The Heterogeneity of Curiosity: Implications for Education, Academic Performance, and Lifelong Learning – A Scoping Review

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Abstract

In today's dynamic and complex world, adaptability, critical thinking, and lifelong learning are essential competencies—among which curiosity is proven to have a central role for overall performance. This scoping review explores the heterogeneous and multidimensional nature of curiosity and its implications in educational contexts and across the lifespan. Drawing on 33 peer-reviewed articles from 2009 to 2024, the review addresses three core research questions: (1) What types of curiosity are measured in relation to academic performance and across which age groups? (2) Is curiosity studied as a distinct construct in educational research? (3) What are the reported implications of curiosity on academic performance, and how can educational environments foster it? The review synthesizes psychological, biological, and pedagogical perspectives, emphasizing curiosity's role in motivation, cognitive engagement, and overall development. Concerning academic performance six thematic research lines are identified, highlighting a notable gap: curiosity is rarely studied in early childhood despite its foundational influence and only cognitive or epistemic curiosity is in the research focus, while emotional and passive dimensions remain underexplored. The review advocates for rethinking curiosity not only as a cognitive trait but as a key educational competence and promotion of its passive – effortless and rewarding form, which is underdeveloped. Its strategic inclusion in teacher training, curriculum development, and educational policy is essential for supporting student engagement, academic success, and lifelong learning.

Keywords: curiosity, epistemic curiosity, academic performance, education, child development, overall development

1. Introduction

1.1 Overview of Theories and Scientific Approaches in the Study of Curiosity

1.1.1 Theoretical Foundations of Curiosity

The role of curiosity in human life during different stages of development is a subject of many discussions. At the dawn of curiosity research only its basis had been discussed. The history of the study of "curiosity" passes through two directions: the first formed in the 1960s and focused mainly on the psychological foundation of curiosity. The second emerged in the 1970s and 1980s and was characterized by attempts to measure and assess curiosity and its significance (Loewenstein, 1994) and explanation of the mechanisms by which people voluntarily express curiosity and situational determinants of curiosity. The framework for some remarkable characteristics of curiosity, such as its intensity, transience, connection to impulsiveness, and the tendency toward frustration and lack of interest once it is satisfied came only later (Loewenstein, 1994). During the following two decades, research in psychology has attempted to characterize curiosity as a form of cognitively induced deprivation, which arises from the perception of a gap in knowledge or understanding (Tough, 2012). For G. Loewenstein, curiosity is entirely an internally oriented process happening on an individual level (Loewenstein, 1994). According to this view, curiosity is strictly inherent to individual striving. It differs from merely seeking information for its own sake, which represents an externally

oriented process. The main critique to this view is that it is often difficult for an outside observer to understand whether the person expressing curiosity is motivated by internal drives or external factors (Kidd & Hayden, 2015). For this reason, the rough formulation of curiosity as a "state" of striving for information is currently preferred. This striving can be internal or external, conscious or unconscious, gradually systematic, or spontaneously occurring, depending on the context.

1.1.2 Definitions and Taxonomies

Concerning definitions curiosity is regarded as a situational trait but also as a personality trait. A solid taxonomy of the different factors constituting the general term still has not been presented. The Lowenstein classification (Loewenstein, 1994) points out to epistemic curiosity (EC), the desire to gain knowledge and resolve intellectual uncertainty, which has been conceptualized as a key driver of learning and inquiry (Berlyne, 1954). Berlyne described EC as a human drive to know that underpins intellectual development and scholarly achievement (Berlyne, 1954, 1966, 1971). Building on this foundation, Litman and Spielberger (2003) distinguished individual differences in EC through: Diversive-EC (interest in new information) and Specific-EC (pleasure in solving problems) (Litman & Spielberger, 2003). Litman and Jimerson (2004) emphasized the motivational importance of information-deprivation states in EC, proposing two distinct types: Interest-type (I-type) and Deprivation-type (D-type) curiosity. I-type curiosity is driven by the anticipation of enjoyment from learning new things, aligning with mastery-oriented goals, while D-type curiosity is motivated by the need to eliminate ignorance, reflecting performance-oriented goals (Litman & Jimerson, 2004; Litman, 2005).

In respect to *different forms of curiosity* Berlyne distinguishes between types of curiosity that most often manifest in humans and primates, deriving the psychological phenomenon in two pairs of dimensions: *perceptual versus epistemic* and *specific versus diversive/heterogeneous*. Perceptual curiosity, according to Berlyne, refers to the driving force that motivates organisms to seek new stimuli, which decreases with prolonged stimulation (Berlyne, 1966). In the second pair of dimensions, Berlyne assigns specific curiosity to the desire for a specific piece of information (Berlyne, 1966). Heterogeneous / diversive curiosity refers to a general desire for perceptual or cognitive stimulation (e.g., in cases of boredom) (Kidd & Hayden, 2015). W. James viewed curiosity as an *impulse toward better knowledge*, referring to the drive and even the eager desire of an individuals to understand what they do not know (James, 1983) (Kidd & Hayden, 2015). It is noted that there is a strong overlap between impulsivity and curiosity in terms of their neural substrates and the ways in which they are measured behaviorally (Marvin, 2020). One essential question arises about the differentiation between the concepts of curiosity and inquisitiveness from a pedagogical and linguistic perspective. The word curiosity refers to a strong desire to understand, learn, and explore something. With these definitions, the difference between conscious striving for learning and the intuitive impulse to understand something is differentiated. Without curiosity, there is no next stage of development – inquisitiveness (Schinkel et al., 2020). In her work, Sophie Von Stumm and colleagues provide a definition of *intellectual curiosity*, also referred to as *scientific curiosity* (Post & von der Molen, 2018), as a fundamental basis upon which science and the academic environment are built (Von Stumm et al., 2011). This definition of intellectual curiosity and relation to critical thinking is discussed by other authors as well (Browne & Keeley, 2007; Lamont, 2009; Marvin et al., 2020).

In view to age curiosity is considered natural in childhood and there are even claims that sometimes curiosity has a nonadaptive influence later in development) (Jirout et al., 2018). Most authors suggest that curiosity plays a central role during this early stage by motivating engagement with the environment and stimulating comprehensive development. (Menning, 2019; Eaude, 2024; Syarif et al., 2024). Curiosity is a foundational element in early education, supporting cognitive development, emotional wellbeing, and educational success (Liquin & Lombrozo, 2020). Although it is difficult to define and measure, curiosity is recognized as a powerful driver of learning, adaptability, and personal growth. Its role in fostering intellectual engagement and lifelong learning is crucial, making it a priority in early childhood education and developmental policies (Shah et al., 2018; Bjerknes et al., 2024). Mechanism and driving forces of curiosity (Ball, 2013) and childhood interventions are believed to effectively nurture curiosity (Shah et al., 2018).

