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COMMENTARY

The Use of ChatGPT in Education: A New Path to Personalized Instruction

Yuhua Luo

Jiangsu Second Normal University, Nanjing 211200, Jiangsu, China

"Success in creating AI would be the biggest event in human history. Unfortunately, it might also be the last, unless we learn how to avoid the risks."
-Stephen Hawking

CHATGPT, an artificial intelligence (AI) program based on natural language processing and deep learning algorithm training, has the capacity to learn human languages and understand their semantics through colossal amounts of text data and to conduct natural language-based communication with humans (Jiao, 2023). It has garnered tremendous attention of the internet users since its release in 2022. It has also instigated a lot of discussions on its application in education among educational researchers and teachers. According to Aljanabi (2023), ChatGPT's potent information search and organization capabilities enable the student to seek out a more complete answer for the question and to obtain learning resources needed using natural language. Chu (2023) argued that ChatGPT could act as an AI teaching assistant to aid teachers in developing course plans and generating questions of varying difficulty levels as well as an intelligent academic supporter to help students with their academic papers and assessments. Research also shows that ChatGPT has significant value in the area of personalized learning.

Personalized learning allows the student to learn at their own pace and by the personally optimal method (Akyuz, 2020). ChatGPT has the potential to facilitate the learner proceeding with their own learning styles and accessing information necessary for their study, so improving the effectiveness of personalized learning and advancing its popularization (Limo et al., 2023). Furthermore, ChatGPT, based on large language models, has its advantage over older-generation intelligent assistance systems in that it has the capability to engage in enduring dialogue and natural language understanding and generation, as well as a certain level of reasoning (Xu et al., 2024), which enables the learner to interact with it in the way that they do with their teacher. This feature enhances its intuitiveness and user friendliness, making it applicable at different levels of education, from primary

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to tertiary education, as well as in personal professional development (Sreen & Majid, 2024). As a result, many researchers and educators have endeavored to integrate ChatGPT into personalized learning environments (PELs) or formal teaching environments. Xu et al.'s (2023) study explores the possibilities of applying ChatGPT to PLEs in higher education to find that it can help innovate learning assessment methods, elevate the student's engagement in learning, and improve digital literacy of teachers and students, thereby being conducive to the resolution of issues encountered in the implementation of PLEs. Some researchers have focused on the impact of ChatGPT on the practical outcomes of personalized learning. For instance, based on a survey of 785 Filipino college students on the use of ChatGPT in personalized learning, Agbong-Coates's (2024) study finds that the application of ChatGPT posed significantly positive effects to student personalized learning by enhancing students' learning experience and improving their academic performance.

The introduction of emerging technology into education often elicits controversy and worry. ChatGPT is no exception. Challenges of ChatGPT application in education include ethical issues related to data privacy, algorithm biases, and the potential risk of over-dependence on AI tools in students (Abas et al., 2023). Legitimate use of ChatGPT in instruction and optimization of its positive effects on student learning warrant further practical explorations. *Perspectives of Undergraduate and Graduate Students on Utilizing ChatGPT: Analyzing Its Role in Question Preparation* in this issue investigates the views of pre-service science teachers on educational application of ChatGPT and their utilization of ChatGPT in question preparation (Ceren Özer et al., 2024). Even though the study is limited to one feature of ChatGPT - question preparation, far from being an exhaustive examination of its roles in education, the research findings of the study can still serve as strong evidence for ChatGPT's positive effects in enhancing educational practices and supporting personalized teaching.

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COMMENTARY

Educational Big Data Initiates a New Era in Education Development

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"Data is the new oil."
-Clive Humby

OVER THE past more than ten years, big data technology has posed profound impacts to almost all sectors including education. This state-of-the-art technology prompts changes in educational notions, pedagogy, and the roles of teachers and students. Educational big data proliferates with the improvement of school digital infrastructure, popularization of campus networks, increase in educational applications, widespread use of learning management systems (LMS) and other terminal devices (Chaurasia & Rosin, 2017). There is a consensus among researchers that judicious exploitation of educational big data is beneficial for optimizing education resource distribution, reaching scientific educational decisions, and elevating the quality of instruction (Cui, 2023). The benefits of big data application in education have also been well recognized by educators; schools and other education institutions are increasing endeavors to integrate big data technology into instruction.

Currently, research on big data's involvement in education at various levels is growing. Feng's (2024) study suggests that visualized learning diagnosis based on big data has positive impacts on primary Chinese language teaching. Li et al. (2022) conducted an empirical study of the intervention outcomes of big data-based precision instruction in the senior secondary math classroom to find that this teaching method is effective in improving math performance of the students and sustaining dynamic precision intervention from the teacher. Zhang (2023) developed a big data-enabled, online case library-based teaching model for the course of jurisprudence. It proved helpful in improving students' understanding and application of basic knowledge of jurisprudence. To provide teachers with effective guidelines for big data-assisted classroom instruction, Wang et al. (2024) summarized nine data-based indicators of high-quality classroom teaching on the basis of

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research findings of previous studies, including educational beliefs, creative questions, critical questions, reflective knowledge, and more. Qian and Zhao (2023) conducted a systematic analysis of the roles of educational big data in teaching quality evaluation, noting that there remain issues with current evaluation systems, such as the low data literacy in evaluators, the lack of high-quality data support and a framework of criteria for evaluation, algorithm limitations, and data ethics-related constraints, despite the progress made in terms of diversification of evaluators, evidence collection, execution, and feedback. These issues hamper the across-the-board application of big data in education as well (Bai, 2021).

