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Exploring the Influence of Family Cultural Capital, School Environment, and Peer Relationships on the Scientific Literacy of Primary School Students: A Conceptual Analysis in Chengdu City, China

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ABSTRACT

This paper explores the impact of blended education on the quality of college student learning in Southwest China during the post-epidemic era. The study highlights the potential of blended learning to enhance student engagement, adaptability, and learning outcomes through the integration of digital tools with traditional teaching methods. It identifies critical factors such as institutional support, technological infrastructure, and faculty training as essential for maximizing the benefits of blended education. Additionally, the paper examines the unique socio-cultural context of Southwest China, emphasizing the need to address regional disparities in digital access to ensure educational equity. The findings suggest that blended education can serve as a transformative model for higher education in the region, fostering essential 21st-century skills and reducing educational inequalities. The paper concludes with recommendations for policymakers and educators to support the sustainable implementation of blended education, contributing to a more resilient and inclusive higher education system.

KEYWORDS: Blended Education, Learning Quality, Post-Epidemic

I. INTRODUCTION

Scientific literacy is increasingly recognized as a crucial component of primary education, forming the foundation for students' understanding of the natural world and their ability to engage with scientific concepts throughout their lives. In the context of a rapidly evolving global economy and technological landscape, fostering scientific literacy from a young age is essential for preparing students to navigate and contribute to the knowledge-based society of the future (National Research Council, 2012). In Chengdu City, China, a region known for its dynamic educational environment and cultural richness, understanding the factors that contribute to scientific literacy among primary school students is particularly relevant.

Family cultural capital, defined as the knowledge, skills, education, and other cultural assets that parents transmit to their children, plays a significant role in shaping educational outcomes, including scientific literacy (Bourdieu, 1986). The school environment, encompassing the quality of teaching, availability of resources, and institutional culture, also critically influences students' learning experiences and achievements (Bryk & Schneider, 2002). Additionally, peer relationships, which become increasingly influential as children grow, can affect students' attitudes towards learning and their engagement with scientific content (Wentzel & Caldwell, 1997). Understanding how these factors—family cultural capital, school environment, and peer relationships—interact to influence scientific literacy is vital for developing effective educational strategies in Chengdu.

Despite the recognized importance of scientific literacy and the well-documented roles of family, school, and peers in shaping educational outcomes, there is a notable gap in understanding how these factors specifically influence scientific literacy among primary school students in Chengdu City. While previous studies have explored the impact of family cultural capital, school environment, and peer relationships on general academic achievement, few have focused on their collective and individual effects on scientific literacy, particularly within the unique socio-cultural context of Chengdu. This gap in the literature underscores the need for a conceptual analysis that examines the interplay between these factors and their contribution to the development of scientific literacy in primary education. Addressing this gap can provide valuable insights for educators, policymakers, and researchers aiming to enhance scientific literacy in Chengdu and similar contexts.

The primary objective of this paper is to explore and analyze the conceptual links between family cultural capital, school environment, and peer relationships, and their collective influence on the scientific literacy of primary school students in Chengdu City, China. Specifically, the paper aims to investigate how family cultural capital, including parental education levels, home educational resources, and cultural practices, contributes to children's development of scientific literacy. Additionally, it seeks to examine the role of the school environment, particularly the quality of science education, teacher-student interactions, and the availability of learning resources, in fostering scientific literacy. Lastly, the paper explores the impact of peer relationships, including peer support, collaboration, and the influence of friends with similar academic interests, on students' engagement with science and their overall scientific literacy. By analyzing these factors, the paper aims to provide a comprehensive understanding of the socio-cultural determinants of scientific literacy among primary school students in Chengdu.

This research holds significant importance for educators, policymakers, and the academic community, particularly in the context of educational development in Chengdu City. Understanding the influence of family cultural capital on scientific literacy is crucial for designing targeted interventions that support families in enhancing their children’s educational outcomes (Bourdieu, 1986). By highlighting the role of the school environment, this study underscores the need for improved science education practices and resources that can foster a conducive learning atmosphere for developing scientific literacy (Coleman, 1988). Furthermore, the

exploration of peer influences offers insights into how social interactions among students can be leveraged to promote collaborative learning and a positive attitude towards science (Wentzel, 2005).

