025; Ashraf et al., 2021), and research approach (Ilma et al., 2023). Revealing the year of publication helps identify trends, show research gaps, and monitor the evolution or decline of interest in a particular topic. It provides insight into how current and relevant research is over time. Moreover, understanding the type of publication will clarify the intended audience, standards of peer review, and formality of the research. This helps assess the credibility and overall impact of the evidence base. Analyzing the country-based distribution highlights global research contributions, uncovers underrepresented regions, and directs future research or policy initiatives to geographic areas that require further study. In addition, analyzing research approaches highlights the diversity of methodological perspectives and their dominance. This can reveal potential biases and guide methodological improvements in future research. Furthermore, educational levels (stages) (Ashraf et al., 2021) and science content (Alizkan et al., 2021) have also been investigated in previous studies. Reviewing the educational stages targeted shows where research efforts are concentrated and may expose neglected or underserved groups. This information highlights gaps across educational levels that warrant further study. Meanwhile, analyzing the scientific content of the research can help teachers, lecturers, or researchers obtain relevant information.

The articles reviewed in this study were 40 indexed in Scopus between 2015 and 2025. The selection of articles published within a 10-year period was intended to maintain the accuracy and relevance of data. It is important to study student motivation in science using recent research. Such studies are valuable because they reflect current educational practices and challenges, making their conclusions relevant and useful for today's students and learning environments (Ramadhani et al., 2024; Willoughby et al., 2024). The highest number of articles was published in 2023, while the lowest number of articles was published in 2020. The contrasting publication numbers between 2020 and 2023 reflect both the immediate impact of global crises and the capacity for recovery and growth (Artyukhov et al., 2024). Research article publication was low in 2020, primarily due to the COVID-19 pandemic, which disrupted research activities and led journals to prioritize COVID-related

studies (Jayaweera et al., 2021), thereby delaying or reducing publication.

The type of publication chosen in this study was 100% from the journal. Many researchers from various countries have evaluated students' motivation for science learning. This study includes 22 countries and 1 region (continent). The country with the most articles sampled is Turkey. The research approaches used in the articles include quantitative, qualitative, mixed-methods, and research and development. The most used research approach was quantitative, and the lowest was research and development. A quantitative research approach is widely used in students' motivation research because the data are collected using motivation scales and questionnaires, which are considered more appropriate. This statement aligns with a previous study that found students' motivation in science education was primarily based on a quantitative research approach (Chan & Norlizah, 2017; Jdaitawi, 2020).

The current research on student motivation in science education mainly uses Likert scales, which rely on self-report questionnaires. Although these are efficient for collecting quantitative data from many students, this exclusive focus has a major weakness: results can be biased (Kholifah & Sofwan, 2024). Students might give socially desirable answers or select similar responses, potentially making motivation seem higher than it truly is or masking its true complexity. Therefore, a clear methodological gap exists regarding the use of mixed methods—combining these surveys with objective and qualitative techniques (such as observation or long-term studies). This will create a more complete and trustworthy picture of how motivation strategies truly work in science education. The research and development approach was least used in students' motivation research because of its complexity and the need for more time than the quantitative approach (Afriani et al., 2025).

Furthermore, this study found that students' motivation was evaluated across various educational levels (stages), with the highest level in high school. Even though the lowest number of articles came from combination of middle and high school students, combination of teacher and students in middle school, and combination of teacher and students in high school, with only one article (2.5%) for each, the results of the analysis show that the evaluation of students' motivation in science learning in elementary is still relatively low compared to middle school, high school, and undergraduate levels. Therefore, there are still many opportunities to seek research novelty related to the students' motivation in science learning at the elementary level (Azahra et al., 2025).

This study also analyzed the effectiveness of the learning models and media used to improve students' motivation in science learning. Analysis of 40 studies indicates that student motivation is primarily influenced by the quality of the student experience, engagement, and perceptions of meaningful learning. All learning models involved in this study used a learner-centered approach that focused on students' experience, needs, and the process of constructing knowledge. This approach prioritizes active student engagement and the development of higher-order thinking skills. Prioritizing active student engagement promotes a learning environment in which students gain content knowledge and develop the critical skills and adaptable mindset necessary to address complex real-world problems (VÎŞCU, 2024). However, this study found that a learning model that did not show a significant difference after the intervention was problem-based learning. Moreover, learning media examined in this research promote high levels of student engagement, particularly in science instruction. This media enhances knowledge acquisition by prioritizing active participation, individualized learning, and direct experiential methods.

