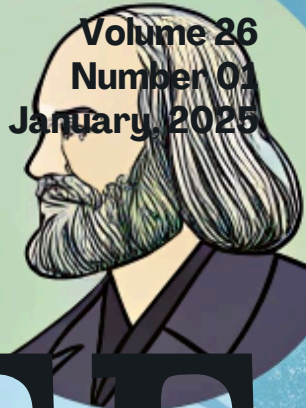


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Conceptual Change in Science Education: From Cold to Hot Approaches

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*“The whole of science is nothing more than a refinement of everyday thinking.”
-Albert Einstein*

SCIENCE education research finds that children may generate misunderstandings about certain scientific concepts based on their personal experiences prior to formal schooling. These misconceptions may present students with learning difficulties and barriers to deep comprehension of scientific knowledge. In response to this issue, researchers advanced the method of conceptual change instruction to help students shift from scientifically incorrect pre-instructional knowledge structures to scientifically accepted ones (Pacaci et al., 2024). Conceptual change has been deemed an effective approach to boosting students' science literacy by improving teaching and learning in science education (Duit & Treagust, 2003; Treagust & Duit, 2008). Duit contended that conceptual change was not about an exchange of pre-instructional conceptions for the science concepts, but rather conceptual learning pathways from students' pre-instructional conceptions to the science concepts to be learned (Duit, 1999; Duit & Treagust, 2003). Conceptual change studies can be traced back to the 1970s. There have been diverse perceptions of conceptual change in researchers, leading to the development of a variety of conceptual change strategies in science education.

Among common conceptual change strategies are the cognitive conflict strategy, cognitive bridging strategy, and ontological category shift strategy. According to the cognitive conflict strategy, the learner needs to recognize the conflict between their prior knowledge and scientific knowledge and raise queries about the former, to realize conceptual change (Posner et al., 1982). As per the constructivist theory, the student's prior knowledge can serve as a valuable resource in their study of new knowledge; therefore, eliciting their dissatisfaction with prior knowledge alone is far from enough. Some studies suggest that providing bridges between prior and new knowledge can help students cor-

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rect misconceptions in science learning. Pacaci et al. (2024) named this type of conceptual change strategy the “cognitive bridging strategy.” Other researchers borrowed terminologies from ontology to describe the process of conceptual change. As ontology holds that knowledge of each domain has its own structure with every concept belonging to a certain category, the ontological category shift strategy treats conceptual change as a process in which concepts shift from an ontologically wrong category to an ontologically appropriate one (Chi & Roscoe, 2002).

Conceptual change strategies, including the said three types, emphasize the role of cognitive skills (such as logic) with disregard for affective factors like motivation and are, thereby, characterized as “cold conceptual change” (Kural, 2015), as opposed to “hot conceptual change.” Pintrich et al. (1993) first advanced the notion of hot conceptual change to stress that conceptual change is not only a cognitive process but also entails motivational, affective, and contextual components (Sinatra, 2005). Inspired by the work of Pintrich et al., later studies developed a variety of hot conceptual change models. For example, the Teaching Model for Hot Conceptual Change (TMHCC), created by Kural and Kocakulah (2016), uses motivational and metacognitive strategies to support conceptual change in student physics learning. Despite the recognition of the critical role of affective factors in conceptual change among teachers and education researchers, there is a dearth of in-depth research into the practical outcomes of hot conceptual change models or strategies.

The Effect of Hot Concept Change on Students’ Views of the Nature of Science in this issue focuses on the development of a fresh instructional model that combines inquiry-based learning (IBL) and hot conceptual change strategy, which is compared with a purely IBL-based model. The purpose of the study is to investigate the effects of the integrative model on the conception of nature of science (NOS) in seventh graders (Savas & Kocakulah, 2025). Although the article addresses the use of hot conceptual change strategy in the NOS course, it can provide valuable implications for the across-the-board implementation of conceptual change instruction in science education.

References

- Chi, M. T. H. & Roscoe, R. D. (2002). The Processes and Challenges of Conceptual Change. In: Limón, M., Mason, L. (eds) *Reconsidering Conceptual Change: Issues in Theory and Practice*. Springer, Dordrecht. DOI: https://doi.org/10.1007/0-306-47637-1_1
- Duit, R. (1999). Conceptual change approaches in science education. In W. Schnotz, S. Vosniadou, & M. Carretero (Eds.), *New perspectives on conceptual change* (pp. 263-282). Amsterdam, NL: Pergamon.
- Duit, R., & Treagust, D. F. (2003). Conceptual change: A powerful framework for improving science teaching and learning. *International journal of science education*, 25(6), 671-688. DOI: <https://doi.org/10.1080/09500690305016>
- Kural, M. (2015). Teaching for Hot Conceptual Change: An Example of Photoelectric Effect. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education*, 9(2), 85-124. Available at: https://web.archive.org/web/20160415165136id/http://www.nef.balikesir.edu.tr/~dergi/makaleler/yayinda/19/EFMED_FZE197.pdf
- Kural, M., & Kocakulah, M. S. (2016). Teaching for hot conceptual change: Towards a new model, beyond the cold and warm ones. *European Journal of Education Studies*, 2(8). Available at: <https://files.eric.ed.gov/fulltext/ED573491.pdf>
- Pacaci, C., Ustun, U., & Ozdemir, O. F. (2024). Effectiveness of conceptual change strategies in science education: A meta-analysis. *Journal of Research in Science Teaching*, 61(6), 1263-1325. DOI: <https://doi.org/10.1002/tea.21887>

- Pintrich, P. R., Marx, R. W., & Boyle, R. A. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational Research*, 63(2), 167-199. <https://doi.org/10.3102/00346543063002167>
- Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of scientific conception: Toward a theory of conceptual change. *Science Education*, 66(2), 211-227. DOI: <https://doi.org/10.1002/sce.3730660207>
- Savas, E., & Kocakulah, A. (2025). The effect of hot conceptual change on students' views on the nature of science. *Science Insights Education Frontiers*, 26(1), 4207-4231. DOI: <https://doi.org/10.15354/sief.25.or689>
- Sinatra, G. M. (2005). The "warming trend" in conceptual change research: The legacy of Paul R. Pintrich. *Educational Psychologist*, 40(2), 107-115. DOI: https://doi.org/10.1207/s15326985sep4002_5
- Treagust, D. F., & Duit, R. (2008). Conceptual change: A discussion of theoretical, methodological and practical challenges for science education. *Cultural Studies of Science Education*, 3, 297-328. DOI: <https://doi.org/10.1007/s11422-008-9090-4>

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Childhood Left-Behind Life Experience: A Painful Memory

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*“We get strength and encouragement from watching children.”
-Hayao Miyazaki*

PARENTAL love and affection play a crucial role for a child’s growth. Yet, left-behind children, a special group in China, have to live in separation with their parents in childhood, deprived of parental care. The issue of left-behind children is a consequence of the disparities in economic development between rural and urban China and between western and eastern China. A large population of rural young laborers has left native places to seek better employment opportunities in developed regions. Constrained by factors related to China’s registered residence system (Hukou), these migrant workers can hardly have their families live with them in cities, and their young kids become left-behind children in rural homeplaces (Zhang & Li, 2016).

Left-behind children are often entrusted to their grandparents or other relatives. These guardians are far from ideal substitutes for their own parents. In some households, the elderly grandparents may even need the care from their young grandchildren. As a result, these left-behind children suffer additional life pressures while being deprived of parental care and protection. Also, parental absence leads to the dearth of home education in this group (Liu et al., 2016). Furthermore, rural primary and secondary school teachers typically have heavier work burdens than their urban counterparts due to teaching staff shortages and subpar operation conditions in rural schools (Zhou et al., 2005). This makes it almost impossible for left-behind children to receive special attention and supervision from their teachers, which could lower the likelihood of their being influenced by delinquent juveniles. The inadequacies in home and school education substantially increase the risks of mental problems, such as depression, anxiety, and bigotry, in this group (Zhang, 2016).

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It should be acknowledged that not all left-behind children have encountered the said challenges. With the assistance of telecommunication technologies, some of them manage to keep close contact with their parents, perceiving solid parental affection despite the distance between them. Others may benefit from their early left-behind lives, developing strong character and the ability to live independently (Liang, 2020). Still, the majority of them suffer more difficulties than their non-left-behind peers, and some of their difficulties may lead to social problems. That is why the issue of left-behind children has provoked wide attention of Chinese society. To ensure the healthy growth of these children, the Chinese government and numerous third-sector entities have taken action to improve the welfare of this group. In the meantime, many researchers have conducted in-depth studies of the issue of left-behind children and proposed coping strategies. Nevertheless, less attention has been paid to their mental and social development in adulthood. According to Liu and Xu's (2020) research findings, there is a positive correlation between the early left-behind life and adulthood social difficulty. Lai's (2021) study suggests that the early parent-child separation has negative effects on mental health in college students as former left-behind children. The existing literature, though limited, demonstrates the long-term negative impact of childhood left-behind life experience.

Mental Health Issues in Chinese College Students as Former Left-Behind Children: A Literature Review in this issue is a review of 40 prior studies of mental health states of Chinese college students who experienced separation with their migrant worker parents in the early years, aiming to investigate the impact of this childhood life on their mental well-being as adults (Chen, 2025). Despite these college students constituting only a small portion of adults with this left-behind life experience, the article provides a valuable perspective for a comprehensive understanding of its long-term mental health consequences.

References

- Chen, X. (2025). Mental health issues in Chinese college students as former left-behind children: A literature review. *Science Insights Education Frontiers*, 26(1), 4261-4280. DOI: <https://doi.org/10.15354/sief.25.re449>
- Liang, F. (2020). The focuses of care and protection of rural left-behind children. *Teaching and Administration*, 2020(7), 24-25. Available at: https://kns.cnki.net/kcms2/article/abstract?v=WpTTvLMLsy12KTK6Tf120QXaxIUgk8vEdmgvsjQR92itWunVFVt8qYTFzDI_fwfSBwGVyyqVL3iuHFd8-Eo6sGolbYsEkpgdeMVFe-8ynNFVKy3ZIJdCK5KC2dDxmGLZUI7m-MHduxdKnoPkIAKeIB0kGKZ34BOE2aq0qWA2yjh3DIJpdbhOQ==&uniplatform=NZKPT&language=CHS
- Liu, Z. & Xu, F. (2020). Left-behind life experience and social difficulties: An empirical study of the new-generation migrant workers. *Chinese Journal of Social Development*, 7(3), 61-78+243. Available at: https://kns.cnki.net/kcms2/article/abstract?v=ZkvsKdWJ3ST9zZyPXwgGcUiHCA1whs19a4ZEQsBKduytA0Qeo0B9DQfAXzoiPFwVjSYyXtfgkfhXv2Yat_Hzeg-P7inEFxseDQS1abg684sqrup5bpoakyXBtZJbKpVV_ILuLt0fpCeRs8ry0qsesHKveXIRD0PNPMLf0RarTTNM4mN8zodqw==&uniplatform=NZKPT&language=CHS
- Liu, Y., Wei, L., & Zhou, F. (2016). The tough existence of rural left-behind children and development strategies: A typical sample from Guizhou. *Rural Economy*, 2016(3), 117-122. Available at: https://kns.cnki.net/kcms2/article/abstract?v=WpTTvLMLsy39AiDLkS-gnRKAzG3K982-J-o1GC1tlnaLe0aTdZG5-O0e39UPHthuY7ooqlAru-8dPm3tpnY6NO6jqj5mcZT1zAhhO8K8RPM4Yh0yiOyXJpfwhwsINovwdM7dbdFprdg1K1SLNHW8JUyC_z21sLTR4o5m1bZzlLhbGqCZOUSVQ==&uniplatform=NZKPT&language=CHS
- Lai, Y. (2021). Factors influencing the mental well-being of Chinese college students as former left-behind children and relevant educational recommendations. *Chinese Journal of School Health*, 42(10), 1590-1595. DOI: <https://doi.org/10.16835/j.cnki.1000-9817.2021.10.036>

- Zhang, B. & Li, W. (2016). The issue of left-behind children in rural China and its governance. *Journal of Chongqing University (Social Sciences Edition)*, 2016(2), 200-206. Available at:
https://kns.cnki.net/kcms2/article/abstract?v=ZkvsKdWJ3SSGPJbLPrxPgRJOKkf5ivHkojEeqrtgJZqFcnKuD3MxsRB4v3dKr-3lx2_P33aitq48XPiXAc7IHolG2CIVz3qU6o8Eq3UivqBD3q7Awd3GYRHH8r1DQENaaovoe9eHzHOUCP53dmiseIcIzAroAbhMIWY9ruP8xuAvH6u5xN_URHA==&uniplatform=NZKPT&language=CHS
- Zhang, G. (2016). A literature review on mental health of left-behind children. *Journal of Shandong Normal University (Humanities and Social Sciences Edition)*, 2016(5), 119-129. DOI:
<https://doi.org/10.16456/j.cnki.1001-5973.2016.05.011>
- Zhou, Z., Sun, X., Liu, Y., & Zhou, D. (2005). Mental development of rural left-behind children and relevant educational issues. *Journal of Beijing Normal University (Social Sciences Edition)*, 2005(1):71-79. Available at:
<https://kns.cnki.net/kcms2/article/abstract?v=ZkvsKdWJ3SQAPZhsT6sDIJtubxnZ4iieQUBzn9D4hqKTQa7GtBPgIC7cBre9NoQWlaQdcyfXSwSXWxdTYHppqeaxAdVGmtIqnRo8foL4Lpp0mISARH5fPgnET-FAe8SDAHzUyBPLfUlfnpS0ocSlwSo5Yy7b2mvybdgOFI9RfyTirCgy5mfg==&uniplatform=NZKPT&language=CHS>

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The Effect of Hot Conceptual Change on Students' Views on the Nature of Science[‡]

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Abstract: This study aims to investigate the effect of the teaching model developed for hot conceptual change on middle school 7th-grade students' understanding of the Nature of Science (NOS) aspects. In this qualitative and exploratory study, activities were carried out with 24 students of two classes in a village school in the South Marmara region using a pretest-posttest control group quasi-experimental design. Students in control (inquiry-based learning-IBL) and experimental (hot conceptual change based on IBL) groups used instructions for teaching the NOS topics in the 7th-grade light unit. The pre-test and post-test data on the NOS were obtained by the Opinions on the Nature of Science Questionnaire (ONSQ). In the analysis of ONSQ data, students' views on the aspects of the NOS were scored according to the adequate (3), variable (2), and weak (1) categories. These scores were converted into gain scores and considered in the comparison between the groups regarding those aspects. Semi-structured interviews were conducted with two students from each group before and after the implementation. The gains related to NOS aspects obtained with the instructions carried out for seven weeks were presented and results were discussed in the context of the literature on hot conceptual change, IBL, and NOS. Finally, suggestions were made for new research and teaching practices for teachers.

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Introduction

SCIENCE literacy is important for children to understand what is scientific or non-scientific. For this purpose, important steps have been taken and innovations have been made in science curricula in Turkey in the last 10 years (Ministry of National Education, 2013; 2017; 2018).

One of the important subcomponents of science literacy skill is the nature of science (NOS), a very popular subject area in the literature (Akerson et al., 2000; Lederman, 2007). This subject area is the key point in understanding science (Lederman, 1992; McComas & Olson, 2004). In addition, learning NOS positively affects the teaching of science concepts (Abd-El-Khalick & Lederman, 2000; Chaiyabang & Thathong, 2014; Papadouris & Constantinou, 2011; Papadouris & Constantinou, 2014; Michel & Neumann, 2016).

The Nature of Science Aspects

Defining the nature of science is difficult due to the problems experienced in defining the concept of science. On the other hand, there is a consensus on the definitions of the nature of science, except for minor disagreements (Abd-El-Khalick, 2005; Lederman, 2007; McComas, 2004; Ozcan, 2013). Although McComas (2002) considers these definitions as 14 aspects in his study, at the secondary education level, these headings can be increased or decreased according to students' grade level. Cil (2010), in her experimental study conducted with 7th-grade secondary school students, addresses the common aspects in accordance with the age level. These were; defining science (1), the provisional nature of scientific knowledge (2), the empirical nature of scientific knowledge (3), being a product of imagination and creativity (4), being theory-laden (5), the social and cultural structure of science (6), and the difference between observation and inference (7). The first step in most research is to select these aspects according to grade level for a selected sample.

The 90's in NOS studies were about the description of student situations about selected aspects (Abd-El-Khalick & Lederman, 2000b; Lederman, 1992; Lederman et al., 1998; McComas, 1996). Later, studies focusing on the organization of the teaching process to achieve a contemporary understanding of the nature of science came to the fore (Khishfe & Abd-El-Khalick, 2002; Bell et al., 2011; Erdogan & Koseoglu, 2015). Didactically, the teaching of NOS aspects with the explicit-reflective approach and implicit approach (Akerson et al., 2000) and the historical approach are also presented as support (Clough, 2006; Kim & Irving, 2010; Solomon et al., 1992). The explicit-reflective approach argues that NOS

aspects should be addressed in a deliberate and planned manner, whereas the implicit approach argues that NOS aspects should be learnt while engaging in science (Abd-El Khalick & Lederman, 2000; Akerson et al., 2000; Demirbas & Balci, 2013). However, the most important difference between the two approaches lies in the way they handle NOS aspects. While the implicit approach considers NOS as an affective learning by-product, the explicit-reflective approach considers NOS as a cognitive learning product similar to other science concepts (Abd-El-Khalick, 2005; Abd-El-Khalick & Lederman, 2000; Khisfe & Abd-El-Khalick, 2002). At the last point, it is stated that teaching with explicit-reflective approach yields effective results (Abd-El-Khalick & Lederman, 2000; Akerson et al., 2000; Flick & Lederman, 2004; Ozcan, 2013). Khisfe and Abd-El-Khalick (2002) also mention that effective results are possible with cognitive teaching.

Regarding students' views on the nature of science, McComas (1996) shared the misconceptions about the nature of science with a 15-item list of 'scientific myths'. It is thought that the role of the preconceptions encountered in or before learning situations in the emergence of these myths is great. Considering the nature of science as a cognitive product (Khisfe & Abd-El-Khalick, 2002), its permanence, and the fact that it requires a deliberate and planned intervention in many studies, it is possible to define these 'scientific myths' as misconceptions. Vosniadou (2008) states that the most important feature that distinguishes misconceptions from other types of errors is that they are permanent and resistant to change.

The Need for Hot Conceptual Change

Science educators have organized various learning situations to eliminate misconceptions in their studies for many years and have emphasized the effectiveness of conceptual change strategies (Dole & Sinatra, 1998; Gregoire, 2003; Kocak ullah & Kural, 2010; McLure et al., 2020; Nadelson et al., 2018; Posner et al., 1982; Sinatra, 2005). Conceptual change is considered by Nussbaum and Novick (1982) as a process activated by cognitive and conceptual conflict. Posner et al. (1982) put forward the strategy of conceptual change through a cognitive balancing process that starts with cognitive dissatisfaction with the concept and continues until the search for a comprehensible, plausible, and an efficient new concept (Hewson & Hewson, 1984; Posner et al., 1982). Vosniadou (2008) defined this model as the classical model and stated that the cognitive characteristics of the learner and the conceptual change process were addressed. The classical model's limited focus on students' cognitive processes and the learner-centered approaches in the learning-teaching processes emerging afterwards necessitated including affective and cognitive characteristics in the instruction process. The limited focus of conceptual change on cognitive

aspects is characterized as cold conceptual change by Pintrich et al. (1993). The focus of the criticism is that motivational aspects related to the individual are not taken into account. Addressing the effect of motivation and metacognition, Dole and Sinatra (1998) define the process of conceptual change as lukewarm and argue that while dissatisfaction supports motivation, high motivation supports high-level cognition and even metacognition and full conceptual change will be achieved (Özdemir & Kocakulah, 2021). Gregoire (2003) discussed the importance of motivation, self-efficacy, and intuitive-systematic processing processes and clues in the model called warm conceptual change. The warm and hot tendencies of conceptual change mentioned here have led to the idea that there is a multifactorial structure in the process and that each new factor increases the temperature by one level (Kural & Kocakulah, 2016). Considering that there are many factors that directly and indirectly interact with hot conceptual change in learning and teaching processes, a multifactorial conceptual change model has been presented today (Kocakulah, 2024; Nadelson et al., 2018; McLure et al., 2020). As seen, the conceptual change model has also changed in the historical process, as in the approach to NOS teaching.

There are many studies in which NOS aspects are included in the teaching process by combining the explicit-reflective approach with different methods or techniques. In recent years, research-inquiry (Capps & Crawford, 2013; Khisfe & Abd-El-Khalick, 2002; Kinyota, 2020; Ozgelen et al. 2013; Schwartz et al., 2008; Widowati, 2017), argumentation (Acar et al., 2010; Eymur, 2019; Khishfe, 2012; Khishfe, 2014; Khishfe, 2021; Khishfe, 2022; Kutluca & Aydin, 2017; McDonald, 2010), problem-based learning (Akerson et al., 2006; Akerson et al., 2014; Dogan, 2017; Moutinho, et al., 2015; Sousa, 2020) and conceptual change (Abd-El-Khalick & Akerson, 2004; Cho et al., 2011; Clough, 2006; Cil, 2014; Mansour et al., 2016) approaches are frequently encountered in the NOS teaching. Despite these studies, there have been no studies found directly teaching the features related to NOS with the hot conceptual change model in which some affective aspects are also taken into consideration.

Addressing all the above mentioned, this study aims to determine the effectiveness of hot conceptual change strategy based on inquiry-based learning compared with mere inquiry-based learning in changing 7th grade students' NOS views. More specifically, the focus of this study is to evaluate the effect of the application of hot conceptual change to the teaching model on students' understanding of NOS. For this purpose, the following research question was asked: What is the effect of hot conceptual change based teaching on 7th grade students' understanding of NOS.

Material and Methods

Participants

The study was conducted with a total of 24 7th-grade students studying in two different classes in a village school (middle and low socio-economic level) in the South Marmara region of Turkey. From the two classes, the 7/A class was selected as the control group (14 students: 4 girls) while the 7/B class was selected as the experimental group (10 students: 3 girls) by the lottery method. The teaching continued throughout the Light Unit. The 2013 science curriculum was based on the inquiry approach. In both groups, the NOS aspects were integrated with the subject matter in a explicit-reflective approach. In the experimental group, unlike the control group, teaching was planned by including the hot conceptual change model in the process.

Data Collection Tools

The data of the study were obtained by using the Opinions on the Nature of Science Questionnaire (ONSQ) and semi-structured interviews. The ONSQ was administered as a pre-test approximately one month before teaching. Then, semi-structured interviews were conducted with selected students. Thus, the students' pre-instructional views on NOS were obtained. In the lesson after the completion of the instruction, the ONSQ was applied as a posttest. In the following week, semi-structured interviews were conducted again. The posttest data were used to determine how the students' views on NOS changed as a result of the instruction.

ONSQ: A questionnaire with nine open-ended questions developed by Cil (2010) compiled from different studies was used to determine the views on the aspects of the nature of science. The opinions of three faculty members in science education department were obtained about the scale in this form. It was administered to 25 8th-grade students. It was observed that each question generally elicited responses related to the feature to be measured. As such, it was deemed appropriate to administer the ONSQ to the experimental and control groups as pretest and posttest.

Semi-structured interviews: After the administration of the questionnaire, two students from each group were selected voluntarily and interviewed individually. During the interviews, the students were given the questionnaires to examine their own responses and the items in the questionnaire were asked again verbally, thus increasing the validity of the answers given to the questionnaires (Lederman et al., 1998). In addition, the students were asked different questions about science and its characteristics, and their views were tried to be analyzed in depth. The interviews lasted an average of 30 minutes and were then recorded on a computer and transcribed.

Teaching Practices

In the study, NOS aspects were addressed within the 7th-grade light unit. In the learning process, inquiry-based learning (IBL) in the Minister of National Education (2013) Science Curriculum is the basic approach. In the learning process designed for the experimental group, the hot conceptual change model and IBL were integrated. Teaching practices included the concepts of light and NOS aspects (*general view about science, empirical aspect, tentative aspect, imagination and creativity, subjective aspect, social aspect, the difference between observation and inference*). In the present study, the practices related to the 7th-grade learning outcomes were carried out by the researcher, who was a teacher in the Republic of Turkey Ministry of National Education, for 4 hours per week during 7 weeks. In addition, factors and activities for factors were introduced for 4 hours. The practices continued for a total of 28 hours.

While organizing the learning process, the learning cycle was integrated with the inquiry cycle discussed by Pedaste et al. (2015) and the “*Guided Inquiry Process*” described by Kuhlthau et al. (2007). In this way, a learning process in which students will demonstrate their metacognitive skills and motivation is defined. While the instructional strategy IBL, the focus of the curriculum, was arranged, the guided inquiry was brought to the forefront at the 7th-grade level (Ministry of National Education, 2013). For this reason, the guided inquiry was preferred in the study considering the readiness of the students. Kuhlthau et al. (2007) base the guided inquiry process on theories about the knowledge-seeking process, the third domain, and *know-want-learn* (KWL). The knowledge-seeking process is the provision of all the guidance needed to the learner. The third domain is the creation of a learning process that is life itself by placing the school in the third domain where the pre- and post-learning intersect. KWL is explained as a process in which students take responsibility for all their learning by asking themselves “*What do I know?*”, “*What do I want to learn?*”, “*What have we learnt?*”, “*How do I find out?*”, “*How do I share what I have learnt?*” and “*What’s next?*” questions in all teaching stages, thus providing support in terms of motivation and metacognition factors (**Figure 1**).

Table 1 shows the IBL process and stages in the experimental and control groups, which were formed by associating the learning process in **Figure 1** with the learning cycle.

Table 1 and **Figure 1** guided the development of lesson plans and student worksheets as well as the IBL process. Experimental and control group lesson plans and student worksheets were prepared for each learning outcome. In the selection of the contents of the control group’s lesson plans, the Ministry of National Education textbook was used. In the experimental group, the contents of lesson plans were created by selecting the activities designed by the researchers. Since the development process of the worksheets can be the subject of another research, a detailed explanation is

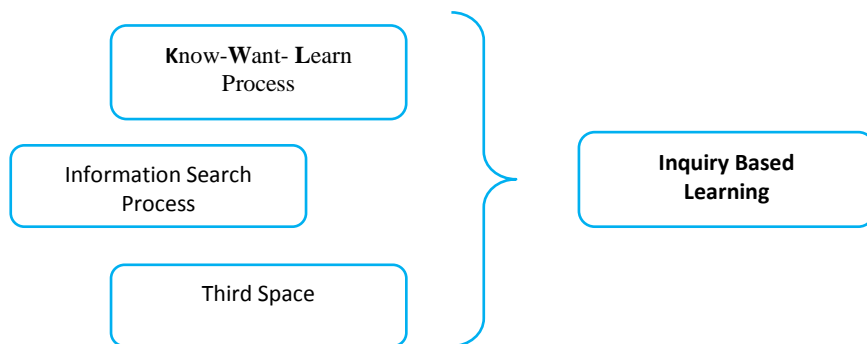


Figure 1. Components of Inquiry-Based Learning.