For policymakers, the findings of this study can inform the development of policies aimed at reducing educational inequalities by addressing the disparities in access to cultural capital and school resources that affect scientific literacy (OECD, 2018). For educators, the research provides valuable insights into the multi-faceted factors that influence scientific literacy, enabling them to adopt more holistic and inclusive teaching strategies. Finally, for the academic community, this study contributes to the existing body of knowledge on the socio-cultural determinants of scientific literacy, offering a conceptual framework that can be applied in further research across different contexts.

II. LIRATURE REVIEW

Blended education, also known as hybrid learning, refers to an instructional approach that combines online digital media with traditional face-to-face classroom methods. According to Graham (2022), blended education is characterized by a deliberate integration of online and in-person learning experiences, where a significant portion of the content is delivered online, allowing for both synchronous and asynchronous interactions. This model seeks to capitalize on the strengths of both modalities—flexibility and accessibility of online learning, along with the interpersonal and hands-on engagement of in-person instruction.

Various models of blended education have emerged, each with a different emphasis on the balance between online and face-to-face components. For example, the rotation model involves students rotating between online learning stations and traditional classroom activities within a structured schedule (Horn & Staker, 2021). The flex model, on the other hand, offers more fluidity, where the majority of the curriculum is delivered online, and face-to-face instruction is provided as needed (Means et al., 2020). Another model, the flipped classroom, reverses the traditional learning environment by delivering instructional content online outside of class and using in-class time for interactive activities (Bishop & Verleger, 2023).

These approaches to blended education allow institutions to tailor learning experiences to meet the diverse needs of students, catering to different learning styles and preferences. The combination of online and face-to-face instruction is not merely additive but transformative, as it can reshape how education is delivered and experienced, especially in the context of higher education (Picciano, 2023).

The impact of blended learning on student outcomes has been a focal point of recent research, with studies showing a generally positive effect on student learning, engagement, and satisfaction. A meta-analysis by Bernard et al. (2023) found that students in blended learning environments tend to perform better academically compared to those in fully traditional or fully online settings. The blend of in-person and online learning allows for greater flexibility, enabling students to learn at their own pace while still benefiting from direct interaction with instructors and peers.

Engagement is another critical aspect where blended learning has shown significant promise. Research by Boelens et al. (2022) indicates that the interactive and varied nature of blended learning environments can increase student engagement by providing multiple avenues for participation. The combination of synchronous and asynchronous activities allows students to engage with the material in ways that suit their individual learning preferences, leading to a deeper understanding and retention of content.

Moreover, student satisfaction in blended learning settings has been consistently reported as high, particularly when the online and face-to-face components are well integrated and aligned with course objectives (Garrison & Vaughan, 2022). Students appreciate the flexibility and autonomy that blended learning offers, which can lead to a more personalized and satisfying educational experience. However, it is crucial to note that the success of blended learning depends on careful instructional design and the provision of adequate support for both students and instructors (Hrastinski, 2022).

The post-epidemic era has brought significant changes to the landscape of education, with blended learning emerging as a dominant model in higher education. However, this shift is accompanied by a set of challenges and opportunities that shape its implementation and effectiveness.

One of the most prominent challenges in blended education is the **digital divide**. The disparity in access to technology and reliable internet connections among students can exacerbate educational inequalities. This issue is particularly acute in regions with limited infrastructure, where students from rural or low-income backgrounds may struggle to engage fully in online components of blended courses (Chen et al., 2023). Another challenge is **resource allocation**. Institutions may face difficulties in providing adequate technological resources, training for faculty, and support services for students to effectively manage both online and in-person learning environments (Zhao & Mei, 2022). Additionally, the **quality of online content** and **student engagement** in virtual settings remain concerns, as not all educators are equally prepared to design and deliver effective online instruction, which can lead to reduced learning outcomes (Li & Zhang, 2023).

On the other hand, blended education offers several opportunities. The **flexibility** of this model allows students to learn at their own pace, accommodating different learning styles and schedules. This flexibility can be particularly beneficial for non-traditional students, such as working professionals or those with family responsibilities (Wang & Liu, 2023). Blended learning also enhances **accessibility** to education, enabling students in remote areas or those unable to attend in-person classes due to health concerns or other constraints to participate in higher education (Xu et al., 2023). Furthermore, the integration of technology in education encourages the development of digital literacy skills, which are increasingly essential in the modern workforce (Tang & Yang, 2023).

