Volume 24
Number 02
October, 2024

SIEF

science insights education frontiers

pISSN: 2644-058X eISSN: 2578-9813

Published Monthly by
Insights Publisher

Science Insights Education Frontiers

pISSN 2644-058X
eISSN 2578-9813
(Monthly)

Volume 24, No. 2

October 2024

Insights Publisher

Science Insights Education Frontiers

pISSN 2644-058X
eISSN 2578-9813

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COMMENTARY

Problem-Based Learning: An Effective Teaching Method for Science Competence Development

Liaojian Qu

School of Education, Jiangnan University, Wuxi 214122, China

"A problem well stated is a problem half solved."
-John Dewey

MODERN society places exceptionally high premiums on science education. To make science classes more productive, researchers and educators have experimented with a plurality of non-traditional instructional approaches that are expected to be effective in fueling students' interest in science subjects and fostering their scientific reasoning ability and creativity. Among them, problem-based learning has been well received by teachers. Its adoption in science classrooms was first recommended by certain researchers in the 20th century (Gallagher et al., 1995). Problem-based learning enables the student to develop knowledge through analyzing and solving problems, rather than through memorizing a wealth of existing information and theories. It can help the student transition from a passive receptacle of knowledge to an active learner and a problem solver (Akınoğlu & Tandoğan, 2007). Despite there being no conclusive definition of this teaching method, the three features summarized by Akcay (2009) are deemed basic elements of problem-based learning: (i) engaging students as stakeholders in a problem situation; (ii) organizing the curriculum around this holistic problem, enabling student learning in relevant and connected ways; (iii) creating a learning environment in which teachers coach student thinking and guide student inquiry, facilitating deeper levels of understanding.

Over the last few decades, researchers have come up with a variety of models for implementing problem-based learning. For example, Wood (2003) proposed a 7-step problem-based learning model, which includes term identification, problem definition, brainstorming, retrospection and elaboration, objective formulation, independent study, and intra-group exchanges. There is not a fixed implementation pattern for this teaching

method; rather, the pattern varies by discipline, instructional objective, and other factors. Yet, the majority of studies have focused on the following components in developing problem-based learning activities: nature of problems, small group, student-centered iterative inquiry process, communication of the group's findings to whole class, learning resources (e.g., library, experimental equipment), technology (e.g., internet, educational platform), partnership with community, and teachers' role as facilitators (Merritt et al., 2017). Considering the method's heavy demands on education resources, some researchers conducted experimental studies to identify the most relevant factors related to its outcomes. According to Pease and Kuhn (2011), the focus on engagement with a problem is the core advantage of problem-based learning, whereas collaborative organization, such as group study, is not as important as generally assumed. This finding may serve as an implication that the teacher can save those non-fundamental steps in implementing problem-based learning in the context of limited teaching conditions.

While problem-based learning has been acclaimed as an ideal method for science education, its efficacy in science classrooms deserves more rigid examination. *Problem-Based Learning (PBL) in Science Education: A Mixed-Meta Method Study* in this issue is a mixed-meta-analysis of the method's effectiveness in science education, consisting of a meta-analysis of quantitative data from 78 experimental studies and a meta-thematic analysis of qualitative data from 15 studies based on literature reviews (Yaşar et al., 2024). Its research results reveal that most of the studies included suggest that problem-based learning is supportive of the enactment of science education, with positive effects on student academic achievements and the development of the 21st century skills in them. Also discussed are the method's negative effects on science instruction. This article offers a broader lens for our understanding the outcomes of problem-based learning in science education.

References

Akcay, B. (2009). Problem-based learning in science education. *Journal of Turkish Science Education*, 6(1):28-38. Available at: https://www.tused.org/index.php/tused/article/view/104

Akınoğlu, O. & Tandoğan, R. Ö. (2007). The effects of problem-based active learning in science education on students' academic achievement, attitude and concept learning. *Eurasia Journal of Mathematics, Science and Technology Education*, 3(1):71-81. DOI: https://doi.org/10.12973/ejmste/75375

Gallagher, S. A., Sher, B. T., Stepien, W. J., & Workman, D. (1995). Implementing problem-based learning in science classrooms. *School Science and Mathematics*, 95(3):136-146. DOI: https://doi.org/10.1111/j.1949-8594.1995.tb15748.x

Merritt, J., Lee, M. Y., Rillero, P., & Kinach, B. M. (2017). Problem-based learning in K–8 mathematics and science education: A literature review. *Interdisciplinary Journal of Problem-Based Learning*, 11(2). DOI: http://dx.doi.org/10.7771/1541-5015.1674

Pease, M. A., & Kuhn, D. (2011). Experimental analysis of the effective components of problem-based learning. *Science Education*, 95(1):57-86. DOI: https://doi.org/10.1002/sce.20412

Wood, D. F. (2003). Problem based learning. *BMJ*, 326(7384):328-330. DOI: https://doi.org/10.1136/bmj.326.7384.328

Yaşar, M. D., Batdi, V., Kiliç, A. N., & Yilmaz, Z. A. (2024). Problem-based learning in science education: A mixed Meta method study. *Science Insights Education Frontiers*, 24(2):3971-3992. DOI: https://doi.org/10.15354/sief.24.re406

Correspondence to:
Liaojian Qu
School of Education
Jiangnan University
Wuxi 214122
Jiangsu
China
E-mail: quliaojian@jiangnan.edu.cn

Conflict of Interests: *None*

Doi: *10.15354/sief.24.co351*

COMMENTARY

Decentralizing the School: The Necessity of Teacher Involvement in School Management

Yaodong Yang

School of Education Science, Jiangsu Normal University, Xuzhou 221116, China

"Excellence is to do a common thing in an uncommon way."
-Booker T. Washington

THE ROLE of school management is to ensure that the school is run in efficient and orderly ways, providing an ideal education environment for teachers and students. Effective school management can substantially promote teacher professional development whereas flawed school management undermines the teacher's job satisfaction and identification with the teaching career, leading to increased turnover rates (Stockard & Lehman, 2004; Tang, 2024). Also, the leadership style of the school is closely related to the students' quality of learning, making a significant difference to their interest, motivation, and outcomes (Robinson & Gray, 2019; Yu et al., 2021). Therefore, developing legitimate school management patterns is of vital significance for educational quality enhancement.

In effect, a portion of schools are suffering from out-of-date management styles and the consequential low management productivity, hampering effective education and teaching enactment. In the Chinese context, bureaucratic centralization constitutes a major factor that curbs management outcomes of the school (Liu & Wu, 2013). Bureaucratic centralization is a form of management that is centered around bureaucrats, who have absolute control over all decision-making processes at the expense of marginalizing other members of the organization (Meng, 2019). With the presence of this management style, the teachers, the pivotal educational actors, become the subordinates of the school administrators, being deprived of their autonomy in instruction and teaching research planning and implementation, which severely impairs their career development; in the meantime, school administrators can easily develop the mentality that they are entitled to make arbitrary decisions in school management with no need to pay regard for the central roles of the teachers in education and teaching (Liu & Wu, 2013; Meng, 2019), which could result in injudicious resource allocation and a decline in morale, downgrading the education standards of the school.

Encouraging teacher participation in school management is an effective countermeasure to the harm of bureaucratic centralization to school development. Involving teachers in school decision-making helps develop their ownership of school operation, increasing their senses of responsibility for the improvement of the school as well as igniting their enthusiasm for further personal professional development (Zhang, 2023). Meanwhile, teacher involvement in school management is beneficial for the school reaching more scientific and informed decisions. This is because the teachers are the most capable of providing workable suggestions to the school leadership as they are most familiar with the school's everyday operation and witness students' cognitive and non-cognitive behavior on a daily basis in carrying out the regular instructional duties (Liu, 1998). In order to ensure democratic management in Chinese schools and safeguard the teachers' rights to participate in school management, the *Teachers Law of China* stipulates that the teacher has the right to air their opinions and suggestions on school education, teaching, management, and administration work and the right to participate in school management via the congress of faculty and staff or other devices (Standing Committee of the National People's Congress of China, 1993).

Despite the growing advocacy of decentralizing the school and increasing the weight of the teachers' management involvement on the part of the Chinese government and academia, there remain many barriers to their substantive involvement in school governance. *Challenges of Teacher Involvement in School Management in China* in this issue examines the significance of teacher involvement in school management and summarizes its complications and causes in China (Zhou, 2024). Although the article does not give a detailed analysis on how to resolve the issues with Chinese teachers' school management involvement, it still offers valuable implications for further explorations of their potential roles in school governance.

References

Liu, H. (1998). Teacher involvement in school management. *Journal of Political Science and Law*, 1998(S1):17-20. Available at: https://kns.cnki.net/kcms2/article/abstract?v=Dm4VI7mKrXO8DHJ9i2HfKx46n6DbxGwhYvK4ikS51_5T4_2hbKBHBbb3PpTi9-eYqqRYsiJkNN2Oyw_IUX1rs0a8q1WvoeblGdv01BOHY8Dyg_nHXhXRXko2hyynduDE4XUwClqC9bs6ZmHid1SVhjDAipImd2sQ6sKBvGqg-ROmrrnnzc7VxA==&uniplatform=NZKPT&language=CHS

Liu, X. & Wu, J. (2013). Rethinking the participation of college teachers in school management: Based on the perspective of empowerment theories. *Journal of Jiangxi Education College*, 34(3):138-140. Available at: https://kns.cnki.net/kcms2/article/abstract?v=Dm4VI7mKrXNmPhpbTCeR1IPoXmJB13jliH2Kbjp3vtTDIE6tEDsxEht18Mb0Y0pbvuevkxMEt-Y1jbNYWZkxtV1qTzbwMS79BdFeLiOpx75Aed9uhG62f_uS_TK4nuxyXk3OLgl1FjzuC5DXDAavIReUMr12XwRoQglWApPcNFWfY512tO-T4A==&uniplatform=NZKPT&language=CHS

Meng, L. (2019). The significance of abandoning the mentality of bureaucratic centralization for university administrative staff. Proceedings of the First Symposium of the Teaching Research Committee of Guangxi Writing Society in 2019. (pp.62-64). School of Humanities, Northeast Normal University. Available at: https://kns.cnki.net/kcms2/article/abstract?v=Dm4VI7mKrXM4TTOeWWjX2TfPV4K0noMlsKxGsdrpRrB1QWl0OgWQpqK3H6CUmDLorhvLyOAU5lvUyMMAXTb56NID-Yup9jrt2H6WcNDxL1mxUraOLo4gdsPJ5zCfpksM5X4y4lKAr0n9jiu-_vEKPzorIxFQ_I_c1-ayhEXpdnf_afpGZKMRPxMtpEGF02Ax&uniplatform=NZKPT&language=CHS

Robinson, V. & Gray, E. (2019). What difference does school leadership make to student outcomes? *Journal of the Royal Society of New Zealand*, 49(2):171-187. DOI: https://doi.org/10.1080/03036758.2019.1582075

Standing Committee of the National People's Congress of China (1993). The Teachers Law of China. Available at: http://www.moe.gov.cn/jyb_sjzl/sjzl_zcfg/zcfg_jyfl/tnull_1314.html

Stockard, J. & Lehman, M. B. (2004). Influences on the satisfaction and retention of 1st-year teachers: The importance of effective school management. *Educational Administration Quarterly*, 40(5):742-771. DOI: https://doi.org/10.1177/0013161X04268844

Tang, K. (2024). A review of rural school management in the context of the increased turnover rates in rural teachers. *Guide to Science and Education*, 2024(3):61-63.

Yu, H., Guan, T., & Liu, T. (2021). How rural principal leadership affects student academic performance: the mediating effects of the collective efficacy of teaching staff and the school culture. *Forum on Contemporary Education*, 2021(1):111-117. DOI: https://doi.org/10.13694/j.cnki.ddjylt.20201116.001

Zhang, Q. (2023). The effectiveness of teacher involvement in school management: Conceptual analysis and conceptual framework development. *Journal of Educational Development*, 2023(6):51-59. DOI: https://doi.org/10.16215/j.cnki.cn44-1371/g4.2023.06.002

Zhang, Q. (2024). Challenges of teacher involvement in school management in China. *Science Insights Education Frontiers*, 24(2):3993-4002. DOI: https://doi.org/10.15354/sief.24.re419

***Correspondence to**:*
Yaodong Yang
School of Education Science
Jiangsu Normal University
Xuzhou 221116
Jiangsu
China
E-mail: 986822877@qq.com

***Conflict of Interests**: None*

***Doi:** 10.15354/sief.24.co356*

ORIGINAL ARTICLE

Pre-Service Science Teachers' Conceptual Integration Understandings in Explaining the Subject of Metabolism with the Concepts of Physics and Chemistry

Mustafa Hamalosmanoğlu

Erciyes University, Kayseri, Turkey

***Abstract**: This study focuses on exploring pre-service science teachers' conceptual integration understandings in explaining the subject of metabolism with the concepts of physics and chemistry. Action research was employed in this study. Nine pre-service science teachers taking the General Biology II course participated. Participants were taught metabolism considering conceptual integration. Data were collected via paper-and-pencil questionnaire administered before and after the intervention. The results showed that the pre-service science teachers could not understand physics and chemistry concepts at a sufficient level while explaining metabolism. Although the activities and practices were executed for conceptual integration in the action plan, only three participants achieved complete conceptual understanding for better conceptual integration at the end of the course in the first question. Thus, future studies could design interventions to be effective in conceptual integration. Further research could also design experimental investigations to examine how conceptual integration is necessary for establishing the relationship between science and other fields.*

Science Insights Education Frontiers 2024; 24(2):3927-3949
DOI: 10.15354/sief.24.or636

How to Cite: Hamalosmanoğlu, M. (2024). Pre-service science teachers' conceptual integration understandings in explaining the subject of metabolism with the concepts of physics and chemistry. Science Insights Education Frontiers, 24(2):3927-3949.

***Keywords**: Action Research, Conceptual Integration, Metabolism, Pre-Service Science Teacher, Science Education*

***About the Author**: Mustafa Hamalosmanoğlu, Associate Professor, Department of Science Education, Erciyes University, Kayseri,Turkey, E-mail: hamalosmanoglu@erciyes.edu.tr, ORCID: https://orcid.org/0000-0002-1126-0268*

***Correspondence to**: Prof. Mustafa Hamalosmanoğlu at Erciyes University in Turkey.*

***Conflict of Interests**: None*

***Funding**: No funding sources declared.*

***AI Declaration**: The author affirms that artificial intelligence did not contribute to the process of preparing the work.*

Introduction

INTERDISCIPLINARY learning is a curriculum approach that enhances and enriches learning by meaningfully combining multiple disciplines or subject areas (Cone, et al., 1998). Klein (1990) and Newell (1998) suggested four major steps for interdisciplinary education; determining the problem, determining the disciplines to be integrated, drawing an integrating framework plan by determining the concepts of each discipline, and integrating with the current information in the disciplines. Students can benefit in many ways from the application of interdisciplinary education. They may, for instance, have an increased sensitivity to ethical issues, have a better ability to synthesize or integrate, broaden their perspectives or horizons, become more creative, original, demonstrate unconventional methods of thinking, have more humility, increase their listening skills, or have an increased level of sensitivity to prejudice (Newell, et al. 1990, pp.70-71). Interdisciplinary education enables teachers to identify areas of learning. Moreover, students actively use the concepts of different disciplines in their learning processes (Lederman & Niess, 1997). Many education systems expend high levels of time, effort, and resources to educate qualified individuals equipped with 21st-century skills. These skills are mainly problem-solving, critical thinking, entrepreneurship, creativity, innovation, communication, co-operation, information, and technological literacy (Koenig, 2011). To acquire these skills, individuals need to think multidimensionally and relate multiple disciplines to one another (Daugherty, 2013). This approach positively contributes to the improvement of individuals' 21st-century skills and the meaningful learning of concepts (Crowther, 2012; diSessa, 1993; Taber, 2008). Thus, this study was guided by the interdisciplinary approach and aims to explore pre-service science teachers (PSTs)' conceptual integration (CI) of physics and chemistry concepts in explaining metabolism. The metabolism unit is among the most crucial biology units, and it is necessary to utilize the concepts taught within various physics and chemistry units to meaningfully learn it (Yip, 1998). For these reasons, this unit was chosen.

In the literature, CI is defined as the ability to establish relationships between concepts by using the prerequisite knowledge of a discipline while learning information regarding another (Taber, 2003a; Toomey & Garafalo, 2003). For instance, external respiration can be defined in biology as the exchange of carbon dioxide in the blood and oxygen with the air using the lung. A plausible explanation of the same phenomenon by an individual utilizing CI might be as follows: An individual, while inhaling, expands their chest cavity volume by tightening their diaphragm and opening their ribs. In this way, the oxygen fills the lungs in the chest cavity, which has a lower pressure than the atmospheric pressure, and mixes with the blood. Carbon

dioxide also passes from the blood to the lung. After the transition, the exhaling individual reduces the volume of their chest cavity by loosening their diaphragm and narrowing their ribs. Hence, the chest cavity, which has a higher pressure than the atmospheric pressure, compresses the lungs inside and sends the air filled with carbon dioxide into the atmosphere (Reece et al., 2015). Therefore, the individual in question will have utilized both the concept of pressure learned in physics and Boyle's law learned in chemistry. However, Taber (2003b) has stated that learners do not tend to bring relevant physics concepts to mind when learning about chemistry. Similarly, students may not bring relevant physics and chemistry concepts to mind when learning about biology. For meaningful learning to occur in the area of biology, the use of chemistry and physics concepts could be crucial. In fact, learning biology using the symbolic and microscopic language of chemistry could be very important to give students 21st-century skills. Although CI is essential, students consider it to be an unreasonable demand to use the concepts of other fields in the learning of science (Taber, 1998). Therefore, this study is crucial as it explains that the concepts of chemistry and physics should be used in the learning of biology.

Previously conducted studies have indicated that the CI of the disciplines reduced students' misconceptions (Çıray, 2010; Ganaras, et al., 2008; Taber, 2003b) and improved their scientific thinking (Taber, 2003a; Taber, 2008b). For instance, Çıray (2010) reported that interdisciplinary analogy-based teaching was effective in improving junior high school students' academic achievements and simultaneously reduced their misconceptions. Thus, it is necessary to acknowledge how to facilitate sufficient conceptual integration across different teaching disciplines (Authors, 2016).

The interdisciplinary approach suggests that students' 21st-century skills will increase through the integration of concepts in different disciplines (Xie, et al., 2015). Although the interdisciplinary approach has been started to be integrated into curricula at different levels of education, the concepts of different disciplines have been taught without being linked to one another (Akpınar & Ergin, 2004). One of the main reasons for this circumstance is the teachers who have difficulty using the interdisciplinary approach (Stinson, et al., 2009). For instance, Dervisoglu and Soran (2003) have discovered that most biology teachers are not equipped with knowledge regarding interdisciplinary teaching. Authors of a previously conducted study (2018) have stated that science teachers and PSTs had insufficient knowledge regarding CI, as they had not previously received training for an interdisciplinary approach. Consequently, CI is essential for the achievement of meaningful learning, the development of scientific thinking, the reduction of misconceptions, and the acquisition of science literacy and 21st-century skills. Therefore, teachers have great responsibilities for enabling students to

use CI effectively. In this respect, further studies should be conducted to investigate pre-service teachers' subject-matter knowledge about CI (Caudill, et al., 2010; Godrick & Hartman 2000).

Previously conducted studies found in the literature have mainly focused on the CI of students at secondary and university levels or integrating the concepts across two disciplines (Salah & Dumon, 2011, 2014; Taber, 2008; Toomey & Garafalo, 2003). Moreover, investigations have concluded that the integration of biology, physics, and chemistry concepts is at an insufficient level (Authors, 2018). This study consequently investigated how PSTs integrate physics and chemistry concepts in their teaching of the concept of the metabolism. The following research questions guided the study:

- Can PSTs use the physics and chemistry concepts while explaining the concepts in the metabolism unit? How?
- Does the instruction considering conceptual integration contribute to PSTs to explain the concepts in the metabolism unit by using the concepts in physics and chemistry? How?

Methodology

Research Design

This study employed the action research method. In action research, the researcher identifies one or more problems and prepares an action plan regarding them. Similarly, they gain an understanding on whether or not the aforementioned action plan was effective in resolving the aforementioned problem(s). Hence, the researchers attempt to conclude the study by finding an appropriate solution to the problem (Creswell, 2009). In this study, the initial extent of the CI in PSTs during the teaching of the metabolism was determined. Afterwards, an action plan was designed and implemented to help participants achieve the desired CI level.

Study Group

The study group was determined using purposeful criterion sampling in which one or more criteria are used in the determination of participants (Merriam, 2009). In this study being conducted on PSTs, taking the "General Biology-II" course for the first time was the criteria set in determining the participants. Therefore, the participants consisted of sophomore PSTs at a public university in Turkey. Nine students who volunteered to participate in the study were selected. The participants consisted of eight women and one man. All names depicted throughout the study are pseudonyms. The study was conducted in accordance with ethical rules, and the participants filled

out an informed consent form regarding their participation. The PSTs had graduated from four-year teacher education programs. They were required to take many courses regarding biology, chemistry, physics, mathematics, teaching as a profession, and general culture, and to complete the program in a total of 148 credits of coursework.

Data Collection Tool(s)

Data was collected via a paper-and-pencil questionnaire. In the questionnaire, the participants were asked questions regarding how they could integrate physics and chemistry into some concepts related to metabolism. The questionnaire included six questions concerning the topic "metabolism", in which students could integrate physics and chemistry. The questions were prepared based on the content of related literature texts (Bozcuk, 2004; Keeten, et al., 1999; Reece, et al., 2015). The contents of the questions were as follows; "The concept of energy and its types", "The importance of energy to living things", "The differences in the chemical structures of oil", "The differences in the mechanisms of moving of living things", "The importance of energy conservation for living things", "How living things produce their energies.". The questions were examined by two experts of science education to ensure the validity of their content.

The Data Collection Process

The data of the study was collected via paper-and-pencil questionnaires administered to nine PSTs before and after the application of the intervention (**Figure 1**). The PSTs were given 50 minutes to complete the questionnaire. The PSTs' answers to the questionnaire before the intervention were analyzed, and the extent to which PSTs integrated physics and chemistry concepts in their explanations of the concept of the metabolism was determined. Following the intervention, the students were given the questionnaire once again to determine whether the PSTs integrated physics and chemistry concepts at a sufficient level in the process of explaining the metabolism.

Action Plan

The intervention consisted of a three-week action plan in which the PSTs were taught the topic of metabolism, with consideration being paid to CI. The class assembled for six 50-minute periods per week. Metabolism was taught considering concepts such as energy, photosynthesis, heat, temperature, chemical reaction, light, and mass and using various activities such as videos, experiments, and portfolios for three weeks by the first

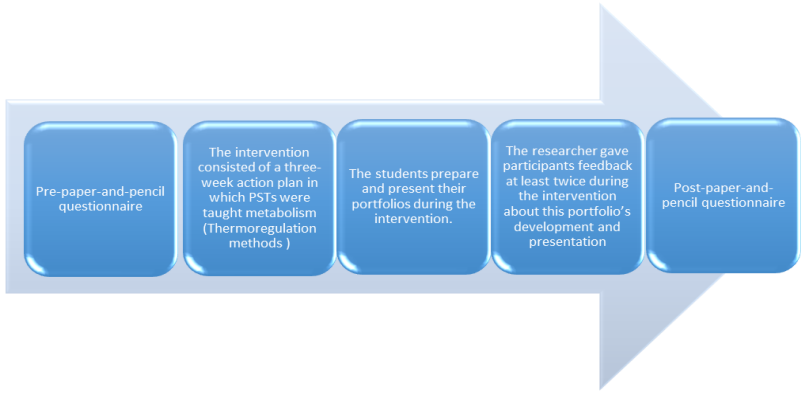


Figure 1. Data Collection Process.

Table 1. Biology Course Based on Conceptual Integration.