Table 1. The Process and Stages of IBL in the Experimental and Control Groups.		
Main Stages	Sub Stages	Learning Process Question
Preparation	Recalling prior knowledge about the subject	What do I know?
Conceptualization	Questioning and problem-creation	What do I want to know?
Conduct Research	Exploration- experimentation- Interpreting	How to find out and research
Finalization	Sharing Result	What have I learnt? How can I use what I've learnt? What's next?

not given here. However, in terms of validity and reliability, the opinions of 3 experts in the field of science education were taken. In addition, the whole process described here was tested with a pilot study in the same school one year before the actual implementation. All stages and activities were reviewed and deficiencies were eliminated.

The learning process carried out in the experimental group requires the combination of hot conceptual change and IBL. In the hot conceptual change model, the assumption that an individual's affective characteristics affect the conceptual change process together with his/her cognitive characteristics is accepted. In this study, cognitive characteristics were determined as NOS aspects and light concepts, while affective characteristics were determined as motivation towards science lessons, metacognition, and scientific epistemological beliefs. These factors and the hot conceptual change discussed in the current study are shown in **Figure 2**.

As can be seen in **Figure 2**, metacognition, motivation towards science lessons, and scientific epistemological belief factors were integrated

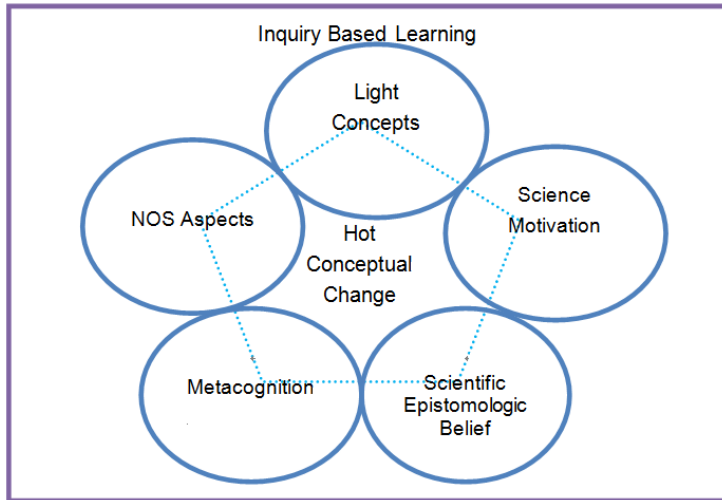


Figure 2. Background of Hot Conceptual Change.

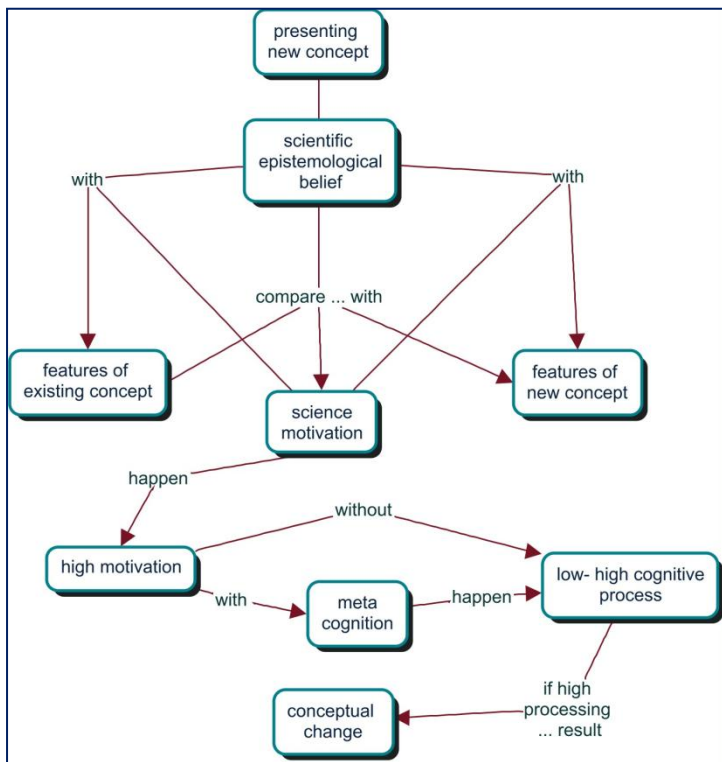


Figure 3. Hot Conceptual Change Process Applied in the Experimental Group.

in accordance with the IBL process to determine a hot path for complete conceptual change. Warm conceptual change was achieved with these factors. Four different activities were designed for motivation and metacognition support. These 5- 10 minutes activities were applied when the students felt that they were having problems, thus students were supported in terms of motivation and metacognition factors. Scientific epistemological beliefs were provided by adding content related to the history of science and the nature of science and thought-provoking questions to the course materials. In this way, students were encouraged to interact to create new ideas. In terms of these factors, students were encouraged to question themselves. For this purpose, they were encouraged to evaluate themselves scientifically. A student list was prepared on the class board. On this board, the class rules created together was listed. At the end of each activity, “the best and the favorites” was determined with the class and symbolic rewards were given. Students’ interaction with the factors was ensured through rewards. **Figure 3** shows the flow chart of the hot conceptual change.

The stages in the preparation of lesson plans in the experimental and control groups during the learning process are given in **Table 1** and **Figure 2**. Differently, in the experimental group, planning was made by following the processes in **Figure 3**. During the learning process, the experimental and control group students were divided into subgroups of 3 to 4 students. These groups were tried to be heterogeneous in terms of participation and success. In this situation, the researcher, who is the first author of the article, benefited from his previous experience with the students since he was already the teacher of the course. The students followed the questions and activities in the worksheets given to them during the lessons. Each lesson started with the preliminary knowledge and preparation phase, and it was aimed to understand the learning outcome with the examination of the preliminary knowledge. Students were required to ask themselves the question of “*what do I know?*” This was followed by the conceptualization phase. Here, students started to realize the new outcome. Then, the students were asked the question “*what do I want to know?*” In the experimental group, in addition, “*the comparison of the existing concept and the new concept*” took place at this stage. The next stage was the “*conducting research*” section in both groups. In this section, students designed the learning process through the research process. The teacher presented alternative ideas in addition to the students’ own ideas and guided them in the ways they would choose. The main question of the research section was “*How will I learn and research?*” Different from the control group, the students were guided to realize that their existing concepts did not solve the existing problem by comparing the concepts and thus to see the formation of the new concept as a need in the experimental group. In the subgroups that could not achieve this awareness, the researcher provided guidance with

additional questions. Finally, in the finalization phase, an evaluation of what has been learnt was made. In addition, a scientific communication process was created, and the student sought answers to the questions “*What have I learnt?*”, “*How can I use what I have learnt?*” and “*What is next?*” In the experimental group, at this stage, the results of conceptual change were evaluated, and activities were included for transferring the new concept and monitoring the results. All these processes were presented in separate sections as questions and activity applications in the worksheets of the students, and it was a resource for both the researcher and the student as a lesson plan and course material to follow different parts of the course.

Data Analysis

During the content analysis, students’ ONSQ responses related to the aspects of the nature of science were coded as sentences as the unit of analysis. Responses to different questions related to the same aspect were analyzed. In this way, students’ ideas about the aspects were categorized as weak (1), variable (2), and high (3). A gain score was calculated between the scores obtained in the pre-test and the scores obtained in the post-test. While calculating the gain score, the normalized gain score (<n>) proposed by Marx and Cumming (2007) was used. In this context, the <n> calculation allows comparison on a student basis and provides a strong statistical basis as the results are high (Setiawan, 2020). Equation 1 was used to find the normalized gain scores.

Equation 1,

$$<n> = \begin{cases} \frac{POST - PRE}{FULL - PRE} & , (POST > PRE) \\ 0 & , (POST = PRE) \\ \frac{POST - PRE}{POST} & , (POST < PRE) \end{cases}$$

The coding and scoring process was carried out for the pretest and posttest data. Then, mean <n> was obtained for the groups. To interpret these values, those less than 0.00 were categorized as negative gain; between 0.00 and 0.30 as low gain; between 0.30 and 70 as medium gain; and between 0.70 and 1.00 as high gain (Marx & Cummings, 2007). Comparisons of the groups are presented in the findings section. For the reliability of the scoring, the pretest and posttest ONSQ data were also coded and scored by a faculty member who is an expert in the field of science education. Cohen’s kappa analysis was applied for inter-coder agreement

Table 2. Experimental and Control Groups Gain Scores for the Aspect of General Opinion about Science.

Aspect	Group	Pre-test	Post-test	<n>	Gain value
General Opinion about Science	Control Group	1.36	1.64	0.174	Low
	Experimental Group	1.40	2.10	0.438	Middle*

Table 3. Experimental and Control Group Gain Scores for the Empirical Aspect.

Aspect	Group	Pre-test	Post-test	<n>	Gain value
Empirical	Control Group	1.29	1.50	0.125	Low
	Experimental Group	1.20	1.40	0.111	Low

(Kilic, 2015). Cohen's kappa value was found to vary between 0.77 and 0.96 in all aspects and the secondary researcher agreement was interpreted as good and very good ($p < 0.05$). This result is presented as evidence for the scoring reliability of the scale.

Results

The findings obtained by analysing the ONSQ data and the student opinion change schemes are shared respectively. **Table 2** shows the gain scores and values of the experimental and control groups for the aspect of general opinion about science.

According to **Table 2**, it is seen that the experimental and control group students differed in terms of the “*general opinion about science*” aspect and that the control group students had a low level gain and the experimental group students had a medium level gain. When the interviews were analyzed, student K12 said “*science is an invention, discovery and invention*” before the teaching and changed his opinion as “*science is the knowledge found by experiment, observation and research*” after the teaching. Regarding the same subject, D7 first defined science as “*things that make life easier and make the mind work*” and in the last interview, he said, “*It is the correct information that changes and is proven. It can be proved, it can change, it is discovered as a result of experiments*”.

Table 3 shows the gain scores of the experimental and control groups for the empirical aspect. When **Table 3** is examined, it is evident that the groups could not differentiate on the “*empirical aspect*” feature of science,

Table 4. Experimental and Control Group Gain Scores for the Tentative Aspect.

Aspect	Group	Pre-test	Post-test	<n>	Gain value
Tentative	Control Group	1.71	2.57	0.667	Middle
	Experimental Group	1.60	2.40	0.571	Middle

both groups remained at low level gains, but the gain value was in favor of the control group.

In the interview records, student D3's statement "*You cannot try something without experiments*" in the pre-interview was changed to "*We cannot try something without experiments. It cannot be done at once, it must be done again and again. Experiments are done to prove, discover and explain*". Furthermore, it is found that the explanation of the K8 that "*experiments are done to discover and investigate*" in the pre-interview was changed to "*science cannot exist without experiments. I don't know why they are done*". **Table 4** shows the gain scores and values for the tentative aspect as another NOS aspect.

Table 4 shows that the experimental and control group students were at intermediate level of gain and did not differ. On the other hand, it is seen that the normalised gain scores were in favor of the experimental group. When the pre-interview records were analyzed, K12 said "*old knowledge is forgotten and not used. Even the methods here are not used*" and D3 shared the view that "*old knowledge is accepted, but missing knowledge is added*". In the post interviews, K12 used the expression "*old knowledge is forgotten and no longer used*" and D8 used the expression "*old knowledge is forgotten*". On the other hand, in response to the explanation of K12 that "*atoms are first likened to different shapes and then new models are produced according to experiments and their results*", D8 said "*One scientist said that light comes to the eye, another said that it comes to the object. Another one found that we see with the light reflected from the object*" and supported his sufficient opinion about the tentative aspect with an example. The next findings regarding the gain scores and values of the experimental and control group students related to imagination and creativity are shown in **Table 5**.

Regarding the "*imagination and creativity aspect*", it was found that the experimental and control group students were in the middle level of gain, that is, they could not differentiate (**Table 5**). On the other hand, it is seen that there is a differentiation in favor of the experimental group in the normalized gain scores. In the pre-interviews, it was determined that K8 shared the explanation of "*imagination is what you think*" and D3 shared the explanation of "*creativity is design*". In the final interviews, it was observed

Table 5. Experimental and Control Group Gain Scores for the Imagination and Creativity Aspect.

Aspect	Group	Pre-test	Post-test	<n>	Gain value
Imagination and Creativity	Control Group	2.21	2.57	0.455	Middle
	Experimental Group	1.70	2.40	0.538	Middle

Table 6. Experimental and Control Group Gain Scores for the Subjective Aspect.

Aspect	Group	Pre-test	Post-test	<n>	Gain value
Subjective	Control Group	1.93	2.50	0.533	Middle
	Experimental Group	1.60	2.70	0.738	High*

Table 7. Experimental and Control Group Gain Scores for the Social Aspect.

Aspect	Group	Pre-test	Post- test	<n>	Gain value
Social	Control Group	2.14	2.29	0.167	Low
	Experimental Group	1.80	2.80	0.833	High*

that K8 stated “*imagination is to dream*”, while D3 stated “*imagination is the beginning of the next invention*”.

Table 6 shows the findings including the gain scores and values of the groups regarding the ‘subjective element’. When **Table 6** is analyzed, it is observed that the experimental group obtained high level gain and the control group obtained medium level gain. There is a difference in favor of the experimental group in terms of the subjective aspect. In the pre-interview, it was found that the students in the experimental and control groups answered the question about the reason why scientists’ explanations about the same subject were different with the common explanation “because their feelings and thoughts were different”. In the final interview, it was observed that student K8 said “*they do not use their emotions, there is no need because they already find out through experiments and observations*”, whereas D7 said “yes, they do, but emotions, thoughts and ideas can change according to everyone”. **Table 7** shows the gain scores and values of the experimental and control group students about the social aspect of the NOS.

When the “social aspect” data is examined, results in favor of the experimental group are noticed. It was found that the experimental group students had high gains while the control group students had low gains

Table 8. Experimental and Control Group Gain Scores for the Difference between Observation and Inference.

Aspect	Group	Pre-test	Post- test	<n>	Gain value
Difference between Observation and Inference	Control Group	1.79	2.00	0.176	Low
	Experimental Group	1.80	2.70	0.750	High*

(**Table 7**). When the interview records were analyzed, it was found that student K8 stated “*it does not affect the society, but it affects the structure of the society: science is affected by the society, it takes the society’s opinion*” and D3 also stated “*it does not affect the society, it affects (later), I do not know*” in the pre-interviews. In the final interviews, student K8 stated that “*science affects the societies, the traditions of the society they live in are important. It meets the needs of the society they live in, after all, the society uses what is found*”; D3 said, “*No, it does not affect. It meets the needs of the society they live in. Society cannot exist without science; science cannot exist without society*”.

Table 8 presents the results of the analyses of the gain scores and values of the students in the experimental and control groups on the last aspect, the difference between observation and inference.

Differences were found in the gain scores and values of the experimental and control groups regarding the difference between observation and inference in favor of the experimental group (**Table 8**). Among the students’ opinions obtained from the interviews related to this aspect are as follows: In the pre-interview, student K12 said “*Observation is to analyze something. Inference is to deduce the result of a process.*” For D7, “*observation: I have no idea*” and did not mention inference. In the post interviews, the student in the control group stated that he had no idea about observation and inference and provided the explanation that “*weather forecasts are made from satellites outside the world*”. In the post interview of the experimental group, D7 said “*Observation is looking at something. It is to see how something happens in experiments. It is to take note of what is seen. Inference is the interpretation made as a result of observation*”.

Discussion

In this study, the effect of the instructional model developed on the basis of hot conceptual change on middle school 7th-grade students’ understanding of NOS aspects was investigated. The analyses showed that the experimental and control group students had largely weak views in terms of all NOS aspects before the instruction. Considering that the students participating in

this study have been taking science courses since the 3rd-grade, the results obtained can be interpreted as that the current science program does not contribute to the students' adequate level of NOS understanding. Similar to the results of this study, many studies in the literature reveal that although students have received a formal science education, their understanding of NOS is not at the desired level too (Bell et al., 2011; Kang et al., 2005; Khishfe, 2020; Parker et al., 2008; Peters-Burton et al., 2022).

The results obtained after the instruction show that the gain scores of the students in both groups are in the direction of positive gains ranging between low and high levels. Although science-related activities produce effective results in the development of NOS, they do not provide the development of a comprehensive understanding of NOS (Alisir & Irez, 2020; Flick & Lederman, 2004; Khishfe, 2022). However, it is thought that the reason for the small gain differences in the present study is that the practices in both groups were directly based on the philosophy of explicit-reflective approach. In support of this idea, Ozer et al. (2021) state that more activities do not mean more development of accurate NOS understanding.

It was found that the gain scores in the aspects of general view about science, social aspect, and subjective aspect, the difference between observation and inference in the experimental group were higher than the gain scores in the control group, which may be due to the hot conceptual change. Dole and Sinatra (1998) defined cognitive conflict and motivation for conceptual change and the motivation processes that lead to the activation of metacognition. In the present study, the use of quotations from the history of science and interesting activities may explain the results in favor of the experimental group. It is also seen in the literature that historical scientific events as a complement to science-related activities are an effective way to develop students' understanding of the nature of science (Abd-El-Khalick, 2005; Alisir & Irez, 2020; Khishfe, 2022; Solomon et al., 1992). On the other hand, no significant difference was found between pre-service teachers who received a short education on the history of science and philosophy of science and those who did not receive this education in terms of NOS views (Erdas Kartal et al., 2018). Based on all these results, it is thought that the changes in some NOS views in favor of the experimental group in the current study are the product of hot conceptual change. On the other hand, it is not possible to know how much the effect of the history of science stories and activities used to support the teaching process in the study. Investigation of such an effect can be carried out as the subject of another study.

Although both groups obtained positive results in terms of NOS aspects, it was found that the control and experimental groups did not differ in terms of empirical aspect, tentative aspect, imagination, and creativity. After the application, it was concluded that weak opinions decreased in both

groups, but there was no differentiation in gain values although variable and sufficient opinions increased. The first aspect related to this situation is the empirical nature of science where low gains are seen. When the studies focusing on the teaching of NOS aspects are examined, it is seen in various studies that there are weak opinions about the empirical aspect before the application (Bakirci et al., 2017; Bell et al., 2016; Brunner & Abd-El-Khalick, 2020; Schellinger et al., 2019).

It is stated that research-based activities contribute to the change of students' views on the nature of science (Akerson et al., 2014; Schellinger et al., 2019). Similarly, studies that obtained significant results related to the experimental aspect with the conceptual change process were also found (Bakirci et al., 2017; Bell et al., 2016; Clough, 2006). In addition, it was observed in the interviews that the students maintained the view that "*there is no research without experimentation*". It is thought that this finding may have resulted from the association of experiments with science, which is very appropriate to the nature of science education (Irez, 2015; Khishfe, 2022; McComas, 2004). It is also thought that the guided inquiry planned in the research phase of the course in this study may have revealed the belief that "*experiment is a must*" (Akerson et al., 2014). This situation arising from the nature of teaching can be presented as a limitation. However, considering that the foundation of students' naive ideas is shaped from an early age, it can be argued that the "*crazy scientist figure doing explosive experiments*" that students may encounter in the media or in various books may have contributed to the establishment of the view that "*science is experimentation*" as a fundamental and indestructible misconception. However, it may be suggested to plan different studies to reveal how this view is so ingrained in the minds of the students.

It was observed that another aspect in which the experimental and control groups reached medium level gains before the application and did not differentiate as a result of the application was the tentative nature of science. Variable opinions were found to be intense in both groups and similarly, weak and variable opinions were found in different studies in the field before the implementation (Bakirci et al., 2017; Bell et al., 2016; Clough, 2006; Schellinger et al., 2019). After instruction, the groups gained medium level gains related to the tentative aspect. In addition, hot conceptual change did not cause differentiation between the groups. Although significant results were obtained in different age groups with the applications carried out in some studies on the tentative aspect (Bell et al., 2016; Clough, 2006; Khishfe, 2022; Schellinger, et al., 2019), it was observed that the pedagogy related to conceptual change also revealed positive results (Bakirci et al., 2017; Cil, 2014). However, no study has been encountered regarding the hot conceptual change and the tentative aspect. It is thought that the activities in the worksheets prepared for the hot

conceptual change process in the current study may not have been followed by the students or may have been boring. In addition, the fact that students do not read scientific content in daily life is another problem (Bakirci, et al., 2017). As a suggestion here, the motivation process can be contributed to by creating a conflict process with cartoons involving more pictures or with short documentaries on the history of science. Considering these, experimental research can be conducted to determine which one affects the hot conceptual change process more.

Another result is that the gain scores related to the aspects of imagination and creativity constitute medium level gains for the experimental and control groups. Prior studies show similarities in the distribution of opinions before the instruction in different age groups (Erdas Kartal et al., 2018; Bell et al., 2016; Khishfe, 2022). Despite the decrease in weak opinions after the instruction, the rate of adequate opinions in the experimental group was 40% and 64% in the control group. It has been observed that there are studies that have achieved positive results in the opinions of the sample with different applications (Bell, et al., 2016; Erdas Kartal et al., 2018; Khishfe, 2022). However, positive results of the applications related to conceptual change on student development in the aspect of imagination and creativity are also found (Bakirci et al., 2017; Cil, 2014). On the other hand, in Ozer et al.'s (2021) study, while there was no significant difference in the results of 5th- and 6th-grade students in the context of age groups, a significant difference was found in 7th-grade students. As a result of this study, it was explained that there is a misconception in Turkey because creativity and imagination are handled in the context of art and artists. It is necessary to evaluate the situation in the current study differently. Although there was an improvement in the groups towards creativity and imagination aspect, there was no differentiation in the experimental group. However, it is thought that this situation may have occurred as a result of a common effect of age, aspect, and application due to the disadvantages of the settlement where the sample is located. The reasons for the emergence of this result can be suggested as the subject of another study.

Accordingly, it was concluded that the hot conceptual change model applied in the experimental group was effective on some NOS aspects. Bakirci et al. (2017) examined the effects of the *Common Knowledge Constructs Model* (CKCM) and the 5E model on 6th-grade students' views on the nature of science. In the study, results were obtained in favor of the experimental group in terms of the development in NOS views. In the literature, there are other studies in which positive developments have been observed in the groups in which conceptual change pedagogy for NOS was applied (Cil, 2010; Cil & Cepni, 2016). In another similar study in which the sample was selected as pre-service teachers, Abd-El Khalick and Akerson

(2004) determined that the views of pre-service teachers who initially had weak views improved with the explicit-reflective NOS approach under conceptual change-based learning conditions. These studies in the literature provide evidence to support the results obtained in this study.

It was concluded that the explicit-reflective approach based guided IBL process applied in the control and experimental groups was effective in developing positive gains related to NOS aspects compared to the pre-instruction. When the literature is examined, it is stated in many studies that successful results can be obtained by addressing NOS aspects as an explicit, reflective, and cognitive product (Lederman et al., 1998; Schwartz et al., 2004; Teig et al., 2019). Sagır and Kilic (2013) explain that scientific discussions in which communication and discussion are at the forefront are more effective than the traditional method. Here, the Guided IBL process in the basic framework of teaching practices is considered as a process that includes all the skills mentioned (Constantinou et al., 2018). In this respect, it is thought that the Guided IBL process may have contributed to students' understanding of the NOS.

The qualitative findings obtained from this study shows that metacognition, motivation towards science lessons, and scientific epistemological belief factors were effective in supporting the hot conceptual change process. In addition, these findings could explain the results obtained in favor of the experimental group in terms of some of the NOS aspects in the experimental and control groups. It should be noted that the student group in which the research was conducted was located in a rural area and had families at low socio-economic level posed a significant problem for the researchers during the teaching process. During this research, it was observed that students' transfer to school by shuttle sometimes caused them to be late, and this situation caused some lessons to be prolonged and as a result, their motivation decreased. Therefore, it is recommended that such factors should be taken into consideration in future similar studies.