The results showed that students' motivation was evaluated in Science, Physics, Biology, Chemistry, and in the integration of science with other subjects. Most learning models and learning media reviewed in this study show a positive effect, including improving, promoting, and enhancing students' motivation in science learning. Most of the learning models and learning media used show a significant improvement in students' motivation after the treatment. Some examples of learning models that have a positive effect on students' motivation in Science include mobile gamification to teach insect understanding to 102 elementary students (Su & Cheng, 2015) and out-of-school learning environments for 56 middle school students (Yuliastini et al., 2018). Mobile gamification success positively affects students' motivation due to its convenience and enjoyment of delivering material related to the topic. This is in line with a previous study that found that gamification increases student motivation in science learning. Students were satisfied with gamification applications and found them attractive and enjoyable (Hursen & Bas, 2019). In addition, the learning media that successfully improve students' motivation in Science are digital stories (Başar, 2022), immersive virtual reality (Liu et al., 2022), and PhET interactive simulation-based (Banda & Nzabahimana, 2023). Immersive virtual reality significantly improves students' science motivation, as it engages students and enables them to visualize abstract concepts. Previous research found that it can create highly engaging digital environments that fundamentally alter the way students interact with and manipulate virtual representations of scientific concepts and phenomena (Zhang et al., 2025). Moreover, using PhET interactive simulations provides students with an active, visual, and engaging experience of complex experiments. This is supported by previous research that found that PhET interactive simulations offer interesting, engaging, and varied experiences, leading students to be more focused

and enthusiastic about their learning (Firdaus & Murtiyasa, 2021; Gani et al., 2020; Susilawati et al., 2022).

Some examples of learning models that have a positive effect on students' motivation in Physics are agent-based learning to teach force to 139 middle school students (Chen & Chou, 2015), AR-based flipped learning to teach magnetic force (Chang & Hwang, 2018), blended learning to teach direct current (Radulović et al., 2023), and a flipped classroom to teach movement on earth and work-energy (Aşıksoy, 2017). Besides that, there is only one learning model that does not have a significant impact on students' motivation, which is problem-based learning (Argaw et al., 2017). When implementing problem-based learning, students may feel demotivated by the complexity of the problem and a lack of teacher guidance. This statement is supported by previous research findings that, despite initially higher motivation, experienced students often become less engaged over the course, indicating that effective problem-based learning requires greater instructor support and guidance (Fukuzawa et al., 2017). Furthermore, some of the learning media that give a positive effect on students' motivation in Physics are ethnoscience-based engklek game (Hariyono et al., 2023), inquiry-based virtual lab to teach Ohm's Law (Chen et al., 2025), mobile-based micro-learning and assessment to teach electric currents and currents (Nikou & Economides, 2018, and gamifying physics laboratory to teach introductory physics for engineering course (Okariz et al., 2023). Although there were three types of assessments used in (Nikou & Economides, 2015), only two types had a positive effect on student motivation, which are computer- and mobile-assisted, while the other, paper-based assessment, had no positive effect on student motivation. It is because paper-based systems have lacked immediate and specific feedback, which has also limited students' engagement. This aligns with a previous study that found immediate feedback is essential for reinforcing learning and motivation, as it allows students to recognize and correct mistakes promptly (Jordan, 2012).

In addition, in Biology all the reviewed learning models have a positive effect on students' motivation such as active learning interventions (Corkin et al., 2017), design thinking teaching method to teach cell (Bawaneh & Alnamshan, 2023), flipped classroom to teach human anatomy and physiology (Dixon & Wendt, 2021), and inquiry-based (Ellwood & Abrams, 2018). When students actively engage in their learning process rather than passively receiving information, they experience substantial improvements in motivation, engagement, and academic performance. At the same time, the design thinking method gives students the opportunity to apply the scientific knowledge and skills they have acquired in real-life situations. It also allows students to think, reflect, and exchange feedback at the end of each stage, opening the door to constructive dialogue and discussion and helping students increase their motivation efficiently. In learning media, such as Augmented Reality (Erbas & Demirer, 2019; Khan et al., 2019; Ziden et al., 2022) and virtual reality laboratory simulation, there is a positive effect. However, two learning media do not have a positive effect: the biology project (Özarslan & Çetin, 2018) and mobile augmented reality (Ciloglu & Ustun, 2023).

In Chemistry, learning models that positively affect students' motivation include AR-based experiential learning to teach atomic structure (Liu et al., 2023), gamification (Chans & Portuguez, 2021), and inquiry-based learning to teach ionizing radiation (Meulenbroeks et al., 2024). The gamification activity proved valuable, fair to all learners, useful, and engaging. It also enabled students to maintain focus, feel encouraged, increase their class participation, and enhance their comprehension of chemistry topics. In addition, Lee et al. (2021) taught oxidation and reduction, acids and bases, and neutralisation reactions using cooperative flipped learning, which successfully improved students' motivation. Although cooperative flipped learning helps low-achieving students participate more in class, this method does not train high-level tasks, and the possibility of problems in interaction, such as chatting and wandering in class, is repeated. Moreover, the learning media used that successfully improve students' motivation include chatbots and AI-powered gamification (Nkereuwem et al., 2023), game-transformed inquiry-based learning to teach properties of liquid (Srisawasdi & Panjaburee, 2019), and an interactive computer animation and simulation module to teach electrolysis (Ahmad et al., 2021).