Therefore, while educational big data has showcased positive effects in enhancing the quality of education, the technology also faces many challenges regarding data security, data quality, application probelms, etc. Researchers need to undertake more theoretical and practical explorations of this relatively new area. Also, successful cases of educational big data application deserve more attention from academics. *The Application of Big Data-Based Precision Teaching in Chinese Education: Using Xichuan Experimental School in Chengdu City as an Example* in this issue encapsulates popular application modalities of big data-based precision teaching in China and expounds on its implementation procedures, using the practice of Xichuan Experimental School as an example (Chen & Zhou, 2024). The study exhibits the advantage of big data-based precision teaching over traditional precision instruction in increasing teaching outcomes. Further observations and validations of its effects are clearly warranted.

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ORIGINAL ARTICLE

An Investigation into the Mental Structure of Science Teacher Candidates towards the Concept of "Atom"

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***Abstract**: This study aimed to identify science teacher candidates' mental structures about the concept of the atom. This study included 120 science teacher candidates who were chosen using the convenience sampling method. This research is a phenomenological study. The data on students' mental models of the atom was collected using a metaphor form and an open-ended question form. Forms were utilized to collect written feedback from teaching candidates. The research data were subjected to content analysis. In addition, the MAXQDA application was utilized to assess and generate categorization. As a result of the research, science teacher candidates' mental structures about the concept of the atom were divided into six major categories. It has been discovered that atom models are most vividly represented in the mental structures of science teacher candidates while addressing the concept of the atom. Then, mental structures relating to the atom's structural properties, definition or conceptual explanation, historical process, subatomic particles, and functional function arose in that order. When the codes in these categories were reviewed in detail, it was discovered that the explanations provided were extremely cursory.*

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Introduction

CHEMISTRY is a science that examines the structure and behavior of matter, which is closely related to life (Samon & Levy, 2020; Seçen, 2013). In reality, traces of chemistry can be found in all activities performed at all stages of the day, beginning with waking up in the morning and washing our hands and faces with tap water and ending in the evening. This has prompted humans, who are also matter, to be obsessed with understanding matter and its structure from its inception (Sözbilir, Kutu, and Yaşar, 2013). Many scientists have worked hard to better comprehend the structure of matter, developing many models and theories. Models and theories are widely used to teach chemistry. In fact, science can be thought of as largely concerned with developing models for diverse aspects of the natural world (Adbo & Taber, 2009). The atom was central to these models and chemical activity (Tuvi and Nachmias, 2001). The concept of atoms dates back to before Christ and took centuries to completely understand (İnce, 2019). This is one of the most significant, popular, and central chemistry concepts and disciplines taught at all levels, from primary to university. It is clear that research into atoms and atomic structure, which we cannot directly observe and are difficult to visualize in our minds and imaginations, has a lengthy history, dating back to Democritus and continuing to the Modern Atomic Theory. Thus, various ideas, models, and explanations for the atom have been developed up to the present. An atom is a unit of matter that cannot be chemically divided. High-energy particle accelerators divide the atom into protons and neutrons, which are made up of quarks and antiquarks (Erdik & Sarıkaya, 2016). In this regard, the atom is one of the most fundamental notions that allow us to comprehend chemistry. To understand and experience the world around us, we must have a solid understanding of chemistry.

As a matter of fact, we make sense of the world by forming concepts and relationships between them. Concepts are also associated with mental structures (Atasoy, 2018). Scientific concepts represent the socially negotiated meanings of phrases or processes that people use to describe their interactions with the physical world (Hubber, 2006). Concepts can be defined as units of thought created by bringing together the common features of certain events, facts, and objects (Laçin-Şimşek, 2019). Concepts provide consistent meaning to events, processes, and objects across individuals (Özgür & Bostan, 2007). Teachers and teacher candidates in chemistry education and training must be knowledgeable about their field and subject. This field and subject knowledge mostly have an abstract structure. In the teaching of chemistry, such subject and field knowledge requires explanations that provide causal relationships between observed phenomena and abstract microscopic dimensions (Wheldon, 2012). Furthermore, students must develop mental models that are based on scientific knowledge of chemical ideas. Students' mental models of a concept provide valuable information about whether or not it is fully grasped. Mental models are shaped by individuals' cognitive systems and how they perceive concepts, and they might offer us information regarding misconceptions that people hold (Demirci, Yılmaz, & Şahin, 2016). Mental models are dynamic mental structures formed by individuals through cognitive processes (Atasoy, 2018). Individuals create mental models when interacting with their surroundings, which are then processed and comprehended in connection to pre-existing mental models (Hubber, 2006). Correct mental models are important guides for producing correct thoughts, and individuals who do not have mental models in accordance with scientific models cannot produce correct thoughts (Atasoy, 2018). Chemistry as a discipline is dominated by the use of models (Coll & Treagust, 2003). Students have difficulty developing mental models that are supported by scientific knowledge about the structure of the atom. Examining students' mental models, including university students, provides us with the required insights to measure their conceptual progress and detect their misconceptions. However, since the existing studies are few in number, studies on mental models related to the structure of the atom need to be expanded (Demirci, Yılmaz & Şahin, 2016). It seems that teachers' views on science-related concepts have been examined extensively in the last thirty years (Papageorgiou & Sakka, 2000). Research on students' mental models of atoms (Nakiboğlu, Karakoç, and Benlikaya, 2002; Özgür and Bostan, 2007) and content analysis of related papers (Demirci, Yılmaz, and Şahin, 2016) were undertaken. Additionally, students' mental models of other concepts in science, such as acid-base (McClary & Talanquer, 2011), ionic bonding (Coll & Treagust, 2003), diffusion (Stains & Sevian, 2015), optics (Hubber, 2006), environment (Shepardson, Wee, Priddy & Harbor, 2007), etc., have not been examined. When the literature is reviewed, it is clear that many studies have been undertaken to determine students' mental models, which include misconceptions about the structure of the atom. However, such research primarily focuses on determining conceptual learning and misunderstandings about the atom and its structure. These types of studies are really essential. It is equally crucial that additional such research be conducted. Conducting contemporary studies on the concept of the atom is critical to determining how the current situation will proceed. The current study seeks to identify which categories science teacher candidates' mental structures about the concept of an atom fall into. It was also investigated whether these mental structures are compatible with today's scientific reality. Thus, the concept of the atom, its structure, and evolution are addressed from a contemporary standpoint.

