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Review Article

From Curiosity to Active Engagement: The Teacher's Role in Physics Learning

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ABSTRACT

Purpose of the study: This study aims to analyze how teachers foster students' curiosity and engagement in physics learning by identifying effective pedagogical patterns that simultaneously support active participation and enhance students' intrinsic motivation.

Methodology: This study employed a qualitative approach using a Systematic Literature Review (SLR) based on the PRISMA 2020 guidelines. Data were collected from Taylor & Francis, Springer, and MDPI databases. Purposive sampling selected 29 articles (1984–2025). Data were analyzed using thematic analysis with document extraction sheets.

Main Findings: Teachers act as facilitators, motivators, and learning designers in fostering curiosity and engagement. Effective strategies include inquiry-based learning, project-based learning, contextual approaches, and open-ended exploration. These strategies enhance intrinsic motivation and support cognitive, emotional, and social engagement, while promoting deeper conceptual understanding, scientific character development, and sustained curiosity through inquiry, experimentation, and reflective dialogue.

Novelty/Originality of this study: This study integrates student curiosity and engagement into a unified analytical framework in physics education, offering a perspective that has rarely been addressed in prior research. This PRISMA-based SLR provides a systematic synthesis of evidence and advances understanding of how adaptive and collaborative teaching practices foster scientific curiosity in contemporary learning contexts.

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1. INTRODUCTION

Physics learning throughout the world plays a strategic role in developing scientific thinking and evidence-based problem-solving skills. Globally, physics learning focuses not only on concept transfer but also on inquiry and exploration of natural phenomena, fostering students' curiosity and critical thinking skills [1]. In developed countries such as Finland, Japan, and the United States, approaches to physics learning have focused on active learning and scientific reasoning, integrating theory and practice [2]. Teachers act as facilitators, not only transferring knowledge but also fostering character values through meaningful learning. This aligns with the view that science education should encourage students to understand the relationship between scientific concepts and everyday life [3]. Therefore, a character-building approach to physics learning is urgently needed in the Indonesian education system.

In the Indonesian context, the direction of physics learning has undergone significant changes along with the development of the national curriculum. The history of the Indonesian curriculum shows a transformation from the 1968 Curriculum to the 2013 Curriculum, which focused on mastering concepts, to the Independent Curriculum, which emphasizes learning freedom and character development [4], [5]. This shift is a response to the needs of 21st-century education, which demands students develop critical, collaborative, and reflective thinking skills. The Independent Curriculum aims to balance the cognitive, affective, and psychomotor dimensions to make the learning process more contextual and meaningful. In physics learning, this requires teachers to design strategies that not only teach concepts but also foster scientific attitudes such as curiosity, perseverance, and academic honesty. Curiosity is a key element in learning that plays a role in building motivation and higher-order thinking skills [6], [7]. Thus, a curriculum that adapts to scientific character becomes the foundation for developing students who are active and reflective about natural phenomena.

Curiosity is an intrinsic drive that drives individuals to seek new knowledge and understand things they don't yet know. In the context of physics learning, curiosity drives students to ask questions, investigate, and reason about natural phenomena around them [8]-[10]. Research shows that curiosity has a positive correlation with student learning outcomes [11], [12]. When teachers are able to manage learning strategies that foster curiosity, student active engagement will increase significantly. Therefore, curiosity is an important characteristic in increasing the effectiveness of science learning in schools.

The character of curiosity is important because it plays a major role in the formation of scientific competence and a lifelong learning attitude [13]. Students who have a high sense of curiosity tend to have strong intrinsic motivation, better critical thinking skills, and resilience to learning difficulties. Conversely, if this character isn't developed, students tend to be passive, give up quickly, and view physics learning as merely a cognitive burden. Teachers have a significant responsibility to create a safe, open, and challenging learning environment that encourages students to experiment and ask scientific questions. Therefore, fostering curiosity is not merely a pedagogical issue but a fundamental necessity for developing a generation of adaptive and innovative learners.

Various previous studies have shown that curiosity is an important character that needs to be developed in science learning. Research [14] confirms that teaching strategies designed systematically by teachers can increase students' curiosity, thus having a positive impact on learning outcomes. In addition, a study in Indonesia by Aryani and Sartika [15] found a positive correlation between students' curiosity and science achievement. However, most of these studies still focus on curiosity as an individual variable or partially link it to learning outcomes, without examining student engagement as an interconnected learning process. Furthermore, studies that systematically synthesize the role of teachers in integrating curiosity and student engagement, particularly in the context of physics learning, are still limited.

Student engagement is a multidimensional construct encompassing students' cognitive, emotional, and behavioral involvement in the learning process [16], [17]. This engagement is considered an important indicator of learning quality because it reflects the extent to which students are active, motivated, and participate in learning activities. Research shows that physics learning that provides space for exploration, discussion, and contextual problem-solving can significantly increase student engagement [18], [19]. However, studies on student engagement often stand alone and have not explicitly linked curiosity as the initial trigger for such engagement.

Teachers play a central role in managing learning that fosters both curiosity and student engagement. Various approaches such as inquiry-based learning, project-based learning, and contextual learning have been reported to be effective in encouraging students' exploratory activities in physics learning [9], [20]. However, previous studies generally discuss the effectiveness of these approaches separately, without synthesizing how the teacher's role integrates curiosity and student engagement simultaneously. Based on a critical analysis of the literature, a research gap exists, indicating the need for a systematic study that integrates the teacher's role, curiosity, and student engagement within a single analytical framework. Therefore, this study aims to systematically synthesize empirical findings related to the teacher's role in fostering student curiosity and engagement in physics learning. The urgency of this research lies in the need to provide a conceptual and empirical mapping of teacher pedagogical practices that are oriented not only toward conceptual mastery but also toward strengthening students' scientific character. The findings of this study are expected to provide theoretical contributions to the development of physics education studies, as well as practical implications for teachers and policymakers in improving the quality of meaningful and character-oriented physics learning.

2. RESEARCH METHOD

This study employed a qualitative approach using the Systematic Literature Review (SLR) method through document analysis. This method was chosen to identify, evaluate, and synthesize relevant research findings related to the role of teachers in fostering student curiosity and engagement in physics learning. The SLR approach enabled researchers to obtain a comprehensive overview of learning strategy patterns, empirical findings, and research gaps in the existing literature.