1.1.3 Biological Foundations of Curiosity

From biological point of view, curiosity can be considered in the context of Tinbergen's four questions (Tinbergen, 1963), providing four complementary scientific perspectives on each specific type of behaviour when curiosity manifests (Burkhardt, 2014). Through the lens of Tinbergen's four questions, each summarized in one word: (1) Function; (2) Evolution; (3) Mechanism; (4) Development asked about animal behaviour (Tinbergen, 1963), they are considered fundamental and universal (Burkhardt, 2014). For humans the most popular theory regarding the function of curiosity is that it motivates learning. And it is confirmed that curiosity improves the learning, memorization, and

understanding of information (Kang et al., 2009). This understanding has been embraced in education sciences for several decades (e.g. Day, 1971; Engel, 2011; Engel, 2015; Gray, 2013). One concept derived from Loewenstein's research, later confirmed by Kang and colleagues (Kang et al., 2009), is the connection between curiosity and a sense of confidence. A constructive manifestation of curiosity is present when knowledge and awareness of the knowledge gap are available. In this context, curiosity appears as a *thirst for knowledge*, or, in the style of scientific literature, as cognitively induced deprivation arising from the perception of a knowledge and understanding gap, which manifests best when confidence is available. It is emphasized that this type of confidence does not close the gap in knowledge but provides enough certainty in the existing knowledge to drive a desire for further development. On the contrary, an awareness of the lack of knowledge, as well as a lack of confidence, also leads to a lack of curiosity toward new information (Loewenstein, 1994). In this context, curiosity plays a motivational role in the learning process. When the learner has the opportunity to satisfy their curiosity, they focus their efforts on acquiring useful information that they do not yet possess also in relation to Bloom's Taxonomy of Knowledge Domains (Danov, 2016). There is increasing evidence that curiosity allows even the youngest learners to take an active role in optimizing their learning experiences. It is assumed that allowing the learner to independently uncover and reach the information they need would be more effective in improving the encoding and retention of new information compared to passive observation and memorization of already gathered information, where the learner may remain unable to apply and enrich it (Kidd & Hayden, 2015).

1.1.4 Curiosity Across Species and Neurophysiological Insights

Different types of behaviour across species are distinguished, forming a spectrum of curiosity. Some authors also propose an *epistemic and perceptual subdivision* of curiosity as a phenomenon (Gross et al., 2020). Even slight eye movements or pupil dilations are informative in the manifestation of curiosity (Gottlieb, 2016). Elementary information-seeking behaviour is observed even in lower species (Calhoun et al., 2014); solving tasks with a compromise on the quality of information (Costa et al., 2015); and time-bound resolution of tasks with uncertainty (Bromberg & Hikosaka, 2009). Although in humans the manifestation and type of curiosity are much more complex, there are significant similarities with its presence in most animal species (Gottlieb, 2020).

From a neuropsychological point of view, the relation of and reward is broadly discussed (Blanchard, 2018). Furthermore, it is noted that information processing can evoke negative states, provoking anxiety and difficulties (Jepma, 2012). This is addressed by combining these conclusions - curiosity is viewed as a lack of something desired (information), and therefore unpleasant. This unpleasant feeling motivates the search for information that alleviates it (Kang et al., 2009). Some results suggest that although curiosity reflects internal motivation, it is mediated by the same mechanisms as externally motivated rewards (Gruber et al., 2014). A replication is that the unexpected appearance of information and its unexpected validation trigger the same pleasure mechanisms in the brain as receiving a reward (Bromberg-Martin & Hikosaka, 2011). Experiments in this line led to the conclusion that dopamine synthesis during reward (Blanchard & Shaevitz, 2015) and the manifestation of curiosity are distinct processes in the brain and that curiosity itself is a separate phenomenon and not a concurrent reaction (Rushworth et al., 2011; (Schwartenbeck et al., 2019).

1.1.5 Curiosity in Infancy and Early Learning

The *development of curiosity* is the fourth of Tinbergen's questions related to the development of behaviour. Curiosity holds a central place in the study of attention and learning in infants and children and is a primary focus in research on early education for decades (Berlyne, 1978; Willingham, 2014; Hagtvedt et al., 2019; Chu & Schulz, 2020). Within the broader definition curiosity is viewed as any mechanism that directs the organism toward new information, regardless of the awareness level in this process. Notwithstanding how infant behaviour heuristics for learning are classified, the infants actively expressed attention leads them to the path of acquiring knowledge, whereas external motivation is not sufficient for acquiring knowledge and competencies (Tough, 2012). Children structure their play in ways that reduce uncertainty and allow them to discover causal structures in the world (Schulz & Bonawitz, 2007) or seeking for information, believed to be available, thus forming construct knowledge (Saracho, 2017). If curiosity aims to reduce uncertainty in the world, it would be expected that learners exhibit increased curiosity toward stimuli in the world that they do not understand (Bonawitz, 2024). Indeed, this behaviour is well documented in studies by Elizabeth Bonawitz and colleagues. A series of studies show that children prefer to play with toys whose mechanisms are still unknown to them. They play longer with toys for which no instructions or explanations about how they work have been provided, and they need to discover this on their own. Moreover, children who were not given prior explanations about the toys managed to discover more of their functions and more applications (Bonawitz, 2012). The idea that children structure their play in ways sensitive to the acquisition of

information is further supported (Cook et al., 2011). These findings are important because they emphasize that children's curiosity appears particularly well suited to teaching them the causal structure of the world. Therefore, these strategic behaviors for seeking information in young children are much more complex than the simple attention heuristics that characterize early childhood attention (Van Schijndel et al., 2015) (Sobel & Letourneau, 2018).

In summary the complicated and comprehensive nature of curiosity as an instinct and emotion intrigues scholars from the fields of biology, psychology and pedagogy. Each approach examines and describes curiosity from a different perspective. The common point is that curiosity lies at the foundation of learning, it is the driving force for the instinct for survival and development. In biological aspect, curiosity can be viewed through the lens of Tinbergen's four questions, each summarized in one word: (1) Function; (2) Evolution; (3) Mechanism; (4) Development. From psychological point of view, it is considered a personality trait. And hence, different types of curiosity get distinguished which vary during the ontogenesis. The pedagogical aspect puts the emphasis on the curiosity in the educational process. The learners should be in an active role, i.e. in the position of creators and explorers. The essence and development of curiosity have been the focus of numerous psychological studies, particularly recent efforts to establish an integrated framework for its investigation.

1.2 Research Aim and Objective

The current express scoping review aims to systematize and present the findings from studies on curiosity. It focuses on two basic aspects of this topic, namely: 1) The curiosity in educational contexts and 2) Curiosity and academic performance.

2. Method

2.1 Search Strategy

Publications were identified by keywords from the scope of research in the scientific databases Scholar Google, SinceDirect, PubMed. Initially a narrower search was conducted in WoS (Web of Science) and Scopus databases, but because these retrieved only a few studies, so search was expanded to include the aforementioned databases. The keywords used to structure the search in the database were curiosity + academic performance. No specific age has been set due to the limited number of studies, which is why Google Scholar was also used as a more comprehensive database. Proposed categories are described, with some studies relating to more than one category. It can be noted that there are no detailed summaries regarding *passive curiosity*, a term we use in this article in view to focus on the *effortless, pleasurable and unintentional state, which, however can be guided*. The suggestion was that academic performance is likely to be focused mainly on the cognitive characteristics of curiosity.

Keywords Used: The primary keywords used to structure the search were "curiosity + academic performance.

The choice of "curiosity" as a broad keyword was to identify the types of curiosity being measured2.