Purpose and Research Questions

This study sought to uncover the mental structures of science teacher candidates regarding the concept of the atom. The investigation aimed to answer the following questions:

1. What categories do science teacher candidates' mental structures about the concept of an atom fall under?
2. What are the perceptions of science teacher candidates towards the concept of the atom?
3. How do science teacher candidates visualize the concept of an atom in their minds?

Method

This research is a phenomenological study. The goal of phenomenology is to turn lived experience into a description of its "essence," allowing for reflection and analysis (McMillan & Schumacher, 2010). Phenomenological studies are suitable for studying affective, emotional, and often intense human experiences (Merriam, 2009). Phenomenological studies concentrate on phenomena such as events, experiences, perceptions, trends, conceptions, and circumstances that we are aware of but do not fully comprehend (Yıldırım & Şimşek, 2008). The concept of the atom is the phenomenon under investigation in this study. Although students are familiar with the concept of an atom, it is difficult to observe and comprehend because it is an abstract structure.

Participants

This research included 120 science teacher candidates who were selected through the convenience sampling method. A convenience sample is a group of participants chosen because they are easily available or convenient (McMillan & Schumacher, 2010). Participants in this research volunteered to take part and were chosen because they were convenient and easy to reach.

Data Collection Tools

Data on students' mental models of the atom were gathered through the administration of a metaphor form and one open-ended question form. Forms were used to elicit written opinions from teacher candidates. To uncover their metaphors for the concept of atom, teacher candidates were asked to complete the sentence "*Atom is like... because...*" Written opinions of teacher candidates were taken in the form of an open-ended question in order to determine their level of understanding and categories of the concept of atoms. The open-ended question in the form is, "*What do you understand from the concept of an atom? Explain.*"

Data Analysis

Content analysis was performed on the research data. A type of qualitative data analysis is content analysis. Patton (2014) defines content analysis as a qualitative data reduction effort aimed at the basic consistencies and meanings of the loaded and voluminous qualitative material or data received. It is the process of arranging and analyzing similar material within the framework of certain concepts, codes, categories, and themes (Yıldırım & Şimşek, 2008).

In this research, content analysis was conducted in two parts. In the first step, science teacher candidates' understanding of the concept of atom was subjected to content analysis. The data acquired from the form of open-ended questions was examined at this step. As a result of the content analysis, prospective teachers' explanations about atoms were divided into six main categories. These categories and the number of subcodes they contain are as follows: mental structure for the:

1. Atomic models: It contains 223 codes.
2. Structural properties of the atom: It contains 129 codes.
3. Definition/conceptual explanation of the atom: It contains 121 codes.
4. Historical process of the atom: It contains 78 codes.
5. Subatomic particles: It contains 51 codes.
6. Functional function of the atom: It contains 29 codes.

The second stage was to analyze the metaphors created by science teacher candidates on the concept of the atom. This concept's metaphors have been determined. At this point, it was checked to see if the metaphors were written completely and if the reasons behind them were clarified. Codes are used to express the recognized metaphors. The explanations and justifications supplied by teacher candidates for the metaphors were evaluated, and categories reflecting each code, that is, metaphor, were constructed.

Results

The findings of the research were presented in two stages. The results of the open-ended question are included in the first stage, followed by the results of the metaphorical form in the second.

Stage 1: Results Obtained through the Open-Ended Question

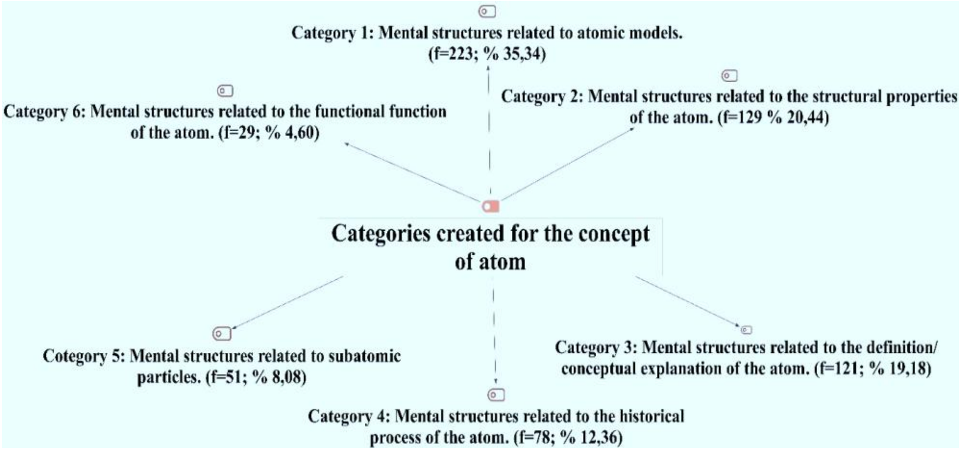

Figure 1. Categories Created for the Concept of Atom.