Question No	Biology Lesson for Previous Years	Biology Lesson Based on Conceptual Integration	
		Physics	**Chemistry**
1	• Living things need energy. • Chemical energy (focus on ATP) • Explaining the transport of energy through only the ATP	Energy is the ability to do work.	• Energy can be obtained through chemical changes. • One of the most important energy sources is found in atomic nuclei.
		Potential, kinetic, heat, light, electricity, nuclear, and sound energy etc.	Potential, kinetic, and chemical energy etc.
		Explaining the energy transfer using the concept of heat energy in addition to ATP	Explaining the energy transfer using the concept of chemical energy in addition to ATP
2	• Living things obtain energy from food. • Foods that provide energy are carbohydrates, fats, and proteins.	Living things use light energy. Thus, they heat the water with sunlight and generate electricity with solar panels.	Symbolic display of reactions using ATP as energy source $6CO_{2(g)} + 6H_2O_{(aq)} \rightarrow C_6H_{12}O_{6(s)} + 6O_{2(g)}$
3	• Olive oil and Sunflower oil are obtained from plants, while butter is obtained from animals. • Vegetable oils are liquid at room temperature, while butter is an emulsion. • Vegetable oils are unsaturated, and butter is saturated fats.	-	The differences between the chemical formulas of these oils have been examined. Symbolic level was used to explain the differences.
4	• Animals actively make relocation movements. • They make these movements using their muscles and skeletons. • Movement in plants is in the form of tropism (orientation) and nastic.	• Explaining the physical strength, suction pressure, the pushing and pulling forces that muscles create with contraction and relaxation in animals. • Explaining the movement of plants by factors such as light, temperature and pressure	-
6	• ATP is an organic compound involved in energy conversions in all living cells. • ATP is a special nucleotide containing the adenine base, ribose sugar and three groups of phosphates.	-	Explain the structure of the ATP using microscopic and symbolic levels in chemistry

researcher. During the activities, the relevant topic or concept was explained using not only the concepts of biology, but also the concepts of chemistry and physics.

Table 1 depicts CI in the current biology course for each question the fifth, as well as the content of the biology course conducted in the previous years without using CI. For the fifth question, the first researcher explained in previous years during biology lessons why our body remained at the same temperature with the following definition:

"Body temperature is kept constant by homeostasis. People are warm-blooded creatures. The body temperature of warm-blooded creatures is always constant. Energy is constantly produced and expended in the human body. Meanwhile, the heat released allows the body to warm up. There is a center that controls body temperature. At the same time, the skin provides insulation to maintain body temperature. Excess heat is given by evaporation. In this way, the human body always remains at the same temperature."

However, in the study, the first researcher used thermoregulation methods to achieve CI. Thus, he explained the concepts of convection, conduction, and electromagnetic radiation in physics, and evaporation in chemistry at an in-depth level. Thus, the students realized that enzymes cannot catalyze reactions by denaturing at extreme temperatures and that the body is cooled by thermoregulation methods such as evaporation and convection. Additionally, the students understood that the system had to fulfill its functions in order to live in accordance with the laws of thermodynamics. Thus, they realized that the heat energy to be given to the system while the work is being done and the heat energy released from the system should be equal. As a result, they realized that physics and chemistry lessons should be integrated with biology concepts to understand the thermoregulation methods. The students were required to prepare and present their portfolios after the first administration. Their portfolios included the subject topic, concept maps, puzzles, essays, stories, etc. The researcher gave participants feedback at least twice during the intervention about the aforementioned portfolio's development and presentation. Moreover, this researcher gave participants feedback regarding their portfolios after the intervention until the second administration was conducted.

Data Analysis

Content analysis, an unobtrusive technique used to analyze unstructured data in terms of meanings, symbolic qualities, and expressive contents (Krippendorff, 2013), was employed in this study. Newell (2001) stated that

better integration will ensure complete understanding. Thus, while assessing the PSTs' answers to the questionnaire, the following criteria were used:

- Complete Conceptual Understanding (CCU): The participant should provide a complete conceptual understanding for better conceptual integration
- Partial Conceptual Understanding (PCU): The participant should provide a partial conceptual understanding for weak conceptual integration.
- No Conceptual Understanding (NCU): The participant should not provide any conceptual understanding for conceptual integration.

For instance, the following answer to the question "Explain one of the sources of energy used by living things with their reasons" was regarded as NCU as it was answered only through the utilization of only biology concepts: One of the energy sources utilized by living beings is light. Light is a renewable source of energy. It is the source of life. All living beings on earth continue their lives in the presence of light. Plants perform photosynthesis by using the energy in sunlight and thus produce food. Moreover, the following answer to the same question was rated as CCU: One of the sources of energy used by living beings is light. Plants perform photosynthesis by using the energy of the light from the sun, the carbon dioxide (CO_2) in the atmosphere, and minerals from the soil and water (H_2O). As a result of this process, glucose ($C_6H_{12}O_6$) and oxygen (O_2) are produced. This expression is shown at the symbolic level as depicted below.

$$6CO_{2(g)} + 6H_2O_{(aq)} \xrightarrow[\text{Chlorophyll}]{\text{Light Energy}} C_6H_{12}O_{6(s)} + 6O_{2(g)}$$

On the other hand, as indicated above, all wavelengths of light energy are not utilized in photosynthesis. Plants absorb the light in the wavelength range of 380-700 nm to perform photosynthesis. This light energy from the sun is generated during the transformation of hydrogen molecules into helium atoms. Here, light energy at this wavelength range is used in photosynthesis since the chlorophyll molecule can only absorb light energy at this wavelength.

The answer depicted above successfully demonstrated that the PST utilized physics and chemistry concepts such as the symbolic and microscopic language of chemistry, chemical reactions, and the wave theory of light to explain why light is a source of energy. Finally, the answers including biology and chemistry concepts or biology and physics concepts, but only to some extent, were categorized as PCU. Two researchers read both the questionnaire responses and the portfolios separately. They later got together and reached an agreement on different codes. Finally, the third researcher checked the codes. After the three researchers agreed on the codes,

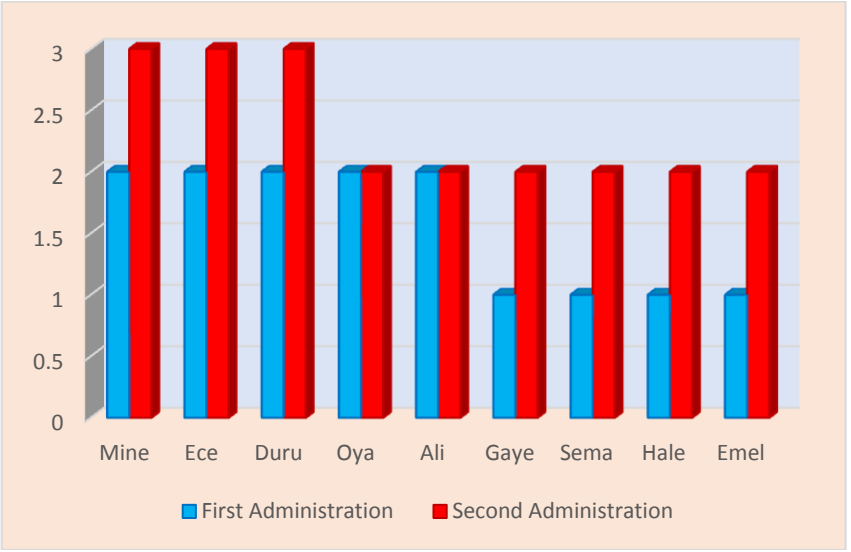


Figure 2. The Changes in Participants' Conceptual Integration for Question 1.

another science educator checked them and brought the analysis to its conclusion. The coding conformity percentages were calculated according to Miles and Huberman's (2015) formula resulting in a value higher than 80% indicates that the research is reliable (Miles & Huberman, 2015). The coding conformity percentage was found as 82%. Internal validity was thusly achieved. The analysis of the portfolios was carried out according to the three categories mentioned above. The evidence was gathered from participants' portfolios for all three categories. To increase the internal validity of the study, the participants' thoughts were depicted in the form of an excerpt. Additionally, the codes generated as a result of data analysis were submitted to be controlled by an expert.

Result and Discussion

Changes in Participants' Conceptual Integration for the Question of "Energy and its types"

The integration categories of the participants based on their responses to the questions of "What do you think energy is?", "What types of energy are there?", and "Explain one of the types with examples" during the first and second administrations were depicted in **Figure 2**.

As can be seen in **Figure 2**, five PSTs were able to partially utilize CI during the first administration while the others could not fulfill the CI

criteria. On the other hand, it was observed that three PSTs could fulfill the requirements for complete CI, while six participants demonstrated partial CI in the second administration. Furthermore, examples from some participants' portfolios were presented to support both the first and second administrations' data.

Ece, who scored partial CI in the first administration, stated that "*...It can be measured with some tools in many ways. The units can be joules, calories, etc.*" Ece also wrote similar statements in her summary of the topic in the portfolio she prepared after the first administration, and defined heat energy as "*It is the energy transferred from high-temperature area to low-temperature area". Moreover, she explained the calorie, as the unit of heat energy, as* "*...it can be used as a unit of heat".* In the second administration, Ece completed the CI by writing the following expression*: "...energy is the capacity to make any change in something. There are many different forms of it such as chemical energy, potential energy, kinetic energy, heat, nuclear energy, etc. While some can be measured by a device, there are special formulas for some to be calculated. Heat can be measured by a calorimeter. It is also calculated by the formula Q = m.c.dt. The unit of energy is calories or joules.*" Ece rewrote her previous summary following the instruction and feedback given by the first researcher and reached complete conceptual understanding (CCU). Ece's sentences in her summary supporting her CCU were as follows:

"As the most general definition of energy, it is the capacity to do work. It is the ability to move matter against opposing forces such as gravity and friction. In other words, energy is the ability to rearrange a community of matter .... Energy forms include kinetic energy, potential energy, electrical energy, light energy, chemical energy, heat, and nuclear energy. ... Heat can be transferred from the high-temperature area to the low-temperature area. Its unit is calories (cal). The heat cannot be measured directly. It is calculated by measurements made with a calorimeter. Meanwhile 1 cal = 4186 j. It can be calculated by the following equation (Q = m.c.dt, Q)".

Duru, one of the participants who made scored partial CI in the first administration, stated that: "*...There is internal and external energy. Kinetic energy and potential energy. The unit is Joule.*" In the second administration, Duru made complete the CI by stating "*...the energy is the ability to do work. We can measure the transformation of energy into each other. For example, if a substance loses kinetic energy and gains potential energy, we can measure the transition between them. Units are kg(m/s)2 and mgh*." Emel could not make the CI in the first administration and she stated as "*Energy is not one thing. The whole of the universe, life, which people need and is occurring naturally or artificially, is energy*". Emel was coded partial the CI for the second administration: She wrote as "*It is necessary to apply force to*

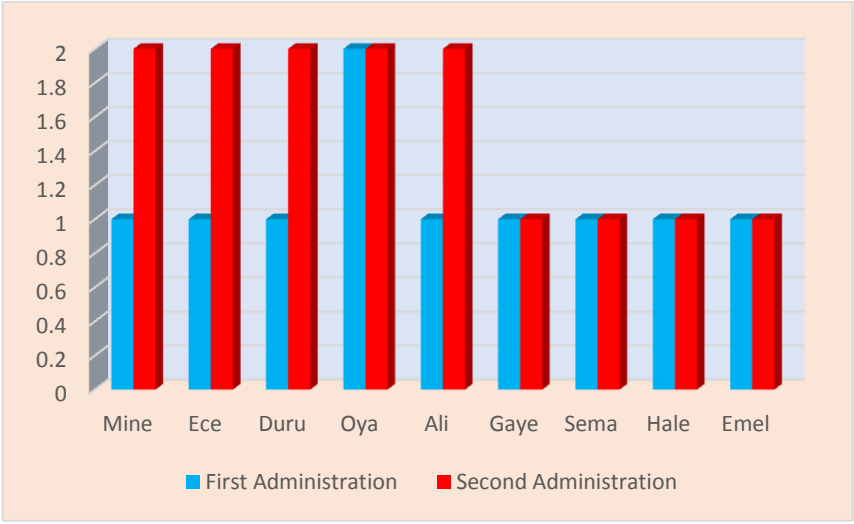


Figure 3. The Changes in Participants' Conceptual Integration for Question 2.

do work. The unit of energy is calorie or joule. Energy can be measured with coefficients in respiration and formulas."

Changes in Participants' Conceptual Integration for the Question of "The Importance of Energy for Living Beings"

The integration categories of the participants in relation to their responses to the question of "Explain one of the sources of energy used by living things with their reasons" during the first and second administrations were depicted in **Figure 3**.

As can be seen in **Figure 3**, one participant made partial the CI while the other eight PSTs could not make any the CI in this question. In the second administration, five PSTs made partial the CI while four participants could not make any the CI.

Mine, one of the PSTs who were unable to fulfill the requirements for CI, stated that: "*Living things continue their lives by producing ATP*." In the second administration, she made partial the CI with the following explanations: "*There are varieties of energy sources that can be used by living things such as solar, wind, and geothermal energy. People use chemical energy to carry out their vital activities such as eating, drinking, and running by taking it from the nutrients (there is chemical energy available at any time stored in nutrients)*" Oya, who made partial the CI in the first administration, stated, "*…The primary energy source is the sun. In*

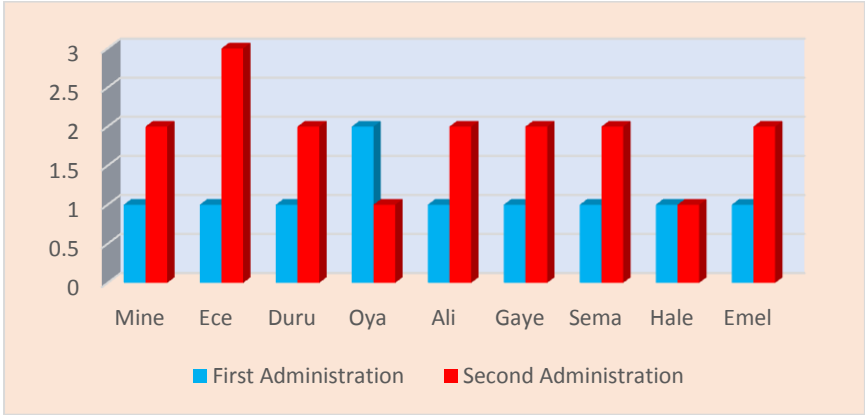


Figure 4. The Changes in the Participants' Conceptual Integration for Question 3.

fact, it would not be wrong if it was called fission and fusion reactions." In the second administration, Oya achieved partial CI with the following explanations: "*Living things can only get energy for their body from food. The food contains solar energy. Living things can use the existing energy for various things. For example, they can benefit from natural gas in cooking.*" Gaye, who was unable to reach the CI threshold in the first administration, stated that "*We take energy from the food we eat.*" In the second administration, she could not make the CI again with the following explanations: "*...Living things get energy from food*."

Changes in Participants' Conceptual Integration for the Question of "Differences in Structures of Oils in Terms of Chemistry"

The integration categories of the participants in relation to their responses to the question of "Although olive oil, sunflower oil and butter consist of the same monomers, what can be the reason(s) for their structural differences? Please explain." during the first and second administrations were depicted in **Figure 4**.

As can be seen in **Figure 4**, one participant reached partial CI while the other eight PSTs could not reach the required CI threshold in the first administration. In the second administration, however, it was determined that only one participant could achieve complete CI. In contrast, six PSTs reached partial CI, and two PSTs could not achieve CI at all. Moreover, Oya, who achieved partial CI in the first administration, could not achieve CI in the second administration.

Ece, one of the participants who was unable to reach the CI threshold in the first administration, stated, "*Monomers have different forms of attachments*." In the second administration, Ece achieved complete CI by answering the question with the following: "*These oils are examples of saturated and unsaturated fats…. Unsaturated fatty acids are double bound fatty acids and unsaturated with hydrogen. The reasons why these kinds of fats are different are as follows: First, the oils show cis-trans isomer because of their double-bonded alkene structure. Cis and trans have different structures. Because their position in the molecule is different. Second, in fatty acids, even if one hydrogen has a different position in the molecule, that fatty acid differs from the other acids. Therefore, their melting and boiling points differ, as well. Saturated fatty acids are types of fats whose structures are fully saturated with hydrogen. Again, the reason why these oils are different is that the molecular structures of fatty acids are different.*" Ali, who was among the participants who were unable to reach the CI threshold in the first administration, stated: "*They may be composed of the same monomers, but if they are different in their arrangement and attachment, they are not the same*." In the second administration, Ali fulfilled the requirements for partial CI by explaining that: "*… They differ in terms of their structures because the bonding forms and positions of the atoms are different. As known, unsaturated fats contain double bonds. The location of the double bond, i.e., pi bond, may be different*." Hale, one of the participants who was unable to reach the CI threshold in the first administration, stated: "*While olive oil and sunflower oil are vegetable oils, butter is an animal fat. Monomers of animal fats are saturated fatty acids while vegetable oils contain unsaturated fatty acids*." In the second administration, Hale answered the 3rd question with the following: "*The monomers of olive oil, sunflower oil, and butter are the same, but olive oil and sunflower oils are vegetable oils and butter is animal fat. More generally, olive, and sunflower oils are unsaturated fats, and butter is saturated fat*." Hence, she was unable to achieve CI again. Oya, who was able to achieve partial CI in the first administration, wrote that "*Monomers can have forming bonds, bond angles, sigma and pi numbers, etc.*" In the second administration, Oya could not provide any conceptual integration in the following explanation: "*The reason for the different substances is that they bind in different ways and numbers, just like in enzymes and DNA.*"

Changes in Participants' Conceptual Integration for the Question of "Differences in Movement Mechanisms of Living Things"

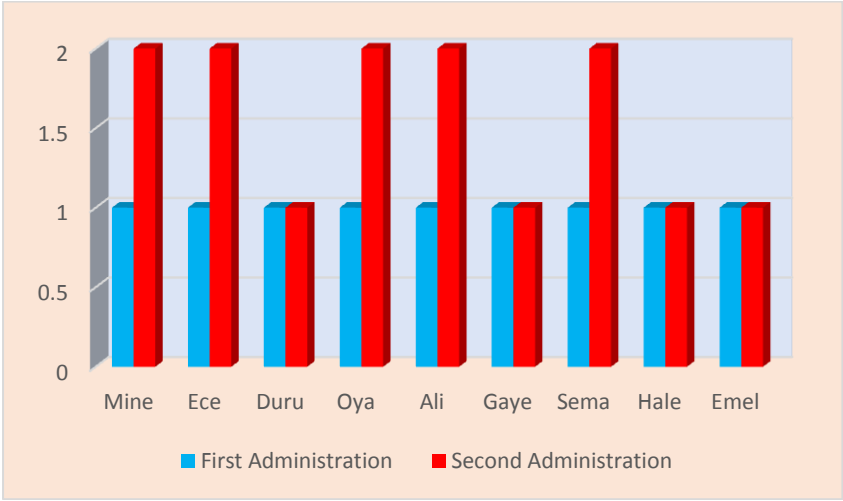


Figure 5. The Changes in Participants' Conceptual Integration for Question 4.

The integration categories of the participants in relation to their responses to the question of "Explain the fundamental difference in the movement mechanisms of animals and plants." during the first and second administrations were depicted in **Figure 5**.

As can be seen in **Figure 5**, no participant was able to reach the CI threshold for this question in the first administration. In the second administration, however, five participants achieved partial CI while four PSTs could not achieve any degree of CI as was in the first administration.

Oya, who was unable to demonstrate CI during the first administration, stated: "*...When animals are actively moving, plants move where they are. They make various passive movements.*" She could not answer this question in the portfolio she prepared before the implementation of the course. On the other hand, Oya achieved partial CI in the second administration by stating: "*Muscles cause the movement of an animal while hormones and the stimulation of these hormones or turgor pressure cause the movement of a plant. The growth is also considered as the movement, that is,* " In the portfolio she prepared at the end of the term, it was demonstrated that she had a similar opinion that could be categorized as PCI. Her sentences were as follows: "*Every living thing moves, passively or actively... Animals move with their muscles. These muscles are the filaments of actin and myosin. We can explain the movements of the muscles with the sliding filament model. ... The movements of plants are tropism and nastic movement. Hormones such as auxin and gibberellin are effective in the tropism while sudden changes in turgor pressure are effective in nastic movement.*" Emel could not reach the CI threshold in the first administration,

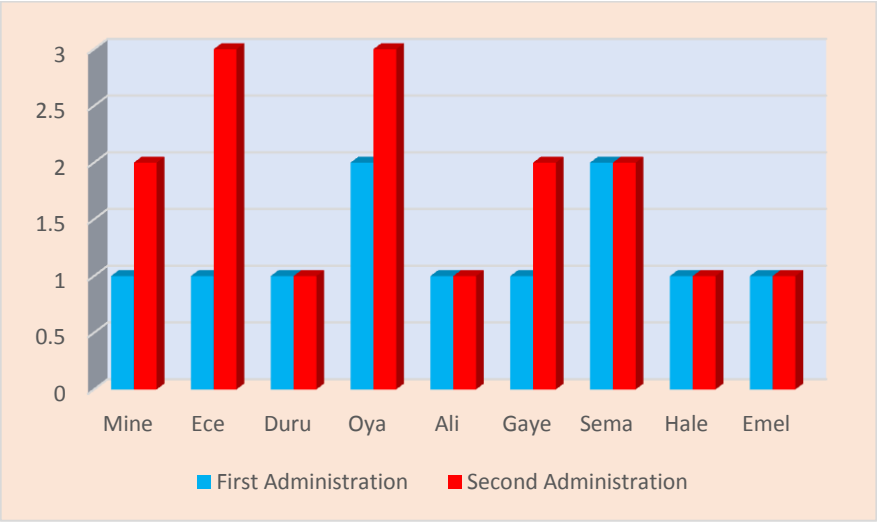


Figure 6. The Changes in Participants' Conceptual Integration for Question 5.

wrote the following statements: "*All living things are in motion, but some cannot move. While animals carry out their movements in an active way, the plants move with nastic movement and tropism, turning movements. This turning movement is slow and long-term*." Emel was similarly unable to achieve a sufficient level of CI in the second administration by stating: "*...Animals are living things with the skeletal system and nervous system; so, they can move actively. Plants do not have a nervous system to direct them, and they cannot move actively because they need nutrients in the soil. They can only do turning movements.*"

Changes in Participants' Conceptual Integration for the Question of "The Importance of Energy Conservation for Living Beings"

The integration categories of the participants in relation to their responses to the question 5, "What is the main reason for our body to stay at the same temperature? Please explain." during the first and second administrations were depicted in **Figure 6**.

As can be seen in **Figure 6**, two PSTs were able to demonstrate partial CICI while the other seven could not utilize integration for this question during the first administration. In the second administration, however, two participants demonstrated complete CI while three PSTs reached the partial CI threshold and four PSTs could demonstrate CI.