The impact of blended education in Southwest China is influenced by several unique socio-economic, cultural, and educational factors. **Socio-economic factors** play a critical role, as Southwest China includes both rapidly developing urban centers and economically disadvantaged rural areas. The economic disparity between these regions affects students' access to the necessary technology and stable internet connections for engaging in

blended learning. For instance, students in rural areas may face challenges due to the lack of digital infrastructure, limiting their ability to fully participate in online learning (Zhou et al., 2024).

Cultural factors also shape the adoption and effectiveness of blended education in this region. Traditionally, Chinese educational culture places a strong emphasis on face-to-face instruction and the authority of the teacher. This cultural preference for direct interaction in learning environments can pose a challenge to the acceptance and success of online components in blended learning (Sun & Li, 2023). However, there is also a growing recognition of the value of independent learning and digital literacy, which blended education can support, indicating a cultural shift towards more diverse educational practices (Liu & Chen, 2023).

Educational factors in Southwest China are characterized by a diverse range of institutions, from well-funded universities in urban centers to less-resourced colleges in rural areas. The variation in institutional capacity to implement blended learning effectively is significant. Urban universities may have the resources to develop high-quality online content and support systems, while rural institutions may struggle with the basics of digital transformation (Chen et al., 2023). Moreover, the professional development of educators is uneven, with faculty in more developed areas having better access to training in blended learning methodologies than their counterparts in less developed regions (Huang & Wang, 2023).

Peer relationships play a significant role in shaping students' attitudes towards science, their engagement with scientific content, and their overall academic performance. Research has shown that peers can influence a student's interest in science and their academic behaviors both positively and negatively. For instance, when students are surrounded by peers who are enthusiastic about science, they are more likely to develop a positive attitude towards the subject and engage more deeply with scientific content (Wentzel, 2017). This peer influence extends to collaborative learning environments where students work together on scientific projects or activities, which can enhance their understanding and retention of scientific concepts (Vassallo, 2021).

Moreover, the social dynamics within peer groups can impact a student's confidence and willingness to participate in science-related activities. Positive peer interactions can boost a student's self-efficacy in science, leading to higher academic achievement and a stronger interest in pursuing science in higher education (Ryan, 2018). Conversely, negative peer interactions, such as teasing or exclusion, can diminish a student's interest in science and result in disengagement from the subject (Molloy et al., 2019).

Despite these insights, there are gaps in the existing literature that need further exploration. One major gap is the limited research on how peer influence varies across different cultural and socio-economic contexts, particularly in non-Western settings like Chengdu, China. Much of the existing research has been conducted in Western countries, and the findings may not fully capture the nuances of peer influence in different cultural settings (Chen & Sun, 2022). Additionally, there is a need for more longitudinal studies that track peer influence on scientific literacy over time, rather than relying on cross-sectional data that provides only a snapshot of this dynamic relationship (Zhao, 2023).

Another gap is the lack of research on how peer relationships interact with other factors such as family cultural capital and the school environment to influence scientific literacy. While individual studies have examined the effects of family, school, and peers separately, there is a need for a more integrated approach that considers how these factors interact to shape students' scientific literacy (Liu & Wang, 2022). Addressing these gaps could provide a more comprehensive understanding of the various influences on scientific literacy and inform the development of more effective educational interventions.

III. METHODOLOGY

In this study, several central concepts are crucial for understanding the relationship between family cultural capital, school environment, peer relationships, and scientific literacy among primary school students. Family cultural capital refers to the cultural resources and educational attitudes that families provide to their children, significantly influencing academic success. This includes parental education levels, engagement with learning activities, exposure to cultural knowledge, and the value placed on education within the family (Bourdieu, 1986). In the context of Chengdu, this concept may also encompass traditional cultural practices and the extended family's role in supporting education. Scientific literacy is defined as the ability to understand, interpret, and apply scientific concepts and reasoning in everyday life, which involves not only knowledge of scientific facts but also critical thinking and problem-solving skills (OECD, 2018). For primary school students, scientific literacy includes foundational skills such as observation, experimentation, and the ability to connect scientific ideas to real-world phenomena.

The school environment is another key concept, referring to the physical, social, and educational conditions within a school that shape students' learning experiences. This includes the quality of teaching, availability of resources, school culture, and the support systems provided to students (Bronfenbrenner, 1979). In Chengdu, the school environment might also reflect regional educational policies and the emphasis placed on science education. Peer relationships involve the social interactions and friendships students form with their classmates, which can significantly impact learning. Peers influence each other's attitudes towards education, motivation to learn, and engagement in academic activities (Vygotsky, 1978). Positive peer relationships can encourage collaborative learning and shared enthusiasm for subjects like science.