This study did not involve primary data collection through questionnaires, interviews, or field experiments, as all data were sourced from published scientific articles. Therefore, the terms sample, respondents, hypothesis, and internal consistency of the questionnaire are not applicable in the context of this study. The research procedure followed the PRISMA 2020 guidelines [21], which emphasizes transparency and reproducibility in the process of searching, selecting, and reporting literature. The research stages include identification, screening, eligibility assessment, and inclusion of final articles.

Taylor & Francis Online database using a combination of keywords: *"teacher strategy"* , *"physics learning"* , *"curiosity"* , and *"character education"* . The search process was conducted in October 2025 with a publication year filter of 1984–2025 to ensure the literature used was up-to-date and relevant to the context of the Independent Curriculum. From the initial search results, 29 articles were obtained related to the research theme. Each article was recorded on *a data extraction sheet* including the author's name , year, research context, objectives, and main results. This data was then used as a basis for further filtering stages.

inclusion criteria for this study included: (1) empirical or quasi-experimental research articles; (2) discussing teacher strategies or learning approaches that foster student curiosity; (3) focusing on physics or science in secondary schools; (4) published between 1984 and 2025; and (5) accessible in *full text* in English or Indonesian. The exclusion criteria included: (1) conceptual or opinion articles without empirical data; (2) non-science research; (3) articles that only touched on general curiosity without a physics learning context; and (4) duplicate publications between databases. After applying these criteria, from a total of 320 initial articles, 29 final articles met the inclusion criteria and were ready for analysis. The application of these criteria aims to ensure that the articles analyzed are thematically and methodologically relevant to the research focus.

The article selection process follows four stages according to the PRISMA model: 1) Identification: 320 articles were found from three databases; 2) Screening: 29 articles were removed because their titles and abstracts were not relevant to the topic of curiosity or teacher strategies → 291 articles remained; 3) Eligibility: Of the 291 articles, 262 articles were eliminated because they were not available in full text or did not focus on physics learning → leaving 29 articles; 4) Inclusion: 29 final articles were selected for in-depth analysis.

The procedure for searching and selecting articles can be seen in the following scheme in figure 1.

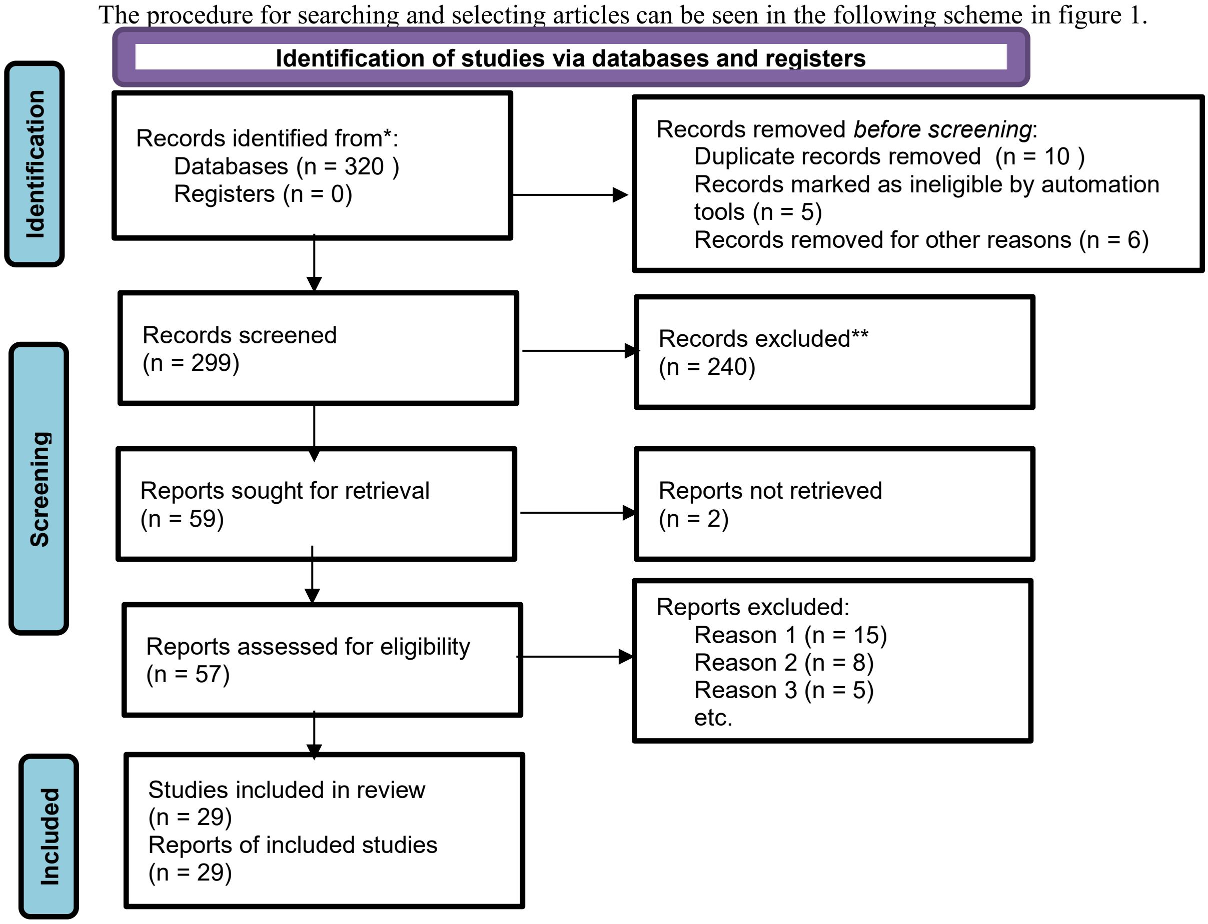

Figure 1. Research flow

The research instruments consisted of a data extraction sheet and a thematic coding sheet. The data extraction sheet was used to gather primary information from each article, while the coding sheet was used to identify themes and subthemes related to teacher roles, curiosity, and student engagement. Because this study was based on document analysis, no questionnaires, open-ended questions, or psychometric instruments were used. Therefore, testing the questionnaire's internal consistency and instrument construct validity was not applied.