"Academic performance" was chosen due to the focus on the role of the school setting and teachers in creating favorable conditions for learning, and the recognized role of curiosity in learning despite a reported decrease in intrinsic motivation

2.2 Inclusion Criteria

- Publications reporting research on curiosity and academic performance
- Studies from all age groups, ranging from kindergarten to tertiary (university) level
- Research conducted within an educational setting

2.3 Exclusion Criteria

- Reviews that fell outside the scope of academic performance (e.g., measuring curiosity in organizational settings).
- Duplicated studies
- Studies measuring other effects of curiosity not related to academic performance (e.g., employee learning).
- Publications that only mentioned curiosity in the title but did not explore it
- Publications focused solely on the adaptation of scales used to measure curiosity

This is supported by the conclusions that academic performance is usually measured depending on external criteria observed, provoking our interest in the overall role of curiosity in performance and difficulties in its measurement

and seeking answer to question of its multidimensional facets being involved in educational interactions (Fig. 1).

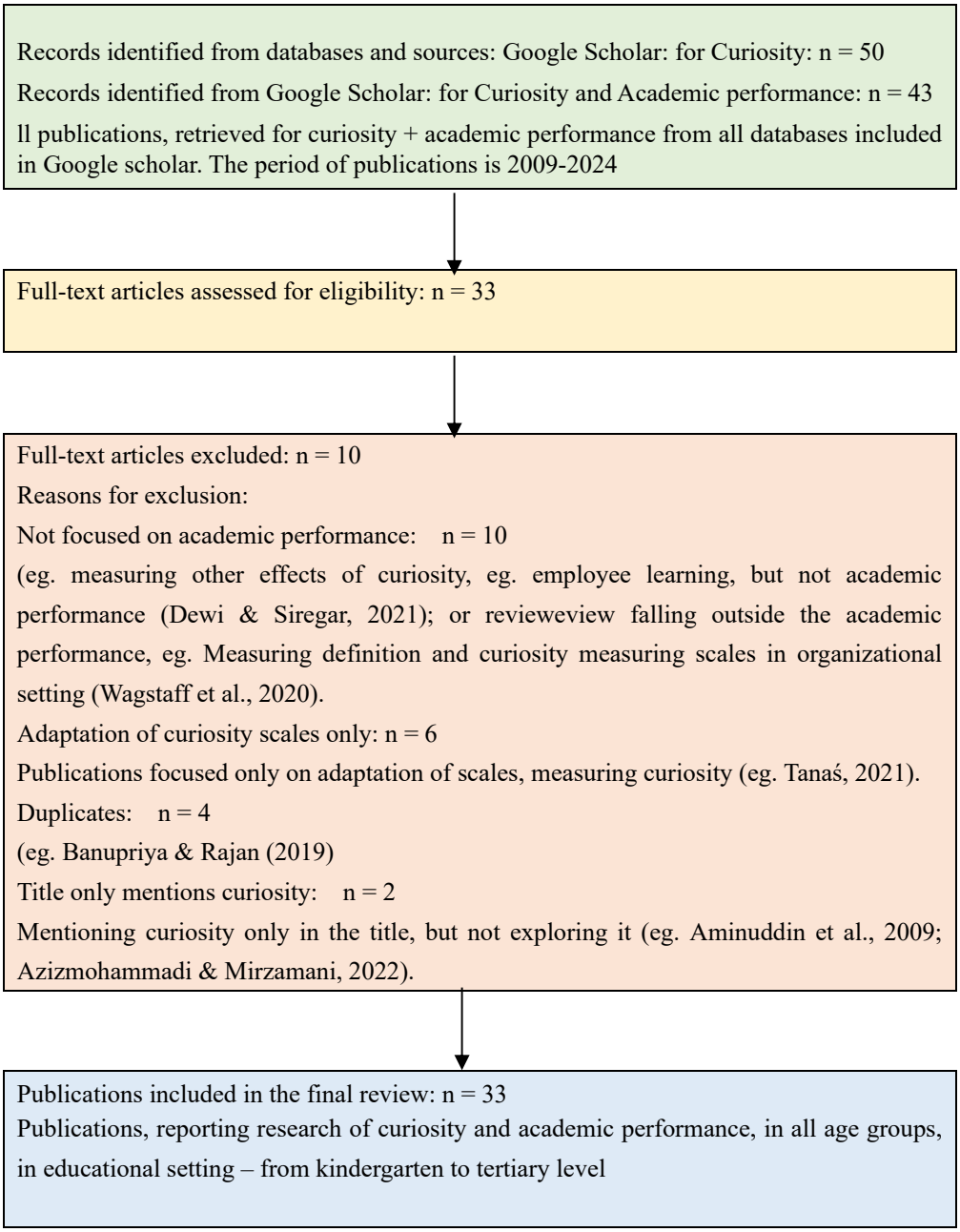

Figure 1. PRISMA Flow Diagram

In this paper the focus is strictly on curiosity as a key component of the educational process, and the analysis is based on inclusion and exclusion criteria used to identify research that defines the main constructs and characteristics of curiosity in an academic context. The methodological framework design aims to find answer to three research questions:

- RQ1: What type of curiosity is measured in respect to academic performance and in what age groups?
- RQ2: Is curiosity measured as a distinct construct in educational setting
- RQ3: What type of curiosity implications in academic performance are reported and what is the place of educational environment for promotion of curiosity

3. Results

The retrieved 33 publications were grouped based on expert assessment into 6 research lines. These research lines were consolidated based on the focus of research and key conclusions. Some of the investigations are referred to more than one group due to their focus, eg. Maksum & Khory (2020) discuss intellectual curiosity and environment effect and life-long development; others refer to intellectual curiosity and older subjects (von Stumm et al., 2011); cognitive aspect of curiosity and environment (Mussel, 2022). In addition is reported the age groups, in which studies had been performed.

*In respect to age m*ost of the publication outline the link of curiosity and academic performance among university students, followed by publications related to school and less examine the issue in early childhood in kindergartens. Research in preschool setting are only two, one cross-sectional (Hassinger-Das & Hirsh-Pasek, 2018) and a longitudinal study in kindergarten (Shah et al., 2018). Research in school setting generated 10 publications: one study in relation to PISA (Ali et al., 2024), one study in primary school (Taheri et al., 2024) and 9 in school setting (Banupriya & Rajan, 2019; Tang & Salmela-Aro, 2021; Mahama, 2022; Singh & Manjaly, 2022; Mussel, 2022; Mahama et al., 2023; 2024; Jovanović et al., 2024), one of which in respect to students with SEN (Ataei et al., 2023). Concerning university students 16 publications were found: (Vidler, 1980; von Stumm et al., 2011; Richards et al., 2013; Abakpa et al., 2018; Shah et al., 2013; Powell & Nettelbeck, 2014; Belecina & Ocampo, 2016; Jaen & Baccay, 2016; Powell et al., 2017; Pourzanjani, 2018; Eren, 2009; Maksum & Khory, 2020; Vracheva et al., 2020; Mussel, 2022; Shin, 2024; Hudaya et al., 2025). Five other reviews are also included: one concerning the socioeconomic status (Nurishlan et al., 2020), two discussing the educational settling and curiosity (Peterson, 2016; 2020), one review, discussing curiosity in respect to early school dropouts (Singh & Manjaly, 2022), and one meta-analysis on the effect of curiosity fostering interventions in various groups (Schutte & Malouff, 2023).