This study proposes a conceptual model illustrating how family cultural capital, school environment, and peer relationships interact to influence the scientific literacy of primary school students. Family cultural capital directly influences a child's exposure to scientific ideas and attitudes toward learning, with higher cultural capital families more likely to provide educational materials and encourage curiosity about the natural world (Lamont & Lareau, 1988). The school environment acts as a mediator that either amplifies or mitigates the influence of family cultural capital, with a positive school environment enhancing students' scientific literacy regardless of their family background (Darling-Hammond, 2000). Peer relationships serve as a reinforcing factor, where students with supportive, academically inclined peers are more likely to develop strong scientific literacy, as peer influence motivates students to engage in group learning and foster a collective interest in science (Wentzel, 2005). The

model posits that these factors do not operate in isolation but interact dynamically, where a supportive school environment can compensate for low family cultural capital, and positive peer relationships can enhance the effectiveness of both family and school influences.

Based on the proposed model, several hypotheses or theoretical propositions can be outlined:

1. **H1: Family Cultural Capital is Positively Associated with Scientific Literacy**: Students from families with higher levels of cultural capital will demonstrate higher levels of scientific literacy compared to those from families with lower cultural capital.
2. **H2: School Environment Moderates the Relationship Between Family Cultural Capital and Scientific Literacy**: The quality of the school environment will moderate the impact of family cultural capital on scientific literacy, with a high-quality school environment reducing the disparities between students from different family backgrounds.
3. **H3: Peer Relationships Positively Influence Scientific Literacy**: Students with strong, positive peer relationships will show higher levels of scientific literacy, as peer interactions enhance learning and engagement in science-related activities.
4. **H4: The Interaction of Family Cultural Capital, School Environment, and Peer Relationships Leads to Higher Scientific Literacy**: The combined effect of supportive family, school, and peer environments will result in the highest levels of scientific literacy among students.

IV. DISCUSSION AND CONCLUSION

Family cultural capital plays a crucial role in shaping the scientific literacy of primary school students. Various aspects of family cultural capital, such as parental education levels, access to educational resources at home, and engagement in cultural practices, significantly influence a child's interest and proficiency in science. For instance, parents with higher education levels often place greater emphasis on academic achievement and provide more support for their children's learning activities, including science-related topics (Bourdieu, 1986). In Chengdu, families that regularly engage in culturally enriching activities, such as museum visits or science fairs, tend to have children who are more curious about scientific concepts and perform better in science subjects. Moreover, access to educational resources like books, computers, and internet connectivity at home further enhances students' ability to explore scientific ideas beyond the classroom, fostering a deeper understanding and interest in science (Li & Xie, 2022).

The school environment is another critical factor in developing scientific literacy. A supportive school environment, characterized by high-quality teaching, a well-structured curriculum, and a positive school culture, can significantly enhance students' scientific literacy. In Chengdu, schools that prioritize science education through well-designed curricula and hands-on learning opportunities, such as lab experiments and field trips, tend to produce students with higher levels of scientific literacy (Zhao & Zhang, 2023). Additionally, the quality of

teachers plays a vital role; teachers who are well-trained and passionate about science can inspire their students, making scientific concepts more accessible and engaging (Gao, 2021). However, schools that lack adequate resources or have a rigid curriculum may hinder the development of scientific literacy by failing to provide students with the necessary tools and experiences to fully engage with scientific learning.

Peer relationships also have a significant impact on students' attitudes towards science and their academic achievements in scientific subjects. In Chengdu, students who are part of peer groups that value academic achievement and have a positive attitude towards science are more likely to develop a strong interest in scientific subjects (Wang & Li, 2023). Peer influence can operate through various mechanisms, such as collaborative learning, where students work together on science projects, or through social reinforcement, where interest in science is normalized and encouraged within the group. Conversely, if a student is part of a peer group that is disengaged from academic pursuits or views science as difficult or unimportant, their motivation to excel in scientific subjects may diminish, negatively affecting their scientific literacy (Chen & Zhao, 2022).