References

- Abd-El-Khalick, F. (2005). Developing deeper understandings of nature of science: The impact of a philosophy of science course on preservice science teachers' views and instructional planning. *International Journal of Science education*, 27(1), 15-42. DOI: <https://doi.org/10.1080/09500690410001673810>
- Abd-El-Khalick, F. & Lederman, N., G., (2000). Improving science teachers' conceptions of nature of science: A critical review of the literature. *International Journal of Science Education*, 22(7), 665- 701. DOI: <https://doi.org/10.1080/09500690050044044>
- Abd-El-Khalick, F., & Akerson, V. L. (2004). Learning as conceptualchange: Factors mediating the development of preservice elementary teachers' views of nature of

- science. *Science Education*, 88(5), 785-810. DOI: <https://doi.org/10.1002/sce.10143>
- Acar, O., Turkmen, L., & Roychoudhury, A. (2010). Student difficulties in socio-scientific argumentation and decision-making research findings: Crossing the borders of two research lines. *International Journal of Science Education* 32(9), 1191-1206. DOI: <https://doi.org/10.1080/09500690902991805>
- Akerson, V. L., Abd-El-Khalick, F., & Lederman, N. G. (2000). Influence of a reflective explicit activity-based approach on elementary teachers' conceptions of nature of science. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching* 37(4), 295-317. DOI: [https://doi.org/10.1002/\(SICD\)1098-2736\(200004\)37:4<295::AID-TEA2>3.0.CO;2-2](https://doi.org/10.1002/(SICD)1098-2736(200004)37:4<295::AID-TEA2>3.0.CO;2-2)
- Akerson, V. L., Morrison, J. A., & McDuffie, A. R. (2006). One course is not enough: Preservice elementary teachers' retention of improved views of nature of science. *Journal of Research in Science Teaching*, 43(2), 194-213. DOI: <https://doi.org/10.1002/tea.20099>
- Akerson, V., Weiland, I., Park Rogers, M., Pongsanon, K., & Bilican, K. (2014). Exploring elementary science methods course contexts to improve preservice teachers' NOS of science conceptions and understandings of NOS teaching strategies. *Eurasia Journal of Mathematics, Science, and Technology Education*, 10(6), 647-665. DOI: <https://doi.org/10.12973/eurasia.2014.1226a>
- Alisir, Z. N. & Irez, S. (2020). The effect of replicating historical scientific apparatus on high school students' attitudes towards science and their understanding of nature of science. *Science & Education*, 29(5), 1201- 1234.
- Bakirci, H., Calik, M., & Cepni, S. (2017). The effect of the common knowledge construction model-oriented education on sixth grade students' views on the nature of science. *Journal of Baltic Science Education*, 16(1), 43.
- Bell, R. L., Matkins, J. J., & Gansneder, B. M. (2011). Impacts of contextual and explicit instruction on preservice elementary teachers' understandings of the nature of science. *Journal of Research in Science Teaching*, 48(4), 414-436. DOI: <https://doi.org/10.1002/tea.20402>
- Bell, R. L., Mulvey, B. K. & Maeng, J. L. (2016). Outcomes of nature of science instruction along a context continuum: Preservice secondary science teachers' conceptions and instructional intentions. *International Journal of Science Education*, 38(3), 493-520. DOI: <https://doi.org/10.1080/09500693.2016.1151960>
- Brunner, J. L. & Abd-El-Khalick, F. (2020). Improving nature of science instruction in elementary classes with modified science trade books and educative curriculum materials. *Journal of Research in Science Teaching*, 57(2), 154-183. DOI: <https://doi.org/10.1002/tea.21588>
- Capps, D. K., & Crawford, B. A. (2013). Inquiry-based instruction and teaching about nature of science: Are they happening? *Journal of Science Teacher Education*, 24(3), 497-526. DOI: <https://doi.org/10.1007/s10972-012-9314-z>
- Cho, M. H., Lankford, D. M., & Wescott, D. J. (2011). Exploring the relationships among epistemological beliefs, nature of science, and conceptual change in the learning of evolutionary theory. *Evolution: Education and Outreach*, 4, 313-322. DOI: <https://doi.org/10.1007/s12052-011-0324-7>
- Clough, M. P. (2006). Learners' responses to the demands of conceptual change: Considerations for effective nature of science instruction. *Science & Education*, 15, 463-494. DOI: <https://doi.org/10.1007/s11191-005-4846-7>
- Chaiyabang, M. K., & Thathong, K. (2014). Enhancing Thai teacher's understanding and instruction of the nature of science. *Procedia-Social and Behavioral Sciences*, 116, 563-569. DOI: <https://doi.org/10.1016/j.sbspro.2014.01.258>
- Colburn, A. (2000). An inquiry primer. *Science Scope*. 2000(Special issue), 42-44.
- Conley, A. M., Pintrich, P. R., Vekiri, I., & Harrison, D. (2004). Changes in epistemological beliefs in elementary science students. *Contemporary Educational Psychology*, 29(2), 186-204. DOI: <https://doi.org/10.1016/j.cedpsych.2004.01.004>
- Constantinou, C.P., Tsivitanidou, O.E., Rybska,

- E. (2018). What is inquiry-based science teaching and learning?. In: Tsivitanidou, O., Gray, P., Rybska, E., Louca, L., Constantinou, C. (eds) Professional development for inquiry-based science teaching and learning: Contributions from science education research, vol 5. Springer, Cham. DOI: https://doi.org/10.1007/978-3-319-91406-0_1
- Cil, E. (2010) Bilimin doğasının kavramsal değişim pedagojisi ve doğrudan yansıtıcı yaklaşım ile öğretilmesi: Işık ünitesi örneği. Ph. D. diss., Karadeniz Teknik Üniversitesi, Trabzon.
- Cil, E. (2014). Teaching nature of science through conceptual change approach: Conceptual change texts and concept cartoons. *Journal of Baltic Science Education*, 13(3), 339-350.
- Cil, E., & Cepni, S. (2016). The effectiveness of conceptual change texts and concept clipboards in learning the nature of science. *Research in Science & Technological Education*, 34(1), 43-68. DOI: <https://doi.org/10.1080/02635143.2015.1066323>
- Demirbas, M., & Balci, F. (2013). Bilimin doğası ve öğretimi. Pegem Akademi. pp. 73-92.
- Dogan, N. (2017). Blending problem based learning and history of science approaches to enhance views about scientific inquiry: New wine in an old bottle. *Journal of Education and Training Studies*, 5(10), 99-112.
- Dole, J. A., & Sinatra, G. M. (1998). Reconceptualizing change in the cognitive construction of knowledge. *Educational psychologist*, 33(2-3), 109-128.
- Erdas Kartal, E., Cobern, W. W., Dogan, N., Irez, S., Cakmakci, G., & Yalaki, Y. (2018). Improving science teachers' nature of science views through an innovative continuing professional development program. *International Journal of STEM education*, 5, 1-10. DOI: <https://doi.org/10.1186/s40594-018-0125-4>
- Erdogan, M. N., & Koseoglu, F. (2015). Kimyasal denge konusuna entegre edilmiş açık düşündürücü yaklaşımla bilimin doğası öğretimi. *Eğitimde Kuram ve Uygulama*, 11(2), 717-741.
- Eymur, G. (2019). The influence of the explicit nature of science instruction embedded in the argument-driven inquiry method in chemistry laboratories on high school students' conceptions about the nature of science. *Chemistry Education Research and Practice*, 20(1), 17-29. DOI: <https://doi.org/10.1039/C8RP00135A>
- Flick, L. B., & Lederman, N. G. (2004). *Scientific inquiry and nature of science.* Kluwer Academic Publishers.
- Gill, M. G., Ashton, P., & Algina, J. (2004). Authoritative schools: A test of a model to resolve the school effectiveness debate. *Contemporary Educational Psychology*, 29(4), 389-409.
- Gregoire, M. (2003). Is it a challenge or a threat? A dual-process model of teachers' cognition and appraisal processes during conceptual change. *Educational Psychology Review*, 15, 147-179. DOI: <https://doi.org/10.1023/A:1023477131081>
- Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 66(1), 64-74. DOI: <https://doi.org/10.1119/1.18809>.
- Hewson, P. W., & Hewson, M. G. A. B. (1984). The role of conceptual conflict in conceptual change and the design of science instruction. *Instructional Science*, 13, 1-13. DOI: <https://doi.org/10.1007/BF00051837>
- Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67(1), 88-140. DOI: <https://doi.org/10.3102/00346543067001088>
- Johnson, M. L., & Sinatra, G. M. (2013). Use of task-value instructional inductions for facilitating engagement and conceptual change. *Contemporary Educational Psychology*, 38(1), 51-63. DOI: <https://doi.org/10.1016/j.cedpsych.2012.09.003>
- Jones, S. H., Johnson, M. L., & Campbell, B. D. (2015). Hot factors for a cold topic: Examining the role of task-value, attention allocation, and engagement on conceptual change. *Contemporary Educational Psychology*, 42, 62-70. DOI: <https://doi.org/10.1016/j.cedpsych.2015.04.004>
- Kang, S., Schermann, L. C., & Noh, T. (2005). Examining students' views on the nature of science: Results from Korean 6th, 8th, and 10th graders. *Science Education*, 89(2), 314-334. DOI:

- <https://doi.org/10.1002/sce.20053>
Khishfe, R. (2012). Relationship between nature of science understandings and argumentation skills: A role for counterargument and contextual factors. *Journal of Research in Science Teaching*, 49(4), 489-514. DOI: <https://doi.org/10.1002/tea.21012>
- Khishfe, R. (2014). Explicit nature of science and argumentation instruction in the context of socioscientific issues: An effect on student learning and transfer. *International Journal of Science Education*, 36(6), 974-1016. DOI: <https://doi.org/10.1080/09500693.2013.832004>
- Khishfe, R. (2020). Retention of acquired argumentation skills and nature of science conceptions. *International Journal of Science Education*, 42(13), 2181-2204. DOI: <https://doi.org/10.1080/09500693.2020.1814444>
- Khishfe, R. (2021). Explicit instruction and student learning of argumentation and nature of science. *Journal of Science Teacher Education*, 32(3), 325-349. DOI: <https://doi.org/10.1080/1046560X.2020.1822652>
- Khishfe, R. (2022). Nature of science and argumentation instruction in socioscientific and scientific contexts. *International Journal of Science Education*, 44(4), 647-673. DOI: <https://doi.org/10.1080/09500693.2022.2050488>
- Khishfe, R., & Abd-El-Khalick, F. (2002). Influence of explicit and reflective versus implicit inquiry-oriented instruction on sixth graders' views of nature of science. *Journal of Research in Science Teaching*, 39(7), 551-578. DOI: <https://doi.org/10.1002/tea.10036>
- Kilic, S. (2015). Kappa testi. *Journal of Mood Disorders*, 3(5), 142-144. DOI: 10.5455/jmood.20150920115439
- Kim, S. Y., & Irving, K. E. (2010). History of science as an instructional context: Student learning in genetics and nature of science. *Science & Education*, 19, 187-215. DOI: <https://doi.org/10.1007/s11191-009-9191-9>
- Kinyota, M. (2020). The status of and challenges facing secondary science teaching in Tanzania: A focus on inquiry-based science teaching and the nature of science. *International Journal of Science Education*, 42(13), 2126-2144, DOI: <https://doi.org/10.1080/09500693.2020.1813348>
- Kocak ullah, M. S., & Kural, M. (2010). Investigation of conceptual change about double-slit interference in secondary school physics. *International Journal of Environmental & Science Education*, 5(4), 435-460.
- Kocak ullah, A. (2024). Dole ve Sinatra'nın kavramsal deęişim modeli. In B. Pekdağ & N. Azizođlu (Eds.), *Kavramsal Deęişim Kuramları ve Uygulamaları* (pp.121-149). Dora Yayıncılık.
- Kuhlthau, C. C., Maniotes, L. K., & Caspari, A. K. (2007). *Guided inquiry: Learning in the 21st century*. Greenwood Publishing Group.
- Kural, M. (2015). Sıcak kavramsal deęişim için öğretim: 11. Sınıf modern fizik örneđi. Ph. D. diss., Balıkesir Üniversitesi, Balıkesir.
- Kural, M., & Kocak ullah, M. S. (2016). Teaching for hot conceptual change: Towards a new model, beyond the cold and warm ones. *European Journal of Education Studies*, 6(1), 78-90. DOI: <http://dx.doi.org/10.46827/ejes.v0i0.301>
- Kutluca, A. Y., & Aydin, A. (2017). Changes in pre-service science teachers' understandings after being involved in explicit nature of science and socioscientific argumentation processes. *Science & Education*, 26, 637-668. DOI: <https://doi.org/10.1007/s11191-017-9919-x>
- Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching*. 29(1), 331-359. DOI: <https://doi.org/10.1002/tea.3660290404>
- Lederman, N. G., Wade, P. D., & Bell, R. L. (1998). Assessing the nature of science: What is the nature of our assessments? *Science & Education*, 7, 595-615. DOI: <https://doi.org/10.1023/A:1008601707321>
- Lederman, N. (2007). Nature of science: Past, present and future. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of Research on Science Education* (pp. 831-879). Mahwah, NJ: Erlbaum.
- Mansour, N., Wegerif, R., Skinner, N., Postlethwaite, K., & Hetherington, L. (2016). Investigating and promoting trainee science teachers' conceptual change of the nature of science with digital dialogue games 'InterLoc'. *Research in Science Education*, 46, 667-684. DOI: <https://doi.org/10.1007/s11165-016-0000-0>

- [015-9475-9](#)
Marx, J. D., & Cummings, K. (2007). Normalized change. *American Journal of Physics*, 75(1), 87-91. DOI: <https://doi.org/10.1119/1.2372468>
- McComas, W. F. (1996). Ten myths of science: Reexamining what we think we know about the nature of science. *School Science and Mathematics*, 96(1), 10-16. DOI: <https://doi.org/10.1111/j.1949-8594.1996.tb10205.x>
- McComas, WF. (2004). The principal elements of the nature of science: Dispelling the myths: In W.F. McComas (Ed.), *The nature of science in science education: Rationales and strategies*. Dordrecht: Kluwer Academic Publishers. pp. 53- 70
- McComas, W. F., & Olson, J. K. (2004). The nature of science in international science education standards documents. In W. F. McComas (Ed.), *The nature of science in science education*. The Netherlands: Kluwer Academic Publishers. pp. 41–52
- McDonald, C. V. (2010). The influence of explicit nature of science and argumentation instruction on preservice primary teachers' views of nature of science. *Journal of Research in Science Teaching*, 47(9), 1137-1164. DOI: <https://doi.org/10.1002/tea.20377>
- McLure, F., Won, M., & Treagust, D. F. (2020). A sustained multidimensional conceptual change intervention in grade 9 and 10 science classes. *International Journal of Science Education*, 42(5), 703-721. DOI: <https://doi.org/10.1080/09500693.2020.1725174>
- Michel, H. & Neumann, I. (2016). Nature of science and science content learning: The relation between students' nature of science understanding and their learning about the concept of energy. *Science & Education*, 25, 951- 975.
- Ministry of National Education (2013). İlköğretim kurumları (ilkokullar ve ortaokullar) fen bilimleri dersi (3, 4, 5, 6, 7 ve 8. sınıflar) öğretim programı. Ankara: MEB Yayinevi.
- Ministry of National Education (2017). Fen bilimleri dersi öğretim programı (ilkokul ve ortaokul 3, 4, 5, 6, 7 ve 8. sınıflar). Ankara: MEB Yayinevi.
- Ministry of National Education (2018). Fen bilimleri dersi öğretim programı (ilkokul ve ortaokul 3, 4, 5, 6, 7 ve 8. sınıflar). Ankara: MEB Yayinevi.
- Moutinho, S., Torres, J., Fernandes, I., & Vasconcelos, C. (2015). Problem-based learning and nature of science: A study with science teachers. *Procedia-Social and Behavioral Sciences*, 191, 1871-1875. DOI: <https://doi.org/10.1016/j.sbspro.2015.04.324>
- Murat, M. (2022). 1999-2020 Yılları arasında çalışılmış “Bilimin Doğası” konulu makalelere bakış: Bir meta-sentez çalışması. Master's Thesis. Marmara Üniversitesi, İstanbul.
- Nadelson, L. S., Heddy, B. C., Jones, S., Taasoobshirazi, G., & Johnson, M. (2018). Conceptual change in science teaching and learning: Introducing the dynamic model of conceptual change. *International Journal of Educational Psychology*, 7(2), 151-195. DOI: <https://doi.org/10.17583/ijep.2018.3349>
- Nussbaum, J., & Novick, S. (1982). Alternative frameworks, conceptual conflict and accommodation: Toward a principled teaching strategy. *Instructional Science*, 10, 183-200. Available at: <http://www.jstor.org/stable/23368317>
- Ozgelen, S., Yilmaz-Tuzun, O., & Hanuscin, D. L. (2013). Exploring the development of preservice science teachers' views on the nature of science in inquiry-based laboratory instruction. *Research in Science Education*, 43, 1551-1570. DOI: <https://doi.org/10.1007/s11165-012-9321-2>
- Ozcan, H. (2013). Fen bilgisi öğretmen adaylarının fen içeriği ile ilişkilendirilmiş bilimin doğası konusundaki pedagojik alan bilgilerinin gelişimi. Ph. D diss., Gazi Üniversitesi, Ankara.
- Özdemir, E., & Kocak ullah, M. S. (2021). The effect of metacognitive supported argument-based learning approach on conceptual change and metacognition in physics education. *Necatibey Eğitim Fak ultiyesi Elektronik Fen ve Matematik Eğitimi Dergisi*, 15(1), 144-185. DOI: <https://doi.org/10.17522/balikesirnef.902038>
- Ozer, F., Dogan, N., Yalaki, Y., Irez, S. & Cakmakci, G. (2021). The ultimate beneficiaries of continuing professional development programs: Middle school students' nature of science views. *Research in Science Education*, 51(Suppl 2), 757- 782. DOI: <https://doi.org/10.1007/s11165-019-9824-1>
- Papadouris, N., & Constantinou, C. P. (2011). A philosophically informed teaching

- proposal on the topic of energy for students aged 11–14. *Science & Education*, 20(10), 961-979. DOI: <https://doi.org/10.1007/s11191-010-9305-4>
- Papadouris, N., & Constantinou, C. P. (2014). An exploratory investigation of 12-year-old students' ability to appreciate certain aspects of the nature of science through a specially designed approach in the context of energy. *International Journal of Science Education*, 36(5), 755-782. DOI: <https://doi.org/10.1080/09500693.2013.827816>
- Parker, L. C., Krockover, G. H., Lasher-Trapp, S., & Eichinger, D. C. (2008). Ideas about the nature of science held by undergraduate atmospheric science students. *Bulletin of the American Meteorological Society*, 89(11), 1681-1688. DOI: <https://doi.org/10.1175/2008BAMS2349.1>
- Pedaste, M., Mäeots, M., Siiman, L. A., De Jong, T., Van Riesen, S. A., Kamp, E. T., Manoli, C. C., Zacharia, Z. C., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational research review*, 14, 47-61. DOI: <https://doi.org/10.1016/j.edurev.2015.02.03>
- Peters-Burton, E. E., Dagher, Z. R., & Erduran, S. (2023). Student, teacher, and scientist views of the scientific enterprise: An epistemic network re-analysis. *International Journal of Science and Mathematics Education*, 21(2), 347-375. DOI: <https://doi.org/10.1007/s10763-022-10254-w>
- Pintrich, P. R., Marx, R. W., & Boyle, R. A. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational research*, 63(2), 167-199. DOI: <https://doi.org/10.3102/00346543063002167>
- Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science education*, 66(2), 211-227.
- Qian, G., & Alvermann, D. (1995). Role of epistemological beliefs and learned helplessness in secondary school students' learning science concepts from text. *Journal of Educational Psychology*, 87(2), 282. DOI: <https://doi.org/10.1037/0022-0663.87.2.282>
- Saadi, P., Clarita, D., & Sholahuddin, A. (2021). Guided inquiry assisted by metacognitive questions to improve metacognitive skills and students conceptual understanding of chemistry. In *Journal of Physics: Conference Series* (Vol. 1760, No. 1, p. 012023). IOP Publishing.
- Salisbury, J. D. (1996). The effects of text, motivation, self-regulated learning and epistemological beliefs on conceptual change. Ph. D. diss., The Pennsylvania State University, USA.
- Saunders, G.L. (1998). Relationship among epistemological beliefs, implementation of instruction and approaches to learning in collage chemistry. Ph. D. diss., University of Oklahoma, Norman, Oklahoma.
- Sinatra, G. M. (2005). The "warming trend" in conceptual change research: The legacy of Paul R. Pintrich. *Educational psychologist*, 40(2), 107-115.
- Solomon, J., Duveen, J., Scot, L., & McCarthy, S. (1992). Teaching about the nature of science through history: Action research in the classroom. *Journal of Research in Science Teaching*, 29(4), 409-421. DOI: <https://doi.org/10.1002/tea.3660290408>
- Sousa, C. M. (2020). Nature of science through problem-based learning: Effects on science epistemological and biology conceptions of students. Ph. D. diss., Universidade do Porto, Portugal.
- Schellinger, J., Mendenhall, A., Alemagne, N., Southerland, S.A., Sampson, V. & Marty, P. (2019). Using technology-enhanced inquiry-based instruction to foster the development of elementary students' view on nature of science. *Journal of Science Education and Technology*, 28, 341- 352.
- Schwartz, R. S., Lederman, N. G., & Crawford, B. A. (2004). Developing views of nature of science in an authentic context: An explicit approach to bridging the gap between nature of science and scientific inquiry. *Science Education*, 88(4), 610-645. DOI: <https://doi.org/10.1002/sce.10128>
- Teig, N., Scherer, R., & Nilsen, T. (2019). I know I can, but do I have the time? The role of teachers' self-efficacy and perceived time constraints in implementing cognitive-activation strategies in science. *Frontiers in Psychology*, 1697. DOI:

- <https://doi.org/10.3389/fpsyg.2019.01697>
- Wenning, C.J. (2005). Levels of inquiry: Hierarchies of pedagogical practices and inquiry processes. *Journal of Physics Teacher Education Online*, 2(3), 3-11.
- Widowati, A., Widodo, E., & Anjarsari, P. (2017). The development of scientific literacy through nature of science (NoS) within inquiry based learning approach. In *Journal of Physics: Conference Series* (Vol. 909, No. 1, p. 012067). IOP Publishing. DOI: <https://doi.org/10.1088/1742-6596/909/1/012067>
- Windschitl, M. (1997). Student epistemological beliefs and conceptual change activities: How do pair members affect each other? *Journal of Science Education and Technology*, 6, 37-47. DOI: <https://doi.org/10.1023/A:1022516901783>
- Windschitl, M., & Andre, T. (1998). Using computer simulations to enhance conceptual change: The roles of constructivist instruction and student epistemological beliefs. *Journal of Research in Science Teaching*, 35(2), 145-160. DOI: [https://doi.org/10.1002/\(SICI\)1098-2736\(199802\)35:2<145::AID-TEA5>3.0.CO;2-S](https://doi.org/10.1002/(SICI)1098-2736(199802)35:2<145::AID-TEA5>3.0.CO;2-S)
- Vosniadou, S. (2008). *International handbook of research on conceptual change*. New York: Routledge.

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Comparative Study on HPSS Content in Current and Previous Chinese High School

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Abstract: Chinese 2017 General High School Physics Curriculum Standards explicitly include understanding the nature of science (NOS) as core literacy for students. History, philosophy of science, and sociology of science (HPSS) education is an important way to promote students' understanding of the nature of science. In this context, this study analyzed the content of HPSS in two physics textbooks before and after the promulgation of the new curriculum standards using a content analysis method based on the analytical framework of HPSS. The analysis compares the number and copiousness of HPSS content in the current high school physics textbooks published in 2019 and the previous edition of high school physics textbooks published in 2004. The presentation of this HPSS content was also analyzed. It was found that there was an increase in HPSS content in the new edition of the textbook compared to the old edition, mainly a decrease in the history of science content and an increase in both the philosophy of science and sociology of science content. The HPSS content copiousness was low in both the old and new editions of the textbook. Finally, the distribution of the respective sub-dimensions of the HPSS was very uneven.

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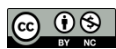
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Introduction

IN THE LATEST round of curriculum reform in mainland China, the objectives of the science curriculum have shifted from knowledge and skills, attitudes and methods, and emotional-attitudinal values to developing students' core literacies, and understanding the nature of science (NOS) has been explicitly included as part of the core literacies of the physics subject in the *Physics curriculum standards for senior high school* (Ministry of Education, 2017). The curriculum standards are the main basis for guiding the development of textbook content, and following the promulgation of the 2017 senior secondary physics curriculum standards, a new version of the physics textbook was published and put into use in 2019. In the latest physics textbooks, the representation of the NOS is mostly implicit, with the consensus view of the nature of science being embedded in stories for expression (Zhuang et al., 2021). This is not surprising, as direct descriptions of the NOS can be difficult for teenagers to understand (X. Li et al., 2020). Integrating History, Philosophy and sociology of Science (HPSS) into the science curriculum effectively promotes a better, more comprehensive, and richer understanding of the NOS (Matthews, 1992).

History, Philosophy, and Sociology of Science (HPSS) education examines the social and cultural context in which scientific knowledge is produced, disseminated, and used. This includes exploring the history of science, the philosophical foundations of science, and the sociological factors that shape the practice of science (Zhang, 2017). In 1895, Mach first suggested that 'no science education can be conducted without attention to the history and philosophy of science (Yuan, 2005), and in the following decades there was a debate about the effective integration of the history and philosophy of science (Laudan, 1989). Following the emergence of the sociology of scientific knowledge, there was a growing awareness of the need for the public to be aware of the various social factors in the social formation and construction of science and for HPSS to support science education as a community (Wylie, 1994). A new model of HPSS education was formed by emphasizing the significance of the sociology of science based on the history and philosophy of science (Monk & Osborne, 1997).

Helping students understand the NOS properly has always been an important goal of science education (Lederman et al., 2002). Much of the current understanding of NOS comes from scholarship in HPSS (Abd-El-Khalick, 2012). Initially, the NOS was considered to be related to the philosophy of science, mainly the epistemology, methodology and ontology of science. Later, the NOS network expanded to include the history and philosophy of science, as it was necessary to understand the history of science to study science, and then the NOS network was further expanded to include the sociology of science (Matthews, 2017). There has been an

intense debate among scientists and science education researchers about what NOS is and from what perspective it is understood (Abd-El-Khalick et al., 1998; Alters, 1997; Wong & Hodson, 2010). We endorse some of these views, namely, that the HPSS is the basis for developing a consensus view of the NOS and that helping students understand the NOS is the goal of HPSS education (Abd-El-Khalick et al., 1998; Abd-El-Khalick, 2012; Abd-El-Khalick et al., 2008).

In recent years, international science education research has begun to focus more on specific pedagogical content rather than macro-level thinking when it comes to HPSS education (Y. Li & Zheng, 2009). Many papers have focused on issues related to the implementation of HPSS education in the classroom in the context of educational reform (Henke & Hättecke, 2015; Monk & Osborne, 1997). However, textbooks are rarely seen as a key element of educational reform. In school science education, textbooks are often one of the most reliable sources of knowledge for students and teachers, and indeed, the effectiveness of integrating the history of science into science education depends largely on which history of science is used and how it is used (Hättecke & Silva, 2011). Often, physics teachers lack relevant knowledge in the history of science, philosophy of science and sociology of science. As a result, their teaching practice in this area relies heavily on what is in textbooks. Teachers will rely on the content of HPSS in textbooks, how the texts in textbooks portray science, and what ideas about NOS are conveyed by textbooks (Leite, 2002).

Textbooks, as the primary source of instructional content, are an effective way to present NOS implicitly through HPSS as instructional content. Therefore, based on the results of a direct analysis of the scientific nature of physics textbooks, it is meaningful to analyse the differences in HPSS content in the two versions of physics textbooks before and after the introduction of the curriculum standards and to compare the changes. Previous studies of HPSS content in textbooks have mainly examined a particular discipline within the HPSS in textbooks or a particular science story in textbooks (Brush, 2000; Gardner, 1999; Klassen et al. 2012; Leite, 2002; Montgomery & Kumar, 2021; Simon, 2016; Persson, 2018; Lin et al. 2022), this study will simultaneously count the history of science, philosophy of science, and sociology of science in textbooks, bringing together the three disciplines and being able to complement past research and visualise similarities and differences between the three disciplines. Being able to analyse the changes in HPSS content in two versions of physics textbooks will allow us to understand how physics textbooks have changed under the guidance of the new curriculum standards and how teachers should respond to the HPSS content in current textbooks.

Literature Review

HPSS Education

What was needed to better advance students' understanding of the NOS was a greater collaboration between historians, philosophers, sociologists, and science educators in training teachers, developing classroom materials, conducting research, and analyzing textbooks (Matthews, 1989). This integration is of course not the use of HPSS as another thematic curriculum but the wider integration of HPSS themes and pedagogy into the science curriculum (Matthews, 1992).

One key aspect of HPSS education is the study of integrating the history of science into the classroom, which seeks students to understand how scientific knowledge has evolved over time and how it has been shaped by social, cultural, and political factors (Clary & Wandersee, 2015). In some science classrooms, scientific knowledge is often presented to students in a completed form, and students lack an understanding of the history of science and therefore of the processes and laws of development of science (Bybee et al., 1991). Integrating the history of science into the classroom can help students understand the nature of scientific knowledge and how it evolves over time (Abd-El-Khalick & Lederman, 2000; Bybee et al., 1991). By studying the history of science, students can learn about the development of key scientific theories, the scientists who developed them, and the social and cultural contexts in which these theories were developed. This can help students see science as a dynamic and ongoing process rather than a fixed body of knowledge (Abd-El-Khalick & Lederman, 2000; Leite, 2002).

Another important aspect of HPSS education is the study of examining science from a philosophy of science perspective in the science classroom, which focuses on enabling students to analyze science and the development of scientific processes from a philosophical perspective (Zhang, 2017). This includes four senses of philosophy of science that students need to understand: (1) worldview presented by science; (2) scientific investigations of science; (3) investigation of science as a social institution; and (4) analysis of science concepts (Martin, 1972). An important aim of the integration of the philosophy of science into science education is to make better scientists out of those students who will be engaged in scientific research, and it is hoped that students will approach their scientific practice more critically after studying the philosophy of science (Grüne-Yanoff, 2014; Boniolo & Campaner, 2020). By studying the philosophy of science, students will enhance their own pluralistic and critical analysis of science and will be able to constantly reflect on existing scientific theories rather than taking them as the ultimate truth (Matthews, 2009).

Integrating the sociology of science into the science classroom is another key component of HPSS education, which examines the social factors that shape the practice of science, including the roles of institutions, power dynamics, and cultural values (Zhang, 2017). This includes studying the ways in which scientific research is funded, conducted, and disseminated, as well as the social and cultural impacts of scientific knowledge and technology (Kelly et al., 1993). The inclusion of the sociology of science in science education can illuminate the social nature of scientists in the construction of scientific theories and will undoubtedly lead to a new understanding of science as students learn about the social context of science (Kelly et al., 1993). Past research has found that the integration of the sociology of science into the curriculum can benefit students by

“(1) preparing all students for the problems and decisions they will face in our increasingly science-dependent society; (2) engendering more interesting and accurate views of science; (3) attracting, interesting, and retaining more students in science, especially women and minorities; and (4) encouraging students to explore new methods and problem spaces” stated by Cunningham & Helms (1998, p.497).