Data analysis was conducted using a thematic analysis approach according to [22]. Each included article was read thoroughly and coded based on key topics related to teacher strategies and curiosity development. The analysis phase included identifying *initial codes* , grouping them into thematic categories, and determining recurring themes in the literature. The analysis revealed four major themes: (1) teacher strategies that facilitate active student engagement, (2) contextual approaches that relate material to real life, (3) learning that encourages reflection and exploration of concepts, and (4) evaluation that emphasizes the development of scientific attitudes, including curiosity. These themes formed the basis for compiling the research findings and discussion, which illustrate best practices in fostering students' curiosity through teacher strategies.

To ensure the validity of the results, each article was analyzed independently by two researchers to ensure consistency in coding and interpretation of the data. The *peer review* process *Debriefing* was conducted to review the accuracy of the theme groupings and avoid subjective bias. Content validity was strengthened by comparing the analysis results with relevant theories and previous findings. In addition, each step of selection and analysis is systematically documented using PRISMA worksheets. Thus, the results of this research synthesis can be accounted for and used as an empirical reference for further research and physics learning practices.

3. RESULTS AND DISCUSSION

The research results were obtained through a thematic analysis of 29 selected articles using the PRISMA 2020 guidelines. This analysis employed open coding, category grouping, and the extraction of key themes, as described in the methodology section. The purpose of the analysis was to identify patterns of teacher strategies that contribute to increasing student curiosity and engagement in physics learning. The results presented in this section represent clean findings without in-depth theoretical interpretation. Interpretation and meaning of the results are presented separately in the discussion section. The thematic analysis indicates that teacher strategies in physics learning can be grouped into four main themes. The first theme relates to strategies that encourage active student engagement through inquiry and problem-solving. The second theme encompasses contextual approaches that link physics concepts to everyday life phenomena. The third theme focuses on exploratory learning that provides space for reflection and scientific uncertainty. The fourth theme relates to pedagogical interactions and evaluations that foster students' scientific attitudes. To facilitate a visualization of the current state of teacher strategies in fostering student curiosity in physics learning, a mapping is presented in Table 1.

Table 1. Results of analysis of research documents regarding teacher strategies in increasing students' curiosity in physics learning

No	Article Title and Researchers	Research methods	Research result	Research Analysis Results
1.	The Scientific Curiosity of Preservice Elementary Teachers and Confidence for Teaching Specific Science Topics [23]	Quantitative/Qualitative mixed (29 prospective teachers, 16 weeks of curiosity journaling)	Shows that prospective teachers' curiosity levels vary; there is limited correlation between curiosity and teaching confidence on specific science topics.	Partially relevant: touches on curiosity, but the context is not middle-grade physics instruction, and focuses on prospective teachers, not students. It could be included as a reference for curiosity journaling strategies.
2	Bjerknes, A-L., Wilhelmsen, T., & Foyn-Bruun, E. E. (2024). "A Systematic Review of Curiosity and Wonder in Natural Science and Early	Systematic Literature Review from 2010–2020, focusing on curiosity and wonder in natural science education	Found that students' curiosity and "wonder" were influenced by teacher strategies: open-ended exploration activities, environmental settings that support inquiry,	Relevant as a theoretical basis for your research; although the context is early childhood and natural science, the teacher strategies identified can be adapted to secondary students'

No	Article Title and Researchers	Research methods	Research result	Research Analysis Results
	Childhood Education Research." DOI: 10.1080/02568543.2023.2192249.		and active interaction between teacher and students .	physics learning.
3	[24] Whitworth, B. A. (2025). Fostering Innovation, Creativity, and Curiosity in Science: Practical Strategies Teachers Can Implement.	Empirical article; practical review of teacher strategies to increase students' curiosity in science	Teachers can use strategies such as triggering open-ended questions, raising "mystery" / phenomena, providing a free exploration environment.	It is suitable for the "analysis results" section on how teacher strategies foster student curiosity; it can be included in the "teacher role model / learning environment" column.
4	[25] Fostering Students' Situational Interest in Physics: Results from a Classroom-Based Intervention Study (2023). DOI: 10.1007/s11165-023-10120-x.	Quasi-experimental (11-meeting intervention in secondary schools)	Students in the intervention group who chose topics based on personal interest experienced an increase in situational interest in physics compared to the control group.	Teacher strategy: giving freedom to choose topics & linking them to students' interests has been proven to increase students' curiosity or interest in physics.
5	[26] Intellectual Curiosity as a Mediator between Teacher–Student Relationship Quality and Emirati Science Achievement in PISA 2022 (2024). DOI : 10.3390/educsci14090977.	Quantitative analysis of a large dataset (17,475 students)	Good teacher-student relationship → increases intellectual curiosity → has a positive impact on science achievement	Teacher strategies that strengthen relationships with students (personal relationships) can be the basis for strategies to foster students' curiosity.
6	[27] Musengimana, T., Yadav, L. L., & Uwamahoro, J. (2025). Instructional strategies for enhancing students' problem-solving skills in physics: a systematic review. Springer, Discover Education, 4, 380. DOI:10.1007/s44217 -025-00733-x	Systematic Literature Review (118 articles) in global physics education	Identification of eleven teacher instructional strategies (e.g., inquiry-based problem-solving, multiple representation model) that are effective in improving students' problem-solving abilities; these strategies also have the potential to foster curiosity due to the exploration and inquiry activities they activate.	Very relevant because of the physics context and teacher strategies; can be immediately used as an important entry in your table for physics teacher strategies
7	[28] Jianfan Zeng, Haoqun Yan and Hongfeng Zhang. How Does Classroom	Quantitative student survey (university context) analysis of the inner curiosity → creativity motivation	Curiosity has been shown to increase student creativity; teacher support/learning	Although in a university context, the relevance to curiosity is clear and teacher/learning environment strategies