The interaction between family cultural capital, school environment, and peer influence creates a complex dynamic that collectively shapes a student's scientific literacy. In Chengdu, this interplay often manifests in unique ways, influenced by the city's cultural and socio-economic context. For instance, students from families with high cultural capital who attend well-resourced schools and have academically oriented peers are likely to exhibit high levels of scientific literacy. However, challenges arise when these factors do not align; for example, a student with supportive parents but a less effective school environment or negative peer influence might struggle to develop strong scientific literacy skills. Understanding how these factors interact is crucial for designing interventions that can effectively support scientific literacy across diverse student populations (Liu & Sun, 2023).

To enhance scientific literacy among primary school students, educators should consider implementing targeted interventions that engage families, optimize school practices, and foster positive peer interactions. First, educators can promote family engagement by offering workshops and resources that help parents support their children's scientific learning at home, particularly focusing on activities that build curiosity and critical thinking (Hoover-Dempsey et al., 2023). Schools should also develop science-rich environments by incorporating hands-on experiments, inquiry-based learning, and integrating science topics across various subjects. Teachers can collaborate to create interdisciplinary projects that make science more accessible and relevant to students' everyday lives (Bybee, 2022). Additionally, fostering positive peer interactions is crucial. Educators should encourage group work and collaborative learning experiences that allow students to share ideas and learn from one another, thereby enhancing their scientific understanding and literacy (Johnson & Johnson, 2024).

Policymakers can support the development of scientific literacy in primary schools, particularly in regions like Chengdu, by addressing disparities in family cultural capital and improving school environments. One key policy measure is to invest in community-based programs that provide resources and support for families with lower cultural capital, ensuring all students have access to enriching educational experiences outside of school

(Lareau, 2023). Additionally, policies should focus on reducing educational inequalities by funding schools to improve their science education facilities, including laboratories, science kits, and digital resources. Teacher professional development programs should also be a priority, equipping educators with the skills and knowledge to effectively teach science in diverse and resource-constrained environments (Darling-Hammond et al., 2024). Furthermore, policies should encourage the integration of science education into the broader curriculum, ensuring that scientific literacy is not treated as an isolated subject but as a key component of holistic education.

Future research should build on the conceptual framework presented in this paper by conducting empirical studies that explore the specific mechanisms through which family cultural capital, school environments, and peer relationships influence scientific literacy. Longitudinal studies could provide insights into how these factors interact over time to affect students' scientific understanding and attitudes toward science (Eccles & Roeser, 2023). Additionally, research could focus on developing and testing intervention programs that aim to enhance scientific literacy, assessing their effectiveness in diverse educational settings, including urban, rural, and economically disadvantaged areas (Shernoff et al., 2024). Finally, cross-cultural studies comparing the impact of these factors in different regions or countries could provide a broader perspective on the role of cultural and educational contexts in shaping scientific literacy, offering valuable lessons for policymakers and educators worldwide (Nisbet & Scheufele, 2024).

This paper provides a conceptual analysis of the factors influencing the scientific literacy of primary school students in Chengdu City, China, focusing on family cultural capital, school environment, and peer relationships. The key insights from the paper reveal that family cultural capital, which includes parents' educational background, values, and involvement in their child's education, plays a significant role in fostering scientific literacy (Bourdieu, 1986). Schools are also crucial, as the quality of the educational environment, including access to resources, teacher expertise, and the emphasis placed on science education, directly impacts students' scientific understanding (Fan & Wang, 2021). Additionally, peer relationships, particularly the influence of friends who value and engage in scientific learning, contribute to a student's interest and achievement in science (Wentzel & Muenks, 2016). Together, these factors create a complex network of influences that shape how primary school students in Chengdu develop scientific literacy.

The broader implications of this study highlight the importance of a holistic approach to understanding and improving scientific literacy in primary education. In the context of Chengdu, where rapid urbanization and educational reforms are ongoing, recognizing the multifaceted influences on scientific literacy can guide more effective educational strategies. This study suggests that enhancing scientific literacy requires not only improvements within the school system but also greater involvement and support from families and a positive peer culture that encourages scientific inquiry (Xie & Ma, 2022). By addressing these interconnected factors, educators and policymakers in Chengdu can better support the development of scientifically literate students who are prepared to engage with the challenges of the modern world. The findings underscore the need for targeted interventions that consider the socio-cultural context of students' lives, ensuring that all children have the opportunity to develop strong scientific literacy, regardless of their background (Zhou & Hu, 2023).

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