Ece, who was unable to demonstrate CI during the first administration, stated her answer as: "*Water and some enzymes in our bodies keep the body temperature constant.*" When the summaries, concept maps, question preparation assignments, and puzzles in her portfolio, which she prepared before the implementation in the course, were examined, no answer was found regarding the explanation of this problem. In the second administration, Ece fulfilled the requirements of complete CI by explaining that: "*This is due to thermoregulation. In other words, heat regulation in Turkish. The role of our skin in this event is important. If our body temperature increases during the ATP production and with heat-releasing reactions, we will remove the excess heat from our body and bring it to its previous temperature thanks to the evaporation of water on our skin by sweating.*" Ece was included in the CCU category with the portfolio she prepared at the end of the term. The answer in her summary indicated that Ece was in the CCU category. Ece's response in the summary that qualified for CCU was as follows: "*...In warm-blooded living organisms, the neural reflex mechanisms that affect heat generation (thermogenesis) and its distribution (thermolysis) ensure that the temperature remains constant. On the skins of these living things, there are special receptors sensitive to temperature changes… When the body temperature increases, capillary vessels expand, sweating increases, and respiration accelerates. These events enhance evaporation… Heat insulation reduces or completely stops heat transfer between two environments of different temperatures. Skin is also an insulating layer for the body… When exposed to cold, the skin aims to reduce heat loss, the veins shrink, sweating decreases or stops, and respiration slows down. Thus, the skin tries to keep the body temperature constant.*" Oya was categorized as partial CI in the first administration, and she wrote that "*There are three main centers in our body that produce heat. While obtaining energy from nutrients, heat is released and distributed through the blood to everywhere in accordance with the laws of thermodynamics.*" In the second administration, Oya was able to achieve complete CI by stating: "*Our bodies work in a wonderful way with physics, biology, and chemistry. The exothermic reactions occur in the mitochondria to form ATP. The chemical bond energy in the nutrients is converted to ATP. The excess heat is transported to other places through the blood. The skin serves as insulation or gives off excess heat to the air with evaporation. Thermoregulation is applied regularly.*" Gaye was unable to meet the requirements of CI in the first administration and she wrote that: "*I think it might be because of the heat exchange.*" In the second administration, Gaye was categorized as partial CI due to her response, stating that: "*Humans are warm-blooded. The body adjusts the heat balance through thermoregulation. By sweating, the excessive heat in the body is removed through evaporation.*" Sema, one of the participants who scored partial CI in the first administration,

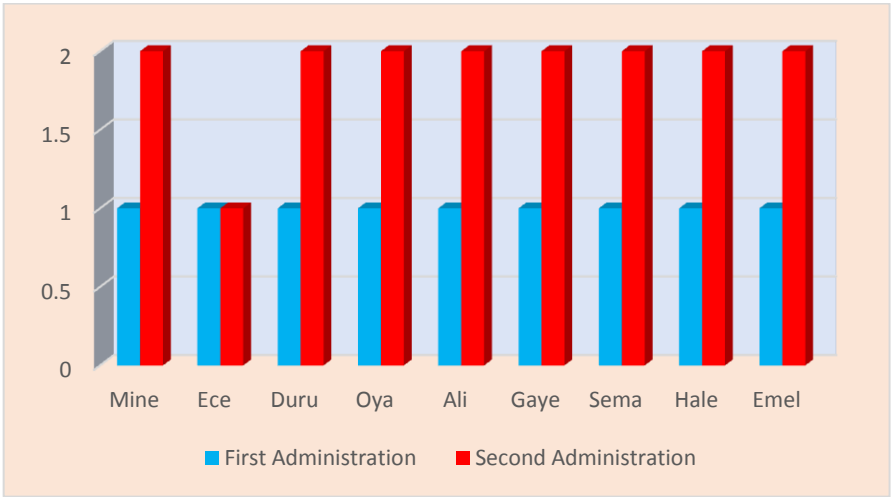


Figure 7. The Changes in Participants' Conceptual Integration for Question 6.

wrote that: "*We sweat when our body temperature rises. Because the water comes out and the temperature of our skin vaporizes this water and allows our body to cool down.*" In the second administration, Sema was categorized as partial CI again as she stated that: "*Our body can adjust itself according to temperature, that is, through thermoregulation. The body discharges to water by sweating at high temperatures, so it lowers the temperature. Since we are warm-blooded, we are always at the same temperature.*" Ali, one of the participants who was unable to achieve CI during the first administration, wrote the following statements: "*Our body maintains the temperature balance by performing adaptations to different temperatures.*" In the second administration, Ali was, again, unable to demonstrate conceptual integration by writing these statements: "*Mammals are warm-blooded creatures. Normally, our body takes a defensive position against external temperature changes with its features such as sweating and piloerection.*"

Changes in Participants' Conceptual Integration for the Question of "Energy Production of Living Things"

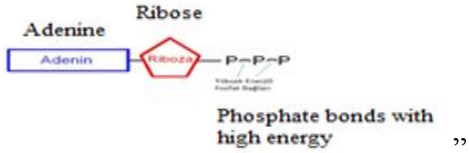
The integration categories of the participants in relation to their responses to the question 6, "What is Adenosine Tri Phosphate (ATP)? How is it produced? Please explain." during the first and second administrations were depicted in **Figure 7**.

As can be seen in **Figure 7**, none of the participants were able to achieve CI for this question in the first administration. In the second

administration, however, eight PSTs achieved partial CI while one PST was unable to meet the CI threshold, as was in the first administration.

Mine, one of the participants who were unable to meet the CI threshold in the first administration, explained that: "*ATP is responsible for the energy production of living things. It is produced in mitochondria. Production occurs when the organism needs energy. The structure of ATP is*

and she made a mistake in the figure she drew in terms of the structure of the ATP. In other words, she utilized the structure of Adenosine monophosphate (AMP) as ATP. In the second administration, Mine achieved partial CI by stating: "*ATP is the way to transfer energy in living things. Each cell produces its own ATP. When energy is needed, the ATP molecule is hydrolyzed, and the energy needs of the living are met. The production of ATP is called Phosphorylation. It is exergonic. The structure of ATP is*



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Ece was categorized as NCI in the first administration, she stated that: "ATP is the energy that our body both produces and uses. It is produced continuously. I do not know exactly where and how it is produced.". In the second administration, Ece was, again, unable to achieve CI by stating that: "*ATP is the energy molecule that can be used by living cells. It can be produced in mitochondria, chloroplasts, or cytoplasm. It is used in the metabolic activities of the cell. It is generated through cellular respiration. ATP is produced by the mixed chain of the chemiosmotic hypothesis.*"

Discussion

This study aimed to investigate how PSTs integrate physics and chemistry concepts in their teachings of the metabolism. The results demonstrated that the PSTs could not understand the physics and chemistry concepts required for conceptual integration to be performed in the context of metabolism at a sufficient level before the intervention. For instance, they had difficulty explaining the energy sources used by living beings and their reasons for using these sources through the CI. It was concluded that five participants suffered from this difficulty and were unable to fulfill the criteria required

for CI at the end of the action plan. Researchers also highlighted that the conceptual integration demonstrated by the PSTs were unsatisfactory in their science educations (Salah & Dumon, 2011; 2014; Taber, 2003b, 2008). Although the activities and practices were executed for CI in the action plan, only three participants achieved complete conceptual understanding for better CI at the end of the course in the first question. Moreover, one participant in question three and two participants in question five were able to achieve complete CI. On the other hand, there were no participants in question two, four, and six who achieved complete conceptual understanding. There are many reasons for why the participants' conceptual integration did not demonstrably improve following the action plan. First of these is the fact that the participants have been unaccustomed to the different activities requested of them as part of the action plan, such as portfolios. Although PSTs voluntarily participated in the study, they have often expressed that these portfolios took a considerable amount of non-class time for them to be completed. They consequently did not have time to do anything else during this period. Second, although the first researcher gave too much feedback to the portfolios outside of the lesson, they may not have been able to change their perception in such a short time. Therefore, educational researchers should consider that participants should not spend too much time on activities to achieve complete conceptual understanding for CI. Moreover, practitioners should act with an understanding of participants' emotional states and prepare them for practice accordingly.

PSTs who were unable to sufficiently demonstrate CI will not be able to help their students achieve meaningful learning when they become teachers in the future. As stated in the literature, meaningful learning must be realized effectively by using CI throughout science education (Duit & Treagust, 2003).Students of these PSTs will simultaneously be unable to develop scientific thinking (Taber, 2003a), relate science to their daily lives (Authors, 2018), reduce their own misconceptions in science subjects (Ganaras, et al., 2008), and be individuals who are science literate (Lederman & Niess, 1998) and have 21st-century skills (Koenig, 2011). Additionally, a PST who is unable to reach a complete conceptual understanding for conceptual integration with regards to the topic of the metabolism at a sufficient level will not be able to understand energy transformations. For instance, a PST who cannot comprehend that light is in different wavelengths will not fully understand the conversion of light energy into chemical energy. In other words, they will consequently be unable to utilize the concept of photosynthesis in their daily lives. Therefore, if they were to grow a plant in a flowerpot at home, they would not be able to decide where to position this plant at home. Another example of this difficulty is that a PST who cannot achieve CI can face difficulties when using oils. More specifically, it should be known that there is a difference

among olive oil, butter, and sunflower oil in terms of a balanced diet. However, a PST who cannot understand this difference will not distinguish between oils by acting as a science-illiterate individual and will decide on using the oil only in terms of its price and taste. On the other hand, an individual capable of achieving CI will be able to determine which oil can be used for a balanced diet by knowing that the mentioned oils are composed of different fatty acids. Like previous studies (Salah & Dumon, 2014; Taber, 2008), this study also demonstrated that complete conceptual understanding for the CI was not achieved at a sufficient level. This is alarming since it has been acknowledged that CI plays an essential role in meaningful learning (Duit & Treagust, 2003), the development of scientific thinking, and the reduction of misconceptions in science (Ganaras, et al., 2008). As a result of this study in which the teaching based on the CI was implemented, it was concluded that PSTs could fulfill the criteria set for CI despite their insufficient level while explaining the concepts of metabolism by relating them to the physics and chemistry concepts. As evidence for this circumstance, it can be shown that seven PSTs raised their CI level by one step (From NCU to PCU or from PCU to CCU) in the first question. Similarly, four PSTs in the second, six in the third, five in the fourth, four in the fifth, and eight in the sixth question increased their conceptual understanding level one step. Furthermore, one PST in the third question and one PST in the fifth question raised their conceptual understanding level from NCU to CCU. To the best of the researchers' knowledge, there is no study in the literature devoted to investigating the effect of the implementation of instructional strategies on students' CI. There are many studies emphasizing the importance of interdisciplinary education (Lattuca et al. 2004; Repko, 2006). These studies have emphasized that interdisciplinary education is crucial for students to obtain 21st-century skills. Therefore, this study additionally aimed to help students acquire 21st-century skills and emphasized the necessity of gaining a full conceptual understanding of CI.

Conclusion

In this study, the subject of the metabolism was studied to explore PSTs' conceptual understandings of CI. Further research could focus on different science subjects across different disciplines. The findings of this study demonstrated that PSTs were unable to understand physics and chemistry concepts at a sufficient level while explaining the concepts of metabolism. Future studies could design interventions to be effectively improving CI. In this study, CI was studied in terms of scientific disciplines. A high degree of CI must be acquired to establish the relationship between science and other fields such as mathematics, engineering, technology, history, geography, and art. Thus, further research could design experimental studies to investigate

how the CI is necessary for establishing the relationship between science and other fields.

References

Bozcuk, S. (2004). Bitki Fizyolojisi (Plant Physiology). Hatipoglu Publishing.

Caudill, L., Hill, A., Hoke, K., & Lipan, O. (2010). Impact of interdisciplinary undergraduate research in mathematics and biology on the development of a new course integrating five STEM disciplines. *CBE-Life Sciences Education*, 9(3):212-216. https://doi.org/10.1187/cbe.10-03-0020

Cone, T. P., Werner, P., Cone, S. L., & Woods, A. M. (1998). Interdisciplinary Teaching Through Physical Education. Champaign, IL: Human Kinetics.

Creswell, J. W. (2009). Research Design, Qualitative, Quantitative, and Mixed Methods Approaches (3rd ed.). SAGE Publications.

Crowther, G. (2012). Using science songs to enhance learning: an interdisciplinary approach. *Life Sciences Education*, 11(1):26-30. https://doi.org/10.1187/cbe.11-08-0068

Daugherty, M. K. (2013). The prospect of an 'A' in STEM education. *The Journal of STEM Education*, 14(2):10-15.

Dervisoglu, S., & Soran, H. (2003). Evaluation of interdisciplinary teaching approach in high school biology education. *Hacettepe University Journal of Education*, 25:48-57.

diSessa, A. A. (1993). Toward an epistemology of physics. *Cognition and Instruction*, 10(2&3): 105-225. https://doi.org/10.1080/07370008.1985.9649008

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. https://doi.org/10.1080/09500690305016

Ganaras, K., Dumon, A., & Larcher, C. (2008). Conceptual integration of chemical equilibrium by prospective physical sciences teachers. *Chemistry Education Research and Practice*, 9:240-249. https://doi.org/10.1039/B3RP90031B

Godrick, E., & Hartman, S. (2000). Integrating introductory biology and general chemistry laboratories. *Journal of College Science Teaching*, 29(3):184-186.

Keeten, W. T., Gould, J. L., & Gould, C. G. (1999). Genel Biyoloji (General Biology), (Translated to Turkish by Demirsoy, A. & Türkan, İ.). Palme Publishing.

Klein, J. T. (1990). Interdisciplinarity: History, Theory, and Practice. Wayne State University Press.

Koenig, J. A. (2011). Assessing 21st Century Skills: Summary of a Workshop. DC: National Research Council.

Krippendorff, K. (2013). Content Analysis: An Introduction to Its Methodology. SAGE Publications.

Lattuca, L. R., Voigt, L. J., & Fath, K. Q. (2004). Does interdisciplinarity promote learning? Theoretical support and researchable questions. *The Review of Higher Education*, 28(1):23-48.

Lederman, N. G., & Niess, M. L. (1997). Integrated, interdisciplinary, or thematic instruction? Is this a question or is it questionable semantics? *School Science and Mathematics*, 97(2):57-58. https://doi.org/10.1111/j.1949-8594.1997.tb17342.x

Lederman, N.G., & Niess, M.L. (1998). Survival of the fittest. *School Science and Mathematics*, 98(4):169-172. https://doi.org/10.1111/j.1949-8594.1998.tb17412.x

Merriam, S. B. (2009). Qualitative Research (2nd ed.). San Francisco: Jossey-Bass.

Newell, W. (1998). Professionalizing Interdisciplinarity. In W. Newell (Ed.), Interdisciplinarity: Essays from the Literature. (pp. 529-563). College Board.

Newell, W. H. (2001). A theory of interdisciplinary studies. *Issues in Integrative Studies*, 19:1-25.

Newell, W. H., Doty, W. G., & Klein, J. T. (1990). Interdisciplinary curriculum development. *Issues in Interdisciplinary Studies*, 8: 69-86.

Reece, J. B, Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., & Jackson, R. B. (2013). Campbell Biyoloji (Campbell Biology). (Translated to Turkish by Gündüz, E. & Türkan, İ.). Palme Publishing.

Repko, A. F. (2006). Disciplining interdisciplinarity: The case for textbooks. Issues in Integrative Studies, 24: 112-142.

Salah, H., & Dumon, A. (2011). Conceptual integration of hybridization by Algerian students intending to teach physical sciences. *Chemistry Education Research and Practice*, 12(4):443-453. https://doi.org/10.1039/C1RP90049H

Salah, H., & Dumon, A. (2014). Conceptual integration of covalent bond models by Algerian students. *Chemistry Education Research and Practice*, 15(4):675-688. https://doi.org/10.1039/C4RP00041B

Stinson, K., Harkness, S., Meyer, H., & Stallworth, J. (2009). Mathematics and science integration: models and characterizations. *School Science and Mathematics*, 109(3):153-161. https://doi.org/10.1111/j.1949-8594.2009.tb17951.x

Taber, K. S. (1998). The sharing-out of nuclear attraction: Or I can't think about physics in chemistry. *International Journal of Science Education*, 20(8):1001-1014. https://doi.org/10.1080/0950069980200807

Taber, K. S. (2003a). Theme issue: Teaching chemistry and physics editor's introduction: facilitating science learning in the inter-disciplinary matrix - some perspectives on teaching chemistry and physics. *Chemistry Education Research & Practice*, 4:103-114. https://doi.org/10.1039/B3RP90009F

Taber, K. S. (2003b). Understanding ionization energy: Physical, chemical and alternative conceptions. *Chemistry Education Research & Practice*, 4:149-169. https://doi.org/10.1039/B3RP90010J

Taber, K.S. (2008). Conceptual resources for learning science: issues of transience and grain-size in cognition and cognitive structure. *International Journal of Science Education*, 30(8):1027-1053. https://doi.org/10.1080/09500690701485082

Taber, K. S. (2008b). Exploring conceptual integration in student thinking: Evidence from a case study. International Journal of Science Education, 30(14):1915-1943. https://doi.org/10.1080/09500690701589404

Toomey, R., & Garafalo, F. (2003). Linking physics with chemistry-opportunities in a constructivist classroom. *Chemistry Education Research & Practice*, 4:189-204. https://doi.org/10.1039/B2RP90044K

Xie, Y., Fang, M., & Shauman, K. (2015). STEM education. *Annual review of sociology*, 41:331-357. https://doi.org/10.1146/annurev-soc-071312-145659

Yip, D. Y. (1998). Identification of misconceptions in novice biology teachers and remedial strategies for improving biology learning. *International Journal of Science Education*, 20(4):461-477. https://doi.org/10.1080/0950069980200406

Received: May 07, 2024
Revised: June 10, 2024
Accepted: June 18, 2024

ORIGINAL ARTICLE

The Relation between Mentalized Affectivity and Negative Emotions in Chinese College Students: The Moderating Effect of Internet Altruistic Behavior

Qing Zhang

Jiangsu Second Normal University, Nanjing 211200, Jiangsu, China

***Abstract**: This article aims to investigate the impact of mentalized affectivity on negative emotions among Chinese college students based on a questionnaire survey of 899 university students. The study adopts a mentalized affectivity scale, an internet altruistic behavior scale, and a self-analysis questionnaire. The study's findings reveal a negative correlation between mentalized affectivity and depression, anxiety, and stress, but a positive correlation with variables linked to internet altruistic behavior in college students. Additionally, the study reveals a significant moderating effect of internet altruistic behavior on the relationship between mentalized affectivity and depression and anxiety. It is concluded that an increased level of affectivity can help modulate negative emotions and that internet altruistic behavior can play a moderator role in the modulation process.*

Science Insights Education Frontiers 2024; 24(2):3951-3969
DOI: 10.15354/sief.24.or639

How to Cite: Zhang, Q. (2024). The relation between mentalized affectivity and negative emotions in Chinese college students: The moderating effect of internet altruistic behavior. Science Insights Education Frontiers, 24(2):3951-3969.

***Keywords**: Mentalized Affectivity, Negative Emotions, Internet Altruistic Behavior*

***About the Author**: Qing Zhang, Jiangsu Second Normal University, Nanjing 211200, Jiangsu, China, E-mail: zhangq12_0102@126.com*

***Correspondence to**: Qing Zhang at Jiangsu Second Normal University in China.*

***Conflict of Interests**: None*

***Funding**: This study is supported by the project of Research on the Effect of Online Emotion Regulation on Adolescent Mental Health (B/2022/01/161), a key project of Jiangsu Province's Education Science Planning.*

***AI Declaration**: The author affirms that artificial intelligence did not contribute to the process of preparing the work.*

Introduction

AFFECTIVITY plays a crucial role in psychoanalytic psychotherapy, representing a sophisticated kind of affect regulation. Mentalization is the capacity to interpret others' minds, which developmentally precedes and then fosters the ability to read and understand one's own mental states (Jurist, 2005). Mentalized affectivity, as an important component of affect regulation, is of vital significance for psychotherapeutic outcomes (Jurist, 2018). It is supportive of the individual's recognizing meaningful events and situations, responding to occurrences, and encouraging appreciation of positive aspects of life, which in turn helps them understand their own emotions and predict future situations (Fonagy et al., 2002). The construct of mentalized affectivity includes three constituent elements: (i) identifying affects, the ability to name or distinguish emotions, as well as understanding and probing their complexity in the context of the individual's history; (ii) processing affects, the ability to modulate emotions, such as changing their duration and magnitude; (iii) expressing affects, the ability to communicate emotions outwardly or inwardly (Jurist, 2005; Greenberg et al., 2017). Compared with emotional intelligence, mentalized affectivity focuses more on the comprehension of present emotions and places greater emphasis on re-evaluating the impact of past experiences on present emotions in an effort to modulate them (Juliet, 2018). It provides a special perspective on the reflective role of emotions (Liotti et al., 2021). Jurist and Sosa (2019) emphasized the necessity of paying more attention to the impact of cultural differences on mentalization. The Mentalized Affectivity Scale (MAS) advanced by Greenberg et al. (2017) was well validated among American and Italian adult groups as well as student groups in Iran (Greenberg et al., 2017; Rinaldi et al., 2021; Sayarfard et al., 2021). For a larger-scale, more efficient survey, Greenberg et al. (2021) developed the Brief-Mentalized Affectivity Scale (B-MAS), a shorter version of the MAS, which has proved to be a robust assessment tool with highly predictive power for 17 mental diseases such as alexithymia, depression, and general anxiety disorder.

Internet altruistic behavior refers to acts performed voluntarily online to help someone else or the community when there is no expectation of receiving a reward (Zheng, 2010). According to Zheng's (2010) College Student Internet Altruistic Behavior Scale, there are four categories of internet altruistic behavior: (i) Internet-support: acts showing appreciation, encouragement, and support to others online, such as expressing good wishes and care to other netizens, listening to their narrative about unhappy events and saying words of consolation, and giving tips for easing emotional issues; (ii) Internet-guidance: acts concerning directions of computer and internet use, such as uploading useful programs, preventing and eliminating

computer viruses, addressing technical issues; (iii) Internet-sharing: acts of information and resources sharing online, including participating in discussion forums and giving comments, reposting meaningful articles and posts published by others, sharing one's successful learning experience, recommending good reads, and more. (iv) Internet-reminding: acts to alert others to cyber hazards, such as online crimes, particularly frauds, and to report one's own online encounters with temptations. Internet altruistic behavior has a positive effect in enhancing the individual's subjective well-being and self-efficacy (Zheng & Wang, 2017). In the information age, the internet has become a pivotal medium for college students' academic and social lives. They spend colossal amounts of time on the internet, learning new knowledge, completing assignments, enjoying entertainment, making friends, shopping, and so on, which significantly increases the incidence of internet altruistic behavior among them.

According to Rudd's (2012) study, positive emotions like awe have the effect of increasing individuals' time input in prosocial behavior, motivating them to spend more time helping others. Nevertheless, the effect of negative emotions on helping behavior remains inconclusive. Isen (1970) argued that negative emotions led to the decline in altruistic behavior. David's (2005) research findings show that negative emotions cause the reduction in child altruistic behavior but contribute to the increase in adult altruistic behavior. As per the Aristotelian theory of emotions, emotions are conducive to the development of perceptual ability in practice, specifically, the capacity to perceive others in the right way and at the right time. Contrarily, the Stoicism theory of emotions asserts that emotions are overwhelming, and thus, one should avoid taking any action under the influence of emotions (Fonagy et al., 2002). As per Yuan and Yang (2023), the online discourse helps release pressure, providing opportunities for temporary emancipation in virtual public spaces. However, Yan and Li (2022) argued that negative emotions on the internet are characterized by decadence, confusion, and excessive sentimentality. College students are a group of heavy users of the internet, experiencing a wide variety of emotions online daily. They also have more chances to express negative emotions online (Wu, 2024). Mentalization is the cognitive and affective ability to understand the thoughts and emotions of oneself and others (Jurist, 2018), which is of higher value to college students who have relatively more needs for active communication and interactions.

The study proposed two hypotheses:

H1: Mentalized affectivity is beneficial for college students coping with negative emotions through effective affect regulation.

H2: Internet altruistic behavior moderates the positive effects of mentalized affectivity on negative emotions, such as depression, anxiety, and stress, in college students.

Research Methodology

Participants

Adopting randomized cluster sampling, the study recruited 917 subjects from two universities in Nanjing, Jiangsu Province. The questionnaire survey was conducted on the principle of anonymity and voluntariness, with informed consent by subjects. After removing those with abnormal answers, the research team obtains 899 valid questionnaires, with 430 from male students, 469 from female students, 641 from freshmen, and 258 from sophomores.

Research Tools

The College Student Internet Altruistic Behavior Scale

The College Student Internet Altruistic Behavior Scale, developed by Zheng (2010), consists of 26 question items in four dimensions: internet support, internet guidance, internet sharing, and internet reminding. The scale adopts the Likert 5-point rating method (from 1 denoting "never" to 5 denoting "always"). The higher the score, the more altruistic actions the subject takes in internet use. In this study, the questionnaire's Cronbach's α is 0.84.

The Depression Anxiety Stress Scales

The study adopted the short-form version of the Depression Anxiety Stress Scales (DASS-21) (Lovibond & Lovibond, 1995). The original Depression Anxiety Stress Scales (DASS-42), also known as the Self-Analysis Questionnaire, include three subscales with a total of 42 items. DASS-21, retaining the three subscales of depression, anxiety, and stress, has 21 items in total with seven in each subscale; the dimensions of the original scale remain unchanged. In the four-point rating scales, 0 represents "did not apply to me at all," 1 means "applied to me to some degree, or some of the time," 2 denotes "applied to me to a considerable degree, or a good part of the time," and 3 signals "applied to me very much, or most of the time." The higher the score, the higher the level of severity of each emotional state the subject has experienced. In Gong et al.'s (2010) survey based on a large sample of Chinese college students, the coefficient of Cronbach's α of the DASS is 0.89, indicating it is a suitable tool for extensive screening in scientific research and clinical practice. In the present study, the coefficients of Cronbach's α for the three subscales of depression, anxiety, and stress are 0.831, 0.808, and 0.818, respectively, with the overall coefficient of the questionnaire being 0.864.