No	Article Title and Researchers	Research methods	Research result	Research Analysis Results
	Curiosity Affect College Students' Creativity? (2024). MDPI, Education Sciences, 15(9), 1101. DOI:10.3390/2227-7102/15/9/1101. [29]	model	environment moderates the relationship between curiosity and knowledge seeking.	are also discussed; they can be adapted to secondary level physics learning.
8	Shumakova, N. (1992) Study of students' curiosity [30]	Not stated in full (possibly quantitative, survey study of students)	The article examines the characteristics of student "curiosity" — how students demonstrate curiosity and the factors associated with it.	This research confirms that curiosity is an important aspect in the learning process and needs to be considered by teachers in learning design; implications for teacher strategies: teachers need to create classroom conditions that stimulate and support student curiosity.
9	Wilcox, J., Zavalza Flores, S., Bruns, M., & Nolting Dredge, S. (2024). Sparking Students' Curiosity: Embedding Strategies to Promote Curiosity Alongside Teaching Static Electricity. Science Scope, 47(4), 30-36. DOI:10.1080/08872376.2024.2363116. [31]	This article uses the implementation of strategies to increase curiosity in static electricity learning (topic: static electricity) within the 5E learning framework (Engage, Explore, Explain, Elaborate, Evaluate) in the classroom.	Some of the research results are: - In the Engage phase, the teacher uses "magic tricks" as a hook to pique students' curiosity. - In the Explore phase, students are given different experimental stations to explore the phenomenon of static electricity and note down what makes them "curious". - In the Elaborate phase, students are asked to design their own research questions (student-generated questions) based on their curiosity. - Throughout the process, the teacher explicitly models curiosity: showing enthusiasm, asking speculative questions, taking interest in students' ideas.	This study shows that if teachers integrate curiosity-provoking strategies (starting hooks/tricks), provide open-ended exploration, ask students to generate their own questions, and explicitly model curiosity, then physics learning (especially the topic of static electricity) can be more engaging and facilitate students' curiosity. Furthermore, strengthening curiosity is not just a side effect, but is actively designed into each phase of learning. Implications for teachers: physics lesson planning should consider specific strategies to build students' curiosity, not just convey physics concepts.
10	Fostering Student Curiosity in Scientific Practices: The SUPeR Approach Using Student Uncertainty	Research describing the "SUPeR" (Student Uncertainty as Pedagogical Resources) approach to enhancing student	The main findings indicate that student uncertainty can be used as a pedagogical resource to stimulate student curiosity in	This article supports that teacher strategies that consciously utilize moments of uncertainty or open-ended questions can strengthen students'

No	Article Title and Researchers	Research methods	Research result	Research Analysis Results
	as Pedagogical Resources [32]	curiosity in scientific practice. Not fully cited in the public abstract (likely qualitative or mixed-method)	science learning; teachers can guide students through the four phases of the SUPeR approach to developing curiosity.	curiosity, suitable as a reference in your research that focuses on teacher strategies to increase students' curiosity and engagement in physics classes.
11	Spektor-Levy, O., Baruch, Y. K., & Mevarech, Z. (2013). Science and Scientific Curiosity in Pre-school—The teacher's point of view. International Journal of Science Education, 35(13), 2226-2253. DOI:10.1080/09500693.2011.631608. [33]	A survey using both quantitative and qualitative approaches: 146 preschool teachers in Israel were surveyed regarding their attitudes toward science teaching and their views on scientific curiosity; 46 of them also answered an open-ended questionnaire about the definition of a "curious child" and how curiosity can be developed.	– The majority of teachers believe that science education should start at an early age and that preschool children are capable of conducting inquiry activities. – However, many teachers feel they do not have enough scientific knowledge to teach science confidently. – Teachers' views on "curious children" and how to cultivate curiosity vary widely: there is no single agreement.	This article shows that teachers' attitudes and perceptions are important factors in the development of students' scientific curiosity and their engagement in science activities. For your research, this means that "teacher strategies" are not only about the technical aspects of learning, but also relate to teachers' beliefs, scientific competence, and understanding of students' curiosity.
12	Shenaar-Golan, V. & Gutman, C. (2013). Curiosity and the Cat: Teaching Strategies That Foster Curiosity. Social Work with Groups. [34]	A descriptive qualitative approach; researchers examined teaching practices in social work education with groups, and identified effective teacher/lecturer strategies for fostering students' curiosity.	Research has found that curiosity can be learned and developed through a learning environment that supports exploration, open dialogue, and reflection. Strategies used by teachers include: allowing freedom to experiment, asking open-ended questions, creating space for reflective discussion, and creating a safe classroom environment for critical thinking and inquiry.	This article emphasizes that teacher strategies play a central role in fostering student curiosity, particularly through interactions that encourage active participation and intrinsic learning. Although the context is not physics, the principles can be applied in physics classrooms to foster student curiosity and engagement, for example by providing opportunities for independent experimentation, reflection on natural phenomena, and open-ended questions that encourage scientific exploration.
13	Ruiz-Alfonso & León (2019). Teaching Quality: Relationships Between Passion, Deep Strategy to	Quantitative (survey, SEM) on high school students.	Teaching quality enhances students' passion for learning, deep learning strategies, and epistemic curiosity.	Show that Quality teaching strategies encourage curiosity through increased motivation and a deep learning approach.

No	Article Title and Researchers	Research methods	Research result	Research Analysis Results
	Learn, and Epistemic Curiosity. [35]			
14	Chak, A. (2007). Teachers' and Parents' Conceptions of Children's Curiosity and Exploration. International Journal of Early Years Education, 15(2), 141-155. DOI:10.1080/09669760701288690. [36]	Quantitative → a questionnaire was developed for teachers and parents about their conceptions of children's curiosity and exploratory behavior.	Teachers and parents have different perceptions of children's curiosity and exploration; many see exploration as an important part of learning, but perceptions of what constitutes a 'curious child' vary.	Showing that the factor of teacher/parent perception towards children's curiosity is important — in your research ("The Role of Teacher Strategies…") it is important to pay attention to how teachers recognize and interpret students' curiosity because this conception can influence the strategies used.
15	Menning SF (2018). Why nurturing curiosity is an ethical endeavour: exploring practitioners' reflections on the importance of curiosity. International Journal of Early Years Education, 27(2), 1-18. DOI:10.1080/09669760.2018.1547632 [37]	Ethnographic qualitative approach + video-stimulated recall + focus groups with ECEC (early childhood education) practitioners in Norway	Practitioners highlight that cultivating curiosity is not just a teaching technique: there are underlying ethical values — namely four value approaches (ethical rationalities) to curiosity: relational, virtue, consequentialist, essentialist.	This demonstrates that teachers' (or educational practitioners') strategies for supporting curiosity must consider their values and beliefs about what curiosity is. For your research (teacher strategies, curiosity, and student engagement in physics classes), this means that in addition to teaching methods, it is also important to consider teachers' values and perceptions of students' curiosity.
16	Eren, A. & Coşkun, H. (2016). Students' level of boredom, boredom coping strategies, epistemic curiosity, and graded performance. The Journal of Educational Research, 109(6), 574-588. DOI 10.1080/00220671.2 014.999364. [38]	Quantitative (survey with 557 high school students in Türkiye) to examine the relationship between students' boredom levels, boredom coping strategies, epistemic curiosity, and grade performance.	It was found that boredom level was negatively correlated with grade performance; epistemic curiosity (interest-type & deprivation-type) mediated the relationship between boredom and performance.	Showing that when students have an active curiosity, boredom is reduced and performance is increased; this is relevant to your research because it shows the importance of the variable "curiosity" in relation to classroom conditions and learning outcomes.
17	van Schijndel, TJP; Jansen, B.R.J.; Raijmakers, M.E.J. (2018). Do Individual Differences in Children's Curiosity Relate to Their Inquiry-Based Learning? [39]	Quantitative in children aged 7–9 years with inquiry-based learning tasks.	Curiosity is positively related to knowledge acquisition, but not to the quality of exploration. Highly structured learning environments help students with low intelligence.	Demonstrates the need for teacher strategies that balance freedom of exploration and learning structure so that curiosity develops optimally.