Overall, HPSS education is important because it helps students understand the complexity and diversity of scientific knowledge and the ways in which it is shaped by social and cultural factors. It also promotes critical thinking and encourages students to consider the ethical and social implications of science and technology.

HPSS Context in Science Textbooks

Over the past few decades, the HPSS has been recognized as an important and valuable addition to science education, and as such, analyzing the HPSS content in science textbooks has been a topic of interest for scholars (Vojř & Rusek, 2019).

In an early study, researchers began to examine the content of HPSS in science textbooks; for example, Brush (2000) qualitatively examined 28 American college physics textbooks. He found that some of the historical facts of modern physics had been ignored and distorted in these textbooks (Brush, 2000). Two recent papers have also qualitatively discussed the relevant history of science in physics textbooks (Montgomery & Kumar, 2021; Simon, 2016). Both Montgomery & Kumar (2021) and Simon (2016) advocate that physics textbooks should present historical information to help students understand the process of scientific inquiry. Rather than analyzing the history content throughout the textbook, Persson (2018) focuses on the history of Planck’s blackbody radiation equation in physics textbooks. He found that the history of science in textbooks did not follow the development of history but presented physical concepts as a result of an incorrect

historical context, and such descriptions were not conducive to students' understanding of the NOS (Persson, 2018). In addition to the qualitative analysis, researchers began to quantitatively study the content of the history of science in physics textbooks. For example, Leite (2002) developed an analytical framework with eight dimensions: (1) Type and organization of the historical information, (2) Materials used, (3) Correctness and accuracy of the historical information, (4) Contexts to which the historical information is related, (5) Status of the historical content, (6) Learning activities dealing with the history of science, (7) Internal consistency of the book, and (8) Bibliography on the history of science (Leite, 2002). Leite (2002) selected five Portuguese secondary school physics textbooks for the study, which showed that the history of science content in these textbooks was not sufficient to give students a good understanding of how science has developed and how scientists work. Twenty years later, Lin et al. (2022) used this framework to analyze the history of science in six Chinese high school physics textbooks. However, Lin et al. (2022) removed "Correctness and accuracy of the historical information" from the original framework because they believe that Chinese textbooks have undergone multiple reviews by different authorities to ensure the scientific correctness of the content. They found that the history of science in Chinese textbooks was too monotonous and rigid, lacking in imagery and authenticity (Lin et al., 2022).

Some studies analyze the origin and development of a concept in a textbook from the perspective of the history and philosophy of science. These concepts include the "Photoelectric Effect" (Klassen et al., 2012; Niaz et al., 2010), "Structure of the Atom" (Farías Camero et al., 2012; Justi & Gilbert, 2000; Niaz, 1998; Niaz & Coştu, 2009), "Covalent Bond" (Niaz, 2001), "Oil Drop Experiment" (Niaz, 2000b; Rodríguez & Niaz, 2004), "Periodic Table" (Brito et al., 2005), and "Kinetic Molecular Theory of Gases" (Niaz, 2000a). These studies usually develop a number of evaluation criteria for a concept based on the theoretical framework of the history and philosophy of science. For example, Klassen et al. (2012) have developed four evaluation criteria for the photoelectric effect: (1) Einstein's Quantum Hypothesis to Explain the Photoelectric Effect, (2) Lack of Acceptance of Einstein's Quantum Hypothesis in the Scientific Community, (3) Millikan's Experimental Determination of the Einstein Photoelectric Equation and Planck's Constant, and (4) Millikan's Presuppositions About the Nature of Light, with four levels for each evaluation criterion (Excellent, Satisfactory, Mention, and No Mention). They analyzed 38 laboratory textbooks based on these criteria and found that these physics textbooks were at best at a satisfactory level and that the vast majority of them stayed at the No Mention level (Klassen et al., 2012). The results of other studies are similar in that details of the history and philosophy of science are often omitted from

science textbooks (Niaz, 1998, 2000b, 2001; Niaz et al., 2010; Niaz & Coştu, 2009; Rodríguez & Niaz, 2004).

There are also some studies that analyze other related topics from the perspective of the HPSS, such as the scientific method (Blachowicz, 2009), the relationship between science and technology (Gardner, 1999), and the gender of scientists (Laçın-Şimşek, 2011). Overall, current research has analyzed the content of HPSS in science textbooks in both quantitative and qualitative ways; however, most of these analyses have focused on a particular concept or aspect of HPSS and lack an analysis of the book as a whole from the perspective of HPSS as a whole. We believe that HPSS is a holistic concept and therefore it makes sense to be addressed as a whole, but history of science, philosophy of science, and sociology of science can each be a separate discipline, and therefore we want to use a set of criteria to measure the content of HPSS in textbooks, and in particular, to understand the similarities and differences of the three disciplines of, the history of science, the philosophy of science, and the sociology of science in textbooks, which will be beneficial to help researchers to have a more all-encompassing understanding of the content of HPSS in textbooks.

Research Questions

Previous studies on HPSS content in physics textbooks have mainly focused on a particular concept or aspect of HPSS (Brush, 2000; Gardner, 1999; Klassen et al., 2012; Leite, 2002; Montgomery & Kumar, 2021; Simon, 2016; Persson, 2018; Lin et al., 2022). The three disciplines of history of science, philosophy of science and sociology of science are often discussed together because of their close relationship, making it necessary to analyze physics textbooks from a holistic perspective. In previous studies, the content of HPSS in physics textbooks has been mostly unsatisfactory. Interviews with textbook editors revealed that curriculum standards are an important factor in the variation of HPSS content in textbooks (Ma & Wan, 2017). Given that understanding the NOS is explicitly stated as core literacy in physics in China's 2017 high school physics curriculum standards, it is important to analyze the HPSS content in the two editions of physics textbooks before and after the promulgation of the curriculum standards.

RQ1: What is the number of HPSS content in physics textbooks after the implementation of the new curriculum standards? How has it changed from the old physics textbooks?

RQ2: What is the copiousness of HPSS content in physics textbooks after the implementation of the new curriculum standards? How did it change from the old version of the physics textbook?

RQ3: What is the presentation of HPSS content in physics textbooks after the implementation of the new curriculum standards? How has it changed from the old version of the physics textbooks?

Method

This study used content analysis to first develop a list of HPSS content categories based on existing research, then categorized and coded textbooks for content related to HPSS education.

Materials

In this study, the Physics textbooks published by People's Education Press in 2019 were selected as the sample of current textbooks (CT) after the introduction of the new curriculum standards. The textbooks published by the People's Education Press have been approved by the national primary and secondary school textbook authorization committee. Books 1, 2, and 3 of the high school physics textbooks published in 2019 have been chosen because the content in these three textbooks is compulsory for all students, not just those who will work in science and technology in the future. Therefore, it is important to analyze these three volumes of physics textbooks. The physics textbooks published by People's Education Press in 2004 were selected as the sample physics textbooks before the introduction of the new curriculum standards. As the chapter structure of physics textbooks varied from period to period, six volumes of the 2004 edition of the Renminbi version of the general high school physics textbooks (later referred to as the previous textbooks (PT), including the corresponding chapters of Book 1, Book 2, Book 3-1, Book 3-2, Book 3-4 and Book 3-5, which corresponded to the scope of knowledge in the 2019 edition of the textbooks, were selected for this study.

Analytical Framework

The analytical framework used in this study was developed based on the structural diagram of science meta-knowledge systems proposed by Professor Zhang (2017), in which HPSS education corresponds to the structure of the science education system. Based on relevant studies (Matthews, 2018; Vesterinen et al., 2014; Zhang, 2017), the conceptual definition of HPSS education and the actual situation in physics were adapted to define the analytical framework for the HPSS content of this study. To make the analytical framework suitable for textbook analysis, three scholars in science education (including a Ph.D. supervisor) discussed it in several rounds and finally defined it as **Table 1**.

Table 1. Analytical Framework of the HPSS.

Categories	Sub-categories	Working definitions
History of Science	The evolution of physical concepts, principles, and laws	Describe the historical context of the changing connotations and development of certain concepts, ideas, and laws in the discipline of physics.
	The laws of science and technology occurrence and development	Describe the historical context of the process of the creation, change, and development of science and technology.
	Significant technical achievements related to physics	A description of the major achievements and technical accomplishments made in the history of physics.
	The evolution of the approach to the science	Describes the historical context of the scientific method used in physics and the process of change and development of paradigms.
	Scientific thought and scientific spirit	Describes the historical content that embodies scientific thought and the spirit of science, including the life of the physicist.
Philosophy of Science	Discussion on the nature of science	Directly describe what scientific knowledge is in the content or explicitly discuss what science is about.
	Scientific and logical structure	Direct describes the existing science are not purely objective but are mixed with subjective elements.
	Scientific epistemology and methodologies	Direct describes the philosophical epistemology and methodology of human knowledge of science.
	Acquisition and testing of scientific knowledge	Direct describes the scientific knowledge created by humans in dynamic practice, something that can be predicted and inferred and can be verified in practice.
	The laws of growth in scientific theory	Direct describes scientific knowledge as the result of an accumulation over time, which does not remain constant but is in a process of relatively absolute evolution.
Sociology of Science	The impact of science and technology on society	Describe the various types of impact of science and technology on the productive life of society.
	The social responsibility of science and technology	Describe the need for science and technology to take on social responsibility, including social security and sustainable development.
	The impact of social activities, and social decisions on science and technology	Describe the place and role of social factors, such as political, economic, cultural, faith, and even religious and personal emotions, in the development of science.
	Social issues related to science and technology	Describe issues in society as they relate to science and technology.

It is undeniable that there is an overlap between the history and philosophy of science, and that much of the philosophy of science is implicitly expressed in the history of science (Reiss, 2020). We are more cautious about coding the philosophy of science, instead of coding philosophical ideas that are hidden in scientific stories, we coded only those sentences that explicitly referred to, for example, expressions such as the epistemology of science and the nature of science. Here is an example of coding, described in a paragraph in CT-Book1.

After using logical reasoning to show that heavy and light objects fall equally fast, Galileo did not stop there but further investigated the laws of free-fall motion through experiments.

While it is also evident in this passage that scientific knowledge is acquired through practice, it is not an explicit expression of a passage that

focuses on Galileo's ongoing verification of the laws of free-fall motion, and thus we encode it only as a history of science, not a philosophy of science.

Counting only the quantity of HPSS content is insufficient, as some content contain very rich information, such as using images, tables, and long paragraphs to describe a historical story. In contrast, other content might only include a simple sentence describing basic information about a scientist. This study also developed coding rules for analyzing the copiousness of HPSS content in past editions of textbooks versus new editions of textbooks. Copiousness in the context of this study refers to the richness and depth of information presented in textbook content. This is measured by various elements, including text length, the inclusion of images, tables, and student activities.

(1) The length of the text usually determines the amount of information it contains. In physics textbooks, a complete sentence of HPSS content is typically around 25-30 words. In textbooks, only a single sentence or two very simple descriptive sentences will fall below 50 words. Therefore, this study uses 50 words as the standard to distinguish whether the text is rich in information. (2) Content that includes images is assigned an additional point because images can convey complex information more effectively and enhance understanding. However, the number of images does not entirely reflect the amount of information covered; thus, even if multiple images appear in a section, only one point is added in this study. (3) Including tables in the content also adds an extra point, as tables organize information in a structured manner that aids in comprehension and analysis. Similarly, even if multiple tables appear in a section, only one point is added in this study. (4) Student activities actively engage learners and often include practical applications of the content, enriching the learning experience. Likewise, even if multiple student activities appear in a section, only one point is added.

The final scoring rules for content copiousness are determined as follows:

- The text under 50 words +1 point
- Text over 50 words +2 points
- Content containing images +1 point
- The table included in the content + 1 point
- Student activities included in the content +2 points

The way in which the content is presented is partly a reflection of the importance attached to the content. In Chinese physics textbooks, content is typically presented in three formats: Main body, Column, Note. The main body is always present, describing the primary content of each chapter. Depending on the learning material, the textbook selectively includes various columns, which may consist of reading materials, exercises, and other resources. If additional information is needed to enhance understanding of

Table 2. The Results of the Reliability Test.

	Published in 2019	Corresponding chapters publish in 2004
Book 1	0.83	0.84
Book 2	0.86	0.87
Book 3	0.86	0.85

the content in the main body or columns, a note is added alongside to provide supplementary explanations.

- (1) Main Body, which contains the essential material that students must read in class, indicating that the content in this section is given the highest priority.
- (2) Columns, of which there are various types, each designed for optional student use, meaning that the content in these columns might be covered in class.
- (3) Notes, which are supplementary explanations of the content in the Main Body or Columns. Notes are intended for optional student reading after class, implying that the content in this section is generally given the least priority.

Analysis Procedures

The two encoders used in this study consisted of two master's students. In the first step, under the guidance of a physics education specialist, the two encoders discussed the analytical framework and coding details. In the second step, they selected the first section of the new version of the Compulsory 1 Physics textbook for precoding and compared the results produced by the different encoders to ensure consistency of coding practices between them. In the third step, they precoded both old and new versions of the Compulsory 1 physics textbook and analyzed the results for reliability. In the fourth step, each encoder analyzed and coded all textbooks independently. The coding reliability was checked again. Finally, the two encoders and the physics education specialist discussed each item analyzed. Differences between the analyses of the encoders were analyzed and discussed until a consensus was reached between the researchers.

Coding reliability referred to the content analysis reliability formula proposed by (K. Li & Xie, 1990), and the stability coefficient R was used as the reliability of this category list; the higher the value of stability R , the higher the reliability of the category list. The reliability of the textbooks analyzed was all at an acceptable level, and the reliability test results are shown in **Table 2**.

Table 3. Number of HPSS Contents of Current and Previous Physics Textbooks.

Book	History of Science		Philosophy of Science		Sociology of Science		Total	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	
CT-Book1	21	41%	13	26%	17	33%	51	
PT-Book1	25	51%	8	24%	16	36%	49	
CT-Book2	29	39%	21	28%	24	33%	74	
PT-Book2	30	48%	14	23%	18	29%	62	
CT-Book3	28	42%	13	20%	25	38%	66	
PT-Book3	32	51%	12	19%	19	30%	63	
Total	PT	78	41%	47	25%	66	34%	191
	CT	87	50%	34	20%	53	30%	174

Results

In order to answer the research question, this study describes the amount of HPSS content as well as Copiousness in physics textbooks before and after the promulgation of the new curriculum standards through quantitative data analysis.

Overview of HPSS

Table 3 summarizes the amount of HPSS content in current and previous physics textbooks, with statistics on the percentage of each of the three HPSS disciplines.

As shown in **Table 3**, the CT shows a small increase in the amount of HPSS content compared to the previous physics textbooks, with all physics textbooks analyzed combined increasing from 174 to 191 HPSS content. The largest increase in HPSS content occurred in Book 2, with 12 additions. Unlike the general changes, the history of science is less represented in current textbooks than in previous textbooks, with Book 1, Book 2, and Book 3 having fewer corresponding chapters in older textbooks. The changing trends in the philosophy of science and the sociology of science are similar, both in total and per physics textbook, with the number of current textbooks being greater than the number of previous textbooks.

The amount of sociology of science content has increased in Book 2 and Book3, from 18 to 24 and 19 to 25, respectively. The current textbooks have added several questions on social activities related to science and technology, and the current textbooks incorporate these questions into exercises for students to discuss.

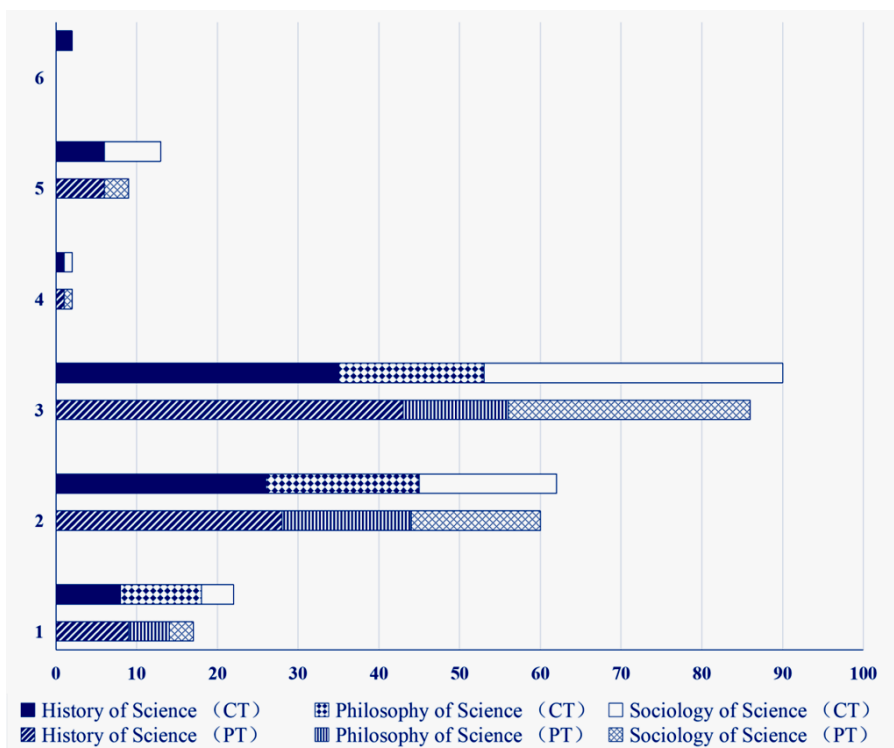


Figure 1. Copiousness of HPSS Contents of Current and Previous Physics Textbooks.

In terms of the proportion of the total in the three disciplines, the trend is similar in all three books; the content of the history of science is declining as a proportion of the total, and the content of the philosophy of science and sociology of science is increasing as a proportion of the total. In total, the current physics textbooks still have the highest percentage of the history of science content, but the percentage has dropped from 50% in the past to 41%. In contrast, the current physics textbooks, although still the smallest in terms of the philosophy of science, have increased their share, from 20% in the past to 25%. This trend is reflected in all three books, particularly in Book 2, where the difference between the history of science, the largest component, and the philosophy of science, the smallest component, is only 11%.

The HPSS content of copiousness of CT and PT is presented in **Figure 1**.

As shown in **Figure 1**, the HPSS content Copiousness of both CT and PT is mainly concentrated in two to three scores, and comparing the HPSS content Copiousness of CT and PT, it can be seen that there is no significant difference between CT and PT in terms of overall content

Copiousness. Focusing on each content, the content of two scores mainly consists of plain text with more than 50 words, while the content of three scores mainly consists of plain text with more than 50 words and images. Only 2 elements were achieved with a score of 6, and both were history of science in CT. Comparing the content of History of Science, Philosophy of Science, and Sociology of Science, it can be noticed that Copiousness is higher in History of Science and Sociology of Science than in Philosophy of Science.

The total number of history of science content in CT is less than that in PT, but the number of history of science content with Copiousness scores of 5 and 6 is more in CT than in PT, the number of history of science content with a Copiousness score of 4 is the same in CT as in PT, and the number of history of science content with a low level of Copiousness scores of 3, 2, and 1 is greater in PT than in CT. The most notable were the two history of science cases with a Copiousness score of 6 in CT, one of which was in p50-p53 of CT-Book1, which contained a total of over 50 words describing the process of Galileo's investigation of the motion of free-fall, several images related to the principle of free-fall, a table of the acceleration of gravity around the world, and a table that required students to measure the acceleration of gravity using a modern tool (smartphone) to measure the acceleration of gravity and compare it to Galileo's idea of measuring the acceleration of gravity.

The highest Copiousness of Philosophy of Science content in both CT and PT only went up to a score of 3. There was more Philosophy of Science content with a Copiousness of 3, 2, and 1 in CT than in PT, and the largest increase was in content with a Copiousness of 1. There was twice as much Philosophy of Science content with a Copiousness of 1 in CT (Number = 10) was twice as high in CT as in PT, and most of this increased Copiousness score of 1 Philosophy of Science content was some additional information to the learning content, usually one or two short sentences. One such case is in CT-Book 3, p4, which expresses the philosophical methodology of human understanding of scientific knowledge in an annotated form next to the introduction of the law of conservation of charge.

The search for conserved quantities is one of the most important methods of physics in the study of the material world, and it often leads to the revelation of objective laws hidden behind physical phenomena.

The number of science sociology with a Copiousness score of 4 in CT and PT is the same as in PT, which is 1 item, and the number of science sociology with a Copiousness score of 1, 2, 3, and 5 is greater in CT than in PT. There are 4 more items of science sociology content with a Copiousness score of 5 in CT than in PT, and there are 7 more items of science sociology content with a Copiousness score of 3 in CT than in PT. Sociology content CT has 7 more items than PT, these 3-point science sociology are some

Table 4. Presentation of HPSS Contents of Current and Previous Physics Textbooks.

Presentation	Book	History of Science		Philosophy of Science		Sociology of Science		Total	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent
Note	CT	11	14%	18	38%	0	--	29	15%
	PT	12	14%	8	24%	0	--	20	12%
Column	CT	24	31%	15	32%	34	52%	73	38%
	PT	28	32%	10	29%	22	42%	60	34%
Main Body	CT	43	55%	14	30%	32	48%	89	47%
	PT	47	54%	16	47%	31	58%	94	54%

illustrated content, one of the more special is the content in p105 of CT-Book1, which has the same textual description in p91 of PT-Book1, it is an exercise on the civil airliner escape airbags, in CT-Book1, in addition to the textual description there is also attached a picture of the real thing to make the content richer.

The HPSS content of the Presentation of CT and PT is presented in **Table 4**.

As shown in **Table 4**, CT and PT have some similarities in the presentation of HPSS content; the most HPSS content in both CT and PT appears in Main Body, followed by Column, and the least in Note. CT and PT are a little different in the specific proportion of HPSS content, the proportion of HPSS content in Note and Column is more, and the proportion of HPSS content in Main Body is less for CT than PT. The proportion of HPSS content appearing in Note and Column is greater for CT than for PT, and the proportion appearing in Main Body is less for CT than for PT.

The amount of history of science content presented in CT and PT is the same, with Main Body more than Column more than Note, and more than half of the content is presented in Main Body.

In PT, 47% of the philosophy of science content is presented in the Main Body, while 38% of the philosophy of science content in CT is presented in Note. It can be found that CT is presented in the form of a note adds explicit philosophical thinking to the original content on the history of science. For example, in previous textbooks, the scientific history of the establishment of the law of universal gravitation is described in detail. In the current textbook, the author adds a text in the form of a note next to these histories of science,

Scientific arguments need to be supported by evidence. Kepler's law of motion of the stars, based on the observations of Tycho, supported the law

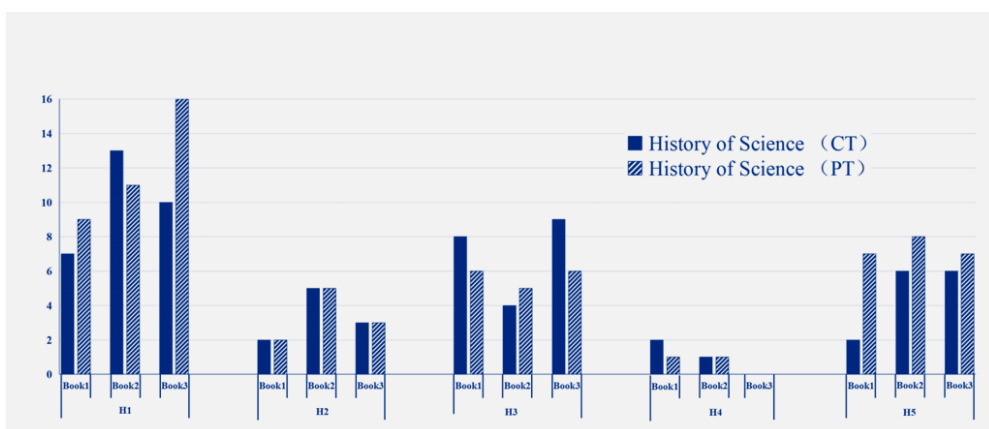


Figure 2. Number of History of Science Contents of Current and Previous Physics Textbooks.

of universal gravitation by the law of planetary motion, and the “Moon-Earth test” further validated the law of universal gravitation.

Neither the CT nor the PT has any of the Sociology of Science content in Note form, whereas the percentage of Sociology of Science content in Column form in the CT has increased by 10 percent compared to the PT, and this content is more in the form of exercises, where several questions on social activities related to science and technology have been added to the CT and incorporated into the exercises for student discussion. For example, on p123 of CT-Book 3, there is an exercise:

Welding operations produce welding arc light, which is harmful to humans. The welding arc temperature is 3,000 °C and radiates a large number of electromagnetic waves with a frequency of 1.0×10^{15} Hz. Which type of electromagnetic wave does it belong to, judging by its wavelength? Why is it necessary for welders to wear professional protective helmets when working?

Sub-categories of History of Science

The amount of content in textbooks for the five sub-dimensions of the History of Science is presented in **Figure 2**.

As can be seen from **Figure 2**, the distribution of History of Science content across the five dimensions is similar in CT and PT.

H1: The evolution of physical concepts, principles, and laws has the most items in the five dimensions of the History of Science in both CT and PT, with 30 and 36 items, respectively. They are often placed alongside textbook explanations of concepts, such as in Book 1 when explaining the calculation of the coefficient of elasticity of a spring, it is mentioned that

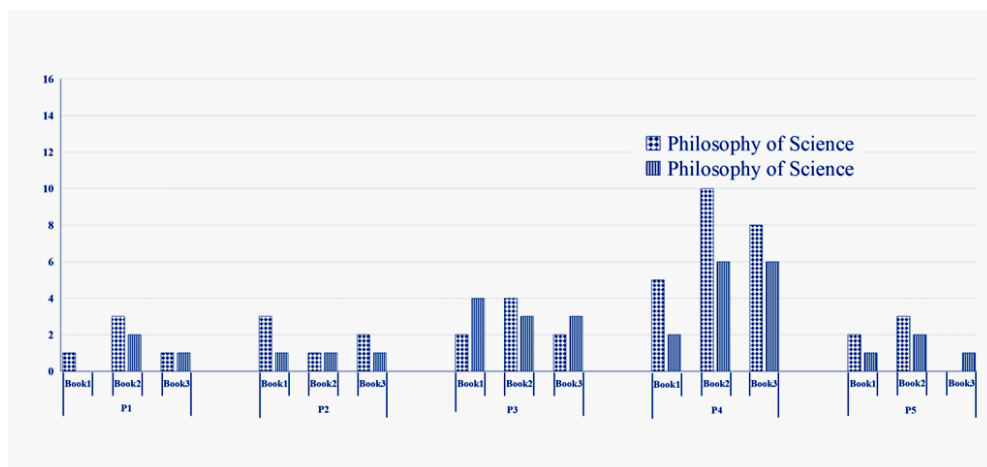


Figure 3. Number of Philosophy of Science Contents of Current and Previous Physics Textbooks.

The law $F = kx$ was discovered by the British scientist Hooke.

In PT H5: Scientific thought and scientific spirit has the second highest number of items among the five dimensions of the History of Science, but in CT the number of items in this dimension drops drastically, especially in Book 1, from seven items in PT-Book 1, to CT- two items in Book1. The main reason here is that some scientists' biographies have been removed.