The Mentalized Affectivity Scale (Adolescent Version)

The Mentalized Affectivity Scale (MAS) is a 60-item self-report measure with three dimensions: identifying emotions, processing emotions, and expressing emotions (Greenberg et al., 2017). The dimension of identifying emotions consists of 24 items, one of which is a reverse-scored item. The dimension of processing emotions consists of 23 items, six of which are reverse-scored items. There are 13 items in the dimension of expressing emotions, eight of which are reverse-scored items. This study adopts the Chinese version of the Brief-Mentalized Affectivity Scale for Adolescents (B-MAS-A), a 19-item questionnaire including four factors: Identifying Emotions, Processing Emotions, Expressing Emotions, and Autobiographical Memory (Hu, 2023). "Identifying Emotions," consisting of four items, is to measure the subject's ability to discern their emotions. "Processing Emotions," with seven items, assesses the subject's capacity to use their cognitive ability to control emotions. "Expressing Emotions," with four items, evaluates the subject's ability to represent and communicate emotions. "Autobiographical Memory," with four items, measures the subject's ability to reflect on their early life and childhood emotional experiences and use them to regulate present emotions. The higher the subject scores, the more skilled they are in emotional identification and processing and in constructing self-narrative through reflections on previous experiences, with a higher tendency towards inward emotional expression. In this study, the coefficient of Cronbach's α of the B-MAS-A is 0.817, and the coefficients of Cronbach's α of the four factors of identifying emotions, processing emotions, expressing emotions, and autobiographical memory are 0.770, 0.877, 0.814, and 0.707, respectively.

Data Analysis

SPSS Amos 21.0 was applied to information analysis, including descriptive statistics and independent sample t-tests. Harman's one-factor test method was used to test common method biases. The direct effects between variables were tested by SEM; the indirect effects between variables were tested by the bias-corrected nonparametric percentile Bootstrap method; and the moderation effect was analyzed using SPSS Process 3.2.

Analysis Results

Test of Common Method Biases

Harman's one-factor test was adopted to test the common method biases in questionnaires (Zhou & Long, 2004). Exploratory factor analysis was

administered to all factors of internet altruistic behavior, negative emotions, and mentalized affectivity. According to the analysis results, there were seven factors with greater-than-1 Eigen values, and the first factor showed a variance of 27.56%, which was much lower than the criterion of 40% proposed by Harrison et al. (1996), indicating that there were no significant common method biases in this study.

Descriptive Analysis of Mentalized Affectivity, Internet Altruistic Behavior, and Negative Emotions among College Students

According to the analysis results, the M±SD value of college students' mentalized affectivity was 93.82 ± 16.18, with a median of 95, which was higher than the median of 76 on the scale. The M±SD value (49.89 ± 15.16) of college students' internet altruistic behavior and the median of 51 were both lower than the scale's median of 65, indicating that internet altruistic behavior among college students under survey was insufficient. The mean of depression among them was 10.64 ± 8.79, within the range of 10-13 for mild depression. The mean of anxiety was 10.09 ± 8.61, within the range of 10-14 for moderate anxiety. The mean of stress was 11.21 ± 8.84, within the range of 0-14 for the absence of stress.

T-test Results of All Variables in Various Dimensions

There was no gender difference in mentalized affectivity among college students ($p > 0.05$). Male students exhibited a higher level of internet altruism than their female peers, showing a gender difference in this regard ($p < 0.05$). There was no significant gender difference in overall levels of depression, anxiety, and stress ($p > 0.05$). The mean of depression in male students was higher than that in their female counterparts, but anxiety and stress in the former were lower than those in the latter (**Table** 1).

There was no grade difference in mentalized affectivity and internet altruistic behavior among college students ($p > 0.05$). The levels of depression, anxiety, and stress were lower in the freshmen than in the sophomores, with statistical significance to varying degrees ($p < 0.05$, $p < 0.01$, and $p < 0.001$, respectively) (**Table 2**).

There was no significant difference in mentalized affectivity ($p > 0.05$) between introverted and extroverted college students. There was an extremely significant difference in internet altruistic behavior between the two groups ($p < 0.001$). Differences in the levels of depression ($p < 0.01$), anxiety ($p < 0.05$), and stress ($p < 0.01$) between them showed varied degrees (**Table 3**).

Table 1. Gender Differences in Mentalized Affectivity, Internet Altruistic Behavior, and Negative Emotions among College Students.

Factors	Gender	N	Mean and Standard Deviation	T Value	P
Mentalized affectivity	Male	430	93.53±17.53	-0.527	0.598
	Female	469	94.09±14.86		
Internet altruistic behavior	Male	430	51.04±15.96	2.175	0.030
	Female	469	48.84±14.32		
Depression	Male	430	11.01±8.76	1.217	0.224
	Female	469	10.29±8.83		
Anxiety	Male	430	9.66±8.63	-1.460	0.145
	Female	469	10.49±8.57		
Stress	Male	430	10.95±8.97	-0.856	0.392
	Female	469	11.45±8.72		

*Note: ***p < 0.001；**p < 0.01；*p < 0.05*

Table 2. Grade Differences in Mentalized Affectivity, Internet Altruistic Behavior, and Negative Emotions among College Students.

Factors	Grades	N	Mean and Standard Deviation	T Value	P
Mentalized affectivity	Freshmen	641	94.26±16.79	1.282	0.20
	Sophomores	258	92.73±14.53		
Internet altruistic behavior	Freshmen	641	50.08±15.49	0.592	0.554
	Sophomores	258	49.42±14.32		
Depression	Freshmen	641	10.18±8.83	-2.452	0.014
	Sophomores	258	11.77±8.61		
Anxiety	Freshmen	641	9.55±8.50	-3.001	0.003
	Sophomores	258	11.45±8.72		
Stress	Freshmen	641	10.35±8.72	-4.667	0.000
	Sophomores	258	13.36±8.78		

*Note: ***p < 0.001；**p < 0.01；*p < 0.05*

Table 3. Introversion versus Extroversion Differences in Mentalized Affectivity, Internet Altruistic Behavior, and Negative Emotions among College Students.

Factors	Personality traits	N	Mean and Standard Deviation	T Value	P
Mentalized affectivity	Introverted	542	93.34±16.17	-1.108	0.268
	Extroverted	357	94.56±16.19		
Internet altruistic behavior	Introverted	542	48.27±15.01	-3.979	0.000
	Extroverted	357	52.35±15.08		
Depression	Introverted	542	11.36±8.54	3.044	0.002
	Extroverted	357	9.54±9.08		
Anxiety	Introverted	542	10.62±8.73	2.230	0.026
	Extroverted	357	9.31±8.36		
Stress	Introverted	542	11.86±8.79	2.715	0.007
	Extroverted	357	10.23±8.83		

*Note: ***p < 0.001；**p < 0.01；*p < 0.05*

Table 4. Correlations between Mentalized Affectivity, Internet Altruistic Behavior, and Negative Emotions among College Students.

	Mentalized Affectivity	Internet Altruistic Behavior	Depression	Anxiety	Stress
Mentalized affectivity	1				
Internet altruistic behavior	0.133**	1			
Depression	-0.108**	0.193**	1		
Anxiety	-0.090**	0.199**	0.727**	1	
Stress	-0.082*	0.180**	0.624**	0.825**	1

*Note: ***p < 0.001；**p < 0.01；*p < 0.05*

Correlational Analysis of Mentalized Affectivity, Internet Altruistic Behavior, and Negative Emotions among College Students

As shown in **Table 4**, there was a positive relation between mentalized affectivity and internet altruistic behavior in college students ($r = 0.133 < 0.4$, $p < 0.01$) and negative relations between mentalized affectivity and depression ($r = -0.108 < 0.4$, $P < 0.01$), anxiety ($r = -0.090 < 0.4$, $p < 0.01$),

and stress ($r = -0.082 < 0.4$, $p < 0.05$). Hence H1 was corroborated. There were low levels of positive relation between internet altruistic behavior and depression ($r = 0.193 < 0.4$, $p < 0.001$), anxiety ($r = 0.199 < 0.4$, $p < 0.001$), and stress ($r = 0.180 < 0.4$, $p < 0.001$), which seems to be contradictory with common sense but is in conformity with the theory of the negative state relief model. According to this theory, individual experiencing adverse emotions may engage in altruistic behavior because they believe that helping others can alleviate their negative emotions. In other words, the individual can relieve their own sadness and distress by helping others (Guo, 2005), which conforms to Zheng's (2012) research finding that anxiety could significantly positively predict internet altruistic behavior ($r = 0.14 < 0.4$, $p < 0.001$).

The Mediation Effect of Internet Altruistic Behavior on the Relation between Mentalized Affectivity and Negative Emotions in College Students

Based on the analysis results of the relations between mentalized affectivity, internet altruistic behavior, and negative emotions in college students, the mediating effect was tested following the procedure introduced by Wen and Ye (2014). Regression analysis was conducted using the causal steps method, and the 95% confidence interval of the mediating effect was calculated using the bias-corrected Bootstrap confidence interval method to determine the presence of any predicted and mediated effects between mentalized affectivity, Internet altruistic behavior, and negative emotions. Specific processes were as follows: First, standardize variables in the test and convert gender, grade, and personality traits (introversion vs. extroversion) into dummy variables for control. After that, Model 4 in SPSS Process 3.2 was employed to verify the mediating effect of internet altruistic behavior on the relation between mentalized affectivity and negative emotions. Under the test procedure for mediating effect, the indirect effect value is 0.0304, and the 95% confidence interval of the point estimation was [0.0118, 0.000], and the coefficient c' was significant. Hence, we made the preliminary assumption that there existed a mediating effect. Subsequent tests revealed that the indirect effect was significant and that a * b and the regression coefficient c' carried opposite signs. The results should be explained as a suppressor effect. It was determined that the indirect effect of internet altruistic behavior on negative emotions was not a mediating effect but instead, a suppressor effect (**Figure 1**).

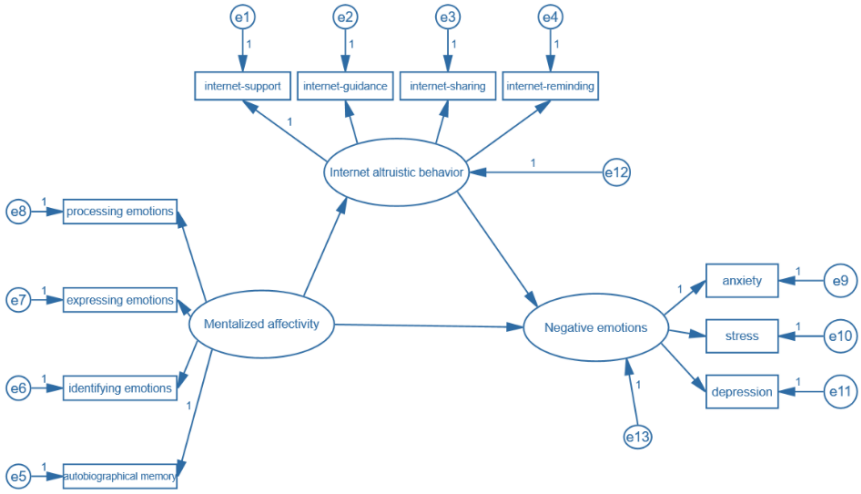

Figure 1. The Suppressor Effect of Internet Altruistic Behavior on the Relation between Mentalized Affectivity and Negative Emotions.

Table 5. The Moderating Effect of Internet Altruistic Behavior on the Relation between Mentalized Affectivity and Negative Emotions (N=899).

Regression Equations		Hypothesis Testing			
Dependent variables	Independent variables	R	ΔR^2	F	P
Self-reported emotions	X*W	0.258	0.067	4.508	0.034
Depression	X*W	0.238	0.0017	1.65	0.198
Anxiety	X*W	0.244	0.0059	5.60	0.018
Stress	X*W	0.221	0.0046	4.304	0.038

The Moderating Effect of Internet Altruistic Behavior on the Relation between Mentalized Affectivity and Negative Emotions among College Students

In the analysis of the moderating effect of internet altruistic behavior, the standard scores of negative emotions were the dependent variables. Mentalized affectivity and internet altruistic behavior were zero-centered, and their interaction term was generated. The zero-centered mentalized affectivity served as the independent variable in the first layer of the regression equation. The zero-centered internet altruistic behavior and the

interaction term served as independent variables in the second layer of the equation. The hierarchical regression analysis revealed that the effect of the interaction term of mentalized affectivity and internet altruistic behavior on the total level of negative emotions was statistically significant ($p < 0.05$), indicating that internet altruistic behavior heightened mentalized affectivity's regulation of negative emotions, and the moderating effect was statistically significant. To investigate which negative emotions were more effectively modulated by mentalized affectivity through the moderating effect of internet altruistic behavior, regression analysis was conducted using depression, anxiety, and stress as dependent variables and the zero-centered mentalized affectivity as the independent variable in the first layer of the regression equation. Subsequently, the zero-centered internet altruistic behavior and the interaction term were deployed as independent variables in the second layer of the equation. The hierarchical regression analysis showed that the moderating effect of internet altruistic behavior on anxiety and stress was statistically significant, but that on depression was not (**Table 5**). Thus, H2 was partially verified.

Discussions

Statistical Results of Mentalized Affectivity, Internet Altruistic Behavior, and Negative Emotions in College Students

College students' average scores of mentalized affectivity and its constituent elements were above the medians on the scale, indicating that their affectivity was of medium-high level. Specifically, their abilities of identifying emotions, processing emotions, and autobiographical memory were relatively strong, and there was a tendency towards inward emotional expression among them. There was no gender difference in the overall level of mentalized affectivity among them ($p > 0.05$), though the mean value of autobiographical memory of male students was significantly lower than that of female students ($t = -2.445$, $p < 0.05$). There was no grade difference in the overall level of mentalized affectivity among college students ($p > 0.05$). However, the freshmen had a significantly higher level of processing emotions than the sophomores ($t = 2.916$, $p < 0.01$). There was no significant difference in the overall level of mentalized affectivity between introverted and extroverted students ($p > 0.05$). Nevertheless, introverted students showed lower levels of identifying emotions ($t = -2.076$, $p < 0.05$) and processing emotions ($t = -3.175$, $p < 0.01$) than their extroverted peers. In terms of expressing emotions, introverted students had fewer outward expressions and were more reserved ($t = 3.166$, $p < 0.01$).

Gong et al. (2010) published a report on the testing of the Depression Anxiety Stress Scales (DASS-21) (Chinese version) among Chinese university students. In this study, M±SD of depression was 5.32 ± 4.39, higher than that of 2.97±4.13 in the report; M±SD of anxiety was 5.04 ± 4.30, slightly lower than that of 5.42 ± 4.96 in the report; and M±SD of stress was 5.61 ± 4.42, slightly lower than that of 6.12 ± 5.54 in the report. Our research findings show that depression among the college student group has undergone a growing trend in recent years and that there were significant grade differences in self-reported depression and anxiety as sophomores typically take more courses and have heavier academic pressures than freshmen. Liu et al. (2023) investigated depression, anxiety, and stress among ordinary residents in Hunan Province. In our study, college students scored 10.64 ± 8.79 on the depression scale, 10.09 ± 8.61 on the anxiety scale, and 11.21 ± 8.84 on the stress scale, lower than those scored by ordinary residents (11.00 ± 4.25, 11.26 ± 4.17, and 12.06 ± 4.22, respectively) in Liu et al.'s research, indicating that the self-reported emotional state of college students (31.95 ± 23.71) was better than that of the Hunan residents surveyed (34.32 ± 12.16). The detection rate of depression in college students was 38.93% (lower than that of 52.16% among ordinary residents in Liu et al.'s study); those suffering from extremely severe depression represented 5.67%. The detection rate of anxiety in college students was 52.39% (lower than that of 80.00% among ordinary residents). It is noteworthy that those with extremely severe anxiety accounted for 12.35%. The detection rate of stress in college students was 19.02%; those feeling extremely stressed accounted for 2.23%. Introverted students had higher levels of depression, anxiety, and stress than their extroverted peers, and the differences were statistically significant to varying degrees ($p < 0.01$, $p < 0.05$, and $p < 0.01$, respectively). The research finding indicates that more attention should be paid to the emotional issues of introverted college students.

Internet altruistic behavior is favorable for mental health improvement in college students (Zheng & Wang, 2017). Encouraging internet altruistic behaviors in college students helps promote the positive role of the internet and build a civilized and harmonious online community (Zhao, 2018). There was a gender difference in internet altruistic behavior ($t = 2.175$, $p < 0.05$), with male students exhibiting higher levels of altruism (51.04 ± 15.96) than their female peers (48.84 ± 14.32), which is comparable to Wang's and Chen's (2021) finding in their research into internet altruistic behavior at X University (male students' 52.61 ± 13.57> female students' 49.48 ± 13.13, $p < 0.01$). Closer examination of specific dimensions revealed an extremely significant gender difference in internet guidance ($t = 3.914$, $p < 0.001$) and a very significant one in internet reminding ($t = 3.029$, $p < 0.01$). There was no grade difference in the overall level of internet altruistic

behavior among college students ($p > 0.05$). However, in the dimension of internet guidance, the freshmen did better than the sophomores, which was statistically significant ($t = 2.142$, $p < 0.05$). The difference in internet altruistic behavior between introverted and extroverted college students ($t = -3.979$, $p < 0.001$) was extremely significant. Looking into specific dimensions, we discovered that there were extremely significant differences in internet support ($t = -3.730$, $p < 0.001$) and internet guidance ($t = -4.621$, $p < 0.001$) and very significant differences in internet sharing ($t = -3.172$, $p < 0.01$) and internet reminding ($t = -2.976$, $p < 0.01$) between the two groups.

The Suppressor Effect of Internet Altruistic Behavior on the Relation between Mentalized Affectivity and Negative Emotions among College Students

Mentalized affectivity was positively related to internet altruistic behavior in college students. Specifically, there were low degrees of positive relation ($r < 0.4$, $p < 0.01$) between mentalized affectivity and internet support, internet guidance, internet sharing, and internet reminding among them. Identifying Emotions, Processing Emotions, and Autobiographical Memory had low degrees of positive relation with internet altruistic behavior ($r < 0.4$, $p < 0.01$). Expressing emotions was negatively related to internet altruistic behavior ($r = -0.081 < 0.4$, $p < 0.05$). In the meantime, internet altruistic behavior was modestly positively related to depression, anxiety, and stress in college students. Specifically, internet-sharing predicted depression, anxiety, and stress to varying degrees. That may be because the longer the students with high levels of depression or anxiety stay online, the more empathetic they become, and the more eager they are to obtain mental satisfaction by being altruistic to offset negative emotions brought on by setbacks in real-world life. Although they do not expect any rewards for their altruistic behavior online, sharing emotions online and garnering likes, followings, and comments indeed gives them a sense of accomplishment psychologically. The regression analysis results showed that the direct and indirect effects had opposite signs, indicating that internet altruistic behavior had a partial suppressor effect on the relation between mentalized affectivity and negative emotions in college students. There are several reasons for this effect. First, internet altruistic behavior concerns act of helping others online without seeking anything in return. It cannot alleviate the stress perceived by the individual and may temporarily suppress their experience of anxiety and depression; as a result, negative emotions are maintained instead of being eliminated. In the worst case, the internet user may even become more emotionally negative because they do not feel rewarded for helping others. Emotion modulation is a long-term progression, and mentalization is a

process of achievement that inevitably comes with pain (Juliet, 2018). Second, under certain negative emotions, individuals may still behave altruistically by helping others (Kou & Tang, 2004). According to the negative state relief model in prosocial theory, the individual sometimes engages in altruistic behavior because they are in a bad mood for the time being and need to mitigate negative emotions and alleviate inner distress by helping others (Guo, 2005). College students with higher levels of depression and anxiety may tend to sustain their online altruistic behavior to suppress negative feelings. Third, there are cultural differences in mentalized affectivity. In collectivist culture, mentalization is primarily aimed at understanding others, and understanding oneself is secondary (Aival Naveh et al., 2019). A portion of Chinese college students have difficulty processing and expressing their own emotions, thus being more susceptible to internet use addiction. They may have more altruistic acts on the internet than those spending less time online; nevertheless, they reported more negative emotions than the latter.

The Moderating Effect of Internet Altruistic Behavior on the Relation between Mentalized Affectivity and Negative Emotions in College Students

The moderating effect of internet altruistic behavior on the relation between mentalized affectivity and negative emotions in college students was statistically significant ($p < 0.05$). It means that the increase in internet altruistic behavior can enhance the role of mentalized affectivity in regulating negative emotions. In order to investigate which negative emotions among depression, anxiety, and stress could be most effectively modulated, regression analysis was conducted with depression, anxiety, and stress as dependent variables and found that the interaction term of mentalized affectivity and Internet altruistic behavior had a statistically significant effect on anxiety ($p < 0.05$) and stress ($p < 0.05$), but with no significant effect on depression ($p > 0.05$). This can be explained as follows: In virtual social networks, individuals can create ideal images of themselves based on selective self-presentation (Manago et al., 2008). To make an impression online, they may choose to engage in proactive sharing and other altruistic actions, which is conducive to the alleviation of their negative emotions including stress and anxiety. On the other hand, the development of the internet has brought on many issues, increasing pressures on individuals in all facets of life and inducing a growing incidence of depression in society (Holden, 2000). As per Wang et al.'s (2021) study, 33.38% of students at Y University showed symptoms of depression. Mobile phone dependence also leads to an increase in depression levels among

college students (Shi et al, 2022). The incidence of major depressive disorder (MDD) has also undergone significant growth (Cao et al., 2023). Internet bullying can lead to depression in college students through online social anxiety (Zhou & Zhang, 2023). Factors like these may compromise the moderating effect of internet altruistic behavior on mentalized affectivity's modulation of depression in college students.

Conclusions and Prospects of Future Research

This study draws the following conclusions: (i) Mentalized affectivity has positive effects in modulating negative emotions including depression, anxiety, and stress among college students; (ii) There are gender differences in mentalized affectivity; Internet altruistic behavior varies between male and female students and between introverted and extroverted students; the levels of negative emotions differ between students of distinct grades and between introverted and extroverted students; (iii) There is a suppressor effect of internet altruistic behavior on the relation between mentalized affectivity and negative emotions; (iv) Internet altruistic behavior can moderate the effect of mentalized affectivity on anxiety and stress but not depression in college students.

Limitations of the study should be acknowledged. First, it would be better to subgroup college student internet users when examining the correlation between their internet altruistic behavior and negative emotions. For instance, students who are active in the actual world may spend less time online and thus conduct fewer altruistic acts, whereas those having more negative emotional experiences are more likely to seek identification in the virtual world. It is advisable to subdivide the internet user group to investigate the differentials in internet altruistic behavior among them. Second, the currently widely used College Student Internet Altruistic Behavior Scale was developed by Zheng in 2010 under the backdrop that internet use was not frequent among college students and applications were limited due to poor internet connectivity on campus and economic constraints. In this context, internet altruistic behavior among them was sporadic (Zheng, 2010). Amid the advances in economy and internet technology in the past more than 10 years, many new features of internet altruism have emerged. Future research should focus on the specific content of altruism among college students in addition to its motivations and forms (Zhang & Li, 2022).

We are considering undertaking deeper explorations in two areas: (i) Divide college students into two groups according to their scores on depression, anxiety, and stress scales. Students with medium, high, and extremely high levels of depression, anxiety, and stress should be identified as emotionally problematic; the rest can be thought of as normal (Henry &

Crawford, 2005). Research will be focused on mentalized affectivity and internet altruistic behavior of the first group. (ii) Delve into the internet behavior and mentalization of individuals with differential levels of depression, anxiety, and stress. More research on how to alleviate negative emotions in college students through cyber emotion and behavior regulation is warranted to provide new perspectives on mental health education for this group.

References

Aival-Naveh, E., Rothschild-Yakar, L., & Kurman, J. (2019). Keeping culture in mind: A systematic review and initial conceptualization of mentalizing from a cross-cultural perspective. *Clinical Psychology: Science and Practice*, 26(4):e12300. DOI: https://doi.org/10.1111/cpsp.12300

Cao, W., Liao, H, Cai, S., Liu, C., Peng, W., Cheng, M. & Yi, J. (2023). The abnormal frontoparietal control network and impaired cognitive function in major depressive disorders. *Chinese Journal of Clinical Psychology*, 31(1):9-15. DOI: https://doi.org/10.16128/j.cnki.1005-3611.2023.01.002

David, G. M. (2005). Social Psychology. (Chinese Translation). Beijing: Post & Telecom Press.