In the first stage, the categories of the science teacher candidates' mental structures regarding the concept of an atom were determined through open-ended questions.

Figure 1 includes categories related to the concept of atom, in line with the statements of science teacher candidates. As shown in the table, six categories have been defined for the concept of an atom. The six categories were mentioned 631 times in total. The reason for this is that science teacher candidates produced multiple explanations or propositions regarding the atom. It was determined that among these categories, the most common ones were "mental structures related to atomic models" (f = 223, 35.34%). The second category consisted of "mental structures related to the properties of the atom" (f = 129, 20.44%), followed by "mental structures related to the definition/conceptual explanation of the atom" (f = 129, 20.44%). Other categories can be seen in detail in **Figure 1** above. In addition, the codes in these six categories and the percentages and frequencies of these codes are presented in detail in **Tables 1-6**.

Table 1 depicts science teacher candidates' mental structures toward atomic models. As shown in the table, 28 distinct codes have been developed for the structure of the atom. These codes were used 223 times by 120 teacher candidates. The first two of these codes were identified as "There are numerous atomic models" (f = 30 and 13.45%) and "There is a Dalton model of the atom" (f = 29 and 13.01%). It has been observed that 7 of these codes—codes 14, 15, 16, 17, 19, 23, and 27—do not comply with scientific reality, and this rate is 5.40%. The remaining codes were found to match scientific reality at a rate of 94.60%.

Table 2 depicts science teacher candidates' mental constructs regarding the structural properties of the atom. The table shows that 26

Table 1. Science Teacher Candidates' Mental Structures Related to Atomic Models.

N	Codes	f	%
1	There are numerous atomic models.	30	13.45
2	There is a Dalton model of the atom.	29	13.01
3	There is the Thomson model of the atom.	26	11.66
4	There is the Rutherford model of the atom.	22	9.87
5	Thomson likened the atom to a raisin cake model.	20	8.97
6	There is the Bohr model of the atom.	19	8.52
7	There is a modern atomic model.	17	7.62
8	Today, modern atom theory is used as the final atomic theory.	13	5.83
9	In the raisin cake model, the batter or cake represents protons, and the grapes represent free-moving electrons.	8	3.59
10	Dalton stated that an atom is indivisible.	6	2.69
11	Dalton likened the atom to a solid, undivided sphere.	5	2.24
12	Rutherford tried to explain the concept of an atom with the "gold plate" experiment.	4	1.79
13	Democritus proposed the atomic shape.	4	1.79
14	Dalton defined the atom as "hollow globules.".	3	1.35
15	Bohr developed a solid-sphere model for the atom.	2	0.90
16	Rutherford used the concept of orbit for the first time in his atomic model.	2	0.90
17	The atom, according to Bohr, is an electron cloud.	2	0.90
18	Democritus likened the atom to an indivisible part.	1	0.45
19	Rutherford postulated that the atom is made up of a nucleus surrounded by electrons and protons.	1	0.45
20	Bohr postulated that the atom consists of a system of orbitals.	1	0.45
21	According to Dalton, the atoms of all elements are the same.	1	0.45
22	Dalton's atom model made no mention of subatomic particles like protons, neutrons, or electrons.	1	0.45
23	Thomson proposed that the atom is the smallest, indivisible building block of matter.	1	0.45
24	Rutherford employed alpha-rays in her atom model experiment.	1	0.45
25	In the atom, electrons are assumed to be in the electron cloud.	1	0.45
26	The atom has been compared to the world model.	1	0.45
27	The atom is like an empty balloon.	1	0.45
28	According to Bohr's atom theory, there are gaps in the structure we define as an atom.	1	0.45
	Total	223	100

N: Number of codes.

distinct codes have been developed for the structure of the atom. These codes were used 129 times by 120 teacher candidates. The first two of these codes were identified as "An atom consists of subatomic particles such as protons, neutrons, and electrons" (f = 49 and 37.98%) and "Protons and neutrons are present in the atom's nucleus, while electrons are in circles around it" (f = 24 and 18.60%). It has been observed that 9 of these codes—codes 2, 5, 10, 11, 19, 20, 23, 24, and 26—do not comply with scientific reality, and this rate is 29.48%. The remaining codes matched scientific reality at a rate of 70.52%.

Table 3 depicts science teacher candidates' mental structures considering the definition or conceptual explanation of the atom. As shown

Table 2. Science Teacher Candidates' Mental Structures Related to the Structural Properties of the Atom.