No	Article Title and Researchers	Research methods	Research result	Research Analysis Results
18	Maynard, E. & Cramphorn, K. (2021). The Professional in 'Professional Curiosity'. [40]	Qualitative, phenomenological study of school pastoral staff in England.	Professional curiosity is influenced by emotions, professional identity, and institutional support.	Shows that the development of curiosity requires the support of the school environment and the professional awareness of teachers.
19	Hogan, K. How Can Technology Enhance Children's Natural Curiosity? [41]	Literature review and/or practical reflection (educational technology) on how technology can support children's curiosity.	Well-designed technology can harness children's natural curiosity by providing interactive experiences, challenges, and exploratory elements that spark children's questions.	Showing that one of the teacher's strategies is to utilize learning technology to foster curiosity, not just traditional methods—in your context (physics class), teachers can consider the use of media/technology as part of a strategy to increase student curiosity.
20	A narrative inquiry into a language teacher becoming an agent of motivational strategies [42]	Qualitative narrative (case study) of a Japanese high school teacher who began implementing research-based motivational strategies.	Teachers develop agency (professional independence) and apply motivational strategies learned from research into their learning practices.	Demonstrates that developing teacher strategies to increase motivation (and can be linked to curiosity & engagement) requires a process of reflection, professional learning, and contextual adaptation.
21	Jubas, K. (2023). Using popular culture in professional education to foster critical curiosity and learning. [43]	Qualitative, case studies on professional learning.	The integration of popular culture makes students more engaged and fosters critical curiosity.	Teacher strategies that link material to contexts close to students are effective in fostering curiosity and learning engagement.
22	Kreitler, S., Zigler, E., & Kreitler, H. (1984). Curiosity and Demographic Factors as Determinants of Children's Probability-Learning Strategies. Journal of Genetic Psychology, 145(1), 61-75. DOI:10.1080/00221325.1984.10532251. [44]	Quantitative: 1st grade students (38 males, 37 females) partially-reinforced discrimination-learning task; measured variables: three curiosity factors (manipulative, conceptual, about the complex), student activity, socioeconomic status (SES).	Curiosity factors correlate negatively with “maximizing” and “perseveration” strategies, and positively with “variability” in answers; gender and SES influence learning strategies.	Showing that curiosity plays a role in determining how children choose learning strategies (e.g., exploration vs. fixed patterns) for your research means that teacher strategies need to take into account that students' curiosity levels differ and influence how they react to learning.
23	Curiosity and Complexity in Middle Level Education [45]	A critical/review article on middle level education — analyzing the relationship between curiosity and educational complexity.	Education that faces high complexity can activate students' curiosity if teachers and the learning environment provide space for exploration.	Showing that in complex learning environments, teachers need to design situations that allow students to feel challenged and curious is relevant to teacher strategies in your physics

No	Article Title and Researchers	Research methods	Research result	Research Analysis Results
				classroom.
24	Whitehouse, S., Vickers-Hulse, K., & Carter, J. (2018). Curious Teachers, Create Curious Learners and Great Historians. Education 3-13, 46(6), 648-660. DOI:10.1080/03004279.2018.1483800. [46]	Qualitative; case study and analysis of history learning policies in elementary schools, with teacher interviews and classroom observations.	Teachers who demonstrate curiosity and use open-ended questions, exploration of historical sources, and controversy in the classroom help foster students' curiosity.	Showing that teacher strategies that actively facilitate student curiosity (through open-ended questions, free exploration, challenging content) can serve as a model for teacher strategies in your research—that is, increasing student curiosity and engagement in physics classes.
25	Curiosity and Exploration: Facilitating Positive Subjective Experiences and Personal Growth Opportunities [47]	Quantitative: measuring curiosity and exploration as motivational-emotional systems.	Curiosity is conceptualized as a positive motivational system, associated with the recognition, pursuit, and self-regulation of novelty and challenge .	Demonstrating that curiosity is not just a passive response to new information, but is actively designed as a condition for learning; teacher strategies must create challenging and novel situations for curiosity to emerge.
26	Whitt, K. C., Beaumont, A., & Lewis, J. (2025). Pumping Up Curiosity: How Child-Led Play Fuels Early Science Learning. Science & Children, 62(3), 58-64. DOI:10.1080/00368148.2025.2482267. [48]	Qualitative-descriptive study: Observation of preschool classrooms and vignettes of child-led play activities in the context of science learning.	Child-led play allows for the natural exploration of scientific phenomena; through the stages of "Exploring a Phenomenon," "Developing & Revising a Model," and "Using the Model to Make Predictions," children develop curiosity and understanding of science.	Teacher/teacher strategy: creating a structured play environment but giving students space to choose and explore on their own can foster curiosity.
27	Lehwald, G. (1991). Curiosity and exploratory behavior in ability development [49]	Quantitative study in elementary school-aged children, measuring exploratory behavior & curiosity.	Curiosity correlates with broader exploratory behavior; teachers/educators are challenged to design environments that support children's exploration.	Teachers need to create learning conditions that provide space for exploration so that students' curiosity emerges and is actively relevant to teacher strategies in physics classes.
28	Kimoto, D. M., Frasco, J., Mulder, L., & Tsitsi, S. (2009). Operation PSA: The Action Learning of Curiosity and Creativity. Journal of Public Affairs	A study of action learning in the classroom, using the "PSA" (public service announcement) project aimed at developing students' curiosity and creativity.	The PSA project prompts students to identify a public issue, design a campaign, and present it this process encourages curiosity about the issue, collaboration, and creativity.	Teacher/teacher strategy: provide authentic tasks that stimulate students' questions about social and scientific contexts, allowing for exploration and creativity. In your context (physics class) teachers can adapt