Fonagy, P., Gergely, G., & Jurist, E.L. (Eds.). (2002). Affect Regulation, Mentalization and the Development of the Self (1st ed.). Routledge. DOI: https://doi.org/10.4324/9780429471643

Gong, X., Xie, X., Xu, R. & Luo, Y. (2010). Report on the testing of the Depression Anxiety Stress Scales (DASS-21) (Chinese Version) among Chinese university students. *Chinese Journal of Clinical Psychology*, 18 (4):443-446.

Greenberg, D. M., Kolasi, J., Hegsted, C. P., Berkowitz, Y., & Jurist, E. L. (2017). Mentalized affectivity: A new model and assessment of emotion regulation. *Plos One*, 12(10), e0185264. DOI: https://doi.org/10.1371/journal.pone.0185264

Greenberg, D. M., Rudenstine, S., Alaluf, R., & Jurist, E. L. (2021). Development and validation of the Brief-Mentalized Affectivity Scale: Evidence from cross-sectional online data and an urban community-based mental health clinic. *Journal of Clinical Psychology*, 77(11):2638–2652. DOI: https://doi.org/10.1002/jclp.23203

Guo, Y. (2005). Personality Psychology: A Study of Human Nature and Its Variation. Beijing: China Social Sciences Press.

Harrison, D. A., McLaughlin, M. E., & Coalter, T. M. (1996). Context, cognition, and common method variance: Psychometric and verbal protocol evidence. *Organizational Behavior and Human Decision Processes*, 68(3):246-261. DOI: http://dx.doi.org/10.1006/obhd.1996.0103

Henry, J. D., & Crawford, J. R. (2005). The short-form version of the Depression Anxiety Stress Scales (DASS-21): Construct validity and normative data in a large non-clinical sample. *The British journal of clinical psychology*, 44(Pt 2):227–239. DOI: https://doi.org/10.1348/014466505X29657

Holden, C. (2000). Global survey examines impact of depression. *Science*, 288(5463):39-40. DOI: https://doi.org/10.1126/science.288.5463.39

Hu, Y. (2023). The Revised Mentalized Affectivity Scale (MAS) for Adolescents and its Preliminary Application in China (master's thesis). Shaoxing University of Arts and Sciences. DOI: https://doi.org/10.27860/d.cnki.gsxwl.202

3.000450

Isen, A. M. (1970). Success, failure, attention, and reaction to others: The warm glow of success. *Journal of Personality and Social Psychology*, 15(4):294-301. DOI: https://doi.org/10.1037/h0029610

Jurist, E. (2005). Mentalized affectivity. *Psychoanalytic Psychology*, 22(3):426-444. DOI: http://dx.doi.org/10.1037/0736-9735.22.3.426

Jurist, E. (2018). Minding Emotions: Cultivating Mentalization in Psychotherapy. The Guilford Press.

Jurist, E. & Sosa, M. P. (2019). Commentary on mentalization and culture. *Clinical Psychology: Science and Practice*, 26(4):Article e12302. DOI: https://doi.org/10.1111/cpsp.12302

Kou, Y. & Tang, L. (2004). The impact of emotions on prosocial behavior. *Journal of Beijing Normal University (Social Sciences Edition)*, 2004(5):44-49.

Liotti, M., Spitoni, G. F., Lingiardi, V., Marchetti, A., Speranza, A. M., Valle, A., ... & Giovanardi, G. (2021). Mentalized affectivity in a nutshell: Validation of the Italian version of the Brief-Mentalized Affectivity Scale (B-MAS). *Plos One*, 16(12), e0260678. DOI: https://doi.org/10.1371/JOURNAL.PONE.0260678

Liu, Y., Liu, Z., Yao, J., Yu, C., Lin, A., Tan, C…& Wan, H. (2023). The correlation between emotional intelligence and levels of depression, anxiety, and stress in residents. *Practical Preventive Medicine*, 30(5):553-557.

Lovibond, S.H. & Lovibond, P. F. (1995). Manual for the Depression Anxiety Stress Scales. Sydney: Psychology Foundation. Available at: https://www2.psy.unsw.edu.au/dass/

Manago, A. M., Graham, M. B., Greenfield, P. M., & Salimkhan, G. (2008). Self-presentation and gender on MySpace. *Journal of Applied Developmental Psychology*, 29(6):446-458. DOI: https://doi.org/10.1016/j.appdev.2008.07.001

Rinaldi, T., Castelli, I., Greco, A., Greenberg, D. M., Jurist, E., Valle, A., & Marchetti, A. (2021). The Mentalized Affectivity Scale (MAS): Development and validation of the Italian version. *Plos One*, 16(4):e0249272. DOI: https://doi.org/10.1371/JOURNAL.PONE.0249272

Rudd, M., Vohs, K. D., & Aaker, J. (2012). Awe Expands People's Perception of Time, Alters Decision Making, and Enhances Well-Being. *Psychological Science*, 23(10):1130-1136. DOI: https://doi.org/10.1177/0956797612438731

Sayarfard, Z., Azadfallah, P., & Farahani, H. (2021). Psychometric properties and factor structure of the Persian version of Mentalized Affectivity Scale. *Journal of Birjand University of Medical Sciences*, 28(4):385-401. DOI: http://dx.doi.org/10.32592/JBirjandUnivMedSci.2021.28

Shi, D., Ma, M., & Cheng, J. (2022). The relationship between mobile phone dependence and depression among college students: The mediating role of core components of self-assessment. *Journal of Western China*, 2022(16):121-124. DOI: https://doi.org/10.16721/j.cnki.cn61-1487/c.2022.16.037

Wang, S. & Chen, Y. (2021). The relationship between the forgiving mindset and internet altruistic behavior among college students. *The Guide of Science and Education*, 2021(27):187-189. DOI: https://doi.org/10.16400/j.cnki.kjdk.2021.27.063

Wang, Y., Li, W., & Lyu, A. (2021) The state of depression of undergraduates under the major public health emergency: Using Jinzhong University as an Example. *Science Education Article Collects*, 2021(12):174-175. DOI: https://doi.org/10.16871/j.cnki.kjwhc.2021.04.080

Wen, Z. & Ye, B. (2014). Analysis of the mediating effect: Methods and model development. *Advances in Psychological Science*, 22(5):731-745.

Wu, L. (2024). Protection mechanisms for online negative emotional expressions among college students. *Journal of Xiamen City Vocational College*, 2024(1):26-32. DOI: https://doi.org/10.16417/j.cnki.cn35-1312/g4.2024.01.004

Yan, D. & Li, F. (2022). The expression of negative emotions among teenagers and ideological concerns from the perspective of online "Sang" culture. *Journal of Jishou University (Social Sciences Edition)*, 2022(3):46-54+77. DOI: https://doi.org/10.13438/j.cnki.jdxb.2022.03.006

Yuan, A. & Yang, Y. (2023). Interpretation,

Criticism, and Transcendence: A study of the internet-based expressions of marginalized urban youngsters. *Journal of Jiangxi Open University*, 2023(3):41-50. DOI: https://doi.org/10.13844/j.cnki.jxddxb.2023.03.012

Zhang, X. & Li, J. (2022). The effect of the "voluntary" fundraising mechanism on the individual's donation behavior: Evidence based on online experiments. *China Soft Science*, 2022(9):64-73.

Zhao, Q. (2018). Moral identity and internet altruistic behavior of college students: The roles of internet ethics and gender. *Chinese Journal of Clinical Psychology*, 26(6):1226-1229.

Zheng, X. (2010). The Development of College Student Internet Altruistic Behavior Scale and Hierarchical Linear Analysis (doctoral dissertation). Shanghai Normal University.

Zheng, X. (2012). The structural model of the relationship between optimism, anxiety, online social support, and internet altruistic behavior. *China Special Education*, 2012(11):84-89. DOI: https://doi.org/10.3969/j.issn.1007-3728.2012.11.015

Zheng, X. & Wang, Y. (2017). The relation between internet altruistic behavior and subjective well-being in adolescents: A mediated moderation model. *Psychological Science*, 40(1):70-75.

Zhou, H. & Long, L. (2004). Statistical test and control methods for common method biases. *Advances in Psychological Science*, 2004(6):942-950.

Zhou, M. &, Zhang, S. (2024). The relationship between online bullying and depression among college students: The effects of online social anxiety and perceived social support. *China Journal of Health Psychology*, 1-13. Available at: http://kns.cnki.net/kcms/detail/11.5257.R.20240321.1729.006.html

Received: September 10, 2024
Revised: September 29, 2024
Accepted: October 06, 2024

REVIEW

Problem-Based Learning in Science Education: A Mixed Meta Method Study

Mehmet Diyaddin Yaşar,[1] Veli Batdi,[2] Ayşe Nur Kiliç,[1] Zeynel Abidin Yilmaz[3]

1. *Harran University, Şanlıurfa, Turkey*
2. *Gazianep University,Gaziantep, Turkey*
3. *Kilis 7 Aralık University, Kilis, Turkey*

***Abstract**: A mixed-meta analysis of research on problem-based learning in science education was the goal of this study. In this instance, document analysis utilizing the mixed-meta method—which combines meta-analysis and meta-thematic analysis procedures—was used to investigate both quantitative and qualitative data. Using CMA and MetaWin programs, studies from certain databases that fit predetermined criteria were analyzed for a meta-analysis. Of the 78 studies that were included in the study, the effect size was found to be large, with g = 0.909. It has been suggested that science education benefits from the problem-based learning approach. Within the framework of the established criteria, 15 researches based on document analysis were subjected to a meta-thematic analysis using the Maxqda program in accordance with content analysis. Codes were acquired based on specific topics. By calculating the compliance values of the relevant codes under the relevant themes, a good degree of agreement was found regarding the effects of problem-based learning in science education on academic achievement, the affective-social dimension, 21st century skills, and the negative aspects of problem-based learning in science education. The research results indicate that there is a consensus among the researchers regarding the benefits of using problem-based learning techniques in science education.*

Science Insights Education Frontiers 2024; 24(2):3971-3992
DOI: 10.15354/sief.24.re406

How to Cite: Yaşar, M. D., Batdi, V., Kiliç, A. N., & Yilmaz, Z. A. (2024). Problem-based learning in science education: A mixed meta method study.

Science Insights Education Frontiers, 24(2):3971-3992.

***Keywords**: Meta-Analysis, Meta-Thematic, Problem-Based Learning (PBL), Science Education*

***About the Authors**: Mehmet Diyaddin Yaşar, Education Faculty, Harran University, Şanlıurfa, Turkey. E-mail: mdiyaddinyasar@harran.edu.tr, ORCID: https://orcid.org/0000-0001-7512-580X*

Veli Batdi, Education Faculty, Gazianep University , Gaziantep, Turkey. E-mail: veb_27@hotmail.com, ORCID: https://orcid.org/0000-0002-7402-3251

Ayşe Nur Kiliç, MSc Candidate, Education Faculty, Harran University, Şanlıurfa, Turkey. E-mail: ayse.nur.5396@gmail.com, ORCID: https://orcid.org/0000-0002-2255-5643

Zeynel Abidin Yilmaz, Kilis Muallim Rıfat Education Faculty , Kilis 7 Aralık University, Kilis, Turkey, E-mail: z07yilmaz@gmail.com, ORCID: https://orcid.org/0000-0003-0150-8810

***Correspondence to**: Mehmet Diyaddin Yaşar at Harran University in Turkey.*

***Conflict of Interests**: None.*

***Funding**: No funding sources declared.*

***AI Declaration**: The authors affirm that artificial intelligence did not contribute to the process of preparing the work.*

Introduction

TRADITIONAL educational approaches are increasingly insufficient in today's quickly changing environment. There is a growing need for teaching strategies that not only engage students actively but also incorporate modern approaches (Yurd & Olgun, 2008). The complexity of our current era, along with the overwhelming amount of information available, necessitates that individuals be equipped not just with rote knowledge but also with essential life skills. These skills are crucial for tackling real-world challenges (Çınar & İlik, 2013). Contrary to this, an outdated focus on the teaching abilities of educators, rather than on the learning capabilities of students' results in a passive educational experience that fails to prepare students for the complexities of daily life (Yaman & Yalçın, 2005).

It might be argued that the major purpose of science education is not only to teach students the essential principles of the topic but also to develop in them a curiosity and interest in science, as well as good attitudes, teamwork, and cooperation. These are critical for developing higher-level thinking skills and actively involving students in the learning process. Utilizing student-centered approaches and methods to keep the student actively involved in the process is more effective for achieving meaningful learning outcomes (Çınar & İlik, 2013). Furthermore, it is clear that our pupils require certain talents in order to succeed (Shamir, Zion, & Spector-Levi, 2008). Problem-based learning (PBL) is more effective than traditional teaching methods in achieving these goals (Çınar & İlik, 2013). It is known as the American educational theorist John Dewey, who systematized the concept of problem solving for the first time (Yıldırım & Yalçın, 2008). PBL has been systematized based on the view of learning by doing put forward by the American educator John Dewey (Koray & Araz, 2008). The PBL approach was initially developed at the university level in the field of medicine (Barrows & Tamblyn, 1980, cited by Chin & Chia, 2004), and then it started to be applied at all levels of education, from primary school to high school (Delisle, 1997, as cited in Chin & Chia, 2004; Şenocak, 2009). Student-centered and small group teaching for medical students PBL, which was designed, took its place in education and training programs ten years later (Kumar, 2010). Problem-based learning, which has been successfully implemented in many vocational education fields, was introduced at the primary and secondary education levels in 1990. In Turkey, it has been in use since 2000. According to Kılınç (2007), there have been numerous published research studies, articles, and theses on this approach. Research indicates that education based on the PBL approach outperforms traditional methods in several key areas. Specifically, it enhances student achievement and boosts their motivation towards coursework. Given these advantages,

PBL has established itself as a student-centered approach that is increasingly considered essential in today's science education (Kaptan & Korkmaz, 2001).

It is seen that it is possible to instill the skills necessary in the 21st century in education in general and in science education in particular (Shamir, Zion, & Spector-Levi, 2008). In this respect, certain stages should be followed while applying the PBL approach. The first stage of PBL is the discovery and definition of the problem, which is a creative process (Chin & Chia, 2004). Then, it consists of stages such as determining the necessary information for the defined problem, determining the sources to reach the information, determining solution methods, evaluating the solutions, and reporting and presenting the solution (Shamir et al., 2008; Kaptan & Korkmaz, 2001). The most crucial of these stages is the identification of the problem situation. It is very important to organize this problem situation according to the student group and level. For example, while it is appropriate to give unstructured problems to gifted children, it is more appropriate to give less structured problems to students at the normal level (Boran & Aslaner, 2008). In addition to these, a good problem situation should not contain unrealistic information, should contain realistic clues that will lead to a solution, and should also arouse the student's curiosity with understandable language. The problem situation should also allow the student to use higher-order thinking skills (Sezen-Vekli, 2012).

In the PBL environment, the role of the teacher is just as critical as the problem scenario itself. Unlike traditional teaching methods, where the teacher acts as an authority figure, here the teacher serves more as a guide or facilitator (Kılınç, 2007). Among the roles of teachers in PBL, there are many such as being a guide, learning together with the student, ensuring the participation of the students, managing and directing the process, and revealing the thoughts of the students (Kaptan & Korkmaz, 2001). The fact that the teacher has these roles in PBL ensures that the student is central and active in learning, unlike traditional methods. Thus, the student becomes active in the learning process, fulfills the responsibilities brought by the problem, shares the information he has obtained with the class, and makes an effort to take on the necessary responsibilities in the groups.

One of the numerous benefits of problem-based learning is that it fosters student involvement and active participation. Thus, the student develops his/her own self-control skills and high-level thinking skills, develops a sense of responsibility and problem-solving skills in group work, and increases the motivation of the student (Kaptan & Korkmaz, 2001). Individuals gain problem-solving abilities as a result of PBL, and they use various and inventive techniques to solve the difficulties they face in their daily lives. At the same time, students have the opportunity to express their ideas freely and to communicate better with other people (Aygün, Atalay-Kılıç, & Yaşar, 2016). The importance of problem-based learning has

increased day by day due to its many advantages for students. The importance of this approach in the literature has been stated in different studies, and many studies have been conducted on PBL in Turkey (Karadeniz-Bayrak and Bayram, 2012; Tatar and Oktay, 2009; Tosun and Taşkesenliğil, 2012; Şahbaz and Hamurcu, 2012; Kılıç and Moralar, 2015). In addition, it is seen that various studies have been conducted to determine the general trends in the use of problem-based learning in science education in Turkey (Tosun & Yaşar, 2015) and to compare these studies with the usage areas and trends in science education around the world (Tosun & Yaşar, 2013). In these studies, it was observed that the focus on the effect of PBL on learning. In addition, both meta-analysis and meta-thematic analysis methods were used together in studies to examine the effect of the flipped classroom method (Doğan, Batdı, & Yaşar, 2023) and project-based learning approaches in science education (Kılınç, Yaşar & Batdı, 2022). It was seen that the mixed-meta method was used. However, when the relevant literature is examined, it is seen that there are no detailed studies based on the mixed meta method for PBL in science education. This study also focused on the meta-analysis and meta-thematic analysis of studies on PBL in science education. Thus, a detailed examination of the applications of PBL in science education was made, and its presentation was made from a wider perspective.

Purpose of the Study

In this study, it was aimed to make a mixed-meta method in which meta-analysis and meta-thematic analysis of studies conducted in Turkey on PBL in science education are used together. The following research questions are posed in relation to the aims of this study:

1. In meta-analytic studies, what is the magnitude of the impact of Problem-Based Learning (PBL) on students' academic achievement in science education?
2. According to participant opinions, what are the effects of PBL applications in science education on: a). Academic performance; b). Affective-social dimensions; c). 21st-century skill development; d). potential drawbacks?"

Method

This research was carried out with the mixed-meta method, in which meta-analysis and meta-thematic analysis processes were used together. In order to determine the effectiveness of the problem-based learning method in science education, this research was conducted within the framework of the mixed-meta method, using the meta-analysis process in the quantitative

dimension and meta-thematic analysis in the qualitative dimension. This method is aimed at dealing with both quantitative and qualitative data regarding document analysis in terms of integrity. In the mixed-meta method, while analyzing quantitative data with computer programs such as CMA and MetaWin; qualitative data is also analyzed with programs such as Nvivo and Maxqda. After the analysis, it provides the opportunity to combine and examine the products from these programs in a research. Therefore, it can be said that the mixed-meta method is a rich method (Batdı, 2020). The studies that we will include in the current mixed-meta research should be scientific as well as those that contain published and accepted quantitative or qualitative data (Batdı, 2021, p. 1218). In this study, meta-analysis and meta-thematic analysis of studies based on PBL in science education were made, and the related process was presented within the framework of two headings: meta-analysis process and meta-thematic analysis process.

Meta-Analysis Process

Meta-analysis studies can be expressed as the synthesis of studies that have been more generalized based on the principle of combining the results of studies that serve the same or related purpose and which have been confirmed by many studies (Büyüköztürk et al., 2018, p. 239). In these studies, conclusions are drawn by combining and interpreting the statistical findings from different studies with similar objectives using specialized methods. Therefore, studies to be included in meta-analysis studies should include statistical findings (Büyüköztürk et al. 2018, p. 239). In the quantitative phase of this research, a meta-analysis process was applied to determine the effectiveness of PBL in Science Education.

Data Collection

In this context, "problem-based learning/teaching methods in science education/teaching," etc., to reach the studies carried out in the literature on problem-based learning in science education. The databases of the National Thesis Center and Google Academy were searched by using keywords. Certain criteria were taken into account in the screening process. These criteria were included in the research, such as national or international publications, applications related to problem-based learning from science education, and examining the effects on students' academic achievement. In addition to these, values such as the arithmetic mean, number of samples, and standard deviation (x, n, ss) that contain data suitable for meta-analysis were also taken into account. The studies that included the determined criteria were added to the scope of this research, and the unsuitable ones were not included. As a result, a total of 130 studies, including 80 theses and

50 articles, were reached by considering certain criteria, and 51 of the 80 theses and 27 of the 50 articles were included in the meta-analysis.

Analysis of Data

Effect size is important in meta-analysis studies. The effect size is used to determine the effect value of the independent variable (causing) on the dependent variable (resulting). This value is determined according to the fixed effects model (SEM) and random effects model (Schmidt, Oh, & Hayes, 2009). The use of REM was preferred in the relevant research due to the limited availability of suitable conditions, according to SEM. While calculating this value, the "Cohen's d" and "Hedge's d" coefficients were used. In this study, the data in the meta-analysis study were conducted with the MetaWin and CMA 2.0 programs, and the level classification of Thalheimer and Cook (2002, p. 4-9) was taken into account in the interpretation of the Hedge's g value obtained. Accordingly, if the effect size is between 0.15 and 0.15, it is insignificant; between 0.15 and 0.40, it is small; between 0.40 and 0.75, it is moderate; between 0.75 and 1.10, it is large; between 1.10 and 1.45, it is very large; and 1.45 and above, it is excellent (Thalheimer and Cook, 2002, p. 3-9).

Meta-Thematic Analysis Process

In the study, it was aimed at obtaining wide and rich data by integrating the findings of qualitative studies by making meta-thematic analysis within the scope of the second dimension. Meta-thematic analysis, based on document analysis, is often used in the social sciences. Meta-thematic analysis can be expressed as a process that involves obtaining qualitative studies on a specific subject related to document analysis, re-analyzing the raw data in these studies, and re-creating themes and codes (Batdı, 2019; 2020). In this context, the statement of Büyüköztürk et al. (2018) that a holistic perspective is obtained by organizing descriptive information and revealing themes in a comprehensible way in terms of thematic analysis supports the meta-thematic analysis process. In this study, it is aimed at creating a more comprehensive perspective on the research subject by making a meta-thematic analysis in addition to the meta-analysis in terms of a holistic understanding. Thus, in the research conducted, 15 studies that met certain qualitative criteria were added to the meta-thematic analysis process.

Data Collection and Analysis

In this research, data on the effectiveness of problem-based learning in science education were obtained with the document analysis technique.

Document review requires the analysis of all written materials that provide information about the case(s) that are planned to be investigated. It allows obtaining a holistic picture of the researched subject by associating the obtained information with each other within a certain framework (Yıldırım & Şimşek, 2018, p. 188).

In this research, the contents of the studies that meet the appropriate conditions according to the criteria determined in the qualitative sense were examined in detail, and similar and common aspects were created. Thus, the analyzed data were classified by considering their structural and semantic common aspects and were interpreted and re-interpreted. As a result, studies containing raw data based on qualitative document analysis were reconsidered, interpreted, and presented with content analysis. In this process, qualitative data were obtained by analyzing the Mawqda-11 program.

Coding

Coding is an important process in meta-thematic studies. It can be defined as the process of coding and deciding on categories. The categories should be clear so that other researchers can come to the same conclusions when examining the same study. In published articles and theses, the researcher focuses on his particular research topic and establishes categories. Identifying categories is a very difficult process. Coding can be done by hand on paper as well as by using computer software. In computer coding, basic office software can be used in addition to word processors. These programs are like Caqdas, Maxqda, or NVivo. These are software programs specially developed for qualitative data analysis (Büyüköztürk et al. 2018, pp. 261-262). In this study, the meta-thematic analysis process was carried out with the Maxqda-11 program. The analysis identified five themes: the impact of PBL on "academic achievement," "affective dimension," "social dimension," "twenty-first century skills," and "negative aspects." These themes were grouped, affective and social dimensions were handled under a group and given under the same model, and qualitative data were presented by creating a total of 4 models.

Reliability in the Meta-Thematic Analysis Process

It is a known fact that qualitative researchers will never be able to capture "truth or reality," that is, objectively. Therefore, qualitative researchers use a number of strategies to increase the "credibility" of their findings (Merriam, 2015, p. 205). At this point, in order to ensure and increase credibility, triangulation using multiple data sources, that is, comparing and crossing the obtained data with people with different perspectives, is required. The

involvement of more than one researcher in the processes of collecting and analyzing data in the same study is defined as researcher triangulation (Merriam, 2015, p. 206). In this research, from the beginning to the end, the two researchers acted together and exchanged ideas in the data collection, analysis, interpretation, and reporting processes. Another approach is expert review or expert review. Examining the article and giving recommendations by an expert who is knowledgeable about the subject and methodology of the research also contributes to its credibility (Merriam, 2015, p. 210). In this study, opinions were received from a second expert researcher during the analysis, coding, and interpretation of the study, and necessary arrangements were made within these opinions. In addition to these, direct quotations from the analyzed sources and data for the themes and codes created were included in the meta-thematic analysis. While interpreting the findings, these direct quotations were included. The sources from which the codes and themes are taken are represented by "M" articles, while Council of Higher Education [CHE] national theses are coded with their own numbers. For example, '187146 p.71' refers to the direct quote on page 71 of the thesis numbered 187146 in CHE.