In addition to Science, Physics, Biology, and Chemistry, students' motivation is also evaluated in science, which is integrated with other subjects. The learning model applied to evaluate students' motivation and give positive effects includes an active learning environment and inquiry-based science education. The aforementioned learning model was implemented in the topic of biomolecule structure and metabolism (Cicuto & Torres, 2016) and STEM (Teplá & Distler, 2025), respectively. Besides the learning model, there is only one learning medium that evaluates students' motivation in integrating science with other subjects; it is an educational computer game that teaches climate change and has a positive effect on it.

The result of this study shows that the most effective learning model to improve students' motivation in science learning is the flipped classroom (Aşıksoy, 2017; Chang & Hwang, 2018; Dixon & Wendt, 2021; Aşıksoy, 2015; Lee et al., 2021), with five articles, and can be implemented for physics, chemistry, and biology content. The flipped classroom model positively impacts student motivation by encouraging active participation, boosting self-confidence, and fostering a more supportive and effective learning environment. This motivates students to take responsibility

for their own education and achieve better results (Lam & Siew, 2024; Mustapha & Abdullah, 2024).

Meanwhile, the most effective learning media to improve students' motivation in science learning is augmented reality (AR) that has been implemented in biology and chemistry (Erbas & Demirer, 2019; Khan et al., 2019; Liu et al., 2023; Ziden et al., 2022), with four articles that have proven significant improvement in students' motivation after treatment. Augmented reality provides engaging and interactive learning experiences that make learning more enjoyable for students. This confirms findings from previous studies that augmented reality enhances learning by combining visualization, interactivity, and flexibility, significantly increasing interest and excitement (Kumar & Mithun, 2024; Nazeer et al., 2023).

Moreover, there are several learning models and learning media that do not have a positive effect on students' motivation in science learning, which are problem-based learning (Argaw et al., 2017), biology project (Ozarslan, 2018), mobile augmented reality (Ciloglu, 2023), and paper-based assessment (Nikou & Economides, 2015). The biology project (Özarslan, 2018), which was implemented here, was chosen based on students' interest in biology and was evaluated by the advisers. For instance, the usage of amygdalin in daily life, the effect of cigarettes on epithermal cells, and other projects. It had a negative effect on the students' motivation because the project did not meet expectations and students' needs (Jannah et al., 2023). Also, the project was not very interesting to do, so students may have decreased motivation (Insyasiska et al., 2015). While mobile augmented reality (Ciloglu & Ustun, 2023) was used in biology to teach students about human body organs, this was conducted through distance education due to the COVID-19 pandemic. Some students find AR engaging and innovative for visualizing complex biological concepts; meanwhile, others may not perceive it as significantly enhancing their motivation or attitudes towards biology. This is in line with the previous study that found the positive effect of mobile augmented reality on students' biology motivation can be limited by obstacles such as device shortages, unreliable internet, and questionable scientific accuracy (Schmidthaler et al., 2023).

4. CONCLUSION

Students often experience a decline in motivation when encountering science, due to the perceived complexity and abstract nature of many scientific concepts, which can lead to a lack of engagement. This research directly addresses this pedagogical challenge by identifying and examining specific learning models and learning media designed to sustain or enhance student motivation. This study analyzed the characteristics of content based on year of publication, publication type, countries evaluating students' motivation in science learning, educational stage (level), research approach, and science content. The study selected 40 articles from high-quality journals (indexed in Scopus). From 23 countries and 1 region (continent), Turkey has the most articles. The research approaches used were quantitative, qualitative, mixed methods, and research and development. Furthermore, students' motivation in science learning has been evaluated at various educational stages (levels). However, implementation at the elementary level remains relatively low. The students' motivation in science has been evaluated in Science, Physics, Biology, Chemistry, and the integration of science with other subjects. This study also analyzed effective learning models and media to improve students' motivation across various topics in science learning. The findings show that the most effective learning model for improving students' motivation in science learning is the flipped classroom. Furthermore, the most effective learning medium for improving students' motivation in science learning is augmented reality (AR), which has been implemented in biology. Therefore, the results of this research will help teachers, researchers, and other science education professionals implement the effective learning model and learning media to promote students' motivation in science learning.

Firstly, this research has its strengths and weaknesses. The strength of this research is that the journals used are reputable international journals. This statement is supported by the fact that the chosen articles were from journals indexed by Scopus (Q1, Q2, and Q3) within 10 years. Additionally, this research can be useful for teachers, lecturers, and other researchers in implementing the best strategy in their learning processes or in research related to students' motivation in science learning. Meanwhile, the weakness and limitation of this research is that the databases used are limited to Scopus-indexed journals. Secondly, the gap in future research is that we have not found any studies that evaluate students' motivation in science learning with the teacher as the subject. Thirdly, although the study presents valid evidence for some claims, the lack of reported data on the research instrument's validity is a significant limitation. This absence raises concerns about the reliability and potential bias of the final results. Lastly, we suggest that future research on student motivation in science learning focus on learning models, media, and topics that have yet to be discussed by previous researchers.

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