The current paper differences the included publications into 6 main research lines: 1) Life-long development and role of environment for fostering curiosity; 2) Intellectual curiosity research; 3) Research of curiosity along with other variables; 4) Research of curiosity in specific subject areas; 5) Definitions and measurement of curiosity; and 6) Interventions, promoting curiosity. This scoping review identified six key themes in the current literature on curiosity and academic performance (Table 1).

Table 1. Summary of the Research Lines Identified in the Express Scoping Review

Theme	Summary
1. Life-long Development and the Role of Environment in Fostering Curiosity	This research strand emphasizes the significant influence of the environment on the development of curiosity, viewing curiosity not as an innate trait but as shaped through learning experiences. Supportive environments, particularly within the family and educational settings, are highlighted as crucial in shaping curiosity and cognitive patterns (Maksum & Khory, 2020). Schools are identified as key spaces that should cultivate curiosity, creativity, personal initiative, and reflective thinking by fostering a learning climate that encourages freedom of thought and exploration (Mahama, 2022; Peterson, 2020, Issarathammo & Sutheejariyawattana, 2023). A review stresses that schools must recognize curiosity as a malleable characteristic, shaped by biopsychosocial factors and the broader educational context (Peterson, 2020). Moreover, the teacher–student relationship plays a mediating role in enhancing intellectual curiosity, which, in turn, supports academic performance, underscoring the strategic role of educators in stimulating curiosity (Ali et al., 2024). Research gap observed: Emphasis is given mainly to university and school-age students and early childhood remains underrepresented. Despite strong theoretical arguments, curiosity in children under 6 remains underexplored in empirical research.
2. Intellectual Curiosity Research	Studies consistently demonstrate the link between intellectual (or cognitive) curiosity and academic achievement. Intellectual curiosity and associated thinking styles are found to influence academic outcomes (Maksum & Khory, 2020). Research highlights the distinct impacts of various types of curiosity—for example, interest-type curiosity predicts performance in language, while epistemic curiosity correlates with mathematics achievement (Tang & Salmela-Aro, 2021). A longitudinal study revealed a strong connection between cognitive ability, curiosity, and academic outcomes, without supporting the environmental enrichment hypothesis (Mussel, 2022). Other findings emphasize the additive predictive power of intellectual curiosity and effort, equating their combined influence to that of intelligence (von Stumm et al., 2011). While some studies identify conscientiousness as the most robust predictor of academic success (Powell et al., 2017), others suggest a more complex role for curiosity,

	particularly in science education, where intellectual curiosity mediates the teacher-student relationship and student performance (Ali et al., 2024). Notably, Eren (2009) found that curiosity as a feeling of deprivation, rather than interest, better predicts students' achievement goal orientations. Research gap observed: definitions and research of curiosity is primarily studied as a cognitive or epistemic construct; affective, social, and contextual dimensions are often neglected.
3. Curiosity in Relation to Other Variables	Curiosity is frequently examined alongside variables such as intelligence, motivation, and personality traits in relation to academic performance. Motivation has been found to significantly predict performance in subjects like mathematics (Jaen & Baccay, 2016). Pourzanjani (2018) concluded that intrinsic motivation (autonomous regulation) and curiosity (need for cognition) are significant predictors of academic achievement. Similarly, epistemological beliefs and mathematics-specific curiosity significantly influence performance in that subject (Belecina & Ocampo, 2016). Other research explores the interrelationship of curiosity, creativity, and motivation, concluding that these factors collectively enhance academic achievement (Mahama, 2022; Mahama et al., 2023; 2024). Hudaya et al. (2025) also demonstrated the combined effects of curiosity and digital literacy on students' achievement motivation. Engagement was found to mediate the relationship between different types of curiosity and student development (Vracheva et al., 2020), while curiosity and self-regulation both positively correlated with academic achievement (Shah et al., 2013). Beyond academic success, curiosity has been examined in the context of well-being. For example, Taheri et al. (2024) studied the impact of curiosity on depression, anxiety, and fear of success among elementary students. Findings on the correlation between curiosity, happiness, and academic performance remain mixed (Banupriya & Rajan, 2019). Research gap observed: Curiosity is often treated as background variable – just a few studies center curiosity as the main construct; it is frequently included as a secondary or descriptive trait.
4. Subject-Specific Research on Curiosity	Curiosity has been studied in relation to performance across specific domains, particularly STEM fields such as mathematics (Belecina & Ocampo, 2016; Jaen & Baccay, 2016; Abakpa et al., 2018; Mahama, 2022), science (Ali et al., 2024), and physics (Jovanović et al., 2024). Tang & Salmela-Aro (2021) examined its role in both language and mathematics exams. Studies in digital and early childhood education contexts also highlight curiosity's influence, noting that high curiosity buffers the negative effects of low self-efficacy in remote learning (Shin, 2024) and contributes to learning outcomes in kindergarten (Hassinger-Das & Hirsh-Pasek, 2018). Specific groups, such as adolescents with physical disabilities (Ataei et al., 2023) and students from low-income backgrounds (Nurishlah et al., 2020), have also been examined, revealing unique patterns in how curiosity interacts with other learning factors like peer interactions and teacher support. In dropout prevention research, curiosity is associated with improved student motivation when framed as intrinsic enjoyment of learning (Singh & Manjaly, 2022). Research gap observed: Curiosity considered important within specific areas without accounting its general developmental role.
5. Definitions and Measurement of Curiosity	This research area addresses how curiosity is conceptualized and measured. Curiosity is viewed both as a stable trait and as a situational state, characterized by the joy of discovery and the motivation to resolve uncertainty. However, measuring trait curiosity remains challenging (Hassinger-Das & Hirsh-Pasek, 2018). Richards et al. (2013) provided a review of existing tools designed to measure epistemic curiosity, highlighting the variability in approaches and outcomes. Research gap observed is the lack of standardized measurement tools – there is still inconsistency in how curiosity is measured, limiting comparability across studies.
6. Interventions Promoting Curiosity	A recent meta-analysis of curiosity-focused interventions confirms their effectiveness in promoting positive outcomes such as life satisfaction, academic achievement, and workplace engagement (Schutte & Malouff, 2023). Interventions targeting general curiosity demonstrated greater effectiveness than those focused on domain-specific curiosity. Activities incorporating mystery and game elements yielded especially strong effects across age groups and over time, underscoring the importance of structured efforts to foster curiosity in educational settings. A gap in pedagogical implementation observed: Although curiosity is recognized as valuable, few studies explore practical strategies to foster it in classroom settings.

3.1 Curiosity in Educational Contexts

The most popular Information Gap Theory defines curiosity as the desire to resolve uncertainty or fill a gap in knowledge. It suggests that the answer to the question of how to make a person curious is relatively simple—curiosity can be provoked by pointing out a gap in knowledge, regardless of the age group. However, the gap in knowledge presented to the subject should neither be too large (to avoid overwhelming them with the idea that it is impossible to grasp and fill), nor too small (to be considered insignificant). By default, there are individual differences in knowledge, and the pre-existing knowledge of the individual determines the information gaps (Jirout & Klahr, 2012).