N	Codes	f	%
1	An atom consists of subatomic particles such as protons, neutrons, and electrons.	49	37.98
2	Protons and neutrons are present in the atom's nucleus, while electrons are in circles around it.	24	18.60
3	Atoms can be split and divided.	13	10.08
4	The majority of atoms are hollow.	6	4.65
5	Atoms cannot be divided, or disintegrated.	5	3.88
6	Matter cannot be split into atoms and analyzed under normal conditions.	3	2.33
7	In laboratory environment, atoms of matter can be investigated.	3	2.33
8	The majority of atomic mass is made up of nuclei.	2	1.55
9	Protons and neutrons are concentrated at the center of the atom, while electrons form an electron cloud surrounding it.	2	1.55
10	The atom is mobile.	2	1.55
11	An atom is shaped like a solid sphere.	2	1.55
12	There are isotope atoms.	2	1.55
13	There are isotone atoms.	2	1.55
14	There are isoelectronic atoms and ions.	2	1.55
15	Isotope atoms have the same number of protons but differ in the amount of neutrons.	1	0.78
16	Isotone atoms have the same number of neutrons but differ in the number of protons.	1	0.78
17	Isoelectronic atoms and ions have the same number and configuration of electrons.	1	0.78
18	There are isobar atoms.	1	0.78
19	Elements are in a cycle within the atom.	1	0.78
20	Atoms are the most basic structure of subatomic particles.	1	0.78
21	Each atom has its own mass number.	1	0.78
22	Electrons rotate both around themselves and the nucleus.	1	0.78
23	The orbit closest to the nucleus has the smallest energy.	1	0.78
24	The energy of the orbitals increases as they move away from the nucleus.	1	0.78
25	The atomic structure contains both positive and negative charges.	1	0.78
26	There are atoms in the molecular structure.	1	0.78
	Total	129	100

N: Number of codes.

in the table, 17 distinct codes were developed for the defining or conceptual explanation of the atom. These codes were used 121 times by some of the 120 teacher candidates. The first two of these codes were identified as "An atom is the smallest unit of matter" (f = 68 and 56.20%) and "An atom is the smallest particle of matter that can be divided" (f = 12 and 9.92%). It has been observed that 9 of these codes—codes 1, 2, 7, 8, 9, 10, 11, 14, and 17—do not comply with scientific reality, and this rate is 76.85%. The remaining codes were discovered to be compatible with scientific reality at a rate of 23.15%.

Table 3. Science Teacher Candidates' Mental Structures Related to the Definition/Conceptual Explanation of the Atom.

N	Codes	f	%
1	An atom is the smallest unit of matter.	68	56.20
2	An atom is the smallest particle of matter that can be divided.	12	9.92
3	An atom is a unit of matter made up of small structures and subatomic particles known as mesons and quarks.	9	7.44
4	The atom is the smallest unit of matter that possesses all of its properties.	6	4.96
5	The atom is the most fundamental particle of matter.	6	4.96
6	An atom is the smallest particle of matter that may be divided into smaller pieces and retains all of its properties.	5	4.13
7	An atom is a unit of matter that exhibits all of its qualities and cannot be divided into smaller parts.	3	2.45
8	An atom is the smallest particle of an element.	2	1.65
9	An atom is a model that has protons and neutrons in its nucleus and electrons moving in layers around it.	2	1.65
10	An atom is the concentrated form of the energy of matter.	1	0.83
11	An atom is matter's smallest energy state.	1	0.83
12	The atom is the smallest structural unit that describes the physical and chemical properties of matter.	1	0.83
13	An atom is a unit that exhibits the properties of matter.	1	0.83
14	An atom is defined as everything that occupies space and has mass.	1	0.83
15	The atom is the fundamental structural unit of the universe.	1	0.83
16	Atoms are models of atomic processes.	1	0.83
17	An atom is energy that can change into solid, liquid, gas, or plasma and is in a constant state of motion and vibration.	1	0.83
	Total	121	100

N: Number of codes.

Table 4. Science Teacher Candidates' Mental Structures Related to the Historical Process of the Atom.

N	Codes	f	%
1	When the first atom theories were proposed, the atom was thought to be indivisible.	21	26.92
2	Theories, models, and concepts that the atom is divisible have been proposed over time.	19	24.36
3	Many researches have been conducted on the atom up to the present day; it has gone through many processes, and many scientists have thought and produced ideas on the atom.	17	21.78
4	Democritus named it "atomus" originally, which means "indivisible" in Greek.	8	10.26
5	With modern atomic theory, it has been seen that the atom is divisible.	3	3.85
6	Chadwick discovered the neutron.	2	2.56
7	Rutherford discovered the proton.	2	2.56
8	Thomson discovered the electron.	2	2.56
9	Dalton made the first definition and study of the atom.	2	2.56
10	Following Democritus, Dalton conducted the first examination of the atom model.	1	1.28
11	Aristotle explained the atoms as fire, water, air, and earth.	1	1.28
	Total	78	100

N: Number of codes.

Table 5. Science Teacher Candidates' Mental Structures Related to Subatomic Particles.

N	Codes	f	%
1	Protons have a positive charge.	12	23.53
2	Electrons have a negative charge.	12	23.53
3	Neutrons have no charge.	10	19.61
4	Orbitals are the most likely locations for electrons to be discovered.	2	3.92
5	Electrons are being exchanged.	2	3.92
6	The number of protons represents the atomic number.	1	1.96
7	Subatomic particles such as electrons, neutrons, and protons are not the smallest particles of matter because they lack matter's characteristics.	1	1.96
8	When an atom acquires an electron, it becomes an anion.	1	1.96
9	When an electron is lost, the atom is transformed into a cation.	1	1.96
10	There is no proton exchange.	1	1.96
11	There is no neutron exchange.	1	1.96
12	Electrons make up the majority of the atom volume.	1	1.96
13	The mass of the electron is very small compared to other subatomic particles such as protons and neutrons.	1	1.96
14	When electrons move from the upper orbit/layer to the lower orbit/layer, they emit light.	1	1.96
15	Electrons become more stable as they move away from the nucleus.	1	1.96
16	Electron orbits/layers are formed when protons and electrons interact electrically.	1	1.96
17	Ionic bonding occurs through electron exchange.	1	1.96
18	Covalent bonding occurs as a result of electron sharing.	1	1.96
	Total	51	100

N: Number of codes.