No	Article Title and Researchers	Research methods	Research result	Research Analysis Results
	Education, 15(3), 361-382. DOI:10.1080/15236803.2009.12001566. [50]			similar projects relevant to physics to spark students' curiosity and engagement.
29	Curiosity, collaboration and co-creation: using Grand Challenges to develop employability and tackle 21st Century problems [51]	A qualitative case study of an extracurricular program that uses "Grand Challenges" as a learning framework.	Programs that emphasize collaboration, co-creation and the use of real-world challenges increase students' curiosity and engagement in learning.	Teacher/mentor strategies that use big challenges, enable collaboration between students and co-creation activities, can be an inspiration to increase student curiosity and engagement in the classroom (including physics classes).

The first theme shows that strategies such as inquiry-based learning, problem-based learning, and project-based learning consistently foster student curiosity. These strategies encourage students to actively ask questions, investigate phenomena, and build conceptual understanding. Most articles report increased student cognitive and behavioral engagement when these strategies are implemented. The teacher acts as a facilitator, guiding the exploration process without dominating the learning. This finding suggests that active learning is a key foundation for fostering student curiosity. The second theme shows that a contextual approach significantly contributes to student emotional engagement. Linking physics concepts to real-world phenomena makes learning more meaningful and relevant for students. The articles analyzed show that students are more enthusiastic when learning is linked to everyday experiences. This approach also helps students understand abstract physics concepts more concretely. Thus, real-life contexts serve as triggers for curiosity and learning engagement.

The third theme emphasizes the importance of exploratory and reflective learning in fostering epistemic curiosity. Strategies such as open-ended experiments and open-ended questions encourage students to think critically and reflectively. Teachers provide space for students to experience scientific uncertainty as part of the learning process. The articles analyzed indicate that this environment enhances students' intellectual confidence. These results confirm that exploration and reflection are important elements in physics learning.

The results of this study reinforce previous research that emphasized the role of teachers in fostering student curiosity and engagement. Active and contextual learning strategies have proven effective in creating meaningful learning environments. These findings align with the constructivist perspective, which positions students as knowledge builders. Curiosity emerges when students are given opportunities to explore and ask questions. Therefore, teacher strategies are a key factor in character-oriented physics learning. This research shows that curiosity and student engagement are two interrelated constructs. Curiosity serves as the initial trigger for student engagement in learning activities. Conversely, sustained engagement deepens students' curiosity about physics concepts. This reciprocal relationship has rarely been discussed in an integrated manner in previous research. Therefore, this study provides new insights into the simultaneous relationship between these two variables.

The practical implication of these findings is the need for physics teachers to design exploratory and contextual learning. Teachers not only deliver material but also design challenging learning experiences. Open-ended experimental activities and reflective discussions need to be systematically integrated. A supportive learning environment encourages students to actively participate. This has an impact on increasing students' intrinsic motivation in learning physics. This study has several limitations that should be considered. First, it is a literature review and therefore does not involve direct empirical data. Second, variations in context and educational level in the articles analyzed may affect the generalizability of the findings. Third, the instruments used to measure student curiosity and engagement were not uniform across studies. This limitation opens up opportunities for further, more in-depth research.

Further research is recommended to test these findings through empirical studies in physics classrooms. Experimental or mixed-methods designs can be used to directly test the effectiveness of teacher strategies. The development of standardized instruments to measure student curiosity and engagement is also needed. Furthermore, future research could explore different cultural contexts and curricula. This would expand the theoretical and practical contributions of this study.

4. CONCLUSION

Based on the results of document analysis using the PRISMA approach, this study concludes that the role of teachers is crucial in fostering students' curiosity and engagement in physics learning through inquiry-based, contextual, and exploratory learning strategies. Curiosity and student engagement are proven to be interrelated and work simultaneously in encouraging active participation, intrinsic motivation, and the formation of students' scientific attitudes. These findings indicate that effective physics learning focuses not only on mastering concepts but also on designing learning experiences that provide space for scientific exploration, discussion, and reflection. Conceptually, this study offers an integrative framework that views student curiosity and engagement as a pedagogical unity in teacher strategies. The implications of this study emphasize the need for physics teachers to design meaningful and adaptive learning so that physics learning can build conceptual understanding and scientific character in students in a sustainable manner.

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CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