This theory has significant practical implications. For instance, identifying and calibrating knowledge gaps can help educators foster curiosity effectively across age groups (Peterson, 2020). A critical aspect is identifying what leads to curiosity where curiosity but measure knowledge or skills. The discussion about the importance of curiosity in the learning process leads to numerous studies seeking guidance for overcoming and expanding research on curiosity for educational application (Jirout et al., 2018).

Concerning *research gaps and challenges* a challenge in measuring curiosity through observations and deriving robust conclusions is also addressed (Meyer et al., 2011). Another research gap and challenge outlined is that, little attention has been paid to the role of curiosity in mature individuals, and specifically in the aging population (Sakaki et al., 2018). Another challenge and gap highlighted is that numerous studies in neuropsychology highlight the connection between the brain's reward system and curiosity, but research on understanding of how curiosity impacts learning is relatively scarce (Gruber et al., 2019).

At this background there are a large body of reported positive outcomes. People displaying more curiosity in their everyday lives show higher levels of life satisfaction and happiness. They also show lower levels of stress and higher tolerance when confronted with novelty and significant changes. Positive social interactions benefit from an open and curious way of thinking (Kashdan et al., 2013). Curiosity correlation with wellbeing is confirmed also with two broad types—*stretching* and *embracing*—linked to higher life satisfaction and reduced depressive symptoms. Stretching curiosity reflects a proactive growth mindset, while embracing curiosity aligns with mindfulness and acceptance. These traits foster resilience, creativity, and personal development (Gallagher & Lopez, 2007; Sharma & Garg, 2016).

In a state of high curiosity, the information perceived is remembered much more resiliently and is functionally linked. This line of research is thought to bridge laboratory findings on curiosity with its application in the educational environment (Gruber et al., 2019). It remains to be studied how curiosity can be used to improve educational systems for the benefit of human development and well-being. The growing presence of Artificial Intelligence in human life clearly highlights the need to understand the phenomenon of curiosity. This is one of the main reasons why in recent years, an increasing number of studies have been dedicated to curiosity in the fields of psychology, cognitive neuroscience, and pedagogy (Cervera et al., 2020). The survival mind, which does not have enough information about the environment, is always searching to reduce uncertainty. However, curiosity is also seen as the search for information that has no instrumental use (Cervera et al., 2020).

An indisputable fact is that curiosity is a fundamental element of our cognition, but still little is known about the pedagogical methods to make it present in view to the exceptionally important role of curiosity in the development and well-being of humanity (Gross et al., 2020; Kidd & Hayden, 2015).

The topic of how pedagogical approaches can be improved to encourage children to become researchers of the surrounding world is discussed (Ivanova, 2017). In a study on preschool teachers' attitudes toward curiosity and the study of natural sciences, most of the surveyed educators report the following: although they find it easier to increase curiosity toward natural sciences compared to other topics, overall, the preschool teachers participating in this study assess that they lack essential knowledge on how to foster children's curiosity (Soydan & Erbay, 2013). This review of practices and approaches for fostering curiosity is considered relevant and is proposed to be included in national teacher training programs (Goldstein, 2020). Various activities are proposed in natural science education that contribute to increasing the emotional value in the process of exploring nature, with the aim of enhancing curiosity (Kirilova, 2012). Various pedagogical concepts in European programs for kindergartens place the learners – the children – in the role of creators and researchers and account for inexhaustible potential of preschool children (Ivanova, 2015). Jirout and colleagues develop the conceptual framework of curiosity in classrooms (CiC), identifying behaviours and language that either promote curiosity or suppress it, regardless of the subject (Jirout et al., 2022). Some conclusions in respect to natural sciences also the conclusion suggests that the lack of curiosity in the classroom is not due to a lack of knowledge and research skills on the part of the children but are due to

inappropriate pedagogical approaches, such as a weak reward system, insufficient stimulation of curiosity, and limited freedom of reasoning in the classroom (Post & van der Molen, 2018). Of course, the issue of supporting and maintaining curiosity in the educational environment according to different age groups remains complex. This also touches upon the topic of lifelong learning as a priority (Takvorian-Solakian, 2015). Few studies focus on observing curiosity in children under the age of three. One explanation for this trend is that curiosity is viewed as a method for achieving the goal – quality learning. Rarely in the scientific literature is curiosity and its maintenance and support seen as an end in itself (Bjerknes et al., 2024). A study shows that, to support curiosity in the classroom, teachers should help students define for themselves what epistemic benefits they gain from showing curiosity toward a specific topic (Watson et al., 2018). The assumption that curiosity decreases in higher grades is supported by numerous studies (Engel, 2011) with focus on individual teachers' approach, natural sciences and mathematics, and lessons specificity (Evans et al., 2023). The importance of play in the educational process for children is identified as a crucial element for maintaining and supporting curiosity in the educational process (Chu & Schulz, 2020).

An enormous challenge for educators is outlined by the topic of how curiosity works in the digital world (Venneti & Alam, 2018, Li et al., 2025). Numerous new factors influencing the manifestation of curiosity in different age groups are defined, as well as social media influence on curiosity to learn more about specific topics (Dubey & Griffiths, 2020a, 2020b). This highlights the significance of popularized topics as a stimulus for curiosity in various possible contexts. The effect of popularized topics through social networks as a stimulus for curiosity is significant not only in research fields but also for educational environments (Waldron, 2022). Over the last fifteen years, a trend has emerged in research measuring the effects of smartphone use on interest, curiosity, and academic achievement in learning (Norris & Soloway, 2011; Wali & Omaid, 2020). One such example is a study concluding that the use of smartphones for studying physics lessons increases students' curiosity about the topics covered (Hochberg & Müller, 2018). The use of online educational platforms like "SCOPE" for "STEM" and "STEAM" (Science, Technology, Engineering, Art and Mathematics) pedagogical approaches shows results in enhancing curiosity toward lessons at school (Beattie et al., 2020). The results of gaming experiment show that a typical seven-year-old child can perform quite well in the game with minimal practice and knowledge of the rules. In comparison, well-prepared gamers, with higher education and solid knowledge fail. The reason is that the game is based on searching for and solving problems related to deeply exploring the unknown and experimenting with novelties. This decision-making principle involves several factors that contradict the learning styles characterized by deep theoretical preparation and strict logic. The second part of the experiment compares achievements and Artificial Intelligence. The results favour Artificial Intelligence, which was pre-programmed with functions imitating curiosity—as a goal-directed process of searching for and acquiring information (Cervera et al., 2020).

Relating to the goals of pedagogy the main challenge relates to *operationalization of curiosity.* The reason for the existing disagreement is naturally the multifaceted construction of curiosity as a cognitive process (Jirout et al., 2018). A second significant reason is that although the importance of curiosity in the educational process is leading, empirically measuring this cognitive phenomenon is a serious challenge. Relating to children's curiosity, it is difficult, if not impossible, to directly observe it (Bjerknes et al., 2024). Jirout and Klahr offer two main methods for studying curiosity through self-report questionnaires and behavioral metrics. For younger children, observations of tasks involving exploration and information seeking are more suitable as measures of curiosity than questionnaires (Jirout & Klahr, 2012). However, observing research behaviour in a child is not a precise measure of curiosity. It is difficult to determine the motivation behind this exploratory behavior, namely whether it is externally imposed or internal, originating from the individual. For example, if a child participates in a research activity, it does not necessarily mean that they are curious about the results of the research. It is possible that the child simply wanted to fulfil the desires of the people who attracted them to the research activity or was tempted by social interaction with other participants in the activity (Kesner Baruch et al., 2016).