Results

In this section, the findings obtained by the mixed-meta method for problem-based learning in science education are included and interpreted. Meta-analyses of quantitative data and meta-thematic analyses of qualitative data were made and presented.

Findings Related to the Meta-Analysis Process

Table 1 contains the findings regarding the meta-analysis process. According to the findings, the effect level in the calculations done using REM within the scope of the influence of PBL on the academic achievement of students in science education is 0.909 [0.737; 1.081]. This level of influence was determined at a large level in terms of the classification made by Thalheimer and Cook (2002, p. 3-9), and this revealed the conclusion that PBL has a positive effect on the academic success of students in science education. In addition, when **Table 1** is examined, it is seen that the effect size for academic achievement (Q = 701.158; p.05) shows a heterogeneous distribution according to the heterogeneity test value.

Figure 1 reflects the Funnel Plot data. This graph was obtained with the MetaWin and CMA data analysis programs, and there is the possibility of publication bias in the visual dimension of the results of the meta-analysis data set in the graph (Cooper et al. 2009, p. 428). In the analyses made with CMA or MetaWin programs, sometimes there may be deviations or

Table 1. Meta-Analysis Table.

			95% Confidence Interval		Heterogeneity		
Models	**n**	**G**	**Lower**	**Upper**	**Q**	**P**	**I²**
SEM	78	0,669	0,613	0,725	701,158	0	89,018
REM	78	0,909	0,737	1,081			

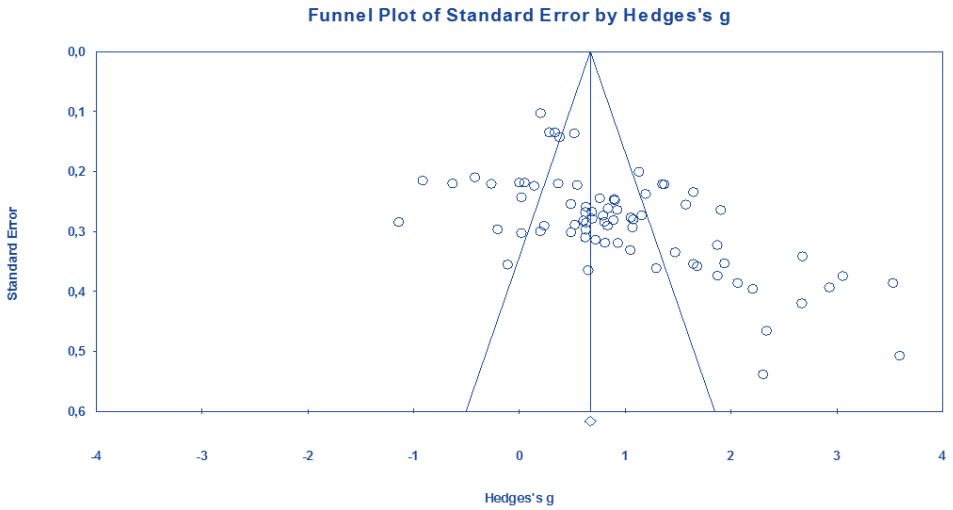

Figure 1. Funnel Plot plot (Funnel Scatterplot).

scattering in the effect size (Borenstein et al. 2009, p. 278). In this study, Funnet Plot results were examined to detect publication bias. According to the results, a value of 4561 was found, and this calculated value is the number of error protections used to minimize or eliminate publication bias in the meta-analysis process [Fail-safe (FSN)] (Rosenthal, 1979, p. 638). The value of 4561 obtained as a result of the calculations indicates that the bias can be reduced to zero by including 4561 studies in the current study. However, since this value is too high, it is not possible to reach this value. Therefore, it has been concluded that the relevant value does not contain publication bias since it requires a number of studies that are unlikely to be achieved (Cheung & Slavin, 2011, p. 288) and the data obtained by meta-analysis is quite reliable.

Findings Related to the Meta-Thematic Process

In the meta-thematic analysis phase of the research, models created for the themes and codes of the data obtained from the qualitative studies carried out

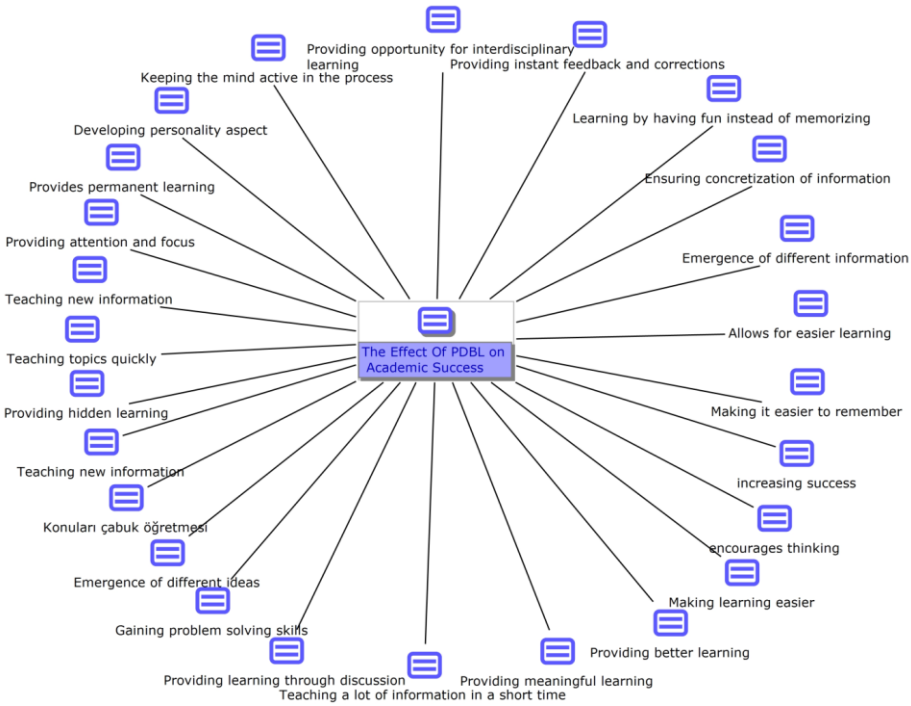

Figure 2. The Effect of Problem-Based Learning (PBL) on Academic Achievement.

to support problem-based learning in science education were included. As a result of the analysis, it has been determined that it consists of themes such as the effect of the PBL on "academic success," "the affective-social dimension," "21.yy skills," and "negative aspects" of the PBL, and the codes of these themes.

Figure 2 shows the codes for the effect of PBL on academic achievement. When the effect of PBL on academic success was examined, it was seen that expressions and codes such as "*Providing permanent learning, providing meaningful learning, increasing success, and learning with fun instead of memorization*" came to the fore. The expressions and codes of scientific studies that constitute a source in the creation of the codes of the effect of PBL on academic success "*…1. It was very good that I got an exam 59 and a second exam 90. My teacher is density, broken heart, d = m/v. Now, when I say broken heart, this is the first thing that comes to my mind. I don't forget anymore. (451230, p. 135) "; "I was interested in prob*lem-*based learning. Nice method. We learn in an entertaining way. We started to love problem solving. We learn the definitions according to the cartoon characters. I'm in favor of continuing education like this. (191667, p. 121)*". In addition, other codes are detailed in **Figure 2**.

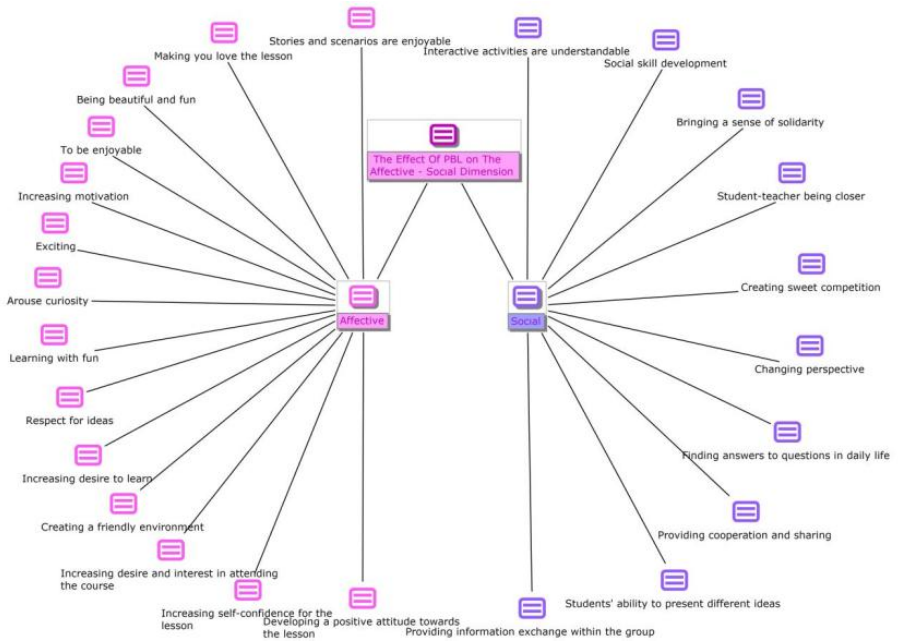

Figure 3. The Effect of Problem-Based Learning (PBL) on Affective-Social Dimension.

In **Figure 3**, the effect of PBL on the affective-social dimension is given as two themes. As can be seen in **Figure 3**, some of the codes related to the effect of PBL on the affective dimension are "*Increasing motivation, arousing curiosity, developing a positive attitude towards the course,*" etc., codes can be given as examples. Examples of direct quotes from these codes are "*I felt good; sometimes I got excited because I was curious. Trying to solve the question is instructive… It wasn't boring, it was enjoyable… (504726, p. 246)*"; "*…It has changed; it has become more fun; my love has increased. The previous method was tedious (506216, p. 97)*".

As can be seen in the second part of **Figure 3**, some codes related to the effect of PBL on the social dimension were determined as "*student-teacher being closer, helping, sharing, and gaining a sense of solidarity*". Direct quotations for these codes are "*We were spending more time with our teacher and we were doing research on different things (487946, p. 83)*"; "*…Yes. Because it is very important to get the ideas of our friends and share them with them (313398, p. 151)* "; "*Working in the group is good. It provides solidarity. It enables working together. Intimacy grows. I enjoyed being in a group (562135 p. 101).*" Other codes for the effect of PBL on affective-social dimensions are given in **Figure 3** in detail.

In **Figure 4**, the codes obtained regarding the effect of PBL on the 21st century are shown. Some of the codes related to the effect on their skills

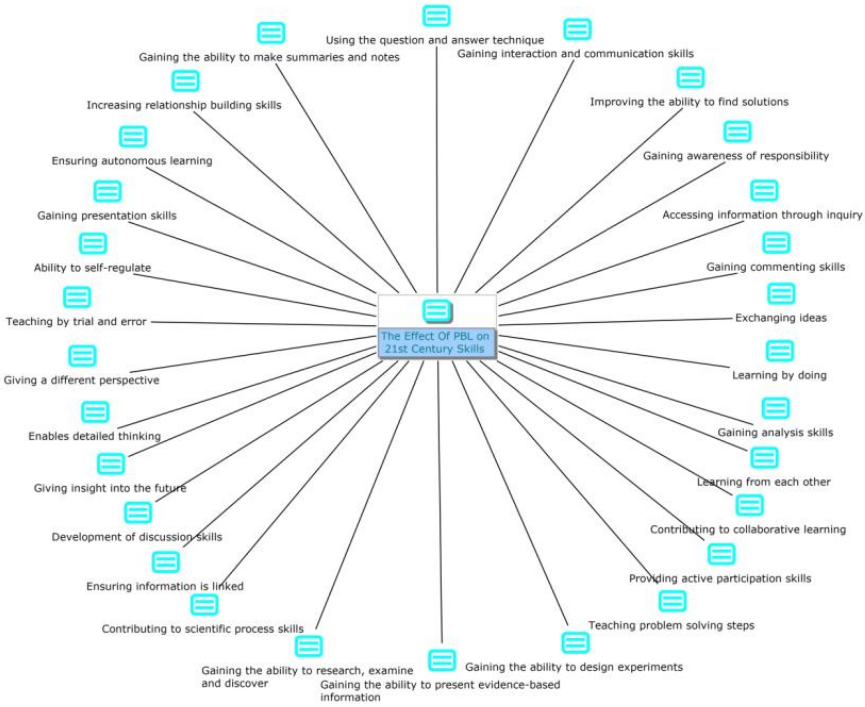

Figure 4. The Effect of Problem-based Learning (PBL) in the 21st century skills.

were determined as "*growing awareness of responsibility, contributing to collaborative learning and contributing to scientific process skills.*". Some of the expressions and direct quotations that can be references to these codes are "*positive aspects: everyone knew and fulfilled their own responsibilities. More importantly, he sought help from his friends and tried to understand the subjects he did not understand. Negative aspects: When I assigned them as the group leader, they did not care about me and did not fulfill their duties…*" (487946 p. 83) (T23); "*Teacher, we are processing this ourselves, I did not understand the cell part very well, I did not understand it much because you explained it. I understood this unit better because we worked with the group here (451230 p. 135)* "; "*… In today's world, where science and technology are developing at an incredible rate, giving such applications in lessons contributed to the development of our scientific process skills, which are an important component of science and technology literacy. Especially such applications made it easier for me to experiment, so my interest in the laboratory increased (343967 p.153)*". Other codes for the effect of PBL on 21st-century skills are given in **Figure 4**.

Apart from the advantages of the problem-based teaching method in different aspects, it has been determined by analyzing the data that there are

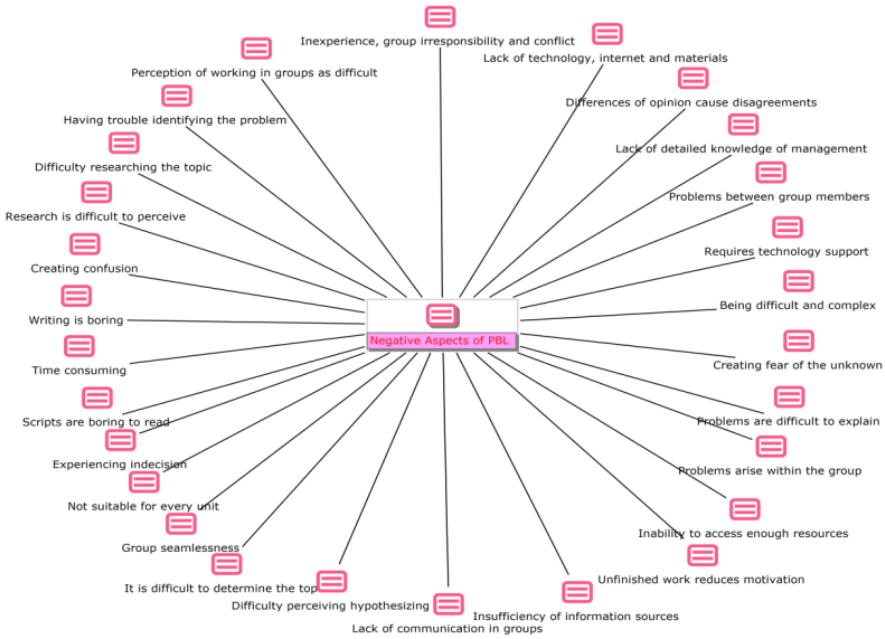

Figure 5. Negative Aspects of the Problem-Based Learning (PBL).

some negative aspects to this subject. In **Figure 5**, the codes related to the negative aspects of PBL are seen. Some of these codes were determined to be "*time consuming, group irresponsibility, insufficient information resources and lack of communication in groups.*" Some of the expressions and direct quotes that can refer to these codes are "*Actually, it is productive. But it's time-consuming. How many hours did I spend trying to solve the problem? There are additional questions, and I'm dealing with them. Time passed quickly before I could finish the topic (504726 p. 272)"*; "*Sir, we are working well with the group, but now M is doing something; M does not agree much; he makes fun of him; he acts according to his head; and because of him, we are discredited. (451230 p.132)* "*Positive: do not work as a group. Negative: lack of information resources (487946 p. 83)*"; "*The possible lack of communication between the members of the groups formed (200888 p. 70)*". Other codes related to the negative aspects of PBL are given in **Figure 5**.

Conclusion and Discussion

In this study, the effect of PBL in science education was determined by the mixed-meta method. This method is based on document analysis. Thus, the meta-analysis of the quantitative studies on PBL in science education and the

meta-thematic analysis of the qualitative studies were carried out together. In this context, it is aimed at evaluating the studies made with the PBL in science education with mixed-meta method. In this section, the data obtained as a result of the analyses are discussed by comparing them with the results of other studies in the literature. In the first stage of the research, which was based on document analysis, quantitative data were determined by meta-analysis, and qualitative data were identified and presented in the second stage using meta-thematic analysis. The study, which was conducted concurrently with the research method, took a complementary and comprehensive approach. When the meta-analysis data were examined, it was concluded that PBL in science education had a positive and significant effect (g = 0.909) on the academic achievement of students. This suggests that the experimental group's PBL activities are more effective at improving academic achievement than the control group's traditional practices. In addition, when the obtained value (g = 0.909) was compared with the level classification values determined by Thalheimer and Cook (2002, p. 4-9), it was concluded that this effect value was positive, large, and significant. When the results obtained in this study are compared with the study of Çınar and İlik (2013) in the literature, similar results were obtained, and it was concluded that PBL increased the success of the students in the 6th grade "Electricity Directing Our Lives" unit in a positive and meaningful way.

In order to support and complement the results obtained from the meta-analysis, according to the results of the meta-thematic analysis of the data obtained from the qualitative studies, themes and codes related to the effectiveness of PBL in science education were obtained. Models were created for the themes and codes created. One of these themes is to determine the effect of PBL on academic achievement in science education. When the effect of PBL on academic achievement in science education is examined, it is concluded that codes are formed such as providing permanent learning, latent learning, that is, learners have knowledge involuntarily, and providing meaningful learning by discussing. As a result, when the findings obtained from this research were evaluated, it was understood that the problem-based teaching method increased the success of the learners, provided learning with fun instead of memorizing, and provided opportunities for easier learning. When the relevant literature is examined, it is seen that there are various studies that have a positive effect on the academic achievement of PBL in science education (Çayan & Karslı, 2014; Çelik, Eroğlu & Selvi, 2012; Demirel & Arslan-Turan, 2010; İnel & Balım, 2010; Peterson & Treagust. 1998; Tatar and Oktay, 2011; Uluçınar-Sagir, Yalçın-Çelik and Öner-Armağan, 2009; Yurd and Olğun, 2008) and it was concluded that these studies are in parallel with the current research findings. Thus, according to the results of this research, which is also supported by the literature, it can be concluded that PBL increases the academic success of

students in science education. The second theme derived from the thematic analysis findings is to determine the impact of PBL on the affective-social dimension of science education. In this context, it is understood from the interpretation of the codes obtained that PBL in science education increases the willingness and interest of learners to participate in the lesson, shows a positive attitude towards the lesson, gives a sense of solidarity among students, and makes the lesson fun with a sweet competition. When the relevant literature was reviewed, similar and parallel results were achieved with the current research. As a matter of fact, Çelik, Eroğlu, and Selvi (2012) concluded in their study that PBL practices in science education develop a positive attitude towards science education in students. In addition, in the study conducted by Tosun and Taşkesenliğil (2012) and Aydoğdu (2012) with science teaching students, it was concluded that PBL increased students' motivation and attitudes towards the lesson and made a positive contribution.

The data collected through meta-thematic analysis sheds light on another topic: the impact of problem-based learning in science education on 21st-century skills. The research results indicate that this approach contributes to learners' scientific process skills, enhances their communication abilities, fosters collaborative learning, and facilitates experiential learning. In other words, it equips learners with the skill of active participation. The literature contains a variety of studies that support the current research findings. As a matter of fact, in their study, Yaman and Yalçın (2005) examined the effect of PBL on the creative thinking levels of teacher candidates, one of the 21st century skills. At the end of the application, it was discovered that the pre-service teachers in the experimental group improved their creative thinking skills more than the students in the control group. Based on these findings, it can be inferred that the Problem-Based Learning (PBL) approach is more effective in enhancing creative thinking compared to traditional teaching methods. The last theme is the negative aspects of the problem-based teaching method in science education, one of the themes obtained in the mixed-meta study in line with the meta-thematic analysis, in addition to its positive aspects and contributions to learning. In this context, it has been determined that the challenges are difficult and complex, that there are conflicts among group members, and that there are negative features such as inexperience, arguments, group irresponsibility, time- consumption, and a shortage of materials. For this reason, in order to create healthier educational environments, it is important and recommended to eliminate the problems encountered in the problem-based teaching method in science education and to remove the obstacles.

References

References marked with an asterisk (*) indicate studies included in the meta-analysis and meta-thematic analysis process.

Akbulut, H. H. (2010). Implementation and evaluation of problem based learning on buoyant force and floating concepts. Master's diss., Karadeniz Technical University, Trabzon.

*Akın, S. (2008). Teaching enviromental problems caused by stubble fires, ozon layer deplotion and vehicles through problem-based learning. Master's diss., Atatürk University, Erzurum.

*Aktı Aslan, S. (2019). The effect of vırtual learnıng envıronments desıgned accordıng to problem-based learnıng approach to students" success, problem-solvıng skılls, and motıvatıons. PhD diss., İnönü University, Malatya

*Arıcı, F. (2021). An investigation of the effectiveness of problem based learning method enhanced with augmented reality in the teaching of cell and divisions subject. PhD diss., Atatürk University, Erzurum

*Aydogdu, C. (2012). The effect of problem based learning strategy in electrolysis and battery subject teaching. *Hacettepe University Journal of Education*, 42:48-59.

Aygün, Ş. S., Atalay, N., Kılıç, Z. & Yaşar, S. (2016). The development of a 21st century skills and competences scale directed at teaching candidates: Validity and reliability study. *Pamukkale Unıversity Journal of Education*, 40:160-175.

*Aysu, G. (2019). An examination of the effects of problem-based learning stem applications on students academic achievements and permanence of learning. Master's diss., Niğde Ömer Halisdemir University., Niğde.

*Bakırlı, G. (2020). Problem based science learning: The effects of hypothesis testing experiments on academic success and scientific process skills. Master's diss., Muğla Sıtkı Koçman University, Muğla.

*Balım, A. G., Deniş-Çeliker, H., Türkoğuz, S., Evrekli, E. & İnel-Ekici, D. (2015). The effect of concept cartoons-assisted problem-based learning method on conceptual understanding levels and problem solving skill perceptions of students. *Journal of Turkish Science Education*. 12(4):53-76.

Batdı, V. (2019). Meta-thematic analysis. V. Batdı (Eds.). Meta-thematic Analysis: Example Applications. Anı Publishing. ISBN : 9786051703244. pp.10-76.

Batdı, V. (2020). Introduction to Meta-thematic Analysis. V. Batdı (Eds.). Meta-thematic analysis in research process.Anı Yayıncılık. ISBN: 9786051704623. pp.1-38.

Batdı, V. (2021). The use of technology in language teaching to foreigners: A mixed-meta method. *Journal of National Education*, 50(1):1213-1244. https://doi.org/10.37669/milliegitim.942631

*Bayrak, R. (2007). Teaching solids by problem based learning. PhD diss., Turk University, Erzurum.

*Benli, E. & Sarıkaya, M. (2011). The investigation of the effects of problem based learning and sexuality to the attitudes toward science and scientific process skills of prospective science teacher: The problem of the boiler stone. *E-Journal of New World Sciences Academy, Education Sciences*, 6(1):1295-1308. DOI: https://doi.org/10.1016/j.sbspro.2012.06.247

*Boncuk çu, G. (2020). The effect of problem based learning model on environmental literacy, problem solving and self-regulatory skills of 8th grade students in sustainable development. Master's diss., Mersin UniversityMersin.

Boran, A. İ. & Aslaner, R. (2008). Problem-based learning in teaching mathematics at the science-art centers. *Inonu University Faculty of Education Journal*, 9(15):15-32.