Table 4 depicts the mental structures of science teacher candidates regarding the historical process of the atom. As shown in the table, 11 distinct codes have been created for the historical process of the atom. These codes were mentioned 78 times by some of the 120 teacher candidates. The first two of these codes were determined to be "When the first atom theories were proposed, the atom was thought to be indivisible." (f = 21; % 26, 92) and "Theories, models, and concepts that the atom is divisible have been proposed over time." (f = 19; % 24, 36). It was observed that three of these codes—codes 5, 9 and 11—did not comply with scientific reality, and this rate was 7.69%. The remaining codes were found to match scientific reality at a rate of 92.31%.

Table 5 depicts the mental structures of science teacher candidates regarding subatomic particles. As seen in the table, 18 different codes have been developed for subatomic particles. It was observed that these codes were expressed 51 times by some of the 120 teacher candidates. The first two of these codes were determined to be "protons have a positive charge." (f = 12; % 23.53) "Electrons have a negative charge." (f = 12; % 23.53). It

Table 6. Science Teacher Candidates' Mental Structures Related to the Functional Function of the Atom.

N	Codes	f	%
1	Atoms exhibit the properties of matter.	8	27.59
2	Atoms combine to produce compounds.	4	13.79
3	Atoms determine the character / properties of elements.	3	10.35
4	Atoms combine to form molecules.	3	10.35
5	The atom determines the chemical properties of matter.	2	6.90
6	The atom determines the physical properties of matter.	2	6.90
7	When atoms are divided, enormous amounts of energy are released.	2	6.90
8	When atoms unite, new substances are produced.	2	6.90
10	When different or the same atoms are joined, they generate atoms with various structures.	1	3.35
11	Atoms are responsible for the transmission of electricity.	1	3.35
	Total	29	100

N: Number of codes.

Table 7. Metaphors Created for the Concept of Atom.

Categories	Codes	f	%
Functional function of the atom	Cell (f=12), Water (f=3), Material / Cement (f=3), Human (f=2), World (f=2), Sun (f=2), Culture (f=2), Letter (f=2), Puzzle/Lego pieces (f=2), Fetus/Zygote (f=2), Backbone of chemistry, Memory substance (Chip), Soil, Essence, Gravity, Organ, Mother, Inside of an Onion, Brain, The tip of a pencil, A piece of wood, Bricks, Family, Nebula, Teacher, Stone, Breath, Bead, Core, Life, Heart, Tree, Seed, Complex fruit juice.	56	46.67
Atom models	Solar system (f=8), Earth (f=8), Round ball (f=3), Universe (f=2), Onion (f=2), Planet Saturn, School, House, Avocado, Human body, Lahmacun, Olives, Menthol candy, Dust cloud, Baklava, Peach.	34	28.33
Structural properties of the atom	Class (f=2), Human (f=2), One of the Pomegranates (f=2), Book (f=2), Magma, Universe, Seed, Building, Dot, Bacteria, Ant, Society, Cake, Water, Cone, Emotions, Soil, Hospital, Family, Cell, House, Hazelnut, Fruit cocktail, Education system, Matryoshka, Chemistry.	30	25.00
Total		120	100

was observed that four of these codes—codes 7, 14, 15, and 16—did not comply with scientific reality, and this rate was 7.84%. The remaining codes were found to match scientific reality at a rate of 92.16%.

Table 6 depicts the mental structures of science teacher candidates regarding the functional function of the atom. The table shows that 11 different codes were created for the atom's functional function. It was observed that these codes were stated 29 times by some of the 120 teacher candidates. The first two of these codes were determined to be "Atoms exhibit the properties of matter." (f = 8; % 27, 59) and "Atoms combine to produce compounds." (f = 4; % 13, 79). It was observed that two of these codes—codes 10 and 11—did not comply with scientific reality, and this rate was 6.7%. The remaining codes were found to match scientific reality at a rate of 93.3%.

Stage 2: Results Obtained through the Metaphor Form

Table 7 shows science teacher candidates' metaphorical perceptions of the concept of atoms. The table shows that their metaphorical views were divided into three categories. The categories are "functional function of the atom," "atomic models," and "structural properties of the atom".

Table 7 shows that science teacher candidates' metaphorical perceptions were primarily categorized as "functional functions of the atom" (f = 56, 46.67%). It was established that the code "Cell" (f = 12) was the most common in this category. In the second category, it was determined that there were "atomic models" (f = 34, 28.33%), and under this category, the codes "solar system" and "world" (f = 8) were mostly mentioned. In the third category, "Structural properties of the atom" (f = 30, 25.00%) was included, and it was determined that codes such as "Class," "Human," "One of the pomegranates," and "Book" (f = 2) were the most repeated. According to the statements of the teacher candidates, some codes, such as human, universe, water, and sun, although they are the same, is placed in different categories in terms of their meaning. **Table 7** contains detailed information on the three main categories and their sub-codes.

Conclusion and Discussion

As a result of the research, the mental structures of science teacher candidates regarding the concept of the atom were grouped into six main categories. It has been revealed that atom models are most vividly represented in the mental structures of science teacher candidates while discussing the concept of the atom. Then, respectively, mental structures related to the structural properties of the atom, the definition or conceptual explanation of the atom, the historical process of the atom, subatomic particles, and the functional function of the atom emerged. When the codes under these categories were examined in detail, it was seen that the explanations put forward were very superficial. In addition, it has been revealed that macroscopic explanations for the concept of atom are dominant, and the concept of atom cannot be detailed as we go to the microscopic dimension. It has also been discovered that some codes, or explanations in this category, contradict scientific knowledge. The codes in each category are addressed separately.