Although the amount of history of science in CT is generally less than that in PT, the amount of content in H3: Significant technical achievements related to physics is more in CT than in PT, and the amount of content in H3 is more in both CT-Book1 and CT-Book3 than in PT. These contents introduce some scientific and technological achievements and their development history, for example, p126-p127 of CT-Book3 describes in detail the development history of the radio telescope FAST and its impact on the scientific community.

The number of H2: The laws of science and technology occurrence and development in CT and PT are the same. These contents have not been changed much in telling the laws of science and technology occurrence and development.

In both CT and PT, H4: The Evolution of the Approach to the Science has the least amount of content among the five dimensions, especially Book 3, which has no relevant content in both CT and PT

Sub-Categories of Philosophy of Science

The number of contents of the five sub-dimensions of Philosophy of Science in the three books is presented in **Figure 3**.

As can be seen in **Figure 3**, the distribution of Philosophy of Science content across the five dimensions is similar in CT and PT.

P4: Acquisition and testing of scientific knowledge is the most frequent item among the five dimensions of Philosophy of Science in both CT and PT, with 23 and 14 items respectively. The content of this section mainly emphasizes the fact that scientific knowledge is acquired from practice, so it often appear in the laboratory activities section of textbooks, for example, in the first section of CT-Book1 that consists entirely of experimental activities, Experiment: Investigating the Laws of Speed of a Cart as a Function of Time, it is written in the form of a comment that

The laws of physics cannot be obtained by thinking alone, but should also be devoted to observation and experimentation.

The other four dimensions of the philosophy of science in CT and PT have a small amount of content, 0-3 places in each book. It is worth mentioning that P2: Scientific and logical structure than in CT-Book1 has 2 more places than in PT-Book1, and in CT-Book3 has one more place than in PT-Book3, which is the dimension with the most additions except P4. This section reflects the subjective nature of science, for example CT-Book1 p125 has a note on Planck's constant

Planck's energon hypothesis was a breakthrough in the ideas and concepts of classical physics that even Planck himself was hesitant to accept, and most physicists of the time naturally had difficulty accepting it.

Sub-Categories of Sociology of Science

The number of contents of the five sub-dimensions of the Sociology of Science in the three books is presented in **Figure 4**.

As can be seen from **Figure 4**, the four dimensions of the sociology of science are unevenly distributed in both CT and PT, with S1: The impact of science and technology on society being the most numerous items in both CT and PT, with 29 and 24 items respectively. S4: Social issues related to science and technology had 23 and 20 items in CT and PT respectively. These two sub-dimensions of the sociology of science have some similarities in content, but S1 refers to the fact that science and technology have impacts on human society that do not necessarily create social issues. S4, on the other hand, refers to a social problem that is related to science and technology, where the relationship between science and technology and the social problem is merely one of correlation, not one-way influence.

S3: The impact of social activities, and social decisions on science and technology is the same in CT and PT, both have only 1 place, it is about

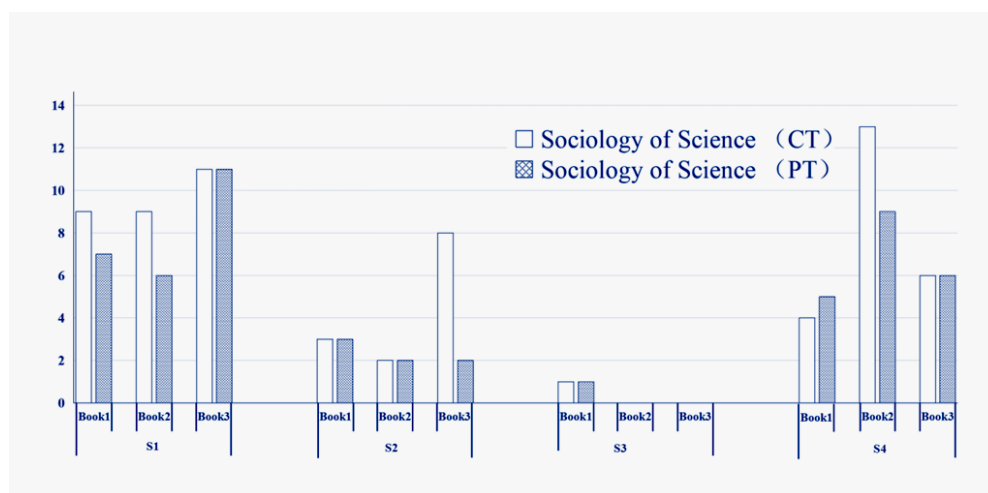


Figure 4. Number of Sociology of Science of Current and Previous Physics Textbooks.

the impact of the social context in which Faraday lived on his subsequent scientific achievements

In PT, this story is described as:

Faraday was born in England to a family of blacksmiths... Faraday lived at a time when the first industrial revolution was being completed. The application of the steam engine gave birth to the great capitalist industries, mankind entered the age of industrial civilization, and the prospect of the application of electricity was beginning to emerge; it was a time when giants were needed and produced. Faraday was born at the right time

The story has been retained in CT, and a sentence has been added.

At the time, Britain was at the forefront of scientific, technological, and industrial development.

The original content already contained society's need for technology, and this added information complements the current state of accumulated technology in society at the time of Faraday's discovery of the phenomenon of electromagnetic induction.

Discussion

The results of this study reveal the situation of HPSS content in CT and, by comparing it with PT, some differences in HPSS content in physics textbooks after the introduction of the new standards. Based on the statistical results, we would like to have some discussions on the writing of HPSS content in textbooks and teachers' use of HPSS content in textbooks.

The amount of HPSS content in CT tends to be balanced, but Copiousness did not improve significantly.

The number of HPSS contents in CT increased compared to PT, and the number of the three contents of history of science, philosophy of science, and sociology of science in CT was more evenly distributed, with only two places of difference between history of science and sociology of science, and the proportion of philosophy of science contents increased from 25% to 30%. The HPSS educational model is a holistic concept to execute the function of science education with the coexistence of history of science, philosophy of science, and sociology of science. The similar proportion of the three HPSS content items in CT textbooks can draw students' sufficient attention to these three items. CT's choice of HPSS content is more reasonable than the PT in which nearly half of the content is history of science, and the reduction of the proportion of history of science does not mean that the importance of history of science decreases, but on the contrary, through the supplementation of philosophy of science and sociology of science, students can better understand these historical materials of science. In particular, the CT's addition of several philosophies of science annotations alongside the history of science stories will allow students to approach the history of science in physics textbooks not only by simply reading a historical story but also by hoping to derive methods of scientific inquiry from this historical fact of science.

Although the three main dimensions of the history of science, philosophy of science, and sociology of science are somewhat balanced, the sub-dimensions under each main dimension, CT, still appeared to be highly unbalanced, as did PT. The evolution of the scientific method continues to be very low in number in the CT, which may not be conducive to students' understanding of science, especially the paradigms of scientific research, and may create a false perception in students' minds that the scientific method is fixed and complete. Almost all of the Philosophy of Science section gathers on the fact that scientific knowledge is gained through practice, which can be helpful for students to focus on the importance of experimentation in science, but the insufficient number of several other dimensions of the philosophy of science is not conducive to the development of a complete understanding of the nature of science. In the sociology of science section, the section on the influence of social factors on science is missing in several books, which may allow students to continue to maintain the plain idea of the nature of science as objective.

Unfortunately, the Copiousness of the vast majority of HPSS content in the CT did not change from the PT, except for individual HPSS content that was able to achieve a score of 6. The lack of student activities is one of

the reasons for the low Copiousness of the HPSS content, which may lead teachers and students to read this part of the textbook only as reading material without thinking deeply about the meaning. The Copiousness of Philosophy of Science is the lowest among the three items, and the Copiousness of all the contents is below 3. Many of the contents of Philosophy of Science added in the CT are only 1. In future revisions, it may be possible to consider increasing the Copiousness of the contents of HPSS, which will help to increase the attention and interest of teachers and students to the contents of HPSS in the textbook.

Teachers should make full use of the HPSS content in textbooks and supplement them with additional reading materials as appropriate.

Through the study of HPSS content in physics textbooks, students can better perceive the content of the textbooks in the context of the development of science and their own lives, which plays an important role in students' understanding and mastery of knowledge.

Teachers should make full use of the HPSS content in teaching, not only explaining the part of the text and ignoring some notes or columns. The HPSS content in CT has increased compared with that in PT, and many of them are in the form of columns or notes to expand the content, so teachers should selectively explain or allow students to understand some of the HPSS content in class according to the actual situation of the students and the focus of the HPSS content in the new edition of the textbook. Teachers should selectively explain some of the HPSS content in class or let students read it after class according to the actual situation of the students they teach and the focus of the HPSS content in the new textbook, so as not to waste these valuable teaching materials.

Teachers can supplement some HPSS contents according to the actual needs of teaching. Previous studies have pointed out the lack of detail of HPSS content in physics textbooks (Brush, 2000; Klassen et al. 2012; Niaz et al. 2010, Montgomery & Kumar, 2021; Simon, 2016). For the history of science, textbooks appear more often with concepts, principles, and laws related to the history of science and the development of scientific and technological achievements related to the history of science and technology, and when explaining the history of concepts, principles, and laws appearing in textbooks, it would be helpful to add some concepts that have been disproved in the year they were able to be recognized with a reasonable It would be extremely helpful for students to know about NOS and to have a deeper understanding of these concepts, principles, and laws. The development of technology is rapid. When explaining the scientific and

technological achievements appearing in textbooks, it is necessary to consult the relevant information in advance and supplement students with the development process and the latest progress of these scientific and technological achievements in the course of teaching. For Philosophy of Science, the new textbook emphasizes the description of the Acquisition and testing of scientific knowledge, which is helpful for teachers to emphasize the importance of experimentation in science learning. CT has also added some content on scientific methodology so that teachers can let students discuss how to apply what they have learned in their teaching. For the sociology of science, CT attaches great importance to the discussion of the relationship between science and society. Teachers can add social hotspots to their teaching, and cultivate students' ability to use their physical knowledge to solve practical problems.

Conclusions

Overall, this study provides us with a picture of the changing nature of HPSS content in physics textbooks and efforts to improve students' understanding of NOS. The results of the study highlight the importance of integrating HPSS education into the science curriculum and the need for continuous assessment and improvement of textbook content to enhance Copiousness in science education. We analyzed the HPSS content in CT and PT using content analysis. One of our study was that the amount of HPSS content in CT increased compared to that in PT, mainly a decrease in the amount of history of science content, with philosophy of science content and sociology of science content both increasing. Finding two is that HPSS content copiousness in CT is consistent with PT as a whole, with the philosophy of science having the lowest copiousness. Finding three is that the sub-dimensions of the HPSS are very unevenly distributed and have their focus in the CT, but may leave students with a lack of understanding of some parts of the NOS.

Limitations and Opportunities for Further Research

Given the limitations of this study, there are two issues to consider when revealing the results. Firstly, there is the issue of the analytical framework; there is a close connection between the historical, philosophical, and sociological sciences, which is why they are discussed together (Zhang, 2017). Coding and discussing them separately in this study may have fragmented the relationship between the three to some extent. In future research, consideration could be given to developing an analytical framework that deeply integrates these three disciplines and analyses textbooks in a way that is more consistent with HPSS research.

The second limitation comes from the fact that this study used uniform Copiousness as a criterion for HPSS content quality, which led to limitations in our results. Future research should develop the development of different quality assessment criteria for different HPSS content, as some studies have already done (Klassen et al., 2012; Niaz et al., 2010), to more effectively understand changes in HPSS content in textbooks.

References

- Abd-El-Khalick, F. (2005). Developing deeper understandings of nature of science: The impact of a philosophy of science course on preservice science teachers' views and instructional planning. *International Journal of Science Education*, 27(1), 15-42. DOI: <https://doi.org/10.1080/09500690410001673810>
- Abd-El-Khalick F. (2012). Examining the Sources for our Understandings about Science: Enduring confluences and critical issues in research on nature of science in science education. *International Journal of Science Education*, 34(3), 353-374. DOI: <https://doi.org/10.1080/09500693.2011.629013>
- Abd-El-Khalick, F., Bell, R. L., & Lederman, N. G. (1998). The nature of science and instructional practice: Making the unnatural natural. *Science Education*, 82(4), 417-436. DOI: [https://doi.org/10.1002/\(SICI\)1098-237X\(199807\)82:4<417::AID-SCEI>3.0.CO;2-E](https://doi.org/10.1002/(SICI)1098-237X(199807)82:4<417::AID-SCEI>3.0.CO;2-E)
- Abd-El-Khalick, F., & Lederman, N. G. (2000). The influence of the history of science courses on students' views of the nature of science. *Journal of Research in Science Teaching*, 37(10), 1057-1095. DOI: [https://doi.org/10.1002/1098-2736\(200012\)37:10<1057::AID-TEA3>3.0.CO;2-C](https://doi.org/10.1002/1098-2736(200012)37:10<1057::AID-TEA3>3.0.CO;2-C)
- Abd-El-Khalick, F., Waters, M., & Le, A.-P. (2008). Representations of the nature of science in high school chemistry textbooks over the past four decades. *Journal of Research in Science Teaching*, 45(7), 835-855. DOI: <https://doi.org/10.1002/tea.20226>
- Alters, B. J. (1997). Whose nature of science? *Journal of Research in Science Teaching*, 34(1), 39-55. DOI: [https://doi.org/10.1002/\(SICI\)1098-2736\(199701\)34:1<39::AID-TEA4>3.0.CO;2-P](https://doi.org/10.1002/(SICI)1098-2736(199701)34:1<39::AID-TEA4>3.0.CO;2-P)
- Blachowicz, J. (2009). How Science Textbooks Treat Scientific Method: A Philosopher's Perspective. *The British Journal for the Philosophy of Science*, 60(2), 303-344. DOI: <https://doi.org/10.1093/bjps/axp011>
- Boniolo, G., & Campaner, R. (2020). Life Sciences for Philosophers and Philosophy for Life Scientists: What Should We Teach? *Biological Theory*, 15(1), 1-11. DOI: <https://doi.org/10.1007/s13752-019-00333-7>
- Brito, A., Rodríguez, M. A., & Niaz, M. (2005). A reconstruction of the development of the periodic table based on history and philosophy of science and its implications for general chemistry textbooks: PERIODIC TABLE AND GENERAL CHEMISTRY TEXTBOOKS. *Journal of Research in Science Teaching*, 42(1), 84-111. DOI: <https://doi.org/10.1002/tea.20044>
- Brush, S. G. (2000). Thomas Kuhn as a Historian of Science. *Science & Education*, 9(1), 39-58. DOI: <https://doi.org/10.1023/A:1008761217221>
- Bybee, R. W., Powell, J. C., Ellis, J. D., Giese, J. R., Parisi, L., & Singleton, L. (1991). Integrating the history and nature of science and technology in science and social studies curriculum. *Science Education*, 75(1), 143-155. DOI: <https://doi.org/10.1002/sce.3730750113>

- Chen, S.-Y., Chen, C.-H., & Liu, S.-Y. (2022). History of Science Reading Materials as Everyday Homework to Improve Middle School Students' Epistemological Beliefs about Science. *International Journal of Science and Mathematics Education*, 20(S1), 69-92. DOI: <https://doi.org/10.1007/s10763-022-10285-3>
- Clary, R. M., & Wandersee, J. H. (2015). The History of Science in the Science Classroom: The Past Is the Key to the Future in Science Education. *Earth Sciences History*, 34(2), 310-332.
- Cofré H., Núñez, P., Santibáñez, D., Pavez, J. M., Valencia, M., & Vergara, C. (2019). A Critical Review of Students' and Teachers' Understandings of Nature of Science. *Science & Education*, 28(3-5), 205-248. DOI: <https://doi.org/10.1007/s11191-019-00051-3>
- Cunningham, C. M., & Helms, J. V. (1998). Sociology of science as a means to a more authentic, inclusive science education. *Journal of Research in Science Teaching*, 35(5), 483-499. DOI: [https://doi.org/10.1002/\(SICI\)1098-2736\(199805\)35:5<483::AID-TEA2>3.0.CO;2-L](https://doi.org/10.1002/(SICI)1098-2736(199805)35:5<483::AID-TEA2>3.0.CO;2-L)
- DiGiuseppe, M. (2014). Representing Nature of Science in a Science Textbook: Exploring author-editor-publisher interactions. *International Journal of Science Education*, 36(7), 1061-1082. DOI: <https://doi.org/10.1080/09500693.2013.840405>
- Farías Camero, D. M., Castelló Escandell, J., & Molina Caballero, M. F. (2012). Análisis del enfoque de historia y filosofía de la ciencia en libros de texto de química: El caso de la estructura atómica. *Enseñanza de las Ciencias. Revista de investigación y experiencias didácticas*, 31(1), 115-133. DOI: <https://doi.org/10.5565/rev/ec/v31n1.489>
- Galili, I., & Hazan, A. (2000). The influence of an historically oriented course on students' content knowledge in optics evaluated by means of facets-schemes analysis. *American Journal of Physics*, 68(S1), S3-S15. DOI: <https://doi.org/10.1119/1.19518>
- Galili, I., & Hazan, A. (2001). The Effect of a History-Based Course in Optics on Students' Views about Science. In F. Bevilacqua, E. Giannetto, & M. R. Matthews (Eds.), *Science Education and Culture* (pp. 229-254). Springer Netherlands. DOI: https://doi.org/10.1007/978-94-010-0730-6_16
- Gardner, P. L. (1999). The representation of science-technology relationships in Canadian physics textbooks. *International Journal of Science Education*, 21(3), 329-347. DOI: <https://doi.org/10.1080/095006999290732>
- Grüne-Yanoff, T. (2014). Teaching philosophy of science to scientists: Why, what and how. *European Journal for Philosophy of Science*, 4(1), 115-134. DOI: <https://doi.org/10.1007/s13194-013-0078-x>
- Henke, A., & Höttecke, D. (2015). Physics Teachers' Challenges in Using History and Philosophy of Science in Teaching. *Science & Education*, 24(4), 349-385. DOI: <https://doi.org/10.1007/s11191-014-9737-3>
- Höttecke, D., & Silva, C. C. (2011). Why Implementing History and Philosophy in School Science Education is a Challenge: An Analysis of Obstacles. *Science & Education*, 20(3), 293-316. DOI: <https://doi.org/10.1007/s11191-010-9285-4>
- Justi, R., & Gilbert, J. (2000). History and philosophy of science through models: Some challenges in the case of "the atom." *International Journal of Science Education*, 22(9), 993-1009. DOI: <https://doi.org/10.1080/095006900416875>
- Kelly, G. J., Carlsen, W. S., & Cunningham, C. M. (1993). Science education in sociocultural context: Perspectives from the sociology of science. *Science Education*, 77(2), 207-220. DOI: <https://doi.org/10.1002/sce.3730770208>
- Kim, S. Y., & Irving, K. E. (2010). History of Science as an Instructional Context: Student Learning in Genetics and Nature of Science. *Science & Education*, 19(2), 187-215. DOI: <https://doi.org/10.1007/s11191-009-9191-9>
- Klassen, S., Niaz, M., Metz, D., McMillan, B., & Dietrich, S. (2012). Portrayal of the History of the Photoelectric Effect in Laboratory Instructions. *Science & Education*, 21(5), 729-743. DOI: <https://doi.org/10.1007/s11191-011-9360-5>
- Laçın-Şimşek, C. (2011). WOMEN SCIENTISTS IN SCIENCE AND TECHNOLOGY TEXTBOOKS IN

- TURKEY. *Journal of Baltic Science Education*, 10(4).
- Laudan, L. (1989). Thoughts on Hps—20 Years Later. *Studies in History and Philosophy of Science*, 20(1), 9-13. DOI: [https://doi.org/10.1016/0039-3681\(89\)90030-7](https://doi.org/10.1016/0039-3681(89)90030-7)
- Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching*, 39(6), 497-521. DOI: <https://doi.org/10.1002/tea.10034>
- Leite, L. (2002). History of Science in Science Education: Development and Validation of a Checklist for Analysing the Historical Content of Science Textbooks. *SCIENCE & EDUCATION*, 11, 333-359.
- Li, X., Tan, Z., Shen, J., Hu, W., Chen, Y., & Wang, J. (2020). Analysis of Five Junior High School Physics Textbooks Used in China for Representations of Nature of Science. *Research in Science Education*, 50(3), 833-844. DOI: <https://doi.org/10.1007/s11165-018-9713-z>
- Li, Y., & Zheng, C. (2009). The Development of International HPS Education and It's Apocalypse for Reform of Science Education. *Comparative Education Review*, 31(05), 13-18.
- Lin, L., Song, Q., Wang, J., Hu, T., Ping, X., & Ling, Y. (2022). History of Science in Two Recent Versions of High School Physics Textbooks in China. *Science & Education*. DOI: <https://doi.org/10.1007/s11191-021-00307-x>
- Ma, Y., & Wan, Y. (2017). History of science content analysis of Chinese science textbooks from the perspective of acculturation. *Science & Education*, 26(6), 669-690. DOI: <https://doi.org/10.1007/s11191-017-9914-2>
- Martin, M. (1972). Philosophy of Science and Science Education. *Studies in Philosophy and Education*, 7(3), 210-225. DOI: <https://doi.org/10.1007/BF00373219>
- Matthews, M. R. (1989). History, philosophy, and science teaching: A brief review. *Synthese*, 80(1), 1-7. DOI: <https://doi.org/10.1007/BF00869945>
- Matthews, M. R. (1992). History, philosophy, and science teaching: The present rapprochement. *Science and Education*, 1(1), 11-47. DOI: <https://doi.org/10.1007/BF00430208>
- Matthews, M. R. (2009). Teaching the Philosophical and Worldview Components of Science. *Science & Education*, 18(6-7), 697-728. DOI: <https://doi.org/10.1007/s11191-007-9132-4>
- Matthews, M. R. (2017). Reconceptualizing the nature of science for science education. *Studies in Science Education*, 53(1), 105-107. DOI: <https://doi.org/10.1080/03057267.2016.1258108>
- Matthews, M. R. (Ed.). (2018). *History, Philosophy and Science Teaching*. Springer International Publishing. DOI: <https://doi.org/10.1007/978-3-319-62616-1>
- Metz, D., Klassen, S., McMillan, B., Clough, M., & Olson, J. (2007). Building a Foundation for the Use of Historical Narratives. *Science & Education*, 16(3), 313-334. DOI: <https://doi.org/10.1007/s11191-006-9024-z>
- Ministry of Education, P. R. (2017). *Physics curriculum standards for senior high school*. People's Education Press.
- Monk, M., & Osborne, J. (1997). Placing the history and philosophy of science on the curriculum: A model for the development of pedagogy. *Science Education*, 81(4), 405-424. DOI: [https://doi.org/10.1002/\(SICI\)1098-237X\(199707\)81:4<405::AID-SCE3>3.0.CO;2-G](https://doi.org/10.1002/(SICI)1098-237X(199707)81:4<405::AID-SCE3>3.0.CO;2-G)
- Montgomery, S. L., & Kumar, A. (2021). Under the Influence: History in Scientific Training, the Case of Textbooks. *KNOW: A Journal on the Formation of Knowledge*. DOI: <https://doi.org/10.1086/716847>
- Niaz, M. (1998). From cathode rays to alpha particles to quantum of action: A rational reconstruction of structure of the atom and its implications for chemistry textbooks. *Science Education*, 82(5), 527-552. DOI: [https://doi.org/10.1002/\(SICI\)1098-237X\(199809\)82:5<527::AID-SCE1>3.0.CO;2-B](https://doi.org/10.1002/(SICI)1098-237X(199809)82:5<527::AID-SCE1>3.0.CO;2-B)
- Niaz, M. (2000a). A rational reconstruction of the kinetic molecular theory of gases based on history and philosophy of science and its implications for chemistry textbooks. *INSTRUCTIONAL SCIENCE*, 28, 23-50.
- Niaz, M. (2000b). The Oil Drop Experiment: A Rational Reconstruction of the Millikan-

- Ehrenhaft Controversy and Its Implications for Chemistry Textbooks. *Journal of Research in Science Teaching*, 37(5), 480-508. DOI: [https://doi.org/10.1002/\(SICI\)1098-2736\(200005\)37:5<480::AID-TEA6>3.0.CO;2-X](https://doi.org/10.1002/(SICI)1098-2736(200005)37:5<480::AID-TEA6>3.0.CO;2-X)
- Niaz, M. (2001). A rational reconstruction of the origin of the covalent bond and its implications for general chemistry textbooks. *International Journal of Science Education*, 23(6), 623-641. DOI: <https://doi.org/10.1080/09500690010006491>
- Niaz, M., & Coştu, B. (2009). Presentation of atomic structure in Turkish general chemistry textbooks. *Chemistry Education Research and Practice*, 10(3), 233. DOI: <https://doi.org/10.1039/b914503f>
- Niaz, M., Klassen, S., McMillan, B., & Metz, D. (2010). Reconstruction of the history of the photoelectric effect and its implications for general physics textbooks. *Science Education*, 94(5), 903-931. DOI: <https://doi.org/10.1002/sce.20389>
- Persson, J. R. (2018). Evolution of quasi-history of the Planck blackbody radiation equation in a physics textbook. *American Journal of Physics*, 86(12), 887-892. DOI: <https://doi.org/10.1119/1.5054005>
- Reiss, M. J. (2020). Science Education in the Light of COVID-19 The Contribution of History, Philosophy and Sociology of Science. *Science & Education*, 29(4), 1079-1092. DOI: <https://doi.org/10.1007/s11191-020-00143-5>
- Rodríguez, M. A., & Niaz, M. (2004). The Oil Drop Experiment: An Illustration of Scientific Research Methodology and its Implications for Physics Textbooks. *Instructional Science*, 32(5), 357-386. DOI: <https://doi.org/10.1023/B:TRUC.0000044641.19894.ed>
- Sachs, M. (1993). On the Problem of Cosmology. *Physics Essays*, 6(1), 32-38. DOI: <https://doi.org/10.4006/1.3029034>
- Simon, J. (2016). Writing the Discipline: Ganot's Textbook Science and the "Invention" of Physics. *Historical Studies in the Natural Sciences*, 46(3), 392-427. DOI: <https://doi.org/10.1525/hsns.2016.46.3.392>
- Solbes, J., & Traver, M. (2003). Against a Negative Image of Science: History of Science and the Teaching of Physics and Chemistry. *Science & Education*, 12, 703-717.
- Solomon, J., Duveen, J., Scot, L., & McCarthy, S. (1992). Teaching about the nature of science through history: Action research in the classroom. *Journal of Research in Science Teaching*, 29(4), 409-421. DOI: <https://doi.org/10.1002/tea.3660290408>
- Teixeira, E. S., Greca, I. M., & Freire, O. (2012). The History and Philosophy of Science in Physics Teaching: A Research Synthesis of Didactic Interventions. *Science & Education*, 21(6), 771-796. DOI: <https://doi.org/10.1007/s11191-009-9217-3>
- Vesterinen, V.-M., Manassero-Mas, M.-A., & Vázquez-Alonso, Á. (2014). History, Philosophy, and Sociology of Science and Science-Technology-Society Traditions in Science Education: Continuities and Discontinuities. In M. R. Matthews (Ed.), *International Handbook of Research in History, Philosophy and Science Teaching* (pp. 1895-1925). Springer Netherlands. DOI: https://doi.org/10.1007/978-94-007-7654-8_58
- Vojíš, K., & Rusek, M. (2019). Science education textbook research trends: A systematic literature review. *International Journal of Science Education*, 41(11), 1496-1516. DOI: <https://doi.org/10.1080/09500693.2019.1613584>
- Williams, C. T., & Rudge, D. W. (2016). Emphasizing the History of Genetics in an Explicit and Reflective Approach to Teaching the Nature of Science: A Pilot Study. *Science & Education*, 25(3-4), 407-427. DOI: <https://doi.org/10.1007/s11191-016-9821-y>
- Wong, S. L., & Hodson, D. (2010). More from the Horse's Mouth: What scientists say about science as a social practice. *International Journal of Science Education*, 32(11), 1431-1463. DOI: <https://doi.org/10.1080/09500690903104465>
- Wylie, A. (1994). Discourse, Practice, Context: From HPS to Interdisciplinary Science Studies. *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association*, 1994(2), 392-395. DOI: <https://doi.org/10.1086/psaprocbienmeetp.1994.2.192950>
- Yuan, W. (2005). A Summary of Studies on Integration of Scientific Science

Curriculum in Foreign Countries.
Comparative Education Review, 10, 62-67.