REFERENCES

[1] L. Bao and K. Koenig, “Physics education research for 21st century learning,” *Discip. Interdiscip. Sci. Educ. Res.*, vol. 1, no. 1, pp. 1–12, 2019, doi: 10.1186/s43031-019-0007-8.
[2] E. A. Dare, K. Keratithamkul, B. M. Hiwatig, and F. Li, “Beyond content: The role of stem disciplines, real-world problems, 21st century skills, and stem careers within science teachers’ conceptions of integrated stem education,” *Educ. Sci.*, vol. 11, no. 11, 2021, doi: 10.3390/educsci11110737.
[3] E. Bardone, M. Burget, and M. Pedaste, “The RRI map: making sense of responsible research and innovation in science education,” *J. Responsible Innov.*, vol. 10, no. 1, 2023, doi: 10.1080/23299460.2023.2198183.
[4] T. Tanti, W. Utami, D. Deliza, and M. Jahanifar, “Investigation in vocation high school for attitude and motivation students in learning physics subject”, *Journal Evaluation in Education (JEE),* vol. 6, no. 2, pp. 479-490, 2025, doi: 10.37251/jee.v6i2.1452.
[5] A. Ramadhani, I. Ismet, and K. Wiyono, “Solar system learning innovation through augmented reality: Increasing student concept solar system,” *Integrated Science Education Journal*, vol. 7, no. 1, pp. 01-09, 2025, doi: 10.37251/isej.v7i1.2443.
[6] K. A. Renninger, J. E. Bachrach, and S. E. Hidi, “Triggering and maintaining interest in early phases of interest development,” *Learn. Cult. Soc. Interact.*, vol. 23, pp. 100260, 2019, doi: 10.1016/j.lcsi.2018.11.007.
[7] J. Chao and C. Wright, “Applying the curiosity-confidence crank: Building critical thinking in higher education through a massive open online course,” *journals.sagepub.com/home/alh*, 2025, doi: 10.1177/14697874251329335.
[8] T. Tanti, A. Astalini, D. A. Kurniawan, D. Darmaji, T. O. Puspitasari, and I. Wardhana, “Attitude for physics: The condition of high school students,” *Jurnal Pendidikan Fisika Indonesia,* vol. 17, no. 2, pp. 126-132, 2021, doi: 10.15294/jpfi.v17i2.18919.
[9] F. Al-kamzari and N. Alias, “A systematic literature review of project-based learning in secondary school physics: theoretical foundations, design principles, and implementation strategies,” *Humanit. Soc. Sci. Commun.*, vol. 12, no. 1, pp. 1–18, 2025, doi: 10.1057/s41599-025-04579-4.
[10] G. M. Fastrich, “How are curiosity and interest different ? naïve bayes classification of people’s beliefs,” *Educational Psychology Review*, vol. 34, no. 1, pp. 73-105, 2022, doi: 10.1007/s10648-021-09622-9.
[11] M. M. Morshed, “An integrative model of green sustainable science, environmental awareness, and eco-friendly practices in community life”, *In. Sci. Ed. J*, vol. 7, no. 1, pp. 25-32, 2025, doi: 10.37251/isej.v7i1.2134.
[12] M. Chaojing, “A study on strategies for cultivating higher-order thinking skills in primary and secondary school students,” *Frontiers in Educational Research*, vol. 6, no. 20, pp. 67–71, 2023, doi: 10.25236/FER.2023.062011.
[13] A. Singh, “Using Curiosity to Improve Learning Outcomes in Schools,” *Sage Open*, vol. 12, no. 1, 2022, doi:

10.1177/21582440211069392.
[14] B. Gurning and A. Siregar, "The effect of teaching strategies and curiosity on students' achievement in reading comprehension," *English Lang. Teach.*, vol. 10, no. 11, p. 191, 2017, doi: 10.5539/elt.v10n11p191.
[15] D. F. Aryani and S. B. Sartika, "Correlation between student's curiosity and science literacy skills with science learning achievement in elementary school," *EduHumaniora | J. Pendidik. Dasar Kampus Cibiru*, vol. 16, no. 1, pp. 1–12, 2024, doi: 10.17509/eh.v16i1.61234.
[16] X. Xu, Z. Shi, N. A. Bos, and H. Wu, "Student engagement and learning outcomes : an empirical study applying a four-dimensional framework," *Med. Educ. Online*, vol. 28, no. 1, 2023, doi: 10.1080/10872981.2023.2268347.
[17] M. Singh, P. S. James, H. Paul, and K. Bolar, "Heliyon Impact of cognitive-behavioral motivation on student engagement," *Heliyon*, vol. 8, no. 7, p. e09843, 2022, doi: 10.1016/j.heliyon.2022.e09843.
[18] N. N. S. P. Verawati, and N. Nisrina, "Reimagining physics education: Addressing student engagement, curriculum reform, and technology integration for learning," *Int. J. Ethnoscience Technol. Educ.*, vol. 2, no. 1, pp. 158–181, 2025, doi: 10.33394/ijete.v2i1.14058.
[19] P. N. Iwuanyanwu, "Facilitating problem solving in a university undergraduate physics classroom: The case of students' self-efficacy," *Interdiscip. J. Environ. Sci. Educ.*, vol. 18, no. 2, 2022, doi: 10.21601/ijese/11802.
[20] O. Goldstein, "A project-based learning approach to teaching physics for pre-service elementary school teacher education students," *Cogent Educ.*, vol. 3, no. 1, 2016, doi: 10.1080/2331186X.2016.1200833.
[21] M. J. Page, J. E. McKenzie, P. M. Bossuyt, I. Boutron, T. C. Hoffmann, C. D. Mulrow, ... and D. Moher, "The PRISMA 2020 statement: an updated guideline for reporting systematic reviews," *Syst. Rev.*, vol. 10, no. 1, pp. 1–11, 2021, doi: 10.1186/s13643-021-01626-4.
[22] S. K. Ahmed, R. A. Mohammed, A. J. Nashwan, R. H. Ibrahim, A. Q. Abdalla, B. M. M. Ameen, and R. M. Khdhir, "Using thematic analysis in qualitative research," *Journal of Medicine, Surgery, and Public Health*, vol. 6, pp. 100198, 2025, doi: 10.1016/j.glmedi.2025.100198.
[23] A. Antink-Meyer, M. Brown, and A. Wolfe, "The scientific curiosity of preservice elementary teachers and confidence for teaching specific science topics," *J. Sci. Teacher Educ.*, vol. 34, no. 8, pp. 883–902, 2023, doi: 10.1080/1046560X.2023.2168858.
[24] A. L. Bjerknes, T. Wilhelmsen, and E. Foyn-Bruun, "A systematic review of curiosity and wonder in natural science and early childhood education research," *J. Res. Child. Educ.*, vol. 38, no. 1, pp. 50–65, 2024, doi: 10.1080/02568543.2023.2192249.
[25] B. A. Whitworth, "Fostering innovation, creativity, and curiosity in science education," *Sci. Teach.*, vol. 9, no. 3, pp. 6–7, 2025, doi: 10.1080/00368555.2025.2491937
[26] H. Brakhage, A. Gröschner, M. Gläser-Zikuda, and G. Hagenauer, "Fostering students' situational interest in physics: results from a classroom-based intervention study," *Res. Sci. Educ.*, vol. 53, no. 5, pp. 993–1008, 2023, doi: 10.1007/s11165-023-10120-x.
[27] N. Ali, O. Abu Khurma, and A. Jarrah, "Intellectual curiosity as a mediator between teacher–student relationship quality and emirati science achievement in PISA 2022," *Educ. Sci.*, vol. 14, no. 9, 2024, doi: 10.3390/educsci14090977.
[28] T. Musengimana, L. L. Yadav, J. Uwamahoro, and G. Nizeyimana, "Instructional strategies for enhancing students' problem-solving skills in physics: a systematic review," *Discov. Educ.*, vol. 4, no. 1, 2025, doi: 10.1007/s44217-025-00733-x.
[29] J. Zeng, H. Yan, and H. Zhang, "How Classroom Curiosity Affects College Students' Creativity?," *Educ. Sci.*, vol. 15, no. 9, 2025, doi: 10.3390/educsci15091101.
[30] N. Shumakova, "Study of students' curiosity," *Roeper Rev.*, vol. 14, no. 4, p. 197, 2016, doi: 10.1080/02783199209553427.
[31] J. Wilcox, S. Z. Flore, M. Bruns, and S. N. Dredge, "Sparking students' curiosity: Embedding strategies to promote curiosity alongside teaching static electricity," *Taylor Fr.*, vol. 47, no. 4, 2024, doi: 10.1080/08872376.2024.2363116
[32] M. Heal, J. Park, Y.-C. Chen, and M. E. Jordan, "Fostering student curiosity in scientific practices: The super approach using student uncertainty as pedagogical resources," *Taylor Fr.*, vol. 48, no. 1, pp. 18–27, 2025, doi: 10.1080/08872376.2024.2433363
[33] O. Spektor-Levy, Y. K. Baruch, and Z. Mevarech, "Science and scientific curiosity in pre-school-the teacher's point of view," *Int. J. Sci. Educ.*, vol. 35, no. 13, pp. 2226–2253, 2013, doi: 10.1080/09500693.2011.631608.
[34] V. Shenaar-Golan and C. Gutman, "Curiosity and the Cat: Teaching Strategies That Foster Curiosity," *Soc. Work Groups*, vol. 36, no. 4, pp. 349–359, 2013, doi: 10.1080/01609513.2013.769076.
[35] Z. Ruiz-Alfonso and J. León, "Teaching quality: relationships between passion, deep strategy to learn, and epistemic curiosity," *Sch. Eff. Sch. Improv.*, vol. 30, no. 2, pp. 212–230, 2019, doi: 10.1080/09243453.2018.1562944.
[36] A. Chak, "Teachers' and parents' conceptions of children's curiosity and exploration," *Int. J. Early Years Educ.*, vol. 15, no. 2, pp. 141–159, 2007, doi: 10.1080/09669760701288690.
[37] S. F. Menning, "Why nurturing curiosity is an ethical endeavour: exploring practitioners' reflections on the importance of curiosity," *Int. J. Early Years Educ.*, vol. 27, no. 1, pp. 34–51, 2019, doi: 10.1080/09669760.2018.1547632.
[38] A. Eren and H. Coskun, "Students' level of boredom, boredom coping strategies, epistemic curiosity, and graded performance," *J. Educ. Res.*, vol. 109, no. 6, pp. 574–588, 2016, doi: 10.1080/00220671.2014.999364.
[39] T. J. P. Van Schijndel, B. R. J. Jansen, M. E. J. Raijmakers, T. J. P. Van Schijndel, B. R. J. Jansen, and E. J. Maartje, "Do individual differences in children' s curiosity relate to their inquiry-based learning ?," *Int. J. Sci. Educ.*, vol. 0693, 2018, doi: 10.1016/j.dr.2012.04.002.
[40] K. Cramphorn and E. Maynard, "The professional in 'professional curiosity'; Exploring the experiences of school-based pastoral staff and their use of curiosity with and about parents. An interpretative phenomenological analysis," *Pastor. Care Educ.*, vol. 41, no. 1, pp. 84–104, 2023, doi: 10.1080/02643944.2021.1977989.