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2009). Introduction to Meta-Analysis. John Wiley. ISBN: 9780470057247

Büyüköztürk, Ş., Kılıç-Çakmak, E., Akgün, Ö. E., Karadeniz, Ş. & Demirel, F. (2018). Scientific Research Methods in Education (25. th edition). Pegem Akademi. ISBN 9789944919289

Cheung, A. C. & Slavin, R. E. (2016). How methodological features affect effect sizes in education. *Educational Researcher*, 45(5):283-292. https://doi.org/10.3102/0013189X16656

Chin, C. & Chia, L. (2004). Problem-based

learning: Using students' questions to derive knowledge construction. *Science Education*, 88(5):707-727. DOI: https://doi.org/10.1002/sce.10144

Cooper, H., Hedges, L. V., & Valentine, J. C. (2009). The Handbook of Research Synthesis and Metaanalysis (2nd Edition). Russell Sage Publication. ISBN: 9780871541635

*Çakıcı, Y., Söyleyici, H. & Oğuzhan Dinçer, E. (2020). Investigation of the effect of problem based learning on the scıentific process skills, attitudes and achievements of middle school students': unit light. *Trakya University Journal of Social Science*, 22(1):419-437. https://doi.org/10.26468/trakyasobed.712347

Çayan Y. & Karslı, F. (2014). The effects of the problem based teaching learning approach to overcome students' misconceptions on physical and chemical change. *Kastamonu Education Journal*, 23(4):1437-1452.

*Çelik, E. (2010). The effect of problem based learning approach in science education on students' academic achievement, attitude, academic risk taking level and retention of knowledge. Master's diss., Gazi UniversityAnkara.

*Çelik, E., Eroğlu, B. & Selvi, M. (2012). The effect of problem based learning approach in science education on students' academic achievement, and attitudes toward science and technology course. Kastamonu Education Journal, 20(1):187-202.

*Çınar, D. (2007). The effects of the problem based learning approach on the higher level thinking skills and levels of academic risk taking in primary science education. Master's diss., Selçuk University, Konya.

*Çınar, D. & İlik, A. (2013). The effects of a problem based learning approach on higher level thinking skills in primary science education. *Journal of Educational Sciences Research*, 3(2):21-34. Available at: https://dergipark.org.tr/tr/pub/ebader/issue/44712/555567

*Çimen, B. (2021). The effect of problem-based STEM activities applied in domestic waste and recycling subject on students' academic achievement and awareness. Master's diss., Ordu University, Ordu.

*Dadlı, G. (2017). The effect of learning activities based on authentic problems in the human and environmental relations unit on the reflective thinking skills, academic success, environmental attitude and awareness of 7th grade students. Master's diss., Kahramanmaraş Sütçü İmam University, Kahramanmaraş.

*Demirel, M. & Turan Arslan, B. (2010). The effects of problem based learning on achievement, attitude, metacognıtive awareness and motivation. *Hacettepe University Journal of Education*, 38:55-66.

*Dilek Eren, C. (2011). The effect of problem based learning (PBL) on critical thinking disposition, concept learning and scientific creative thinking skill in science education. PhD diss., Marmara University, İstanbul.

*Divarcı, Ö. F. & Saltan, F. (2017). The effects of the multimedia supported problem based learning on academic success and attitude in science education. Ahi Evran University Journal of Kırşehir Education Faculty (JKEF), 18(3):1-23. Availabel at: https://dergipark.org.tr/tr/pub/kefad/issue/59420/853347

Doğan, Y., Batdı V. & Yaşar, M. D. (2023). Effectiveness of flipped classroom practices in teaching of science: a mixed research synthesis. *Research in Science & Technology Education*, 41(1):393-421. DOI: https://doi.org/10.1080/02635143.2021.1909553

*Doğanay, K. (2018). The effect of science festivals upon with problem based stem activities on the student's science attitudes and academic achievements. Master's diss., Kastamonu University, Kastamonu.

*Dursun, C. (2015). The effect of problem-based learning method on students' attitude towards the environment and their environmental awareness (7th grade 'Human and Environment' unit example). Master's diss., Pamukkale University, Denizli.

*Eren, C. D. & Akınoğlu, O. (2012). The effect of problem based learning on concept learning in science education. *Journal of Research in Education and Teaching*, 1(3):19-32.

*Eyceyurt Türk, G. (2017). The effect of argumentation-supported problem based learning applications on the acid / bases and gases success of pre-service science teachers. PhD diss., Gazi University, Ankara.

*Fidan, M. (2018). The impact of problem-based science teaching assisted with augmented reality applications on academic achievement, retention, attitude and belief of self-efficacy. PhD diss., Bolu Abant İzzet Baysal University, Bolu.

*Gögüş, R. (2013). Problem based learning teaching science and its effect on students academic achievement and attitudes. Master's diss., Kırıkkale University, Kırıkkale.

*Güzel, Z. (2018). The effects of problem based approach practiced through self and peer assessment on students' achievements and attitudes in science teaching. Master's diss., mettin Erbakan University, Konya.

*Hun, F. (2017). The effect of academic achievement and attitudes on the 7th grade students of problem based learning method and improved 5E learning model. Master's diss., Giresun University, Giresun.

*Hun, F. & Değirmençay, Ş. A. (2020). Effect of 5E teaching model supported by problem based learning on the achievement and attitude. *International Journal of Society Researches*, 16(29):1689-1717. DOI: https://doi.org/10.26466/opus.754216

*İnce Aka, E. (2012). The effect of problem-based learning method used for teaching acids and bases on different variables and students' views on the method. PhD diss., Gazi University, Ankara.

*İnce Aka, E. & Sarıkaya, M. (2014). The effect of problem-based learning method on attitudes of preservice science teachers towards chemistry lesson. *Gazi Unıversity Journal of Gazi Educational Faculty (Gujgef)*, 34(3):451-467. https://doi.org/10.17152/gefad.50447

*İnel, D. (2012). The effects of concept cartoons-assisted problem based learning on students" problem solving skills perceptions, motivation toward science learning and levels of conceptual understanding. PhD diss., Dokuz Eylül University, İzmir.

İnel, D. & Balım, A. G. (2010). The effects of using problem-based learning in science and technology teaching upon students' academic achievement and leves of structuring conceps. Asia Pacific Forum on Science Learning and Teaching, 11(2):1-23. Available at: https://eric.ed.gov/?id=EJ933449

*Kanar, A. (2017). Examination of the effects of the using of problem based learning method in the teaching science and laboratory practice course on pre-service science teachers. Master's diss., Uşak University, Uşak.

*Kanlı, E. (2008). The effect of problem based learning in science & technology instruction on gifted and normal students' achievement, creative thinking and motivation levels. Master's diss., İstanbul University, İstanbul.

Kaptan, F. & Korkmaz, H. (2001). Problem-based learning approach in science education. *Hacettepe University Journal of Education*, 20:185-192.

*Karadeniz Bayrak, B. & Bayram, H. (2012). The effect of problem-based learnıng ın a web envıronment on the academıc achıevement of students wıth dıfferent learnıng styles. *Mustafa Kemal University Journal of Social Sciences Institute*, 9(18):479-497.

*Kayabaş, B.T. (2019). The effect of problem based outdoor-STEM activities on the students' academic achievements and decision making skills. Master's diss., Muğla Sıtkı Koçman University, Muğla.

Keleş, M. (2015). The effect of problem-based learning method on student' recall level and success in the processing of Science and Technology course. Master's diss., Necmattin Erbakan University, Konya.

Kılıç, İ. & Moralar, A. (2015). The effect of problem-based learning approach on academic success and motivation in science education. *Pegem Journal of Education and Instruction*. 5(5):625-636. Available at: https://dergipark.org.tr/tr/pub/pegegog/issue/22565/241087

Kılınç, A. (2007). Problem based learning. Kastamonu Education Journal. 15(2):561-578. Available at: https://dergipark.org.tr/tr/pub/kefdergi/issue/49102/626594

Kılınç, B., Yaşar, M. D. & Batdı, V. (2022). Evaluating the project based learning in science education through mixed-meta method. *Inönü University Journal of the Faculty of Education*, 23(3):1663-1681. DOI: https://doi.org/10.17679/inuefd.1170144

*Kızılkaya, A. (2017). The effect of problem based learning and jigsaw I technic in science teaching on students' academic achievement and knowledge permanence in steps of bloom taxonomy cognitive domain. PhD diss., Atatürk University, Erzurum.

Koray, Ö. & Azar, A. (2008). An analysıs of

hıgh school students' problem solvıng and logıcal thınkıng abılıtıes ın terms of gender and preferred fıeld. *Kastamonu Education Journal*, 16(1):125-136. Available at: https://dergipark.org.tr/tr/pub/kefdergi/issue/49101/626572

*Korucu, E.N. (2007). Comparing with problem and cooperative based learning method applied in primary schools on the success of the students. Master's diss., Selçuk University, Konya.

Kumar, D. D. (2010). Approaches to interactive video anchors in problem-based learning. *Journal of Science Education and Technology*, 19:13-19. DOI: https://doi.org/10.1007/s10956-009-9154-6

*Kuvaç, M. (2014). The effects of problem based learning on preservice Science Teachers' environmental consciousness and metacognitive awareness. Master's diss., İstanbul University, İstanbul.

*Küçük Avcı, Ş. (2017). The effect of problem based learning in 3 dimensional virtual learning environments on conceptual understanding and learning performance based on problem solving. PhD diss., Sakarya University, Sakarya.

Merriam, S.B. (2015). A Guide for Qualitative Research Design and Implementation. (Trans. S. Turan).Nobel Academic Publishing. ISBN: 978-605-133-250-5.

*Moralar, A. (2012). The effect of problem-based learning approach on academic success, attitude and motivation in science education. Master's diss., Trakya University, Edirne.

*Nerse, B., N. (2021). Study of the effect of the problem-based learning approach enrıched with web 2.0 tools on the academic achievement, metacognitive awareness, self-directed learning with technology and digital literacy of students during online education process. Master's diss., Kocaeli University, Kocaeli.

*Özeken. Ö.F. (2011). An investigation of effectiveness of problem based learning in teaching acid-base subject. PhD diss., Atatürk University, Erzurum.

*Özkardeş Tandoğan, R. (2006). The effects of problem based active learning on the student's academic achievement and learning concepts on science education. Master's diss.,Marmara University, İstanbul.

*Öztürk, Z. D. (2019). The effect of problem based learning method on students' academic achievements and scientific process skills in a science course. Master's diss., Pamukkale University, Denizli.

*Öztürk, Z. D. & Özel, M. (2021). The effect of problem based learning on students' scientific process skills. *The Journal of Buca Faculty of Education*, 51:1-31. DOI: https://doi.org/10.53444/deubefd.550710

*Pakyürek Karaöz, M. (2008). The effect of teaching the unit of power and motion? in primary school science course using the problem based learning approach on students science process skills, success and attitude. Master's diss., Muğla University, Muğla.

Peterson, R. &Treagust, D. F. (1998). Learning to teach primary science through problem-based learning. *Science Teacher Education*, 82:215-237. Available at: https://doi.org/10.1002/(SICI)1098-237X(199804)82:2<215::AID-SCE6>3.0.CO;2-H

Rosenthal, R., (1979). The "file drawer problem" and tolerance for null results. *Psychological Bulletin*, 86:638-641. DOI: https://doi.org/10.1037/0033-2909.86.3.638

*Seyhan, M.E. (2019). The effect of problem based teaching method on attitudeand success in science education. Master's diss., Süleyman Demirel University, Isparta.

Sezen Vekli, G. (2012). Developing and evaluating problem based computer aided material related to human endocrine system. PhD diss., Karadeniz Technical University, Trabzon.

Schmidt, F. L., Oh, I. S., & Hayes, T. L. (2009). Fixed-versus random-effects models in meta-analysis: model properties and an emprical comparison of differences in results. *British Jorrnal of Mathematical and Statistical Pyschology*, 62(1): 97-128. DOI: https://doi.org/10.1348/000711007X255327

Shamir, A., Zion, M. & Spector-Levi, O. (2008). Peer tutoring, metacognitive processes and multimedia problem-based learning: The effect of the mediation training on critical thinking. *Journal of Science Education and Technology*, 17:384-398. DOI: https://doi.org/10.1007/s10956-008-9108-4

*Sifoğlu, N. (2007). The Effects of constructivism and problem-based learning on students success in the

teaching the topic heritage at the 8th grade. Master's diss., Gazi University, Ankara.

*Söyleyici, H. (2018). Investigating the effect of problem-based learning on the scientific process skills, scientific attitudes, achievements and conceptual knowledge of middle school: Unit light. Master's diss., Trakya University, Edirne.

*Şahbaz, Ö & Hamurcu, H. (2012). The effects of problem based learning and cooperative learning methods on students' science process skills and learning outcomes. *E-Journal of New World Sciences Academy*, 7(1):734-754.

*Şahin, A. (2011). To analyse the effect of Problem Based Learning (PBL) Approach on academic success of students in teaching basic electrical circuits in general physics laboratory course. Master's diss., Atatürk University, Erzurum.

*Şenel, H. (2010). Problem-based active learning in raisig the environmental consciousness of science teacher candidates. Master's diss., Balıkesir University, Balıkesir.

Şenocak, E. (2009). Development an instrument for assessing undergraduate science students' perceptions: The problem-based learning environment inventory. *Journal of Science Education and Technology*, 18:560-569. DOI: https://doi.org/10.1007/s10956-009-9173-3

*Taşoğlu Kartal, A. (2015). Investigating the effects of the problem based learning approach on understanding the topics of magnetism. PhD diss., Dokuz Eylül University, İzmir.

Tatar, E. & Oktay, M. (2011). The effectiveness of problem-based learning on teaching the first law of thermodynamics. *Research in Science & Technological Education*, 29(3):315-332. DOI: https://doi.org/10.1080/02635143.2011.599318

*Tavukcu, K. (2006). The effects on the learning outcomes of problem based learning in science instruction. Master's diss.,Zonguldak Karaelmas University, Zonguldak.

*Tekin, A.D. (2019). Academic success of 7th grade students of problem based learning approach impact on process skills and motivations. Master's diss., Marmara University, İstanbul.

*Tekin, A. D. & Yıldırım, M. (2020). Investigation of the impact of problem based learning approach on scientific process skills and motivation towards science learning of secondary school students. *Research and Experience Journal*, 5(2):58-71. DOI: https://doi.org/10.47214/adeder.778928

Thalheimer, W. & Cook, S., (2002). How to calculate effect sizes from published research articles: A Simplified Methodology. Workinh Learning Research. Available at: https://paulogentil.com/pdf/How%20to%20calculate%20effect%20sizes%20from%20published%20research%20-%20a%20simplified%20methodology.pdf

*Topal Germi, N. (2020). The effect of problem based learning 5th grade students' change of substance unit on achievements, creative thinking skills, comprehension levels of concepts and their motivations. PhD diss., Ondokuz Mayıs University, Samsun.

*Topsakal, İ. (2018). The research of the system education on the student's learning environment, critical thinking disposition and problem solving abilities perception. Master's diss., Erzincan Binali Yıldırım University, Erzincan.

*Topsakal, İ., & Altun Yalçın, S. (2020). Investigating the effect of problem-based STEM education on students' learning climate. *International Journal of Scholars in Education*, 3(1):42-59.

*Tosun, C. (2010). The effect of problem based learnıng method on understandıng of the solutıons and ıts' physıcal propertıes. PhD diss., Atatürk University, Erzurum.

*Tosun, C. & Taşkesenligil, Y. (2012). The effect of problem based learning on student motivation towards chemistry classes and on learning strategies. *Journal of Turkish Science Education*, 9(1):104-125.

Tosun, C. & Yaşar, M. D. (2013). Comparision of problem-based learning studies in science education in Turkey with the Word: content analysis of research papers. *Asia-Pacific Forum on Science Learning and Teaching*, 14(2):1-24.

Tosun, C. & Yaşar, M. D. (2015). Descriptive content analysis of problem-based learning researches in science education in Turkey. *Kastamonu Education Journal*, 23(1): 293-310.

*Tüysüz, C. & Demirel, O. E. (2020). Examining the effects of problem based and argumentation based learning methods on the "mixtures" unit. *MSKU Journal of Education*, 7(1):43-61. DOI:

https://doi.org/10.21666/muefd.561375

Uluçınar-Sağır, Ş., Yalçın-Çelik, A. & Öner-Armağan, F. (2009). The effect of problem based learnin stratedy in metallic activity subject teaching. *H.U. Journal of Education*, 36:283-293.

*Ulukök, Ş. (2012). The effect of computer assisted pproblem based learning method on the higher level thinking skills of prospective teachers. Master's diss., Kırıkkale University, Kırıkkale.

*Yaman, S. (2005). The impact of problem-based learning on the development of logical thinking skills in science education. *Journal of Turkish Science Education*, 2(1):56-70.

*Yaman, S. & Yalçın, N. (2005a). Effectiveness on creative thinking skills of problem based learning approach in science teaching. *Elementary Education Online*, 4(1):42-52.

*Yaman, S. & Yalçın, N. (2005b). Effectiveness of problem-based learning approach on development of problem solving and self-efficacy beliefs levels in science education. *H.U. Journal of Education*, 29:229-236.

*Yıldırım, C. (2017). The effects of argumentation supported problem based learning on students' inquiry learning skills and problem solving skills and levels of conceptual understanding. PhD diss., Pamukkale University, Denizli.

*Yıldırım, C. & Can, B. (2018).The effects of argumentation supported problem based learning on students' inquiry learning skill perceptions. *PAU Journal of Education*, 44:251-277.

*Yıldırım, H. (2011). The effect of problem based and project based learning styles on primary school students' successes and attitude. Master's diss., Sel çuk University, Konya.

Yıldırım, A., & Şimşek, H. (2018). Qualitative research methods in social sciences (11th edition). Se çkin Publishing. ISBN: 9789750269820.

Yıldırım, H. İ. & Yalçın, N. (2008). The effect of science education based on critical thinking skills on prospective science teachers' problem solving skills. *Gazi University Journal of Gazi Educational Faculty*, 28 (3):165-187.

*Yıldız, E., Şimşek, Ü. & Yüksel, F. (2017). The effect of jigsaw-integrated problem based learning method on students' motivation towards science learning, social skills and attitude towards school. *Kastamonu Education Journal*, 25(5):1957-1978.

*Yıldız, N. (2010). The effect of experiment applications on the success, attitude and scientific process abilities of the students in the solution of the learning scenarios based on problems in science education. Master's diss., Marmara University, İstanbul.

*Yıldız, Ş. (2019). The investigation of the effect of problem based teaching approach on students' problem solving skills and academic achievments in science course. Master's diss., Sakarya University, Sakarya.

*Yıldız, Ş. & Beşoluk, Ş. (2019). The ınvestigation of the effect of problem based teaching approach on students' problem solving skills and academic achievements in science course. *Journal of Individual Differences in Education*, 1(1):50-68.

*Yıldız, T. (2017). Investigation of the effectiveness of problem based teaching method in teaching the particulate structure of matter unit in primary science course. Master's diss., Ağrı İbrahim Çeçen University, Ağrı.

*Yurd, M. (2007). The effect of know-want-sample-learn strategy, which is developed by using problem based learning and know-want-learn strategy, towards the 5th grade students' attitudes in science and technology lesson and towards to remove their misconceptions. Master's diss., Mustafa Kemal University, Hatay.

*Yurd, M. & Olğun, Ö. S. (2008). Effect of problem based learning and know-want-learn strategy to remove misconceptions. *H. U. Journal of Education*, 35:386-396.

*Yurdatapan, M. (2013). The effect of problem based laboratory activities on self-confidence, self-efficacy and science process skills of student. *H. U. Journal of Education*, Special Issue(1):421-435.

*Y ücel Ünal, S. (2019). The effect of problem based learning approach on teaching the subject 'the reproduction, growth and development of plant and animal. Master's diss., Uşak University., Uşak.

Received: March 30, 2024
Revised: April 20, 2024
Accepted: May 01, 2024

REVIEW

Challenges of Teacher Involvement in School Management in China

Ming Zhou

Jiangnan School, Zhenjiang 212008, Jiangsu, China

***Abstract**: The philosophy of "participatory management" has garnered attention in a wide range of sectors. In China, research on teacher involvement in school management began in the late 20th century. The purpose of this article is to discuss the significance of teacher involvement in school management and summarize its challenges and causes in China on the basis of the existing literature, with the view to providing valuable insights for the advancement of school governance and the improvement of the quality of education in this country.*

Science Insights Education Frontiers 2024; 24(2):3993-4002
DOI: 10.15354/sief.24.re419

How to Cite: Zhang, Q. (2024). Challenges of teacher involvement in school management in China. Science Insights Education Frontiers, 24(2):3993-4002.

***Keywords**: Participatory Management, Teacher Involvement in School Management, Teacher's Right to Speak, School Democratic Management*

***About the Author**: Ming Zhou, Jiangnan School, Zhenjiang 212008, Jiangsu, China, E-mail: 929883506@qq.com*

***Correspondence to**: Ming Zhou at Jiangnan School in China.*

***Conflict of Interests**: None*

***Funding**: No funding sources declared.*

***AI Declaration**: The author affirms that artificial intelligence did not contribute to the process of preparing the work.*

Introduction

SINCE the 1960s, the theory of "participatory management" has become increasingly popular in various sectors. It is characterized by information sharing within the organization and the encouragement of employee participation in decision-making and the operation of the organization (Chen, 2009). The theory also provides justifications for maximizing teachers' involvement in school management. Teacher involvement in school management refers to the process in which teachers actively participate in school decision-making and devote time and energy to the management of school affairs on the precondition that they have a comprehensive understanding of the school circumstances and sufficient communication with the school leadership (Liu, 2002). In China, the democratic management of schools is an important component of the construction of democracy at the grassroots level. With the continuous enhancement of their democratic awareness, Chinese teachers have become more active in speaking out on issues concerning their interests and demands, as well as participating in the decision-making and management of school affairs. This tendency is beneficial for safeguarding the democratic rights and legitimate interests of the teacher while also contributing to the establishment of a scientific and democratic decision-making mechanism in the school.

In recent years, Chinese educational authorities have made multiple legislative efforts to clearly define the rights of the teacher in the democratic management of the school and the responsibilities and duties of teacher representatives and have formulated a series of regulations and supervision measures to ensure that the legitimate rights of the teacher to participate in school management are fully guaranteed. In response to the governmental moves, the schools have also carried out profound reforms in their management systems, experimenting with decentralized leadership and the "bottom-up" management strategy. Despite the many institutional supports, the actual level of teacher involvement in school management is still lower than expected (Chu, 2009). Based on the relevant literature, this article focuses on discussing the significance of teacher involvement in school management and summarizing its challenges in the Chinese education world with the intent to contribute to the construction of modern school governance systems in China.

The Significance of Teacher Involvement in School Management

The right of the teacher to participate in education management is an educational application of the democratic rights granted to the citizen by the Constitution. Teacher involvement in school management is also provided in the Teacher Law of China, with Article 7 of its Chapter 2 explicitly stipulating that the teacher is entitled to airing their opinions and suggestions on the school's education, teaching, and management work and the work of education administrative departments, as well as participating in school management through the faculty congress and other means (Wang et al., 2009). Teacher involvement in school management can benefit both the school and the teacher in multiple facets.

Meeting the School's Needs for Democratic Management and Scientific Development

A democratic management climate is the primary feature of the modern, human-centric machinery of school governance (Chen, 2009). The school's development is contingent on the efforts of all faculty and staff. The relationship between the school leader and the teacher is not simply one between the employer and employee. School leaders' thorough understanding of the nature of the teaching profession and the teacher's needs, as well as their capacity to build a highly collaborative team, is crucial for developing a democratic management mechanism in the school.

Specifically, teacher involvement in school management is conducive to the improvement of the school's management efficiency. By listening to the feedback from the teachers, the school leadership can have a clear understanding of the implementation status of their decisions. Accordingly, they can issue targeted instructions and deploy pertinent tasks to circumvent blindness and prejudice in their decision-making and improve their management efficiency (Liu, 1998). Also, involving teachers in the management and decision-making process by modifying the management hierarchy helps reduce the intermediary links and enables the teacher's opinions and suggestions to directly influence the decision-making of the school (Yu, 1995). In addition, fully utilizing the professional knowledge and experience of frontline teachers can make school management better suit the actual teaching needs and reduce the chance of disconnecting it from the actual circumstances of the school as the result of excessive bureaucracy (Wu, 2008).