In the first category, the mental structures of science teacher candidates regarding atomic models were collected under 28 codes. These codes were most commonly expressed by teacher candidates. In other words, when teacher candidates hear the word “atom,” they immediately think of atomic models. Teacher candidates mostly stated the names of models such as Dalton, Thomson, Rutherford, Bohr, and Modern atomic theories that were developed, respectively. However, some teacher candidates stated that the most recently developed atomic theory is the Modern Atom Theory. This has revealed that the atom and the atom model in the minds of the teacher candidates are not compatible with today’s Modern Atom Theory. In addition, some of the statements of the teacher candidates in this category, although very few, such as “Dalton defined the atom as hollow globules,” “Bohr developed a solid-sphere model for the atom,” and “Rutherford used the concept of orbit for the first time in his atomic model,” contradict scientific knowledge. Codes 14, 15, 16, 17, 19, 23, and 27 are also in opposition to scientific knowledge, with a relatively low rate (5.40%). The remaining codes have correct information (94.60%). Although these codes contain accurate information and are at a high rate, they only explain the features of atomic models developed before the Modern Atom Theory that are no longer valid today. In the second category, the mental structures of teacher candidates regarding the structural properties of the atom were revealed. Teacher candidates stated 26 different codes in this category 129 times. When the codes in this category are checked, most teacher candidates indicate that the atom is made up of subatomic particles like protons, neutrons, and electrons. This situation is similar to previous studies (Ekinci & Şen, 2020), where most of the students tend to explain and describe the classical structure of the atom. Furthermore, teacher candidates indicated that the atom is fissionable, has a hollow structure, and cannot be viewed or examined under normal circumstances. It has been noted that the statements made here are only superficial, and the microscopic structure of the atom cannot be fully explained. Additionally, some codes in this category do not match scientific knowledge. The second code in this category, “Protons and neutrons are present in the atom’s nucleus, while electrons are in circles around it,” contradicts scientific knowledge. Bohr Atom Theory defines the structure of an atom using this code. In addition, codes 5, 10, 11, 19, 20, 23, 24, and 26 do not comply with scientific reality, and this is 29.48%. This rate can be considered significantly high. The remaining codes agree with scientific reality by 70.52%. The high rate and compatibility with scientific knowledge should not deceive scientists or researchers. Because, despite the high rate, teacher candidates do not employ modern atom theory to explain the structure of the atom, instead merely superficially discussing the existence of subatomic particles. Also, it has been noticed that the Bohr atom model is more prevalent in the thoughts of teacher candidates. Similar to previous studies (Allred & Bretz, 2019; Ekinci and Şen, 2020; Harrison and Treagust, 1996; Harrison and Treagust, 2000; McKagan, Perkins, and

Wieman, 2008; Nakiboğlu, Karakoç, and Benlikaya, 2002; Özcan, 2013; Özgür and Bostan, 2007), this current study revealed that the structure of the atom is still mostly trying to be explained according to the Bohr atom model. The explanations focused on the concept of "orbit or layer" and made statements that are no longer valid today and do not comply with scientific reality. While students draw and visualize the structure of the atom, it seems that the modern atomic model is neglected (Derman, Koçak, and Eilks, 2019). On the other hand, although Modern Atom Theory is shown in lessons, this situation is reflected in the mental models of very few students (Demirci, Yılmaz, and Şahin, 2016). It should be evident that in modern atomic models, electrons do not "fly around" in the atoms, nor are they concretely "located" in or on any form of shell or circle. However, if teacher educators use the shell metaphor to explain quantum numbers and their accompanying energy levels, science teacher candidates may understand this as "forming shells (Derman, Koçak and Eilks, 2019). According to current modern atom theory, an atom consists of a nucleus in the center and a cloud of electrons surrounding it. Based on this, when explaining the structure of the atom, the electron cloud and orbitals, which are places where electrons are likely to be found, should be brought to the fore. It is important to develop analogies and metaphors for this purpose and use them in science lessons.