3.2 Curiosity and Academic Performance

Curiosity plays a critical role in academic performance by influencing thinking patterns and learning climates that foster reflective engagement. Maksum and Khory (2020) found that curiosity significantly impacts students' academic outcomes, demonstrating that a supportive learning climate enhances reflective thinking, which in turn nurtures curiosity, ultimately improving academic performance. Therefore, fostering curiosity and reflective thinking within educational policies and practices is essential for enhancing student quality (Maksum & Khory, 2020). Curiosity is also key in motivating academic achievement (Nurishlah et al., 2020). Despite its well-established educational importance, the empirical examination of the relationship between epistemic curiosity and achievement goals remains limited. Eren (2009) investigated this relationship and found that epistemic curiosity, particularly in the form of curiosity as a feeling of deprivation, significantly predicts mastery and performance-approach goals. This

indicates that curiosity, especially when it manifests as a desire to resolve uncertainty, drives students to seek knowledge and achieve academic goals, underscoring the necessity of cultivating curiosity within educational environments (Eren, 2009). Moreover, curiosity is widely recognized as a fundamental driver of innovation and discovery. It fuels the willingness to explore across disciplines and pursue unanswered questions, enabling individuals to notice anomalies, formulate new questions, and synthesize knowledge across domains, even in contexts where societal readiness allows for multiple discoveries (Walsh et al., 2022; Root-Bernstein, 1989). Thus, curiosity distinguishes those who advance innovation and invention from others, highlighting its essential role in educational and research contexts (Root-Bernstein, 1989). After all it can be pointed out that it is curiosity that converts failed experiments into innovation in historical retrospection of some of the greatest inventor and academic achievements (Root-Bernstein & Root-Bernstein, 1999; To et al., 2018).

Despite efforts to distinguish its emotional and cognitive components in the mid-20th century, the definition of curiosity remains ambiguous, which continues to affect how it is measured (Jirout & Klahr, 2012). Clear conceptualization and measurement are considered essential for evaluating the impact of curiosity on children's learning and for designing educational interventions (Jirout & Klahr, 2012). Debate over its definition and dimensions persists in even contemporary research (Shah et al., 2013). Most research defines curiosity as a drive to seek information in response to uncertainty (Jirout, 2020). It is viewed as foundational to early learning and marked by the joy of discovery and a motivation to pursue answers (Shah et al., 2018). Jirout and Klahr (2012) classify definitions of curiosity into five operational categories: spontaneous exploration, exploratory preference, novelty preference, preference for complexity or the unknown, and preference for uncertainty or ambiguity. Curiosity has also been framed through theories such as drive reduction, optimal arousal, dynamic subsystem regulation, knowledge-gap models, and spontaneous learning (Peterson & Emily, 2016; Peterson, 2019). Recent study in this direction highlights the challenges in defining and conceptualizing curiosity (Scrivner & Stubbersfield, 2022). Literature reviews characterize curiosity as a multidimensional construct, shaped by both trait and situational factors (Shah et al., 2018). As current research offers an incomplete picture of how curiosity develops and affects memory throughout childhood and adolescence (Gruber & Fandakova, 2021).

In respect to curiosity as a factor for academic development curiosity is considered essential for scientific discoveries, innovations, and an indispensable part of human development. Recent studies emphasize the importance of curiosity in educational contexts. It is considered that curiosity is a key factor in fostering intellectual engagement and academic success. High-curiosity students are typically more industrious, organized, and likely to excel academically. Epistemic curiosity—both interest-driven and deprivation-driven—has been positively correlated with deeper learning, motivation, and academic performance. However, contextual differences, such as in Nigeria, suggest that the relationship between curiosity and achievement may vary. (Mahama et al., 2023). Although curiosity has been linked to traits like diligence and academic success (Mahama et al., 2023), research on its independent role in early academic achievement remains limited (Shah et al., 2018). More broadly, curiosity is positively associated with well-being—specifically life satisfaction and optimism—and negatively related to depression (Priemysheva et al., 2025). A recent comprehensive definition describes curiosity as a set of cognitive, emotional, and behavioural processes rooted in intrinsic motivation to engage with novelty and challenge (Priemysheva et al., 2025). Theories such as curiosity-drive and optimal arousal distinguish between deprivation-driven curiosity and joyous exploration, with the latter being particularly relevant to well-being (Priemysheva et al., 2025). Alongside the widely accepted information-gap theory, the knowledge-emotion framework has also been proposed. This perspective underscores the experiential and cognitive facets of exploration, advocating for greater attention to the often-underestimated experiential component (Scrivner, 2022).

Another key point is the understanding that curiosity arises from a perceived gap in knowledge, triggering exploratory behaviour to restore cognitive balance. According to foundational theories (e.g., Ziv & Diem, 1978; Karakehayova, 2002), curiosity involves both cognitive and emotional mechanisms. Berlyne distinguished between cognitive curiosity (seeking knowledge) and perceptual curiosity (sensory exploration). Prokolienko (1982) viewed curiosity as both a trait and a process indicator of goal-directed thinking. Behavioral manifestations of curiosity in children include persistent questioning and sustained engagement with novel stimuli, often accompanied by emotional responses like surprise. Neurological studies confirm that curiosity enhances memory, not only for sought-after information but also for incidental content (Watson et al., 2018; Huang et al., 2021). Also, it facilitates memory formation through the involvement of the hippocampus, prefrontal cortex, and ventral striatum (Gruber & Fandakova, 2021).

Based on curiosity publications overview are demarcated history and evolution of research, different approaches to curiosity definition and measurement and its inherent developmental role. In view to the complex and broad

definition of curiosity and given the challenges in its measurement, relation to other constructs and place in the overall performance, the aim was narrowing curiosity to academic performance in view the main research gaps and implications for educational setting to be highlighted

In summary of theoretical overview, early studies, including those by John Dewey (1910), emphasized instructional methods that stimulate curiosity. In the mid-20th century, research linked curiosity to academic achievement. While interest in curiosity waned later, recent studies have renewed attention to measuring curiosity in educational settings. Theoretical definitions of curiosity vary, with some frameworks conceptualizing it as a drive to resolve knowledge gaps (Drive Reduction Theory), a search for novelty (Optimal Arousal Theory), or a response to cognitive imbalance (Knowledge-Gap Theory).

Curiosity is understood as a multidimensional construct, with distinctions including:

Perceptual vs. Epistemic Curiosity: Sensory exploration vs. seeking knowledge.

- Interest-Type (I-type) vs. Deprivation-Type (D-type): Pleasure-driven vs. discomfort-driven curiosity.
- Specific vs. Diversive Curiosity: Goal-oriented vs. novelty-seeking.
- Breadth vs. Depth Curiosity: Superficial exploration vs. deep focus.

Trait vs. State Curiosity: Enduring disposition vs. situational curiosity.