Zhang, J. (2017). HPS Education Research. Science Press.

Zhuang, H., Xiao, Y., Liu, Q., Yu, B., Xiong, J., & Bao, L. (2021). Comparison of nature

of science representations in five Chinese high school physics textbooks.

International Journal of Science

Education, 43(11), 1779-1798. DOI:

<https://doi.org/10.1080/09500693.2021.1933647>

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Mental Health Issues in Chinese College Students as Former Left-Behind Children: A Literature Review

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Abstract: *The issue of left-behind children in China has been a consequence of its accelerated economic development in the past few decades. While there is a large body of literature on the physical and mental health states of this group, research on the impact of their early left-behind life on their future development, particularly on their future mental well-being, has been inadequate. This article is a literature review based on 40 prior studies of the mental health states of college students as former left-behind children in China. It encapsulates research topics, methodologies, and tools of these studies and draws the conclusion that these college students' past experiences as left-behind children have long-term impacts, primarily unfavorable ones, on their mental well-being. Also, the study summarizes the factors that possibly affect mental health in this group and proposes certain intervention suggestions.*

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Introduction

MENTAL HEALTH is about the state of emotional, psychological, and social well-being of the individual. A mentally healthy individual has the capacity to recognize and manage their emotions; establish and maintain intimate relationships with others; cope with stress and changes in life; and play various social roles in their cultural context (Bhugra et al., 2013; Fusar-Poli et al., 2020). A healthy mental state enables a person to properly perceive their own value and control over life, helping them develop a profound understanding of their internal psychological processes (such as emotions and motivations) and external behaviors (such as social interactions and workplace performance). Mental health is an integral part of overall well-being and substantively influences the physical health of the individual. Nevertheless, compared with physical problems, mental health issues are less easy to draw the attention of society.

Amid the accelerated economic development and advancement of urbanization in the past few decades, a massive population of rural labor forces left their native places to seek better employment opportunities in cities. According to the statistics of China's seventh national census, the country had a migrating population of approximately 376 million in 2020 (Lu et al., 2024). However, the majority of migrant workers were unable to have their underage children live with them due to the constraints regarding childcare, education, and living conditions. These children were left to the care of their relatives in home places and dubbed "left-behind children." The long-time separation from their parents and a lack of parental custody brought on a variety of challenges to their growth as well as many social issues, which has provoked widespread concerns in Chinese society. Early research in this area has focused on the short-term effects of the abnormal growth environment on the development of left-behind children in terms of educational opportunities, academic performance, physical health, and mental development. In recent years, a portion of researchers began to pay attention to the long-term effects of their experience as left-behind children because they have come to the realization that the negative impact of early parent-child separation may endure in the children's adulthood, despite the fact that the parents' employment in foreign places could successfully increase home incomes and input in child education, building a better foundation for their future development.

College students in China are often deemed a group with high risks of mental issues as they are at the junction of adolescence and adulthood, experiencing multiple kinds of pressures as a result of the change in the living environment, academic and employment challenges, and other factors (Yu, 2017). Many mental health education practitioners in Chinese colleges and universities observed that college students as former left-behind children

(hereinafter referred to as FLBC college students), compared with their non-FLBC peers, are more likely to suffer mental issues, such as low self-esteem, unstable emotional states, social withdrawal, and fear of developing a relationship with a member of the opposite sex (Zhang, 2006; Yu, 2017). A thorough understanding of the impact of the early left-behind life on mental health in them is of vital significance for improving their mental well-being and increasing their capacity to navigate challenges in adulthood. In this context, the present study focuses on investigating the long-term impact of childhood left-behind life experience on mental health in Chinese FLBC college students by encapsulating and analyzing existing research findings from the relevant literature.

An Overview of Prior Studies

This study sources literature from the database China National Knowledge Infrastructure (CNKI). To ensure the academic quality of the included literature, only peer-reviewed articles published by journals listed in “A Guide to the Core Journals of China” and the Chinese Social Science Citation Index (CSSCI) were included in the screening process. “Left-behind children,” “left-behind life experience,” “college student,” and “mental health” are the search words. By December 10, 2024, 211 articles had been retrieved, among which 40 were identified as valid after duplicate articles and articles irrelevant to the research topic were removed.

The studies included in our review were published between 2012 and 2023. Among them, 19 discussed the overall mental health states or psychological qualities of FLBC college students, and 20 addressed the factors influencing their mental well-being and one explores the intervention measures for bolstering their mental states. Frequent words in the literature related to our research topic include mental resilience, subjective well-being, depression, social support, anxiety, suicidal ideation, and childhood traumas, manifesting the focuses of these studies. The overwhelming majority of the included studies adopt the method of quantitative analysis based on questionnaires (N=38); only two of them use the method of qualitative analysis based on interviews. Both comprehensive and non-comprehensive scales are employed as measurement tools by these studies. Comprehensive scales used include the Self-report Symptom Checklist 90 (N=8), General Health Questionnaire (GHQ) (N=2), Chinese College Students Mental Health Scale (CCSMHS) (N=2), and personality questionnaires (N=4). Non-comprehensive scales have specific focuses, including the resilience scales (N=10), social support scales (N=7), well-being perception scales (N=5), trauma scales (N=7), social adaptation scales (N=3), depression scales (N=6), self-esteem scale (N=4), suicidal ideation questionnaires (N=3), self-efficacy scale (N=3), anxiety scales (N=3), and more (**Table 1**).

Table 1. A Summary of Measurement Tools Used in the 40 Studies

Categories of Scales	Types of Scales	Subdivisions	# of Studies
Comprehensive scales	Self-report Symptom Checklist 90 (SCL-90)		8
	General Health Questionnaire (GHQ)		2
	Chinese College Students Mental Health Scale (CCSMHS)		2
Comprehensive scales	Personality questionnaires	Eysenck Personality Questionnaire, EPQ	1
		Chinese Big Five Personality Inventory Brief Version, CBF-PI-B	1
		College Students Personality Questionnaires	2
Non-comprehensive scales	Mental resilience scales	The Connor-Davidson Resilience Scale (CD-RISC)	6
		Resilience Scale for Chinese Adolescents (RSCA)	2
		Chinese Mental Resilience Scale (CMRS)	1
		Short Form of the Resilience Scale (SFRS)	1
	Social support scales	Social Support Rating Scale (SSRS)	4
		Perceived Social Support Scale (PSSS)	3
	Well-being perception scales	General Well-Being (GWB)	3
		Subjective Well-Being Scale	1
		Subjective Well-Being Questionnaire (self-developed)	1
	Trauma rating scales	Childhood Trauma Questionnaire (CTQ)	3
		Childhood Trauma Questionnaire - 28 item Short-Form (CTQ-SF)	3
		Social Trauma Questionnaire (STQ)	1
	Social adaptation scales	College Students Adaptability Inventory (CSAI)	2
		Chinese College Students Adaptation Scale (CCSAS)	1
	Depression scales	Self-rating Depression Scale (SDS)	4
		Center for Epidemiologic Studies Depression Scale (CES-D)	1
		Beck Depression Rating Scale	1
	Self-esteem scale	Rosenberg Self-Esteem Scale (SES)	4
	Suicidal ideation questionnaires	Suicidal Behaviors Questionnaire – Revised (SBQ-R)	1
		Reasons for Living Inventory for Adolescents (RFL-A)	1
		Purpose in Life Test (PIL)	1
	Self-efficacy scale	General Self-Efficacy Scale (GSES)	3
	Anxiety Scales	Self-Rating Anxiety Scale (SAS)	2
		Interaction Anxiousness Scale (IAS)	1
		Obsessive Compulsive Inventory Revised (OCI-R)	1
		Adolescent Self-Rating Life Events Check List (ASLEC)	2
		Security Questionnaire (SQ)	2
	Coping Style Questionnaire (CSQ)	2	

	Adversity Quotient, AQ	2
Adversity questionnaires	Perceived Social Adversity Questionnaire, STQ	1
Buss-Perry Aggression Questionnaire (BPAQ-CCSV)		2
Rejection Sensitivity Questionnaire, RSQ		1
The Depression Anxiety Stress Scale (DASS)		1
UCLA Loneliness Scale		1
Self- Acceptance Questionnaire (SAQ)		1
Social Avoidance and Distress Scale (SAD)		1
Self-compassion Scale (SCS)		1
College Student Behavior Problem Scale (CSBPS)		1
Positive Affect and Negative Affect Scale (PANAS)		1
Positive Mental Characters Questionnaire (PMCQ)		1

Mental Health States of FLBC College Students

The literature reveals that the overall mental health standard of FLBC college students is significantly lower than that of non-FLBC ones (Zhan et al., 2016; Luo & Zhou, 2017; Zang et al., 2018; Cheng & Jiang, 2021). Specifically, there are higher detection rates of severe mental problems and common mental problems in the former than in the latter (Liu et al., 2015; Chen et al., 2017). FLBC college students are more likely to suffer from psychological disorders, including but not limited to somatization, obsessive-compulsive symptoms, inordinate interpersonal sensitivity, depression, anxiety, hostility, terror, paranoia, and psychoticism (Yang et al., 2014). These findings suggest that the negative impacts of the child’s early left-behind life are not limited to their childhood but may extend to their adulthood. The mental health issues of FLBC college students are not only harmful to their academic life but also hamper their interpersonal communication and future career development. Prior studies have looked at the mental health states of this group from the following aspects:

- *Subjective Well-being:* Subjective well-being, also known as self-reported well-being, is an individual’s self-evaluation of their quality of life and mental state, often used to measure their mental health and happiness as well as serving as an indicator of their social functioning and adaptation (He, 2012). According to Zhao et al.’s (2013) and Zhou et al.’s (2014) research findings, college students reported significantly

lower levels of subjective well-being than their non-FLBC counterparts. Wang and Xu (2023) went further to reveal that FLBC college freshmen perceived significantly lower well-being in the dimensions of life satisfaction/interest and relaxation/tension, compared to their non-FLBC peers. All these studies point to the early parent-child separation leading to compromised subjective well-being in FLBC college students as a result of the low quality of life and negative emotions they experienced.

- *Social Adaptability*: Social adaptation, a process of adapting oneself to constant change in the social environment, is the key to the socialization of the individual. Adjusting to the shifts in the external environment helps them maintain inner peace and mental healthiness (Sun et al., 2023). Yang et al.'s study (2021) finds that FLBC college students have lower performance in social adaptation than their non-FLBC counterparts. As per Sun et al.'s (2023) study, social maladaptation of FLBC college students is primarily manifested in their inability to establish and maintain desirable interpersonal relationships or to adapt to new roles in a changed environment. Zhang et al. (2017) argued that FLBC college students had difficulty integrating with their peers, although not all of them performed badly in social adaptation. According to Ji and Han's (2023) study, a portion of persons with prior left-behind life experience could still realize positive social development, able to develop a close relationship with parents, peer relationships on an equal footing, extroverted personalities, stable emotions, and self-efficacy. This finding indicates that FLBC college students' early life is not the decisive determinant of their social adaptability despite its potentially negative impact on their growth.
- *Mental Resilience*: Mental resilience, or psychological resilience, is the ability to cope mentally and emotionally with tough events, such as the adversity, trauma, tragedy, and threat, and return to pre-crisis status quickly (Song et al., 2020). Prior comparison analyses find that FLBC college students score lower in mental resilience testing than the non-FLBC group (Yang et al., 2014; Han et al., 2017; Song et al., 2020), showing that the previous left-behind life experience is not favorable for psychological resilience development in them. Lower levels of psychological resilience, in return, make it more difficult for FLBC college students to recover from adverse events or negative emotions, which may lead to significant psychological problems. This is evidenced by Zhang and Xu's (2022) research findings that for students with lower levels of psychological resilience, traumatic experiences are more likely to lead to negative emotions, whereas among those with higher levels of psychological resilience, the impact of traumatic experiences on emotions is less significant.

- *Depression Symptoms and Adverse Life Events:* There are higher detection rates of depression symptoms in FLBC college students than in their non-FLBC peers (Han et al., 2017; He et al., 2018). Moreover, there is a significant correlation between their depression level and the frequency of adverse life events encountered (Li et al., 2017). FLBC college students are more likely to experience frustrations in romantic relationships and conflicts with family members, as well as other adverse events such as failures in selection activity, being criticized or punished, dropping out, fighting with others, etc. High incidence of adverse events In FLBC, college students make them more vulnerable to depressive disorders.
- *Other Negative Emotions and Problematic Behaviors:* In addition to depression, childhood left-behind life experiences have other emotional consequences in FLBC college students, such as anxiety (Yi & Zhang, 2018; Liang et al., 2019), a lack of self-efficacy (Jie et al., 2021), and security, particularly interpersonal security (Gan et al., 2017). A more concerning psychological issue in FLBC college students is the higher levels of suicidal ideation in them (Liu & Wang, 2017; Gan et al., 2017). In addition, FLBC college students are more likely to develop the obsessive-compulsive tendency, which is corroborated by Liu et al.'s (2019) research finding that the detection rate of the obsessive-compulsive disorder in this group is 26.5%, substantially higher than the normal level. Also, there is a higher incidence of problematic behaviors in FLBC college students than their non-FLBC peers. They are more likely to display impulsive or hostile tendencies in response to undesirable stimuli and even resort to aggressive behavior in extreme cases (Li et al., 2019; Jin et al., 2019; Chen et al., 2022). These behavioral problems bring damage to their interpersonal relationships.
- *Positive Impacts:* Aside from the above negative consequences, FLBC college students' early life may generate certain positive effects for their mental development. According to Wen and Zeng's (2012) study, FLBC college students can actively react to challenges by adopting positive coping strategies like rationalizing the issue and seeking other's assistance. This may be the outcome of their early-year experiences of having to confront difficulties in life and education and solve all sorts of problems independently in the absence of their parents. Also, Dong and Qi's (2014) study finds that the majority of FLBC college students have stronger senses of life purpose than their non-FLBC peers. Research findings like these imply the necessity of examining the impact of the early left-behind life on mental health in FLBC college students from a broader perspective, taking both the potentially negative and positive consequences into consideration.

Factors Related to the Mental Well-Being of FLBC College Students

External Factors

- *Childhood Traumas*: Zhang and Xu's (2022) study finds that 63.9% of FLBC college students sampled had traumatic experiences, which is overwhelmingly higher than the normative level. These traumatic experiences include, but are not limited to, emotional, physical, and sexual abuse and emotional and physical neglect. The literature reveals a close relationship between childhood traumas and adulthood mental issues in FLBC college students. According to Pan et al. (2019), childhood traumas have a direct effect on the mental health states of this group, with an effect size of 0.247. A bigger number of childhood traumatic experiences predicts a higher risk of social maladjustment and a lower level of mental health in FLBC college students (Sun et al. (2023); early traumatic experiences have a positive correlation with aggressive behavior in these students (Jin et al., 2019); childhood emotional traumas directly and positively predict social anxiety among them (Zhang et al., (2022). Drawing on the schema therapy theory, Qin et al. (2019) delved into how childhood traumas influenced adulthood mental health and discovered that children who suffered abandonment, abuse, neglect, and rejection during childhood could develop schemas related to such themes as "loss" and "worthlessness," due to their unmet basic needs for stability, security, and loving nurturing. These schemas, as the core patterns for individuals to process external information, can profoundly influence their emotional responses to life events. In later similar scenarios to childhood traumatic events, these early maladaptive schemas can be easily activated, leading to a recurrence of negative emotions like self-worth denial and distrust in others, thereby increasing the incidence of psychological problems in them. This finding provides a valuable implication for intervention of mental health issues among FLBC college students: the intervention should address not only the direct impacts of their past traumatic experiences but also the consequences of latent maladaptive schemas. Cognitive reconstruction and behavioral training, among other devices, may be helpful in correcting unfavorable schemas and improving mental health in this group.
- *Social Support*: Social support is about supportive behaviors from others, such as approval, respect, care, and assistance that an individual perceives or experiences; it can come from many sources, such as family, friends, organizations, etc. (Zhan et al., 2016). Prior studies suggest that

social support is significantly predictive of positive mental states in FLBC college students (Xie, 2015; Wang & Xu, 2023). Support from the family, peers, and the school is a key factor for their healthy development; detrimental incidents like school bullying and parental emotional neglect can lead to increased negative emotions, impairing their mental well-being. For instance, they may internalize parental neglect and deem themselves a burden on their parents, developing a pessimistic mentality of their existence (Zheng, 2021). In the meantime, their previous life as left-behind children also poses a negative impact on their perception of social support. In her interviews with FLBC college students, He (2013) discovered that this group had difficulty communicating properly with their parents and were unwilling to turn to them for help when encountering troubles. This means they not only perceive lower levels of social support but also have lower levels of motivation for leveraging external support. Hence, it is important to improve the social support system for FLBC college students, which involves their family, peers, and the school, while also assisting them in developing a legitimate self-concept as well as the capacity for navigating life challenges by providing specialist counseling and mentoring.

- *Home Atmospheres and Parenting Style:* The family environment and home education are key to the character formulation and development of the individual. There is a significant relationship between family atmospheres and the mental health state in FLBC college students; the more harmonious the family relationships, the healthier the psychology of the FLBC college student (Cheng & Jiang, 2021). Also, the upbringing style is a critical factor for the mental development of FLBC college students. Both harsh and permissive upbringings can possibly lead to obsessive-compulsive disorders in this group (Liu et al., 2019). Unscientific upbringing may instigate neurotic personality tendencies in the younger generation, causing social interaction problems like emotional instability, self-centeredness, tension, and anxiety (Liu & Wang, 2017). Poor interpersonal communication can, in return, exacerbate the mental problems of the individual. Therefore, guiding households with left-behind children to create a desirable home environment and adopt legitimate upbringing practices is of vital importance for the long-term mental development of their younger generation.
- *Parent-Child Separation Patterns:* The duration of separation from parents, frequency of communication with migrating parents, and the number of parents absent (i.e., one or two parents working outside the homeplace) can all have impacts on the child's mental health in adulthood (Dong & Qi, 2014; Zhang et al., 2017; Chen et al., 2017;

Liang et al., 2019; Cheng & Jiang, 2021). Enduring parent-child separation, low frequency of parent-child communication (less than once every month) in separation, and the absence of both parents or the mother are factors contributing to mental health problems of FLBC college students. On the other hand, He (2012) made the point that it was the quality rather than the frequency of parent-child communication matters more during the separation. Hence, it is important for the migrating parents or parent to maintain adequate, quality interaction with their children to mitigate the adverse effects of their absence on the latter's mental health development.

Personal Factors

- *Gender*: There are detailed analyses of the relationship between gender and the mental health state in FLBC college students in the literature. According to Wen and Ma (2021), symptoms like psychoticism and interpersonal sensitivity are more common in male FLBC college students, as opposed to depressive and hostile emotions in their female counterparts. The incidence of problematic behaviors, particularly those moderate- and severe-level ones, is higher in male FLBC college students than in their female peers (Li et al., 2019). Comparatively, boy FLBC college students have lower levels of self-esteem and mental resilience and are more likely to produce psychosomatic reactions when encountering adverse, stressful events (Han Li et al., 2017). Girl FLBC College students score higher in subjective well-being and life satisfaction (He, 2012; Zhao et al., 2013). This may be due to the variations in social characteristics between the two gender groups: girls are more inclined to find someone to talk their problems through and seek out assistance when facing difficulties and pressures, while boys are more likely to choose to go through a difficult time independently, which is not conducive to the release of psychological stress. In addition, Liu et al.'s (2015) study finds that female FLBC college students benefit more from the positive effects of the early left-behind life experience, possibly because girls typically mature earlier and are more ready to take on the roles and responsibilities of their parents in their absence. On the other hand, despite their slightly higher level of mental health across the board, female FLBC college students received less social support than their opposite sex, which leads to their scoring higher in the dimensions of paranoia and fear. This may be attributable to the influence of the son-preference tradition in Chinese society (Zhan et al., 2016). Under this tradition and the stringent supervision over girls from their grandparents, female left-behind children could actually access less social support.

- *Age:* The literature reveals a decline in the incidence of mental problems in FLBC college students with the increase of their ages. As their grades advance, FLBC college students undergo cognitive progress, develop more effective coping strategies for academic pressures and adverse events, and become better adapted to college life. Han et al.'s (2017) research results demonstrate that first-grade FLBC college students have higher levels of mental well-being than second-grade ones. Despite such a positive tendency, FLBC college students still have higher mental health risks at certain critical points like graduation, postgraduate program application, and employment (Liu et al., 2015). These research findings imply that psychological counseling services for FLBC college students should focus more on the first and fourth graders in this group.
- *Psychological Qualities:* Prior studies also find that positive psychological qualities can successfully moderate the negative effects of the childhood left-behind life on mental health in FLBC college students. First, individuals with high levels of mental resilience can continuously work hard towards established goals, managing negative emotions carefully, viewing setbacks and adversities rationally, and being more ready to seek for assistance from family and others (Yang et al., 2014). This psychological quality is favorable for lowering the risk of mental disorders in FLBC college students (Yue et al., 2019; Liang et al., 2019). Second, personal beliefs about adversity, entailing the individual's perceptions of the nature, causes, and consequences of adversities, as well as coping strategies for them, could be a valuable resource (Xie, 2015). If the adversity is not merely seen as a disadvantage but also an opportunity, its negative impact on the individual experiencing it can be significantly lessened. Ji and Han's (2023) research findings demonstrate that those FLBC college students with positive beliefs about adversity are less susceptible to the mental health consequences of their early left-behind life. Third, the ability to develop active coping strategies is a protective factor for healthy mental development in FLBC college students, potentially making up for the deficits in social support accessible to them (Jie et al., 2021). On the other hand, the literature also discusses certain negative psychological qualities that may exacerbate the mental health consequences of childhood left-behind life in FLBC college students. Yang et al. (2021), for example, investigated the relationship between rejection sensitivity and the mental health state in this group. Rejection sensitivity is about the individual's vulnerability to social rejection and tendency to overreact to it. FLBC college students with higher levels of rejection sensitivity are more likely to develop negative emotions after perceiving rejection, leading to a decline in their social adaptability.

Discussion

Our review of existing investigations of the mental health states of FLBC college students shows that the early left-behind life potentially has a long-term impact on the mental well-being of the individual. Its mental health consequences can possibly endure until their college years, or even longer. These negative consequences include low subjective well-being, hampered social adaptability, a lack of mental resilience, and susceptibility to negative emotions such as depression and anxiety. It is noteworthy that prior research results also indicate the possibility that this childhood experience becomes a positive driver for their future mental development.

Factors influencing the mental health states of FLBC college students are many, including external factors, such as the availability of social support, childhood traumatic incidents, family upbringing style, and parent-child separation pattern, and personal ones like gender, age, and psychological qualities of the student. Furthermore, there exist mutual interactions between these factors (Liu et al., 2019), pointing to the complexity of the issue of mental health in this group and making relevant intervention a challenging task. Currently, research on psychological intervention for FLBC college students remains scarce. Among the 40 studies included in this review, only Zhang (2018) investigated the effects of psychological intervention in improving the mental well-being of this group. This study finds that Naikan Cognitive Therapy (NCT) is effective in enhancing the levels of mental resilience and perceived social support in FLBC college students. This may be because NCT encourages the subjects to perceive the love and care from their loved ones and friends, thereby facilitating their integration into the family and other environments and successfully improving their social psychological capability.

An important implication of Zhang's (2018) research finding is that the various mental health risks faced by FLBC college students can be alleviated by effective interventions. To prevent the long-term negative impacts of the early left-behind life, the interventions should be administered to left-behind children in both the period of their separation from parents in childhood and the post-childhood period.

During the separation from their parents, left-behind children suffer a variety of challenges, such as a lack of parental companionship, financial difficulties, and peer bullying. These challenges not only pose damage to their childhood lives but also have far-reaching negative impacts on their mental health as adults (Zheng, 2021). In addition, left-behind children experience heavier academic pressures than their non-left-behind peers because of their strong desire for academic success, which they hope can bring changes to their own fate as well as their parents' status as migrant workers. This results in high motivation levels and academic achievement

targets in this group. Yet, due to the shortages of high-quality educational resources in rural areas, they need to put in more effort than their urban peers to obtain higher education opportunities, which evidently causes them additional academic pressures. Among these negative factors, Li et al. (2017) ranked the long-term separation from parents as the most detrimental one, followed by the overly heavy academic burdens and the family's financial difficulties. This indicates that parents of left-behind children should pay more attention to keeping stable and warm parent-child communication, enabling their kids to perceive their love and care in their absence via means like the video call. At the same time, the school and the community should strengthen support for left-behind children, providing supplementary tutoring, after-school entertainment, and psychological counseling if needed, to ease their academic pressures and help them alleviate loneliness and senses of inferiority and improve self-esteem and social skills.

In effect, the majority of Chinese parents as migrant workers have realized parent-child separation is detrimental to the kids' growth. Some of them have opted to have their kids live with them, making the latter "migrant children." This approach is far from ideal even though it significantly increases parental companionship. According to Cheng and Jiang's (2021) study, college students as former migrant children, generally, exhibit a higher mental health standard than those as former left-behind children, a standard comparable to that of ordinary students; still, they suffer higher pressures and perceive inadequacy in social support like their peers as former left-behind children do. Therefore, it is important for migrant worker parents to pay attention to their kids' needs for emotional support even if they can have their children live with them.

Furthermore, mental health support for left-behind children should continue after they enter adulthood. For those proceeding to tertiary education, the school should consider their family background and provide them with personalized psychological support and professional counseling, assisting with their adaptation to college life. Psychological counseling providers should focus on guiding FLBC college students to develop an objective understanding of their early left-behind life, learning to examine the positive and negative sides of their childhood experience no matter how painful it was. Also, establishing a mutual support group for FLBC college students is beneficial for their access to peer assistance. At the same time, the parents of FLBC college students ought to continue to give their adult children emotional support, encouraging them to share mental perplexities and confront mental issues with the assistance of parents. Additionally, society should increase their awareness of mental health issues of FLBC college students, working to create an inclusive and supportive social environment for this group.

Conclusion

Based on 40 prior studies on the mental well-being of Chinese FLBC college students, this survey reveals the long-term impact of the early left-behind life on mental health in this group. It also finds that the literature primarily focuses on the mental health issues in FLBC college students, as well as the factors related to them, but pays disproportionately inadequate attention to interventions in this regard. This area deserves more research in the future. Furthermore, the majority of the studies included in this review are cross-sectional analyses, and the several longitudinal analyses in the literature do not show sufficiently extended observation spans. To delve in depth into the patterns of the impact of the childhood left-behind life and explore relevant interventions, more longitudinal follow-up studies are warranted.