Heightening Teachers' Dedication to the Teaching Profession

Teachers' involvement in school management can significantly enhance their dedication to their careers. First, involving teachers in setting the goals and plans for the school help boost their sense of responsibility. As a result, the increased ownership of these goals and plans can motivate teachers to devote more time to their implementation (Liu, 1998). Second, the policy of involving teachers in school management substantially increases their job satisfaction (Hu, 2014). When the teacher is involved in formulating schemes for performance evaluation and incentivization, they realize that decision-making processes like these are directly coupled with their own interests, which enables them to perceive the value of democratic participation, thereby improving their job satisfaction (Zhang, 2010). Third, the democratic style of school management can optimize the utilization of teaching resources, ensuring that each individual teacher has the opportunity to showcase their strengths, expertise, and competences and thus become more interested in their professional development. In this context, the teacher will identify more with their profession and be more ready to invest time and energy in their professional growth (Zhang, 2017).

Issues with Teacher Involvement in School Management in China

Teachers' Reluctance to Be Involved in School Management

Among the majority of Chinese teachers, pervasive is the mentality that a teacher should concentrate on their instructional work, while non-instructional work is irrelevant to their responsibilities, and that they cannot spare any time and energy for school management given their heavy instructional workloads (Yao, 2016). Hou et al. (2019) argued that the reasons for this mentality are twofold: the teacher's lack of recognition of their agency in school management and their loss of interest in it due to their unsuccessful experiences in this regard. According to Mei's (2010) survey in primary schools, most teachers polled focused their attention on teaching work and matters related to their personal interests, rarely paying regard to other school affairs; they limited their professional development to the teaching level without developing adequate awareness of participating in school management. As a result, as school members, they made no contributions to the construction of a democratic management climate in the school.

Furthermore, the teacher's intention of management involvement is related to their attitudes towards the changes in the field of education. In the context of intensified educational reforms, Chinese teachers are developing a

fresh understanding of their roles as educators and nurturing more diverse needs, such as senses of belonging, professional security, and self-actualization. Nevertheless, a portion of teachers who are insensitive or resistant to the ongoing transformations in the education world may still stick to the traditional notion of school management and exclude themselves from the efforts of school governance (Wang, 2023). Kong argued that there were two main reasons for this phenomenon. Firstly, the longstanding authoritarian culture in school management has led the teachers to believe that they do not have the discourse power in school governance. Secondly, the traditional hierarchical management pattern is deeply rooted in the teachers' impression of school management that the responsibility of decision-making resides with school leaders rather than ordinary teachers (Kong, 2013).

At the same time, certain researchers discovered that the teacher's unwillingness to become involved in school management is also due to a lack of legitimate incentive mechanisms. Song's research findings show that the majority of teachers did not receive any incentivization from the school or explicit invitations from the school leaders that encouraged their involvement in school management (Song, 2013). According to Liu's and Wu's study, school leaders tend to prioritize the evaluation of teachers' instructional work but neglect their basic rights as school members, which largely obliterates teachers' intention of participating in school management (Liu & Wu, 2014).

Personal Factors Influencing the Teacher's Involvement in School Management

Gender, service durations, and concurrent administrative positions, among others, are the factors affecting the teacher's participation in school management (Wang, 2023). There are significant gender differences in teachers' involvement in school decision-making. According to Lin's study of management involvement of Chinese primary and secondary teachers, the causes of these gender differences include that (i) the traditional prejudice of the woman taking a back seat is still pervasive and negatively influences female teachers' position in school management; (ii) the stereotype of the married woman being the primary care provider in the family hinders female teachers from devoting time to the school's management affairs; and (iii) the "assertive" presentation of male teachers in contrast to the more "gentle" attitudes of female teachers in the decision-making process makes the former's opinions more likely to be accepted by the school leaders (Lin, 2008).

Moreover, senior teachers are more active in participating in school management than their junior counterparts (Wang et al., 2009). Lin's

research found that teacher groups with prior service durations of 11–20 years and 6–10 years both had higher levels of management involvement than the group with less than five years of service. Often, older teachers' opinions have more weight in school decision-making than their younger peers; the overrepresentation of senior teachers in the faculty congresses of primary and secondary schools well mirrors the issue. Also, senior teachers with richer instructional experience are more likely to concomitantly act as team leaders, grade leaders, or administrators, thus being at an advantage in contributing to school decision-making (Lin, 2008).

Lin's study also suggests that teachers holding concurrent administrative positions have more discourse power than ordinary ones. The majority of Chinese schools adopt the pyramid-style management structure, which gives priority to management efficiency but at the expense of depriving ordinary teachers of the right to speak, resulting in the concentration of decision-making power in a handful of "high-ranking" school members. Ordinary teachers may have difficulty expressing their opinions through easily accessible channels to effectively influence the decisions of school leaders (Lin, 2008).

A Lack of Organizational Arrangements for Involving Teachers in School Management

Popular among Chinese schools is the principal responsibility system, which is basically a hierarchical management model where the decision-making power primarily resides with the principal-centered school leadership. With this system, there are few avenues for ordinary teachers to take on the management work, let alone be involved in the decision-making process (Hou et al., 2019). Some principals and their leadership teams still adhere to the outdated notion that teacher involvement in school decision-making undermines the efficiency and quality of this process in fear of the difficulty of reaching agreement when all staff has the right to speak (Wang, 2013). Yet, the teachers' right to speak is crucial for promoting peer communication among them and developing their sense of belonging to the school. Also, it ensures that they have the opportunity to exercise their power to oversee the school's operations (Zhang, 2020). However, in a school with an authoritarian climate, where the principal is the "boss" who orders the teacher what to do, there is no need for the latter to be shared with the decision-making power (Zhao et al., 2012).

At the same time, in some of the schools that declared the implementation of democratic management, the deployment of democratic procedures is often superficial, only serving as a response to the requirements from the higher-level educational authorities (Hou et al., 2019). While the teachers are seemingly involved in school management, they are

only going through the motions in form. Over time, they develop the perception that their management involvement is ineffective and become indifferent to school affairs (Jin, 2019). In a survey on the role of secondary teachers in school management, nearly 60% of teachers polled contended that organizational arrangements in this regard are far from sufficient (Chen, 2012). In addition, the faculty congress is not functioning as it should in the majority of schools, where ordinary teachers have no chance to express their real opinions (Hu, 2014). A survey of the faculty congress of the school found that 74% of respondents chose to "agree" or "fairly agree" with the statement that this organization is mere a formality with little substantive meaning (Yao, 2016).

Conclusion

In the context of educational reform and advancement, the teacher needs to take on more roles other than just being "Mr. Teaching." Only when teachers truly participate in school management can school leaders, society, and the government understand the real circumstances of the school, the authentic needs of teachers, and most importantly, the needs of students as the future pillars of the country. To this end, it is imperative to institutionalize teacher involvement in school management by specifying the rights and responsibilities of the teacher in this area as well as the concrete enactment procedures to provide an institutional framework for ensuring their participation in school governance. Also, the school needs to strengthen teacher training on education management knowledge and competences to enhance teachers' capacity for decision-making and management involvement. Equally important are consideration of the individual differences among teachers and the provision of personalized opportunities for management involvement to ensure each of them realizes their full potential in the most suitable management area.

References

Chen, T. (2009). Teacher involvement in school management: Conceptual underpinnings and enactment measures. *Journal of Teaching and Management*, 2009(33):15-17. DOI: https://doi.org/10.3969/j.issn.1004-5872.2009.11.006

Chen, X. (2012). The development and innovation of teaching management under the New Curriculum Program. *Primary Science Education*, 2012(5):31. Available at: https://kns.cnki.net/kcms2/article/abstract?v=sxrP1m9hSI804tJp2Sm2jDrbsEbSQ6

N3IAIhNjTmGgGOkpmVDwRKKXQjIXDVENcesHBgzFbBOOUBFKTNZmgbpBttde55sGJsmBh28KehqI-tJh3y1pthKgRe29cbDJJFxMz8zFy7gJ0VJVFbixL9_EZCgAay49uGr3nmN58R1DpiiQwalKKM_vpSIgVDJrkU&uniplatform=NZKPT&language=CHS

Chu, J. (2009). The participation of primary and secondary teachers in school management. *Journal of the Chinese Society of Education*, 2009(8):39-43. Available at: https://kns.cnki.net/kcms2/article/abstract?v=5YEXlE_hGrx2pZFjBtFxu4vuc6xbb5wKB046UiyuNZxXkQCYzy6OlXqEKuN_5AT6ludoLKG76e_DbEvpGXbe9ke1rSgi814CMgxBOFcQLKH1aTwNbV4sPPLsOL-stFCOTsfEKKzB6pxbGd_HxfzE7jcRy9msg8mdDFGpqcYr2YFMm0NJitKqb6t_zJjI5i4X&uniplatform=NZKPT&language=CHS

Hou, Y, Yang, S, & Zhao, S. (2019). Teacher participation in school management: Challenges and countermeasures. *Theory and Practice of Education*, 39(13):29-32. Available at: https://kns.cnki.net/kcms2/article/abstract?v=5YEXlE_hGrz8VV-wIZzmiNIhMgzfje8FmgoiK9-JUACmG9Ks7VKT7_vVDBI2dw9se6JE2RadEYuaT53ngofs0SKGd6XK56xoet40VzuO66M7lenhgikrCQdxRGv3W75ikjys7_3Kdt9UOqrogSgxRZEwvgD9jUAyLt8CgdxI0TcdIMI-ZmAXbKwXb9JUTWoD3lqu8ILqO9U=&uniplatform=NZKPT&language=CHS

Hu, S. (2014). Teacher involvement in school decision making. *Journal of Inner Mongolia Normal University (Education Science Edition)*, 27(8):30-32. Available at: https://kns.cnki.net/kcms2/article/abstract?v=5YEXlE_hGrz3Ph1RNFD5jL8RwHY3bIDwvC6cLUMY4sz3U12KStnXR3YcqbbH23nPxofmu1vaU9RXOLphg4oNzn4gWJm0RDc0EJ3O9vHv7qOGRQZ2Nm97BjvQqgh2EfrHMrED4x-FVMwnanmP0zz45DtI-sjBtKI5AJU7fS-nElxg5eXJbgEWH48oEk8PhScTH&uniplatform=NZKPT&language=CHS

Jin, Y. (2019). Issues with teacher involvement in school management. *Management and Technology of SME*, 2019(12):30-31. Available at: https://kns.cnki.net/kcms2/article/abstract?v=5YEXlE_hGrxxLNlCXTQ90Oxf-810xJncqMrrX0-fZD9BiMXUl6tl6tkOxfnk2hsWbuY6Uxx4b8eJa-YzL8qVFSd5tEGpFQB0XBjr8xu_Stx5R0G99xQOP30snhMEZxjWPeA08YTX6a0Dk3AqqLZPZMpsnNgqQ7uxcw_q6a0-JFSGgQhnQYDSKp9OkGXeqcnJjkjTZaRdKpM=&uniplatform=NZKPT&language=CHS

Kong, F. (2013). Teacher involvement in school leadership and decision-making: Issues and reflections. *The Forum of Leadership Science*, 2013(3):35-37. Available at: https://kns.cnki.net/kcms2/article/abstract?v=5YEXlE_hGrxaEi3qMnnlu0wsqPrlscNi4boxRHXBGWzBORCTTB-N6fQf8NCbv6GrZqAdFhS0tDdE1LUys7cBHV_sm3EURETROX1aGeS1CAzJhU99ajfPbXw5M1fFzpVeH65pB__VgV92cVkUkBUDbDUvndRRBmN6Dhohhe68uxfJysnH7JYYOUDCWKREMzvx&uniplatform=NZKPT&language=CHS

Lin, C. (2008). The current state of the involvement of primary and secondary teachers in school decision-making. *Theory and Practice of Education*, 28(32):43-45. Available at: https://kns.cnki.net/kcms2/article/abstract?v=5YEXlE_hGrxFG7dImIgaT6-Xf51i4Vw9Hg_HIqjko1lBJMdqfdAlPpbA2kob2Qag8DhUGVtpsX5-oyu7gG6tnC5cKVxShMlqyG8yI5of2XnvM24USp0R9K4yDuhfrM2AO2Y9Vg-k-Nn77O2Eochget4xxtP6bxlrKx1ZPo18DnwtAr4Tnlc9SJ2ut67qpQCX&uniplatform=NZKPT&language=CHS

Liu, H. (1998). Teacher involvement in school management. *Journal of Political Science and Law*. Available at: https://kns.cnki.net/kcms2/article/abstract?v=5YEXlE_hGryVxRrFbecCmvo_cQMvrUpdcj4tQ1v8-bGIVJMgn5vKyLSdvo-XVA4jWT8UbGXaqjIAxbpOzm2-Hl9BnloDPnv5GgduUTdHd4jo8365f04Ou3iDt6ON9Z4HBZul032tbymMM1_C0XFS3emL91Uidvb9yHzuya5ZvTmks4u2q0-bfrjfQX58UPBA&uniplatform=NZKPT&language=CHS

Liu, X. (2002). Teacher involvement in school management. *Liaoning Education Research*, 2002(12):29-31. DOI: https://doi.org/10.16697/j.cnki.xdjygl.2002.12.009

Liu, X & Wu, J. (2014). The participation of college teachers in school management: From the perspective of the empowerment theory. *Journal of Jiangsu Open University*, 25(2):90-93. DOI: https://doi.org/10.13425/j.cnki.jjou.2014.0

2.020

Mei, X. (2010). Democratic rights of the teacher. *Journal of Shaoguan University*, 31(10):71-74. Available at: https://kns.cnki.net/kcms2/article/abstract?v=sxrP1m9hSI-844rsN4dRnv6yqOAK-X6kG7L187l6kGEMqQ992oAajjwSa-3zJuaB0D60qXGAwufMMo4PtMzbdpD-hZzlYPtJSj3Yomqt0DZxB09uIrmD7TTLz6WImsyZq6ZM6md-RBHySuoZNpoPcrqa8E8Iutob68aKyKcHicE3mKdZEYRSuNyQVMQINdG5&uniplatform=NZKPT&language=CHS

Song, Y. (2013). The Participation of Middle School Teachers in Shahekou District in School Management (master's thesis). Heilongjiang University. Available at: https://kns.cnki.net/kcms2/article/abstract?v=sxrP1m9hSI88Twvsp6oi1xMPcH2RlpIX-WepfVBzez74r9bR6qmj2pLKp01xzHkxzhTyoCQRXp1zYfHym7INyoh2fC5iWYGXysE_LiWrJHqyX68Y6h5lb0UeecXPAtBOiKcJH3n5Fjoxu30pXqHNw926C477Ylfk9OWeBIKPi_zJFY9xgoNSFk_GLsMELIm0pzSlDmJdkbY=&uniplatform=NZKPT&language=CHS

Wang, C. (2013). The Involvement of Senior Secondary Teachers in School Management: The Current State and Improvement Strategies (master's thesis). Sichuan Normal University. Available at: https://kns.cnki.net/kcms2/article/abstract?v=sxrP1m9hSI9-C7Hwh7KDwkLyiWy94PlrM09z4bmMC9PNzRd9GOGdBAChRUs3oSF7laojdLEEJH6lyD0v7mKpHQ6v-VEGyaghWl9BZ0flA5YhikzecFciMcV-PItU0IwzQojWoiCLXLDMIFUW5_duQ6ChMD9MWygubmB1g7_Uq4tOnkDFyUJXwaWFWcqBncwSMUl4sTM6NEo=&uniplatform=NZKPT&language=CHS

Wang, Q. (2023). The participation of vocational college teachers in school governance: The current state and coping strategies. *Chinese Adult Education*, 2023(8):26-30. Available at: https://kns.cnki.net/kcms2/article/abstract?v=5YEXlE_hGrxFkqKwEYmpwkCML9eB5NDG_yE-lxJzs39XjLU6mKkflZmYZqMi323UlHJThLZl5GVe0biXHWqTzqZe_d-CkY0zG-YojgRHSDT5DLLjpF3hUt5n6hHJQoUjfKsOAJxDjFHEZph1GJip3u57B2EVRCvCX-hC44KFa82Mru3b_h5uBbEcQbJvAuXY2EeXPihltOA=&uniplatform=NZKPT&language=CHS

Wang, Z., Li, L., & Shi, X. (2009). The participation of primary and secondary teachers in school democratic management. *Journal of Inner Mongolia Normal University (Education Science Edition)*, 22(2):127-130. Available at: https://kns.cnki.net/kcms2/article/abstract?v=5YEXlE_hGry_SeI65QvzYyJLaApA7Pai6Oy_mjHmvVs3TnfQA7rqdKo3PjdyAcD2RJM7BFEohGneE9tuk8pRyp7uSftgKzKlh5pPhVxW-v9ogss2DHx7p6HAeEYhrqHuGVGkfTHxmxOLk63Bk-KultYU5EYhG35ZGCRcjmRcg2SXDCvFq-lj8vZTx8isma2z&uniplatform=NZKPT&language=CHS

Wu, Y. (2008). Foreign research on leadership of primary and secondary teachers and its implications. *International and Comparative Education*, 2008(8):52-57. Available at: https://kns.cnki.net/kcms2/article/abstract?v=5YEXlE_hGrygGVG7W8jy2pHBeES0sNiHiOK6A_Fhwt_4dYdwL8ze5yP1rtWsxPKaducWjUSKryPeVdd_8P60QJ06c7eqAgCObTYX-oXIzZB7aEGTCl0QimA7lZYhkNUspqlJix-R3Evw-QnE-y6DtqZRCJ5sBNpIvySzc6XiE_PSCd7YDH8Tm0BzSmgmXehM&uniplatform=NZKPT&language=CHS

Yao, Q. (2016). The Involvement of Primary and Secondary Teachers in School Governance (master's thesis). East China Normal University. Available at: https://kns.cnki.net/kcms2/article/abstract?v=yQB21MkjwM-ftf3gJ5VpoDNJXNEiP1bpFjwI0DqWwaACSJap_JvvHFnj5wjFFJZC4lK6qDGWxYPSfUe3DvDxmJpkMg5BDFf9adQtgEBZS-5lrKhC3cE2-8o9C6Cq41Tine3AoFuswhSj5dOgzJurJf8ebav0kixslgY8q3WfOpoj8Q-vSrjjKYmo_GF-3Rht9FbzrG4TwUE=&uniplatform=NZKPT&language=CHS

Yu, X. (1995). The role of teachers in school management. *Journal of Changzhou Normal University*, 1995(2):16-17. Available at: https://kns.cnki.net/kcms2/article/abstract?v=5YEXlE_hGrxydXS3g1ff35Rg3CLNW8SJuthwnhM3JiyYIB5exvPp-WiyD5DEeecp_aMhXiUOfcshkownkZR8hkJg8AHUokwIe4TeS6UY-hrecZ6DhxaBN-i6TH6lsCC1Wu_1eYQTL3mLmUf2hjYs

ip8A1x656mMwWebeW4AyLprkM7XvUfinkgNB5qpyGBnL&uniplatform=NZKPT&language=CHS

Zhang, J. (2010). The right of the kindergarten teacher to participate in school management: The current state and influencing factors. *Heilongjiang Chronicles*, 2010(17):149-150. https://kns.cnki.net/kcms2/article/abstract?v=5YEXlE_hGrx70FMlCjIiLwzCq7RHk8qYLRH-vqh37VWri_zW5uP_nrTLasRvU_AmQEHR_r3v2IZOIzExI91rahpjlcLSIczNzhVThUpcIjI-OojXxGlitqyaCz3a0ePH5j-qOTPqCWDFFm1jYU37gbltlekyaQ9IkFRYevI0hRnPTMnwLIwYf63jQ_OnlPa2&uniplatform=NZKPT&language=CHS

Zhang, L. (2020). A Brief Discussion on Teacher Participation in School Democratic Management. *Policy and Scientific Consultation*, 2020(1):43. Available at: https://kns.cnki.net/kcms2/article/abstract?v=5YEXlE_hGrzNUTNlXdCxdfINKWId7gDy0WOadugiuvTs9CWwbYZytR8Awhylj8Sfb8cyuLaUDMjPXPjeEcih-bdfLzL91rjgc8yw1Ci7i3OJg3Zr3yczdUOQaJpB7i7B5uFjipqV-pTV1zLUEKjnMxpITSnVqZhlT_BBa_G_MlJ1nZ_F2EejGIpk9HetUbIlZinMEWm06Mo=&uniplatform=NZKPT&language=CHS

Zhang, T. (2017). The participation of college teachers in school management. *Education Forum*, 2017(37):21-22. Available at: https://kns.cnki.net/kcms2/article/abstract?v=sxrP1m9hSI9Tg3T1-WFHjEfccYPuxct7f2m0guYyLtTZSNZFNcG2H6s_WRCTV_Ad9PlCbQu39ISQE7NW37cBQgNH0vX8WDnBWvofs9CHYXEXkc5NTeb7A5pXhBMB6DkodRgCn4TaDQYwYGl0MN1VpiIqC93Sb0FOGt4lBFPLGkNC6s0l4Baxif3o6ElEvDuxtF3onTfxYPE=&uniplatform=NZKPT&language=CHS

Zhao, Z, Wen, J., & Zhou, J. (2012). Teacher Involvement in School Management. *Journal of Teaching and Management*, 2012(15):34-35. Available at: https://kns.cnki.net/kcms2/article/abstract?v=5YEXlE_hGrxX5wbsqcHpzoDasNieg5zgmUOA8Md9ankP_jLyFO39XZq47zTyduTMj6ykU57kBp_s1Mp7xpGUh90CAWbs3HEwoSOGiuqTUkLOy1gEkljLls-_oU3xsOs1i90es84AIuEA3Z-e8kskZAxFSAA1i73DsLWANklJgrgnNNO7o1SfPkAXea8u7v-L&uniplatform=NZKPT&language=CHS

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Received: September 05, 2024
Revised: October 03, 2024
Accepted: October 10, 2024

ERRATUM

Erratum: Using the Mixed-Meta Method to Assess Portfolios in Science Teaching

Mehmet Diyaddin Yaşar,[1] Veli Batdi,[2] Büşra Kilinç,[1] Ayşe Nur Kiliç[1]

1. *Harran University, Şanlıurfa, Turkey*
2. *Gazianep University, Gaziantep, Turkey*

The corrections should be made as below,

- The (Alkan et al., 2019) used in the Methods section needs to be deleted. The Alkan et al. study is a mixed method [(Mixed methods design: a narrative literature review. Journal of Qualitative Research in Education, 7(2):559-582)]. However, the term used in our study is mixed-meta method. In addition, the term belongs to a different author and it has a completely different definition. (On the pages 3900 and 3914).
- Instead of "(Büyüköztürk et al., 2018 p.259-260)" (Batdı, 2020, p.3) should be added under the title "Meta-analysis procedure". (On the page 3903).

Science Insights Education Frontiers 2024; 24(2):4003

How to Cite: Yaşar, M. D., Batdi, V., Kilinç, B., & Kiliç, A. N. (2024). Erratum: Using the mixed-meta method to assess portfolios in science teaching. Science Insights Education Frontiers, 24(2):4003.

***Keywords**: Meta-Analysis, Meta-Thematic, Portfolio, Science Education*

***About the Authors**: Mehmet Diyaddin Yaşar, Education Faculty, Harran University, Şanlıurfa, Turkey. E-mail: mdiyaddinyasar@harran.edu.tr, ORCID: https://orcid.org/0000-0001-7512-580X*
Veli Batdi, Education Faculty, Gazianep University, Gaziantep, Turkey. E-mail: veb_27@hotmail.com, ORCID: https://orcid.org/0000-0002-7402-3251
Büşra Kilinç, MSc Student and Science Teacher, Education Faculty, Harran University, Şanlıurfa, Turkey. E-mail: busra.klnc75@gmail.com, ORCID: https://orcid.org/0000-0003-3777-9866
Ayşe Nur Kiliç, MSc Student and Science Teacher, Education Faculty, Harran University, Şanlıurfa, Turkey. E-mail: ayse.nur.5396@gmail.com, ORCID: https://orcid.org/0000-0002-2255-5643
***Correspondence to**: Mehmet Diyaddin Yaşar at Harran University in Turkey.*
***Conflict of Interests**: None*

Science Insights Education Frontiers
pISSN 2644-058X eISSN 2578-9813

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Science Insights Education Frontiers
Vol. 24, No. 2, 2024

pISSN: 2644-058X
eISSN: 2578-9813
DOI: 10.15354/sief

Science Insights Education Frontiers Vol. 24, No. 2, October 2024 Insights Publisher