Trait curiosity refers to a stable tendency to be curious across various situations, while state curiosity is triggered by environmental factors such as novelty or surprise. Trait curiosity often correlates with greater state curiosity, and both are intertwined with other curiosity dimensions (Kashdan et al., 2018).

Comparing Dimensions and Interrelationships - Curiosity's dimensions differ in terms of the object of curiosity (physical, social, epistemic), its stability (state vs. trait), or the motivation behind it (I-type vs. D-type, specific vs. diversive). These dimensions often interact. For example, sensory curiosity can prompt epistemic curiosity, and trait curiosity may influence preferences for depth or breadth (Grossnickle, 2016).

It is examined that motivates exploratory behaviour, which is distinct from general openness to experience. Particularly in early childhood, curiosity supports scientific thinking and learning motivation. It is linked to active learning, problem-solving, and critical thinking. Children with higher curiosity engage more deeply with educational content, generating questions and actively seeking answers (Spielberger & Starr, 2012). As a contrast it can be pointed out that curiosity is often underappreciated in traditional educational systems, particularly those focused on rigid standards and test-based evaluations. Such systems may unintentionally suppress exploratory learning, diminishing curiosity. Recent meta-analyses (Tang et al., 2020) suggest that curiosity differs from interest. Curiosity is driven by the discomfort of incomplete knowledge, prompting an urgent desire to resolve it—a process regulated by neurobiological mechanisms such as dopamine activation (Peterson, 2020).

4. Discussion

The topic about curiosity has been a focus of philosophical and scientific inquiry for centuries. Classical theories initially viewed curiosity as a component of motivation. Over time, it was recognized as a distinct psychological construct. Early empirical research on curiosity was limited until the mid-20th century, with significant contributions from Berlyne, who distinguished between specific and distinction of the construct. (Shah et al., 2013). Curiosity is viewed as a trait and accent is on the difference between Some scholars emphasize the conceptual separation between curiosity and interest, particularly under the prevalent definition of curiosity as information-seeking (Peterson, 2016; Tang et al., 2020).

Markey and Loewenstein point that it is a true miracle how curiosity survives after formal education (Markey & Loewenstein, 2014). Curiosity is described as an innate trait that drives individuals to explore and acquire new knowledge and experiences (Berlyne, 1954). It is the milestone which shapes various professions such as scientists, inventors or high-tech entrepreneurs, artists, explorers, and therapeutic professionals (Birenbaum et al., 2024). Of course, there are educational techniques that can cultivate curiosity since it is the key factor for success. One example is the inquiry-based learning defined as a process that engages students by making real-world connections through exploration and high-level questioning. It is particularly suitable in science where students work in cooperative groups (Gillies 2023). A long-term study explores how critical pedagogy influences the academic and social growth of students from a marginalized Mexican American borderland community, particularly in relation to their progress in STEM (Science, Technology, Engineering, and Mathematics) fields. Among the other achievements

it highlights the role of early curiosity in sustaining students' interest in STEM, despite encountering obstacles in higher education environments dominated by market-driven influences (Alvidrez 2024). John Dewey states that teachers have the important task of keeping the sacred spark of curiosity alive and fanning the flame that is already glowing (Dewey, 1910). Dewey emphasizes the importance of teachers supporting children's curiosity by adjusting the level of challenge, directing their attention toward exciting information, problems, and questions that are engaging to the learners (Dewey 1910) It is more important for teachers to focus on manifesting and stimulating curiosity rather than on the knowledge and evaluation of learners' results (Schmitt & Lahroodi, 2008). Knowledge and success of learners is suggested to be stimulated and maintained through the increased presence of curiosity anyway (Bjerknes et al., 2024). The manifestation, loss, and absence of curiosity in the learning process are subjects of numerous discussions and studies in pedagogy and psychology (Jirout et al., 2018). Egel points the value of curiosity toward learning and education (Egel, 2011, 2013). Its manifestation enhances the building of interdisciplinary connections, which positively affects creativity (Hagtvedt et al., 2019). Its inclusion in standards and even in educational legislation demonstrates a deep comprehension in the importance of curiosity.

Various authors discuss epistemic curiosity as an educational goal (eg. Papastephanou, 2016). In this line stimulating children's natural curiosity about the world at an early age is supported as being linked to critical thinking, problem solving, cooperation, perseverance, and other adaptive learning skills in various fields, according to other authors as well (Bustamante et al., 2018). Concerning the role of teachers, they are seen as facilitators of the development of critical thinking and scientific interaction with the world in building a culture of education focused on critical thinking, reasoned argumentation, and curiosity (Daniela & Zālīte-Supe, 2025). Curiosity is reported usually as a variable, linked to learning along with other factors. Casali & Meneghetti (2023) tested a model relating five soft skills (epistemic curiosity, creativity, critical thinking, persistence, and social awareness) to achievement and general distress through the mediation of learning-related factors (achievement-related emotions, self-regulated learning strategies, motivational beliefs, and learning persistence).

However, a fundamental discrepancy exists between treating curiosity as a priority within the education system and the reported lack of evidence for its genuine presence in research. A widespread reality emerges: although we recognize curiosity as essential to education, it often becomes lost somewhere along the way within the educational environment (Jirout & Klahr, 2012). From a pedagogical perspective curiosity is associated with children's enjoyment of learning and attending educational environments, whether in school or preschool age. Yet, studies report a considerable decrease in curiosity and a reduced enjoyment of going to school, starting from the early years of schooling (Jirout & Evans, 2023). Therefore, various scholars argue that avoiding discrepancy between goal and outcome is crucial to preserve and cultivate the curiosity in children. In other words, it is one of the greatest challenges for educators. Curiosity is commonly defined as a motivational state oriented toward exploration and learning. Piaget described young children as *little scientists*, emphasizing their intrinsic drive to resolve uncertainty and acquire new knowledge (Piaget, 1952). Also, it is more often than not identified as having both trait-like and state-like dimensions. Trait curiosity is believed to be heritable and stable, whereas state curiosity is considered context-specific and influenced by environmental factors. Factors that enhance curiosity include autonomy, meaningful tasks, and opportunities for self-directed learning (Shah et al., 2018). For instance, to foster curiosity during the preschool years, intentional pedagogical strategies are essential. These include providing opportunities for exploration, modelling inquisitive behaviour, and creating emotionally supportive environments that validate children's questions and discoveries. The role of educators and caregivers is critical in shaping the developmental trajectory of curiosity. By nurturing children's natural inclination to explore, adults can support immediate learning outcomes and lay the foundation for lifelong intellectual engagement. This aligns also to the conclusion academic motivation comprises of reward-based extrinsic motivation and curiosity-based intrinsic motivation (Koyanagi et al., 2021) and that specific forms of interaction, eg. STEAM activities, enhance learners' curiosity, problem-solving skills and self-confidence through learning (Mater et al., 2023).

In reply to the research questions, it can be summarized for RQ 1 (What type of curiosity is measured in respect to academic performance and in what age groups?) that intellectual (cognitive) curiosity is the only aspect, measured and discussed in respect to academic performance and achievements. Furthermore, curiosity is reported to mediate teacher-students' relations, however this aspect is not widely addressed. Curiosity is measured mainly in university and school setting. Having in mind the inherent nature of curiosity and the role of early development this focuses on the need of study and fostering curiosity at early stage.