The limitations of this study should also be acknowledged. The search for relevant studies is inexhaustive, constrained by our literature searching method. In the meantime, it should be noted that the mental health consequences of the childhood left-behind life are not confined to FLBC college students. Certain studies demonstrate that the early left-behind life predicts a significantly slimmer chance of the individual's proceeding to higher education (Hu & Yan, 2020; Xie & Zhao, 2022). That means FLBC college students constitute only a very small portion of the adults with childhood left-behind life experience. Other groups with the same experience may face even more challenges and difficulties. Researchers need to pay comparable attention to them in order to examine the impact of the early left-behind life on mental development from a broader perspective.

References

(The 40 Studies included in the literature review are marked with asterisks)

Bhugra, D., Till, A., & Sartorius, N. (2013).

What is mental health? *International Journal of Social Psychiatry*, 59(1), 3-4.
DOI:

<https://doi.org/10.1177/0020764012463315>

*Chen, R., Zhao, J., & Zhao, J. (2017). Mental health and suicidal tendencies in college freshmen as former left-behind children at X University in Guangzhou City. *Guangdong Medical Journal*, 38(18),

2844-2846. DOI:

<https://doi.org/10.13820/j.cnki.gdyx.2017.18.028>

*Chen, X., Sheng, R., Zhang, C., & Xu, W. (2022). Self-care, anxiety, and aggressive behavior of college students as former left-behind children: The mediating effect of mental resilience. *China Journal of Health Psychology*, 30(2), 243-247. DOI: <https://doi.org/10.13342/j.cnki.cjhp.2022.02.017>

*Cheng, Y. & Jiang, J. (2021). The mental health states of college freshmen as

- former left-behind children. *China Journal of Health Psychology*, 29(2), 293-296. DOI: <https://doi.org/10.13342/j.cnki.cjhp.2021.02.028>
- *Dong, Z. & Qi, H. (2014). The relationship between mental resilience and senses of purpose in life in college students as former left-behind children in ethnic minority regions. *Chinese Journal of School Health*, 35(8), 1179-1181. DOI: <https://doi.org/10.16835/j.cnki.1000-9817.2014.08.021>
- Fusar-Poli, P., de Pablo, G. S., De Micheli, A., Nieman, D. H., Correll, C. U., Kessing, L. V., ... & van Amelsvoort, T. (2020). What is good mental health? A scoping review. *European neuropsychopharmacology*, 31:,33-46. DOI: <https://doi.org/10.1016/j.euroneuro.2019.12.105>
- *Gan, Y., Yang, Y., & Zhang, X. (2017). The relationship between the early left-behind life and suicidal ideation in college students: the mediating effect of the sense of security. *China Youth Studies*, 2017(8),99-104+77. DOI: <https://doi.org/10.19633/j.cnki.11-2579/d.2017.08.014>
- *Han, Li., Wang, Z., Zhang, J., Lyu, L., Wang, J., & Liao, C. (2017). The relationship between negative life events and depression among college students as former left-behind children. *Chinese Journal of Mental Health*, 31(4),326-332. Available at: https://kns.cnki.net/kcms2/article/abstract?v=Ep7N7zfewyRvOnN5DExKleMQL1eGxhExNHoIoTU80Lr4LqxLcE5Jqa_O7yq_2B8sO8ejh1kCNSGOWPocXwEVE8kChmXSzCFVmCDDCGkJgkAh3wRPRPZFQEGRZVGN72SwE6FDt6ulZEyrJxW5WYf9WMPjqb2wCKXSqIVZnkWuFnpQ_CO6VSU4A==&uniplatform=NZKPT&language=CHS
- *He, D. (2012). Subjective well-being of college students as former left-behind children and influencing factors. *Chinese Journal of School Health*, 33(7),863-865. DOI: <https://doi.org/10.16835/j.cnki.1000-9817.2012.07.034>
- *He, D. (2013). The relationship between social support and subjective well-being in college students as former left-behind children. *Chinese Journal of School Health*, 34(8),952-954. DOI: <https://doi.org/10.16835/j.cnki.1000-9817.2013.08.021>
- *He, H., Zeng, Q., & Wanghe, S. (2018). The relationship between the early left-behind life and depression in college students from rural China. *Chinese Journal of Health Education*, 34(11),973-978. DOI: <https://doi.org/10.16168/j.cnki.issn.1002-9982.2018.11.003>
- Hu, J. & Yan, Y. (2020). The childhood left-behind life and higher education opportunities. *Youth Studies*, 2020(4),1-10+94. Available at: <https://kns.cnki.net/kcms2/article/abstract?v=Ep7N7zfewyS3jcIYzpKZJzf7seds2Vmv8f7BVSdInjGPTKB1CLEq0XW5oPv-hyYPzkBMEuZs36UrZJOrxMRIBNk7TzTY8yxjpKPAzDbZbCAYNwsDvBeaYFJrnTFyuNkpI4TO8QYYjky9yyMya-L1lsXOHB3HCaAazEq-lRy5VsmCQorzXRdWg==&uniplatform=NZKPT&language=CHS>
- *Ji, C. & Han, L. (2023). The gaps in social development in rural left-behind children: An analysis based on the life history method. *Journal of Guizhou Normal University (Social Sciences Edition)*, 2023(4),105-115. DOI: <https://doi.org/10.16614/j.gznuj.skb.2023.04.009>
- *Jin, T., Zhang, L., Wu, Y., Yang, H., Liu, Z., & Huang, M. (2019). The relationship between social traumas and aggressive behavior in college students as former left-behind children: An analysis of the mediating effect of affective disorders. *Chinese Journal of Special Education*, 2019(6),91-96. Available at: https://kns.cnki.net/kcms2/article/abstract?v=Ep7N7zfewyTe7DihwnJsRcEDblNGwGUECQR3UqfuoiDrMHF5icqN8pwDvGCScnIBFvkqTdeDVMNxs3SPtkBQg9KIq4-6kYSrtcpN7DF76tx5Zc5dHe-pCSxNvdGEsPiQyFc8plbA7O-9yFINUEN1Nfm4wFTz2n1gl2juG3g1_kuxY1GHMDRc0w==&uniplatform=NZKPT&language=CHS
- *Li, X., Dai, J., Wei, C., Xin, T., Yang, G., & Liu, H. (2017). The relationship between life events and depression in college students as former rural left-behind children in Hebei Province. *Journal of Hygiene Research*, 46(1),57-61+69. DOI: <https://doi.org/10.19813/j.cnki.weishengyanjiu.2017.01.009>
- *Li, Y., Liu, L., & Yang, J. (2019). The relationships between problematic behaviors, negative emotions, and positive personality traits in college students as former left-behind children.

- Chinese Mental Health Journal, 33(4),318-320. Available at: <https://link.cnki.net/urlid/11.1873.R.2019.0226.0906.030>
- *Liang, J., Zhang, S., & Wu, Z. (2019). The relationships between social anxiety, emotional abuse, and psychological resilience in college students as former rural left-behind children. *Chinese Mental Health Journal*, 33(1),64-69. Available at: <https://link.cnki.net/urlid/11.1873.r.20181220.1030.024>
- *Liu, H. & Wang, W. (2017). The relationship between family upbringing and suicidal ideation in college students as former left-behind children: Chain mediating effects of neuroticism and interpersonal sensitivity. *Chinese Mental Health Journal*, 31(10),830-832. Available at: https://kns.cnki.net/kcms2/article/abstract?v=Ep7N7zfewySacXjmWMCysAtLb_Arak-ETlv6PU3BawHkAnK5whEYbgGZyozqvwkESWAlbrUiG1E2gLSso_IgnEWJwWRofidcVH9hOER3pchJi6sBBcFzUS7e3J1sfGbyDZ9nyI4Lp-LU-TF1VywjNMOI16t6UsUUdsiv7kE5KcYcOgQTTsTzg==&uniplatform=NZKPT&language=CHS
- *Liu, H., Wang, J., Lin, L., Hu, N., Han, C., & Sun, H. (2015). An investigation of mental health states of college students as former left-behind children. *Chinese Journal of Health Statistics*, 32(4),636-638+641. Available at: https://kns.cnki.net/kcms2/article/abstract?v=Ep7N7zfewyRt-uH6dySXG5Dh04xYRhFuN-tUxWx537w7-9ziTROVcnWHogp5WaAzzcHmjLu6z057_ooa81YT0ZqkuwCG-2oDMvDOUH9eerPJunjR9-NxBOU_CGZrvWkyn7EoWtF7tALxHf0MmmGTISFW9fe032U2C51g3jaUDS5aR YjvMxMgNQ==&uniplatform=NZKPT&language=CHS
- *Liu, W., Li, J., Yu, B., Qin, R., & Cao, X. (2019). Obsessive-compulsive disorders in college students as former left-behind children: Symptoms and influencing factors. *Chinese Journal of Disease Control and Prevention*, 23(5),597-601. DOI: <https://doi.org/10.16462/j.cnki.zhjbkz.2019.05.021>
- *Luo, S. & Zhou, B. (2017). The relationship between mental health and subjective well-being in college students as former left-behind children: The mediating effect of mental resilience. *Journal of Southwest Jiao Tong University (Social Sciences Edition)*, 2017(1),72-78. Available at: https://kns.cnki.net/kcms2/article/abstract?v=Ep7N7zfewyQvQP_RR4x-WGPNwsCphnyuIQo5esoJenbiWDe9-YQtEw6dGWrk_a7VHCC8DcVGOXh6Fy6qOUoJya9HiOA_8-5SooKWMDC9HQO8r68x6iPwRsLW7W-2cgXn-p_UGsSIvGd8XZBn4kC5dBck8d6ZPe5TVnlfKflrf41th00liiPg==&uniplatform=NZKPT&language=CHS
- Lyu, L., Mei, Z., Li, R., Li, S., Yan, F., Wang, X., & Duan, C. (2024). Life of left-behind children in rural China 2010-2020: The current state and trends of change. *Population Research*, 48(1),103-117. Available at: https://kns.cnki.net/kcms2/article/abstract?v=Ep7N7zfewyTZttv1gpwSC7ZVHabI9ILLE0j_7WdanfIEU11x2T7XqljwOLrZV5g_0VgjJdNrWPMWQixOiZoyN-WSBUKSEfF3sx2bAVk7GPL-hcRV1wdnc8Jzb_jYCpim8GzGf1A3Qd8S5UqK9dXtflJv7VB2mcoSp-VMAZTOj2PppGNmYO==&uniplatform=NZKPT&language=CHS
- *Pan, G., Li, B., Wang, J., Zhang, G., Mo, Y., & Tao, X. (2019). The relationship between childhood abuse and the mental health state in college students as former left-behind children. *Chinese Journal of Disease Control and Prevention*, 23(7), 840-844. DOI: <https://doi.org/10.16462/j.cnki.zhjbkz.2019.07.019>
- *Qin, H., Xu, Y., Yang, Y., & Jiang, J. (2019). The relationship between childhood traumas and depression in college students as former left-behind children: The chain mediating effects of separation and rejection schemas and interpersonal sensitivity. *Chinese Journal of Special Education*, 2019(12),55-62. Available at: https://kns.cnki.net/kcms2/article/abstract?v=Ep7N7zfewySqaHQleKEGS9V1eznR80sSEdJw4V-31fzeELWYy3gMwbDKOmELNwGHipaQKKW-AEK89hFfDSVVeZ_ZUnMf_hOEeCqkkxNhUNOCpqYQe7eBppf5oC3F xv16dqXSe_4wNmJnls61Zifhim9HBb-OCj27QTOH2GsvL6XcSTc_QWS2BRw==&uniplatform=NZKPT&language=CHS
- *Song, S., Xu, X., & You, J. (2020). The

relationships between the childhood left-behind life, mental resilience, and attitudes towards adversities in college students from rural China. Chinese Mental Health Journal, 34(4),373-378. Available at:

<https://link.cnki.net/urlid/11.1873.R.20200326.1459.018>

- *Sun, R, Li, Y., Tian, Z., & Yan, X. (2023). Comparison of mental health levels, social traumas, and social adaptability between college students as former rural left-behind and non-left-behind children. Chinese Journal of Health Psychology, 31(9),1326-1331. DOI: <https://doi.org/10.13342/j.cnki.cjhp.2023.09.009>
- *Wang, Y. & Xu, K. (2023). The relationship between social support and subjective well-being in college freshmen as former left-behind children. Chinese Journal of Health Statistics, 40(4),608-610. Available at: https://kns.cnki.net/kcms2/article/abstract?v=Ep7N7zfewyTXDcjDN_fkbp041DOc33BYUGu-1EAwM-ud4eT3_s5WmYbsvbnA_aOAzeGRRpSpr1BOcOU0zdRl4uRK2MOW7PHcMRx6JKOmWzTgrDJ2huWqD-Oh-vgembun6F58y9_VbY9fC4daMVM_T6XpKCvovEQaTrekeWuKpGzuRZjCTHfQ==&uniplatform=NZKPT&language=CHS
- *Wen, H. & Ma, H. (2021). The relationship between personality traits and the mental health state in college students as former left-behind children: A canonical correlation analysis. Chinese Journal of Health Statistics, 38(3),419-421. Available at: https://kns.cnki.net/kcms2/article/abstract?v=Ep7N7zfewyQB7C6bcxUwJfz-8C6yR3DAPw1ZhNDU_TkFdqIS0_CyS7ORMjzk3tqbnSve2uW1we3PebcsLoTgJpcKD81wven0q-tLYFVS4fkb9mDwu_eS6XUpBjuJGvvgjnHQT8H63cXJfP3wSJMf9aUPSRGW_We3dtW-M9ggnS5XGE_lovnX8O==&uniplatform=NZKPT&language=CHS
- *Wen, Y. & Zeng, J. (2012). The relationships between social support, coping strategies, and social adaptation in college students as former left-behind children. Chinese Journal of Public Health, 28(5),719-720. Available at: https://kns.cnki.net/kcms2/article/abstract?v=Ep7N7zfewyRKR8fVzYb4ATV0pY-ZglwBXfVa1tumaRAFMgoAh4Dglxn6_Uqyr2VywOKCsw4J0v7oNqm_nKvxp0b0Z6wE3moRc9EhSxILdu_yEx8Vvo_DnGMyxQg32H7CA-SY216WsmqbBf1-EUoyaNxfudP_dc-xOKYQYwhfm-7_G496Xp4lA==&uniplatform=NZKPT&language=CHS
- *Xie, Q. (2015). The relationships between social support, personal beliefs about adversity, and loneliness in college students as former rural left-behind children. Chinese Journal of School Health, 36(1),84-86. DOI: <https://doi.org/10.16835/j.cnki.1000-9817.2015.01.025>
- *Xie, X., Lang, F., Zheng, D., Wang, Y., & Zhang, Z. (2021). The effects of coping strategies and senses of security on the relationship between self-efficacy and mental health in college students as former left-behind children in Shandong Province. Medicine and Society, 34(08):98-102. DOI: <https://doi.org/10.13723/j.yxysh.2021.08.020>
- Xie, Y. & Zhao, X. (2022). The impact of the childhood left-behind life on the attainment of higher education opportunities. Education & Economy, 38(2),70-78. Available at: https://kns.cnki.net/kcms2/article/abstract?v=Ep7N7zfewyQY0EiCBqlc3LMmcPWjE9MUG5e3SM170-ZeFNS36jnGDxCHKLPB4KdLajxrb4fngKG7B20YUvjdkQtOnWSi0Y0dyD1vmmLroDmeL135vb0kYrErOmGCRZRbxvMH_RMghIP4HI-mmHfhAvJxTcgLU7QHi8tOkIAUII2vgmmc6zUIFQDA==&uniplatform=NZKPT&language=CHS
- *Yang, X., Ding, K., Huang, K., Cheng, X., Zhang, K., Hu, C., & Zhang, X. (2021). The effect of rejection sensitivity on the relationship between mental resilience and social adaptability in university students as former left-behind children. Chinese Journal of School Health, 42(6),867-871. DOI: <https://doi.org/10.16835/j.cnki.1000-9817.2021.06.016>
- *Yang, X., Feng, X., & Cui, Z. (2014). The early left-behind life, psychological resilience, and pathological symptoms of college students. Chinese Mental Health Journal, 28(3),227-233. Available at: <https://kns.cnki.net/kcms2/article/abstract?v=Ep7N7zfewyTmYYErcmhmTzwDXLNjHORGPCiZjtOHFuFMkjMkS6tUugegZ>

- [K9ty5FWq7AYWB2u-
idiHJS2vTk7O7OW90cWmdx1NYk8ZeF
u7DxAgUSy5hi_uIQZGFLtKOCxlchoyP
n6lnaTvlyXBRegjvmcXNfBEDYChmEu
Rra-F8NLW-
tbd3shYw==&uniplatform=NZKPT&lan-
guage=CHS](https://doi.org/10.16835/j.cnki.1000-9817.2016.04.042)
- *Yi, S. & Zhang, S. (2018). The relationship between childhood abuse and anxiety/depression in college students as former left-behind children: The mediating effect of emotional regulation. *Chinese Journal of Health Education*, 34(10),920-923+951. DOI: <https://doi.org/10.16168/j.cnki.issn.1002-9982.2018.10.014>
- Yu, X. (2017). Mental health issues in college students as former left-behind children. *Education Review*, 2017(7),100-102. Available at: https://kns.cnki.net/kcms2/article/abstract?v=Ep7N7zfewySrPZav_5Vu0S4spfbT4JIGagpoV8xza1uR6rcGL6ALtamEtJDxpIoTcNCEdkdTThotzSED9pGqvrqtSTi078g22qbZTxA3HkP1-YHALVJvHeTJ9Gc-rvIWpv-ul-Bth07E2_j5FdnFwJSOEZhS_9FjAMjOXiBIRaTnXusbopCIA==&uniplatform=NZKPT&language=CHS
- *Yue, P., Hu, H., & Fang, Y. (2019). The relationships between the early left-behind life, mental resilience, and emotional recognition. *Chinese Journal of Special Education*, 2019(6),72-77. Available at: https://kns.cnki.net/kcms2/article/abstract?v=Ep7N7zfewyQdE9D9ZT_U1h4ejnsMbUpmx4hLPJgqNYcVdVXplZPrR6t-E4hymYRriyBNwQz5iZhECfsR-HtR12jKv6DstLgja8R5xgO7vSLpjs9m547iOcQ0rsIHlsMqMCKOYqzC9_vAQF30MXT2cdpOgKviZEwNTM7Dbz-9oLWz1QaKoGINrO==&uniplatform=NZKPT&language=CHS
- *Zang, H., Zheng, D., Lang, F., Liu, J., Zhang, Z., & Zhu, L. (2018). The relationship between perceived social support and mental health in college students as former left-behind children: The mediating role of self-efficacy and self-esteem. *Chinese Journal of School Health*, 39(9),1332-1335. DOI: <https://doi.org/10.16835/j.cnki.1000-9817.2018.09.015>
- *Zhan, L., Lian, Q. & Wang, F. (2016). The correlation between self-efficacy, social support, and mental health in college freshmen as former left-behind children. *Chinese Journal of School Health*, 37(4),614-617. DOI: <https://doi.org/10.16835/j.cnki.1000-9817.2016.04.042>
- *Zhang, C. & Xu, W. (2022). Childhood traumas and negative emotions in college students as former left-behind children: the moderating effect of psychological resilience. *Psychological Development and Education*, 38(4),584-591. DOI: <https://doi.org/10.16187/j.cnki.issn1001-4918.2022.04.15>
- Zhang, L. (2006). Mental states of college students as former left-behind children. *Contemporary Youth Research*, 2006(12):28-30. Available at: https://kns.cnki.net/kcms2/article/abstract?v=Ep7N7zfewyT4TNumqnXw8ITCcoopfXqbuZAWAhveCRzuWhPEqIBUY4W83BCAvOdyS_2gYquiEA0OsXoUZRsYEHipsXdmH9EJXKttVwxbfqgn_YyxCdIn4UkFupoPTMnvcgkibuPtii7IS2AjIiZnLj94P7IMPwgWvEx4BaE9anK3BmVHHdEZcO==&uniplatform=NZKPT&language=CHS
- *Zhang, L. (2018). The effects of Naikan cognitive therapy as an intervention on mental health of college students as former left-behind children. *Chinese Journal of School Health*, 39(9),1407-1409. DOI: <https://doi.org/10.16835/j.cnki.1000-9817.2018.09.038>
- *Zhang, M., Zhao, J., Hou, Y., & Zhao, J. (2017). The reasons for living in college freshmen as former left-behind children in X University and their influencing factors. *Chinese Journal of School Health*, 38(7),1026-1029. DOI: <https://doi.org/10.16835/j.cnki.1000-9817.2017.07.019>
- *Zhang, S., Chen, X., Luo, F., Yang, Y., & Yang, Z. (2022). The relationship between childhood emotional abuse and adulthood social anxiety in college students as former rural left-behind children: The effects of self-acceptance and self-esteem. *Chinese Journal of Clinical Psychology*, 30(3),630-634+639. DOI: <https://doi.org/10.16128/j.cnki.1005-3611.2022.03.026>
- *Zhao, G., Zhang, L., Zeng, L., Dan, J., & Ding, W. (2013). The relationship between the childhood left-behind life, coping strategies, and senses of well-being in college students. *Chinese Journal of Disease Control & Prevention*, 17(7),636-

638. Available at:

https://kns.cnki.net/kcms2/article/abstract?v=Ep7N7zfewySN7Tv7wHbV6hryMGd5-rp8KeF19SQJoKMwenSaHQLqzBxRb4b6Zu-2lvEgTD_a45U1Zyehnsf7TWIzty2zvJZSM50lllWmZAM2Y9MtDIxagkJ1q5ZIZU023ry4R6O4nJxgtoNP0BbskSwBq4MHbzf65QWtwbWtV2vQ4URd6m36yw==&uniplatform=NZKPT&language=CHS

- *Zheng, M. (2021). The relationship between cumulative risks in childhood and suicidal ideation in college students as former left-behind children: A moderated mediation test. *Chinese Journal of Special Education*, 2021(11),74-82. Available at:

https://kns.cnki.net/kcms2/article/abstract?v=Ep7N7zfewyTwqEfv8hXsDznyiU3NyVsxiaUcs_ATxAkLbFk9CW0L0QnwNSZEDAaGMuT6ww6TD7reQHNEtLRMkIPZkLiryh3m2zBmzvZalj7b96DXb8VLmhToM1uA5oUcFjkJrtx0tT28Bup57a0GxjV6W79egBd_jwmJGkQ5WUzmdTujLaNA==&uniplatform=NZKPT&language=CHS

- *Zhou, C., Huang, H., Liu, C., & Wu, H. (2014). The impact of the childhood left-behind life on subjective well-being in college students: The role of parental emotional warmth. *Chinese Journal of Clinical Psychology*, 22(5),893-896. DOI: <https://doi.org/10.16128/j.cnki.1005-3611.2014.05.077>

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The Effects of Reflective Learning on the Quality of English Writing in Chinese University Students: An Analysis Based on Coh-Metrix and Reflective Journals

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Abstract: *This study aims to examine the effects of reflective learning on the quality of English writing in Chinese university students using the Coh-Metrix tool and the students' reflective journals. According to its research findings, reflective learning had significantly positive effects on the students' quality of English writing in terms of content/ideas, organization/development, and language. Furthermore, reflective learning significantly improved the lexical diversity of their English writing; it also enhanced the cohesion and coherence of their writing through the improvement in referential coherence and semantic overlapping. Thematic analysis of the subjects' reflective journals corresponds to these findings while also indicating that reflective learning helps elevate their self-efficacy in English writing.*

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Introduction

REFLECTIVE Learning is an instructional approach based on the student-centered philosophy of education, aimed at improving students' learning outcomes by prompting their deep contemplations. Underlying this learning method is the experiential learning theory and lifelong learning theory. It places heavy weight on the learner's self-adjustment and self-regulation with a special emphasis on the value of reflection in the whole learning cycle. Ongoing reflection contributes to the results of learning by optimizing the learning process and supporting self-directed learning (Ren, 2017). Despite the many studies of the application of reflective learning and its effects in various areas, there has been inadequate research on its effectiveness in English writing instruction, particularly in the Chinese context. This study focuses on examining the effects of reflective learning on the quality of English writing in Chinese university students, drawing on the Coh-Metrix tool and the students' reflective journals, with the view of providing valuable insights into college English writing instruction improvement and writing proficiency enhancement in this group.

Literature Review

Among the multiple theoretical underpinnings of reflective learning, Dewey's (1933) reflective thinking theory could be the earliest source. Dewey defined reflection as the process of combining current ideas with past experiences to solve problems. He contended that even though a positive learning environment could help engage students in meaningful learning, learning experience alone was not enough to enable the student to develop a deep understanding of knowledge and stressed that reflection was an essential factor in successful learning. Kolb (1984), in his research on experiential learning, claimed that the learning process consists of four basic steps: experience, reflection, abstraction, and application, with reflection being the core step in acquiring new knowledge. Schön (1987) described the individual's reflective ability as the bedrock of knowledge application and professional development, with the potential to improve their self-awareness, problem-solving, and critical thinking. Hatton and Smith (1995) emphasized that critical reflection is crucial for fostering the student's critical thinking ability, which was supported by Alfaro-Lefevre's (1995) and Kennison and Misselwitz's (2002) studies, both of which suggest that reflection assists students in deepening their understanding of knowledge and developing critical thinking by prompting deep contemplations and logical analyses.

Researchers have looked into the application of reflective learning from various perspectives. For instance, Cui (2006) argued that reflection training could enable the student to transition from fact presentation-focused

reflection to higher-order reflection with a noticeable improvement in metacognition in language learning. Barney and Mackinlay's (2021) and Liu et al.'s (2021) studies suggest that reflective learning has significantly positive effects on critical thinking development and learning outcomes in students. As per Zhao and Sun (2019), WeChat-assisted reflective learning could help promote mutual learning among students and enhance their critical thinking ability. Regarding the roles of reflective journals in learning, Vygotsky (1986) emphasized that they could facilitate students connecting their thoughts and actions through inner dialogue. Moon (1999) and Boud (2001) argued that reflective journals have the potential to engender deep-level critical thinking and optimize learning outcomes. Xue's study (2021) is a practical validation of the effectiveness of reflective journals in enhancing writing instruction.

As a valuable tool for recording and analyzing the student's learning process, reflective journals play a salient role in upgrading their metacognition, which is of extraordinary significance in language teaching. According to Lin's (2012) study, reflective journals are favorable for critical thinking development and language proficiency improvement in English majors while also facilitating the English teacher's understanding of their learning needs and difficulties. In language instruction, reflective journals are conducive to the cultivation of analysis, reasoning, and evaluation abilities (Chang & Lin, 2014; Zhang, 2014; Li, 2021), as well as the development of metacognitive strategies and emotional attitudes in students (Cazan, 2018; Lina, 2019). Li and Li's (2023) study finds that reflective journals can assist students in lesson review and self-monitoring as well as weakness and gap identification in language learning, who can seek out resolutions and create targeted learning schemes accordingly.

To recap, with solid theoretical foundations and salient practical value, reflective learning has showcased significant effects in enhancing knowledge comprehension, metacognition, and self-directed learning. Nevertheless, research on its application in English writing instruction in Chinese universities remains scarce. More exploration of the effects of reflective learning on the quality of English writing of Chinese college students is, therefore, of practical significance.