[41] K. Hogan, and D. Gomm, “How can technology enhance children's natural curiosity?,” *Computers in the Schools*, vol. 16, no. 3-4, pp. 237-246, 2001, doi: 10.1300/J025v16n03_11.

[42] Y. Nakataa, M. Tokuyama, and Xuesong, “From teacher to teacher-researcher: A narrative inquiry into a language teacher becoming an agent of motivational strategies,” *Asia-Pacific J. Teach. Educ.*, vol. 50, no. 4, pp. 343–356, 2022, doi: 10.1080/1359866X.2021.1940841

[43] K. Jubas, “Using popular culture in professional education to foster critical curiosity and learning,” *Stud. Educ. Adults*, vol. 55, no. 1, pp. 240–258, 2023, doi: 10.1080/02660830.2022.2114690.

[44] S. Kreitler, E. Zigler, and H. Kreitler, “Curiosity and demographic factors as determinants of children’s probability-learning strategies,” *J. Genet. Psychol.*, vol. 145, no. 1, pp. 61–75, 1984, doi: 10.1080/00221325.1984.10532251.

[45] D. Bauer and J. Previts, “Curiosity and complexity in middle level education,” *Middle Sch. J.*, vol. 45, no. 1, p. 2, 2013, doi: 10.1080/00940771.2013.11461875.

[46] S. Whitehouse, K. Vickers-Hulse, and J. Carter, “Curious teachers, create curious learners and great historians,” *Educ. 3-13*, vol. 46, no. 6, pp. 648–660, 2018, doi: 10.1080/03004279.2018.1483800.

[47] T. Takai, M. Nagayama, M. Okuno, T. Ikehara, K. Sakamoto, J. T. Lee, and K. Umeyama, “Postoperative total parenteral nutrition with fat emulsion for patients with esophageal varices,” *Nippon Geka Gakkai zasshi*, vol. 89, no. 3, pp. 325–335, 1988, doi: 10.1207/s15327752jpa8203.

[48] K. C. Whitt, A. Beaumont, and J. Lewis, “Pumping up curiosity,” *Sci. Child.*, vol. 62, no. 3, pp. 58–64, 2025, doi: 10.1080/00368148.2025.2482267

[49] G. Lehwald, “Curiosity and exploratory behaviour in ability development,” *Eur. J. High Abil.*, vol. 1, no. 2, pp. 204–210, 1991, doi: 10.1080/0937445910010212.

[50] D. M. Kimoto, J. Frasco, L. Mulder, and S. T. Juta, “Operation PSA: The action learning of curiosity and creativity,” *J. Public Aff. Educ.*, vol. 15, no. 3, pp. 361–382, 2009, doi: 10.1080/15236803.2009.12001566.

[51] D. Lees and A. Djordjevic, “Curiosity, collaboration and co-creation: using Grand Challenges to develop employability and tackle 21st Century problems,” *Br. J. Guid. Couns.*, vol. 52, no. 1, pp. 119–132, 2024, doi: 10.1080/03069885.2024.2304716.