In reply to RQ2 (Is curiosity measured as a distinct construct in educational setting?) the review reveals that curiosity is not only vaguely defined, but often interrelated most often with interest inquisitiveness, intelligence, motivation, creativity. Given the common features and relations of the constructs some future efforts are needed in view to

separation of curiosity and its view as competence, underlying critical thinking, creativity and motivation throughout lifespan development and learning.

In reply to RQ3 (What type of curiosity implications in academic performance are reported and what is the place of educational environment for promotion of curiosity?) There is research, confirming the role of environment on promotion of curiosity. This mainly indicates on widening the educational approaches and pedagogical techniques as research reveal mainly specific areas addressed – some positive outcomes in natural sciences, specific groups. In view to the role of curiosity even in prevention of early school dropout and its imminent role in inner motivation an important practical task for implementation is ensuring consistent guidelines and resources for teachers. The reported effect of interventions for facilitation of creativity is considered essential in view to beneficial outcomes of creativity, which is undisputable in lifelong perspective.

Nurturing curiosity from an early age holds the potential to enhance children's academic engagement, deepen their learning experiences, and support long-term educational success, affirming its essential role in child development and the educational process. Additionally, supportive family environments that encourage autonomy are linked to intrinsic motivation and higher academic performance, while controlling parental behaviors correlate with extrinsic motivation and lower achievement, indicating that the context in which curiosity is nurtured significantly impacts its contribution to academic success (Ginsburg & Bronstein, 1993). Once more it is shown that the field of curiosity research continues to evolve, further investigation is needed to refine the definitions and measurement of curiosity, understand the specific behaviors mediating its relationship with academic outcomes, and design targeted educational interventions that cultivate curiosity across diverse cultural and socioeconomic contexts (Hassinger-Das & Hirsh-Pasek, 2018). Considering the troubling fact that curiosity and learning have historically been seen as interdependent, there is growing concern that current educational practices suppress rather than cultivate students' innate curiosity. This raises critical questions about the reasons for this inconsistency and what educational practices that truly foster curiosity might entail, especially in contrast to conventional classroom approaches and how children's curiosity can be protected for a sustainable future development in the adulthood (Jirout et al., 2018). As mentioned previously curiosity involves personal characteristics such as openness to new experiences, state curiosity emerges within specific contexts that trigger exploratory behaviuor (Jirout & Klahr, 2012). Given the strong connection between curiosity and learning, promoting curiosity from an early age is vital for supporting children's intrinsic motivation, especially in scientific learning (Bjerknes et al., 2024). However, the lack of a universally accepted operational definition and appropriate measurement tools for young children remains a barrier to fully integrating curiosity into educational practice, necessitating further research to refine definitions, develop reliable measures, and explore culturally and socioeconomically sensitive interventions (Hassinger-Das & Hirsh-Pasek, 2018). By deepening the understanding of the definitions of curiosity and wonder, as well as the strategies to cultivate these qualities within early childhood education and care, it becomes possible to more effectively support children's intrinsic motivation for learning in science (Bjerknes et al., 2024).

Curiosity occupies a central position in the study of motivation, emotion, and cognition, and its significance is analysed in disciplines such as biology, pedagogy, physiology, economics, robotics, and leadership. There are debates about the fundamental principles of curiosity: some researchers argue that the satisfaction of curiosity comes when the answer to the missing knowledge is discovered. However, others are convinced that the manifestation of curiosity itself is an inherently pleasurable experience. The second view leads to the statement that for the learning process to be fruitful, it has to be pleasurable, and therefore provoked by the learner's curiosity.

5. Conclusion

The main limitation of this express scoping review is the opportunity for unequivocal robust conclusions. Inclusion of curiosity as multidimensional construct without a single definition and in view to its relation to motivation, interest and inquisitiveness in academic performance restricts retrieval of reported outcomes concerning curiosity. This, however, was provoked from the interest how curiosity and what forms of curiosity is addressed in school setting.

In summary several conclusions and future research lines can be derived, especially in view to practical implications of curiosity on academic and overall performance.

The biological theories reveal that curiosity is genetically determined feature that is a key mechanism of survival. From psychological point of view, it is considered a personality trait. It gives an advantage in the individual's social development. The pedagogical aspect puts the emphasis on the curiosity in the educational process. In this aspect the

learners should be in an active role, therefore in the position of creators and explorers. This point is crucial because the curiosity can be increased or decreased during the ontogenesis depending on the environment. Also, in educational contexts, the focus is often placed on the intellectual dimension of curiosity. However, curiosity is inherently a dual construct, encompassing both intellectual and emotional components. While intellectual curiosity is often emphasized—particularly in relation to academic performance—emotional curiosity tends to be underutilized and insufficiently explored. This imbalance, when considered alongside the definitions and components revealed in broader analyses, points to a significant research and practical gap, despite the growing body of supporting evidence.

Currently, there is no universally accepted definition of curiosity, nor are there consistent methodological approaches for studying it. This lack of clarity is understandable, given the concept's heterogeneity, and may not necessarily be problematic. On the contrary, it highlights the need for a deeper understanding of and preparedness for the role of context and environment in shaping curiosity. Frameworks often juxtapose trait-based versus environmental influences, as well as intrinsic versus extrinsic motivation

These comparisons are also discussed in terms of deprivation versus satisfaction-based models. Such multidimensional perspectives are essential, as only by considering these intersecting factors can we begin to fully account for the complex and multifaceted nature of curiosity.

This review focuses on the underexplored role of curiosity in early childhood and the importance of teacher-student dynamics and pedagogical environments. The conclusions of the summary lead to the overall highlighted gap between the value placed on curiosity and its operationalization in schools, which is of key importance both for researchers and practitioners.

Main contribution of this study is outlining, along with the reported challenges, an important research gap, addressing the passive form of the curiosity, which is related to effortless rewarded state. Research and interventions are focused on cognitive curiosity, which is very close to inquisitiveness, considered a restricted form of curiosity or only intellectual curiosity or eagerness for knowledge. At the background of the lack of unambiguous definition and measures of curiosity can be broadly discussed as led by deprivation vs satisfaction and comprehensively understood through the integration of interdisciplinary research and their implementation in educational practice and interactions. In view the multidimensional construct curiosity to be covered both cognitive and emotional components have to be concerned. Curiosity is more passive compared to the behavioral expressions of inquisitiveness. It is also different from interest. With regard to the immanent relation of cognitive and emotional aspects from biopsychosocial perspective the main research gap is in the integration of neurophysiological and biological determinants of curiosity and underestimation of the regraded passive form of curiosity. Curiosity is suggested to be competence of the 21st century in the same line as digital competence given its place for intrinsic motivation, critical thinking in the age of uncertain external environment and AI assisted daily performance and in view to survival of humans from biological and evolution perspective as curiosity is suggested to be a core competence, akin to digital or scientific literacy. "*Passive curiosity*" suggested could be framed as *the desire to receive new knowledge or insight without active seeking*—such as curiosity triggered by surprise, supportive environment and rewards. While less studied, this may be relevant in young children or digitally mediated environments (e.g., social media, video learning).

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