Research Design

Research Questions

Q 1: What are the effects of reflective learning in improving the overall quality of English writing of Chinese university students?

Q 2: What are the specific effects of reflective learning on lexical diversity, syntactic complexity, and cohesion and coherence of English writing?

Q 3: What are the improvements that reflective learning makes on students' English writing as indicated by the self-evaluation and feedback in their reflective journals?

Research Subjects

This study includes as subjects seven undergraduates majoring in English at Guangxi University of Foreign Languages, who were promoted as the participants of the provincial-level English language preliminaries of the "2023 National Talent Cup" Foreign Language Proficiency Competition sponsored by the Foreign Language Teaching and Research Press. A pretest was administered to them on September 26th of 2023, and a posttest on October 31st of the same year. During the interval, we offered them intensive writing training applying the reflective learning theory. The training program included the delivery of basic concepts of writing and writing techniques, analyses of writing topics from previous competitions, elaborations on excellent model essays, and sharing of relevant experiences. Every week, the students did 1-2 writing exercises with a time limit and compared their writing with model essays. They were required to write a reflective journal as well as modify their writing after each exercise. The content of the reflective journal entails multifarious aspects, such as the initial conception, choice of words, themes, and techniques of their writing; challenges of writing; the progress they make; the assistance they need from the instructor; and the value of the reflective journal itself. Subsequently, we gave them both collective feedback and one-on-one direction on writing and reflection. Finally, a total of 192 essays, including the 28 pretest and posttest essays (14 pieces of argumentative writing and 14 pieces of expository writing) and 49 reflective journals were obtained. We included the 14 argumentative essays from the pretest and posttest and 49 reflective journals in our analysis to examine the effects of reflective learning on the students' quality of writing.

Research Instruments

In this study, Coh-Metrix, a language processing program, was used to analyze the students' English essays. Coh-Metrix 3.0 is a free, automated evaluation tool that can extract data on language features from texts and discourse (McNamara et al., 2014). It was adopted to calculate 29 linguistic indices of the texts of the subjects' writing in five dimensions: lexical diversity, syntactic complexity, use of connectives, referential cohesion, and

Table 1. Variables and Indices from Coh-Metrix Relevant to the Study.

Nos.	Indices in Coh-Metrix 3.0	Description	Variables
1	LDTTRc	Lexical diversity, type-token ratio, content word lemmas	Lexical Diversity
2	LDTTRa	Lexical diversity, type-token ratio, all words	
3	LDMTLD	Lexical diversity, measure of textual lexical diversity (MTLD)	
4	LDVOCD	Lexical diversity, vocabulary diversity (VOCD)	
5	SYNLE	Left embeddedness, words before main verb, mean	Syntactic Complexity
6	SYNNP	Number of modifiers per noun phrase, mean	
7	SYNMEDpos	Minimal Edit Distance, part of speech	
8	SYNMEDwrd	Minimal Edit Distance, all word	
9	SYNMEDlem	Minimal Edit Distance, lemmas	
10	SYNSTRUTa	Sentence syntax similarity, adjacent sentences, mean	Connectives
11	SYNSTRUTt	Sentence syntax similarity, all combinations, across paragraphs, mean	
12	CNCAII	All connectives incidence	Connectives
13	CNCCaus	Causal connectives incidence	
14	CNCLogic	Logical connectives incidence	
15	CNCADC	Adversative and contrastive connectives incidence	
16	CNCTemp	Temporal connectives incidence	
17	CNCAdd	Additive connectives incidence	Referential Cohesion
18	CRFNO1	Noun overlap, adjacent sentences, binary, mean	
19	CRFAO1	Argument overlap, adjacent sentences, binary, mean	
20	CRFSO1	Stem overlap, adjacent sentences, binary, mean	
21	CRFCWO1	Content word overlap, adjacent sentences, proportional, mean	
22	CRFNOa	Noun overlap, all sentences, binary, mean	
23	CRFAOa	Argument overlap, all sentences, binary, mean	LSA (Latent Semantic Analysis)
24	CRFSOa	Stem overlap, all sentences, binary, mean	
25	CRFCWOa	Content word overlap, all sentences, proportional, mean	
26	LSASS1	LSA overlap, adjacent sentences, mean	
27	LSASSp	LSA overlap, all sentences in paragraph, mean	
28	LSAPP1	LSA overlap, adjacent paragraphs, mean	
29	LSAGN	LSA given/new, sentences, mean	

latent semantic analysis (**Table 1**), for the purpose of evaluating the quality of their writing from multiple aspects. We also conducted thematic analysis on the subjects’ reflective journals to obtain an in-depth understanding of the impact of reflective learning on their quality of writing. The combination of quantitative and qualitative analysis is to lend credence to the findings of our research.

Research Procedures

Table 2. The Rating Scale for Argumentative Writing.

Content/Ideas 40points	<ul style="list-style-type: none"> ◆ Writing effectively addresses the topic and the task; ◆ Writing presents an insightful position on the issue; ◆ The position is strongly and substantially supported or argued.
Organization/ Development 30 points	<ul style="list-style-type: none"> ◆ Writing is well-organized and well-developed, using appropriate rhetorical devices (e.g. exemplification, classification, analysis, comparison/contrast, etc.) to support the thesis or to illustrate ideas; ◆ Writing displays coherence, progression, consistency and unity; ◆ Textual elements are well-connected through explicit logical and/or linguistic transition.
Language 30 points	<ul style="list-style-type: none"> ◆ Spelling is accurate; ◆ Writing displays consistent facility in use of language; ◆ Writing demonstrates appropriate register, syntactic variety, and effective use of vocabulary.

First, we engaged two senior English writing instructors to separately rate the 14 argumentative essays using the rating scale for argumentative writing developed by the organizing committee of the “2023 National Talent Cup” Foreign Language Proficiency Competition. The scale evaluates argumentative writing in three dimensions: content/ideas, organization/development, and language (**Table 2**). The two raters received necessary training to ensure they have an identical understanding of the rating criteria. Also, a reliability test was conducted on the scoring results to generate a Cronbach’s Alpha coefficient of 0.916, which indicates a high level of agreement between the ratings of the two graders. The average of the scores given by the two raters to each essay was seen as an indicator of its overall quality standard.

Subsequently, we conducted thorough analysis of the textual features of the subjects’ essays using Coh-Metrix and saved the results with Excel spreadsheets for the following data processing and analysis. Data on the 29 indices went through statistical analysis with SPSS 21.0. Specifically, paired samples t-tests were carried out to determine whether the differences between pretest and posttest data are statistically significant, in order to establish evidence for the impact of reflective learning on the students’ quality of English writing.

After that, thematic analysis was applied to the subjects’ reflective journals with software NVivo12, a qualitative analysis tool, using methods like word frequency identification and text screening. Thematic analysis is a process of identifying recurring patterns of meaning or themes that are relevant to research objectives and conceptually categorizing these patterns of meaning to interpret the phenomenon presented in the study (Merriam, 1998). Additionally, we engaged two specialists to review the extracted themes to avoid the potential subjective biases of the researchers.

Findings and Discussion

The Effect of Reflective Learning on the Overall Quality of Students' English Writing

According to the paired samples t-test results (**Table 3**), there are statistically significant score differences between pretest and posttest writing ($t = -10.856$, $p < 0.001$), showing significant improvement after the intervention. Moreover, there are also statistically significant score differences in the specific dimensions of content/ideas ($t = -8.741$, $p < 0.001$), organization/development ($t = -3.382$, $p < 0.01$), and language ($t = -7.129$, $p < 0.001$). These results indicate that reflective learning had a significantly positive effect on the students' quality of English writing. The paired samples t-test results also show that the effect sizes of the intervention in the dimensions of organization/development (Cohen's $d = 0.636$) and language (Cohen's $d = 0.690$) are both above the moderate level. The effect sizes for the overall quality of writing and the dimension of content/ideas are both above 0.8, which are of high levels according to Yockey's (2010) standards, indicating substantial improvement of the subjects' English writing in these two aspects.

The Effect of Reflective Learning on Lexical Diversity of Students' English Writing

In the Coh-Metrix system, MTLD and VOCD are measures of lexical diversity, manifesting the degrees of lexical richness and variety of a text. The type-token ratio (TTR) is also a common indicator of lexical diversity, which measures lexical diversity by calculating the ratio of various words (types) to total words (tokens) used in a text. The higher the TTR value, the larger the vocabulary and the fewer repeated words in the text. **Table 4** displays that all indices of lexical diversity had higher values in the posttest than in the pretest, with statistically significant differences in MTLD ($t = -4.340$, $p < 0.01$) and VOCD ($t = -4.575$, $p < 0.01$), indicating that the subjects used a bigger range of vocabulary in their posttest essays. This demonstrates the positive effect of reflective learning on the lexical diversity of students' English writing.

The Effect of Reflective Learning on Syntactic Complexity of Students' English Writing

Table 3. Paired Samples T-test Results of English Writing Scores.

Variables	Pretest		Posttest		Mean deviations	T-value	P-value	Cohen's d
	Means	SD	Means	SD				
Average Scores	81.929	2.335	87.714	1.912	-5.786	-10.856	0.000***	1.409
Content/Ideas	32.500	1.354	35.427	0.787	-2.929	-8.741	0.000***	0.886
Organization/Development	25.357	0.852	26.500	1.041	-1.143	-4.382	0.005**	0.690
Language	24.071	1.305	25.786	0.951	-1.714	-7.129	0.000***	0.636

Note: $p^{***}<0.001$, $p^{**}<0.01$, $p^{*}<0.05$

Table 4. Paired Samples T-test Results of Lexical Diversity of Students' English Writing.

Variable	Indices	Pretest		Posttest		Mean deviations	T-value	P-value
		Means	SD	Means	SD			
Lexical Diversity	LDTTTc	0.653	0.0750	0.656	0.0588	-0.003	-0.212	0.839
	LDTTTa	0.449	0.0516	0.476	0.0364	-0.027	-1.845	0.115
	MTLD	64.707	23.3572	94.804	16.7834	-30.097	-4.340	0.005**
	VOCD	67.749	20.9577	103.873	12.0923	-36.124	-4.575	0.004**

Note: $p^{***}<0.001$, $p^{**}<0.01$, $p^{*}<0.05$

Table 5. Paired Samples T-test Results of Syntactic Complexity of Students' English Writing.

Variable	Indices	Pretest		Posttest		Mean deviations	T-value	P-value
		Means	SD	Means	SD			
Syntactic Complexity	SYNLE	5.108	1.4926	4.845	0.7704	0.263	0.500	0.635
	SYNNP	0.905	0.1206	0.904	0.0560	0.001	0.025	0.981
	SYNMEDpos	0.658	0.0188	0.637	0.0161	0.021	2.429	0.051
	SYNMEDwrd	0.898	0.0172	0.864	0.0291	0.034	2.973	0.025*
	SYNMEDlem	0.885	0.0187	0.841	0.0307	0.044	3.817	0.009**
	SYNSTRUTa	0.111	0.0157	0.105	0.0342	0.006	0.540	0.609
	SYNSTRUTt	0.106	0.0193	0.102	0.0294	0.004	0.433	0.680

Note: $p^{***}<0.001$, $p^{**}<0.01$, $p^{*}<0.05$

Table 5 displays that all indices of syntactic complexity had slightly lower values in the posttest than in the pretest, indicating that there was no improvement in syntactic complexity of the subjects' English writing after the training program. Among these indices, only SYNMEDwrd ($t = 2.973$, $p < 0.05$) and SYNMEDlem ($t = 3.817$, $p < 0.01$) exhibit significant variations in the value between the pretest and posttest writing. SYNMEDwrd is to measure the minimal edit distance between words, i.e., syntactic similarity at the vocabulary level. The decreased value of SYNMEDwrd in the subjects' posttest writing implies that they used more identical grammatical structures in wording. SYNMEDlem is an indicator of the minimal edit distance between lemmas (the basic form of a word). The significant decrease in the value of SYNMEDlem in the posttest writing indicates the use of reduced lemmas by the subjects. Overall, the decreased values of the indices of syntactic complexity, particularly SYNMEDwrd and SYNMEDlem, are emblematic of simpler syntactic structures in the posttest essays.

The Effect of Reflective Learning on the Cohesion and Coherence of Students' English Writing

According to the paired samples t-test results (**Table 6**), 13 out of the 18 indices related to cohesion and coherence in writing had higher values in the subjects' posttest writing than in their pretest writing, with eight of them showing significant enhancement, indicating the students' improved capacity for increasing the cohesion and coherence in writing via more diverse devices after the intervention. Specifically, in the posttest, their writing showed improvement in referential coherence and semantic overlapping, especially in CRFNO1 ($t = -3.993$, $p < 0.05$), CRFAO1 ($t = -2.811$, $p < 0.05$), CRFSO1 ($t = -4.295$, $p < 0.01$), CRFCWO1 ($t = -2.758$, $p < 0.05$), CRFNOa ($t = -2.524$, $p < 0.05$), CRFAOa ($t = -2.443$, $p < 0.05$), and CRFSOa ($t = -2.814$, $p < 0.05$), which exhibited statistical significance. This suggests that the students bolstered the cohesion of their writing mainly by semantic and syntactic overlapping and the recurrence of keywords. Despite the increased devices for coherence, the overall incidence of connectives was lower in the posttest writing than in the pretest writing, with a considerable decrease in the number of causal, logical, temporal, and additive connectives and substantially decreased use of adversative and contrastive connectives ($t = 3.277$, $p < 0.05$). This implies that the subjects became less dependent on explicit connectives with their increased use of more latent devices for cohesion after the training program. Broadly, the students showcased more delicate handling of coherence through using more covert devices such as lexical, syntactic, and structural cohesion. As Liang (2006) noted, the frequency of connectives as overt discourse cohesion markers is not necessarily a comprehensive manifestation of the strength of cohesion and

Table 6. Paired Samples T-test Results of Connective Use, Referential Cohesion, LSA Overlapping in Students' English Writing.

Variables	Indices	Pretest		Posttest		Mean deviations	T-value	P-value
		Means	SD	Means	SD			
Connectives	CNCAI	103.771	23.0915	102.106	19.3354	1.665	0.225	0.829
	CNCAus	29.216	9.2473	27.451	6.5675	1.765	0.630	0.552
	CNCLogic	47.079	10.2871	34.436	10.8943	12.643	2.301	0.061
	CNCADC	18.446	5.2662	10.606	4.7414	7.840	3.277	0.017 [†]
	CNCTemp	12.873	2.8854	17.388	9.0735	-4.515	-1.016	0.349
	CNCAdd	64.161	22.0862	62.078	16.8719	2.083	0.504	0.632
Referential Cohesion	CRFNO1	0.370	0.0985	0.635	0.1363	-0.265	-3.993	0.007 [†]
	CRFAO1	0.471	0.1504	0.684	0.1274	-0.213	-2.811	0.031 [†]
	CRFSO1	0.466	0.1606	0.732	0.0958	-0.266	-4.295	0.005 ^{**}
	CRFCWO1	0.099	0.0262	0.129	0.0358	-0.030	-2.758	0.033 [†]
	CRFNOa	0.318	0.1143	0.523	0.1592	-0.205	-2.524	0.045 [†]
	CRFAOa	0.396	0.0929	0.569	0.1558	-0.173	-2.443	0.050 [†]
	CRFSOa	0.385	0.1448	0.626	0.1477	-0.241	-2.814	0.031 [†]
	CRFCWOa	0.070	0.0173	0.095	0.0305	-0.025	-2.075	0.083
LSA Overlap	LSASS1	0.197	0.0496	0.223	0.0385	-0.026	-1.098	0.314
	LSASSp	0.164	0.0496	0.198	0.0573	-0.034	-1.139	0.298
	LSAPP1	0.464	0.0861	0.494	0.0882	-0.030	-1.375	0.218
	LSAGN	0.319	0.0338	0.321	0.0324	-0.002	-0.217	0.836

Note: p^{***}<0.001, p^{**}<0.01, p^{*}<0.05

Table 7. Frequent Words for the Evaluation of Reflective Learning in the Subjects' Reflective Journals.

Types	Frequent Words	Frequency	Percentages
Conception	Well-crafted structure, creating outlines, establishing arguments, argumentative methods, example use	39	41.05%
Writing Improvement Tactics	Expanding reading, studying model essays, increased writing practice, writing habit, repeated modification	25	26.32%
Language	An expanded range of vocabulary, synonyms, syntactic complexity, sentence structure	22	23.16%
Self-efficacy	Self-motivation, confidence, calmness, perseverance, carefulness	9	9.47%

coherence of the discourse. In the dimension of LSA, the four indices show modestly higher values in the posttest writing than in the pretest writing, but with no significant differences, which may imply that the students' expanded vocabulary and discourse knowledge had not been given full play due to the limited training period.

Table 8. Students' Self-Evaluation of Lexical Diversity and Expression Accuracy of their Writing.

	Self-rating	RJ 1 (# of persons)	RJ 2 (# of persons)	RJ 3 (# of persons)	RJ 4 (# of persons)	RJ 5 (# of persons)	RJ 6 (# of persons)	RJ 7 (# of persons)
Lexical Diversity	Low	6	2	1	1	1	1	0
	Medium	1	5	6	5	5	5	6
	High	0	0	0	1	1	1	1
Expression Accuracy	Low	3	2	1	0	0	0	0
	Medium	4	5	5	6	6	6	6
	High	0	0	1	1	1	1	1

RJ: Reflective Journal

Self-Evaluation and Feedback from Students' Reflective Journals

In their reflective journals, all the subjects stated that reflective learning facilitated their identifying weaknesses in writing, modifying their writing, and elevating their writing standards. **Table 7** encapsulates frequent words in their reflective journals regarding the roles of reflective learning in enhancing conception ability, representation, writing improvement tactics, and self-efficacy in English writing.

The subjects heavily emphasized the importance of reflective learning for enhancing their conception ability in writing in terms of interpreting the topic, establishing the thesis statement and arguments, arguing through examples, and pinpointing the connections between topic sentences. For example, Qingqing, one of the seven students, stated, "Reflective learning is effective in improving the overall standard of my writing, particularly in enhancing the basic structure of my argumentative essays, which have more concise and accurate representations of topic sentences now." Jiji highlighted the value of reflective learning for her mastery of the method of arguing with examples, "I tended to make up stories as supporting examples, which did not lend credence to my arguments at all. Recently, I learned to cite well-recognized facts to make my argumentation persuasive. Also, I have developed the awareness of memorizing those examples that are potentially useful to my writing."

In the meantime, the subjects successfully improved their English representation through reflective learning. **Table 8** shows the subjects' self-evaluation on the lexical diversity and expression accuracy of their writing. In their first reflective journals, the majority of the students were rated the level of lexical diversity of their writing as low, with only one rating it as medium. In their last reflective journals, in contrast, the majority of them rated it as medium, with one elevating the rating to high. Regarding the level of expression accuracy of their writing, three and four of them rated it as low and medium, respectively, in their first reflective journals, whereas, in their last reflective journals, six and one rated it as medium and high, respectively. The coding results imply that reflective learning facilitated the subjects identifying the gaps in lexical diversity and expression accuracy of their writing, prompting them to make targeted improvements. The positive effects of reflective learning on their English representation have been mentioned many times in their journals. For example, Lianlian said, "In the past, I could only use simple sentences and colloquial vocabulary in my writing. Reflective learning has helped improve my syntactic standards. Now I begin to learn to use more complex sentences and academic vocabulary." Jiajia emphasized the impact of reflective learning on her expression accuracy, stating, "Reflective learning made me realize the inadequacies in my expressions and the necessity of rendering them more explicit."

Furthermore, the subjects claimed that reflective learning assisted them in developing writing improvement tactics, such as studying model essays, being mindful of everyday life, and expanding reading. For instance, Lianlian noted, "Reflections make me a better observer." Jiajia said, "Reflective learning prompts me to be more open-minded to new information and document my thoughts in a timely manner." The subjects also agreed that reflective learning helped broaden the scope of subject matter in their writing. Manman stated, "Through the reflection on the question of highlighting Chinese contexts in writing, I increased the awareness of citing distinctive Chinese major events in my essay writing."

Additionally, the subjects reported increased levels of self-efficacy in English writing as a result of reflective learning. Self-efficacy refers to an individual's belief in their ability to complete specific tasks or respond properly to challenges. The subjects emphasized in their journals that they had become more confident, careful, and calm in writing through reflective learning. For example, Linlin said, "Reflective learning is helpful in developing the ability to remain cool and calm in dealing with challenges in writing competitions, from the word count to the difficulty of topics. These competition experiences are valuable for my future writing practices, enabling me to handle various writing topics with ease and confidence." Jiajia also mentioned that reflective learning boosted her confidence in writing. "In prior writing exercises, I often felt nervous and uneasy,

especially when encountering topics new to me, but now, the tension felt in writing has been significantly eased.”

To sum up, reflective learning was effective in improving the students’ quality of English writing and their self-efficacy in writing according to their self-evaluation. Through writing reflective journals, the subjects enhanced their conception ability, lexical diversity, and expression accuracy, which made their representations more colorful and powerful. Their self-evaluation corresponds to the results of the paired samples t-tests. Also, reflective learning assisted with the development of writing improvement tactics, laying the groundwork for further enhancement of their writing proficiency.

Conclusion

Given the positive effects of reflective learning on students’ quality of English writing, we propose the following recommendations for English writing instruction: (i) Increase activities that promote student reflective learning in writing education, such as regular writing workshops, inter-peer evaluation, and teacher-student communication. (ii) Encourage students to reflect on and develop skills in word choice through vocabulary games like synonym replacement exercises to understand the impact of word choice on the meaning and tone of the sentence; provide students with direction on how to conduct self-assessment in sentence pattern exercises and complex sentence analyses as well as how to identify and learn from the use of complex sentences in model essays; require students to review the referential cohesion, use of connectives, and lexical overlapping in their writing in the teaching of textual cohesion and coherence. (iii) Arrange group conversations to enable students to share their writing and obtain peer feedback; help them develop the habit of keeping reflective journals on writing to document their thoughts, challenges, and solutions during the writing process as records of their progress in English writing. (iv) Administer regular self-efficacy assessments to students to track the growth of confidence in writing in them to make them aware of the significance of reflective learning for improving writing competence.

The limitations of the study should be acknowledged. First, the small sample used may hamper the statistical validity and generalizability of the study’s research results. Second, the analysis results of the reflective journals as a form of student self-reports may bear certain subjective biases. Third, due to the short experimental period, this study can only serve as a preliminary exploration of the topic in question. Future research should expand the sample size to include students in different grades and with distinct levels of English proficiency, as well as extending the experimental period to evaluate the long-term impact of reflective learning on the students’

quality of English writing. In addition, a more elaborate qualitative analysis of reflective journals is warranted to explore the effects of reflective learning on writing of various genres and in distinct cultural contexts to provide a broader perspective on this research area to writing instructors.

Note

All statements of the subjects are direct quotations from their reflective journals without any modification from the authors.

References

- Alfaro-Lefevre, R. (1995). *Critical Thinking in Nursing: A Practical Approach*. Philadelphia: Saunders.
- Barney, K. & Mackinlay, E. (2010). Creating rainbows from words and transforming understandings: Enhancing student learning through reflective writing in an Aboriginal music course. *Teaching in Higher Education*, 2010(2),161-173. DOI: <http://dx.doi.org/10.1080/13562511003619995>
- Boud, D. (2001). Using journal writing to enhance reflective practice. *New Directions for Adult and Continuing Education*, 2001(90),9-18. DOI: <https://doi.org/10.1002/ace.16>
- Cazan, A. M. Enhancing self-regulated learning by learning journals. *Procedia: Social and Behavioral Sciences*, 2012(1),413-417. DOI: <https://doi.org/10.1016/j.sbspro.2012.01.154>
- Chang, M.M. & Lin, M.C. (2014). The effect of reflective learning e-journals on reading comprehension and communication in language learning. *Computers & Education*, 71(1),124-132. Available at: <https://www.learntechlib.org/p/200577/>
- Cui, L. (2006). The development of reflective thinking and strategic learning through journal writing. *Teaching English in China*, 29(1),84-111.
- Dewey, J. (1933). *How We Think: A Restatement of Reflective Thinking to the Educative Process*. Boston: D. C. Heath.
- Hatton, N. & Smith, D. (1995). Reflection in teacher education: Towards definition and implementation. *Teacher and Teacher Education*, 11(1),33-49. DOI: [https://doi.org/10.1016/0742-051X\(94\)00012-U](https://doi.org/10.1016/0742-051X(94)00012-U)
- Kennison, M. & Misselwitz, S. (2002). Evaluating reflective writing for appropriateness, fairness and consistency. *Nursing Education Perspectives*, 23(5),238-242.
- Kolb, D. (1984). *Experiential learning: Experience as the Source of Learning and Development*. Englewood Cliffs: Prentice-Hall.
- Li, N. (2019). Developing English Majors' Critical Thinking Ability through the application of reflective journals. *Contemporary Education Research and Teaching Practice*, 2019(17),58+131.
- Li, N. & Li, Z. (2023). The application of reflective journals that incorporate metacognitive training in Chinese-Korean translation instruction. *Theory and Practice of Education*, 2023(2),115-117.
- Li, R. (2021). A practical study of the effects of reflective journals in improving college students' reading competence from the perspective of promoting learning through assessment. *Journal of Tianjin Agricultural University*, 28(1),97-101.

- DOI:
<https://doi.org/10.19640/j.cnki.jtau.2021.10.019>
- Liang, M. (2006). Coherence in EFL Learners' written production. *Modern Foreign Languages*, 29(1),284-330.
- Lin, Y. (2012). Oral English teaching and the cultivation of critical thinking ability: The use of students' reflective journals in an English debate course. *Foreign Languages and Their Teaching*, 2012(5),29-33.
- Liu, Q., Zheng, X., & Deng, W. (2021). Scaffolding based on reflective journals and its application outcomes. *Modern Distance Education*, 2021(5),3-11. DOI: <https://doi.org/10.13927/j.cnki.yuan.20210831.001>
- McNamara, D., Graesser, A. C., McCarthy, P. M., & Cai, Z. (2014). Automated evaluation of text and discourse with Coh-Metrix. Cambridge University Press. DOI: <https://doi.org/10.1017/CBO9780511894664>
- Merriam, S.B. (1998). *Qualitative Research and Case Study Applications in Education*. San Francisco: Jossey-Bass Publishers.
- Moon, J. (1999). *Learning Journal: A Handbook for Academics, Students and Professional Development*. London: Kogan Page.
- Ren, H. (2017). Reflective learning and listening proficiency development in college English learning. *Testing and Evaluation*, 89(4),72-75.
- Vygotsky, L. (1986). *Thought and Language*. Cambridge: MIT Press.
- Xue, S. (2021). The effectiveness of reflective journals in developing critical thinking in English writing. *Journal of Weifang Engineering Vocational College*, 34(6),29-36,42. DOI: <https://doi.org/10.3969/j.issn.1009-2080.2021.06.05>
- Yockey, R. D. (2010). *SPSS Demystified: A Simple Guide and Reference*. (Chinese Translation by Chao Liu & Zheng Wu). Beijing: China Renmin University Press.
- Zhang, W. (2014). Translation Teaching and the Cultivation of Critical Thinking Ability: The role of reflective journals in translation instruction. *Journal of Hefei University (Social Sciences Edition)*, 2014(6),127-130.
- Zhao, X. & Sun, B. (2019). WeChat-assisted reflective learning in English writing instruction. *Journal of Qiqihar University (Philosophy and Social Sciences Edition)*, 2019(3),177-183.

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