In the third category, the mental structures of teacher candidates regarding the definition or conceptualization of the atom were revealed. When the codes in this category were examined in detail, it was seen that the teacher candidates had serious deficiencies and had difficulties conceptualizing the atom. The first two codes in this category say, "An atom is the smallest unit of matter." and "An atom is the smallest particle of matter that can be divided" entirely contradicts modern definitions of the atom. In addition, codes 7, 8, 9, 10, 11, 14, and 17 do not comply with scientific reality, which is 76.85%. The atom is often explained as the smallest piece of matter, the smallest piece of matter that can be divided, the smallest piece of matter that shows all the properties of matter and cannot be divided into smaller pieces, etc. It may be argued that the phrase "smallest" is the one that misleads teacher candidates, students, and pupils. In other words, when discussing the concept of an atom, explanations center on the phrase "smallest," omitting or ignoring all other aspects. The teacher candidates and learners may not be inclined to consciously make such a statement. But what is vital is that the phrase "smallest" gets entrenched in the minds of the teacher candidates and sticks like a nail. This can be considered the foundation of explanations that contradict scientific knowledge. As a matter of fact, while students' mental structures regarding the structure of the atom are examined, concepts such as nucleus, atomic model, mass, particle, electron, and layer or shell come to the fore (Ekinci and Şen, 2020). As can be seen, “particle” is one of the concepts that students associate with. Gradually, this expression “particle” is being replaced by the expression “smallest particle”. The point to underline here is that it is felt that it would be more appropriate to use phrases such as a representative component or unit that explains a property of the matter rather than the smallest part. In this respect, it can be said that it would be more appropriate to define an atom as a part, unit, and structure that determines and characterizes the chemical properties of matter. In the fourth category, teacher candidates’ mental structures on the historical process of the atom were investigated. Teacher candidates explained that the atom has gone through a number of processes until now, that many scientists have thought about the atom and produced ideas, and that it has been the subject of many studies based on a long historical past. They emphasized that when the first atom theories were put forward, the idea that the atom was indivisible was dominant. But they said that over time, theories, models, and ideas were put forward that the atom was divisible. Explanations in this category contain some superficial information about the historical process and development of the atom. The majority of this information appears to agree with scientific knowledge. However, as stated in codes 5, 9, and 11, comments that contradict scientific reality were made, albeit in small numbers, with a rate of 7.69%, which is low. For example, some teacher candidates stated that the atom is divisible according to modern atomic theory. This information or explanation is erroneous, and it was proven that the atom is divisible and that there are subatomic particles long before the Modern Atomic Theory. In the fifth category, the mental structures of teacher candidates regarding subatomic particles were revealed. Teacher candidates mostly focused on the statements “protons are positively charged,” “electrons are negatively charged,” and “neutrons are uncharged.”. They mostly explained the charges of subatomic particles. They also stated that electrons exchange between atoms, but protons and neutrons do not interchange, and that ionic and covalent bonds are formed through electron transfer or sharing. However, they did not mention subatomic particles such as quarks, mesons, etc. other than protons, neutrons, and electrons. It has been recognized that explanations that are incompatible with modern atomic theory have been made, as well as deficiencies in understanding subatomic particles using modern atom theory. However, only two teacher candidates identified the locations where electrons are most likely to be found, as well as the phenomenon or concept of orbitals. It can be argued that there are major deficiencies in explaining teacher candidates’ mental structures relating to atomic particles in detail and that these are not at the microscopic level. However, some codes, albeit very few—codes 7, 14, 15, and 16—do not comply with scientific reality. The phrases used in the codes, such as “Subatomic particles such as electrons, neutrons, and protons are not the smallest particles of matter because they lack matter's characteristics," and "when electrons move from the upper orbit/layer to the lower orbit/layer, they emit light," are just a few examples. Here again, while subatomic particles are explained, the focus is on the Bohr atom model and the expression of the smallest particle of matter. This makes it difficult to perceive, understand, and remember subatomic particles. In the final category, teacher candidates' mental structures about the functional function of the atom were revealed. Teacher candidates explained the functional function of the atom using codes such as "Atoms exhibit the properties of matter," "Atoms combine to produce compounds," "Atoms determine the character and properties of elements,", "Atoms combine to form molecules," "The atom determines the chemical properties of matter," and "The atom determines the physical properties of matter". Although very few statements were made that contradict scientific knowledge, as can be seen from the codes, "When different or the same atoms are joined, they generate atoms with various structures." and "Atoms are responsible for the transmission of electricity."

In this research, teacher candidates' mental structures regarding the concept of the atom were examined. Students or learners have difficulty creating mental models for the concept of the atom (Çökelez, 2012). Students' misunderstanding of concepts causes them to create non-scientific mental structures and models regarding science concepts (Didiş-Körhasan and Wang 2016). In science classrooms and lessons, analogies like the solar system, the cell, and the shell metaphor are used to convey the notion of the atom. Before employing analogies and metaphors with students in scientific classrooms, teachers openly clarify their importance in both common language and science (Derman, Koçak and Eilks, 2019). Similar results were obtained in this study, and it was discovered that the solar system and the word model emerged as prominent metaphors in the teacher candidates' atom-related metaphors. As a conclusion, in this current study, while explaining the atom, teacher candidates focused on atomic models, structural properties of the atom, the definition or conceptualization of the atom, the historical process of the atom, subatomic particles, and the functional function of the atom. While teacher candidates explain the atom using these categories, they may have some deficiencies and mistakes. It is obvious that these explanations are very superficial. It has also been noticed that they cannot make sense of the atom by reducing it to a microscopic level. But it is also important that they focus on these six categories. Because when we say atom, these categories explain how the atom comes to life in the imaginations of teacher candidates in particular and learners in general. The most crucial aspect is that these six categories should be interpreted and supported by current atomic theories, theses, and scientific knowledge. This may take some time and prove tough in the short term. However, it should not be forgotten that the concept of the atom was developed more than 2,000 years ago. It is a well-known yet complex concept that takes a long time and involves several processes. It can also be argued that the concept and structure of the atom gained a fully scientific identity over the last two centuries, beginning with the Dalton atom theory and continuing with modern atom theory. Of course, it will be difficult for the concept of the atom, which takes a long time, is significant, and is the foundation of science and chemistry, to be fully grasped, precisely, and in harmony with scientific knowledge, as well as to be structured in the minds of the students or learners. However, realizing this makes it necessary to take precautions and make appropriate arrangements. There is no need to wait another 2000 thousand years for the atom to be comprehended and perceived. However, even if it will take a long time for the concept of the atom, which is compatible with scientific knowledge, to become embedded in the minds of the students, this risk must be taken.

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ORIGINAL ARTICLE

Perspectives of Undergraduate and Graduate Students on Utilizing ChatGPT: Analyzing Its Role in Question Preparation

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***Abstract**: Artificial intelligence (AI) is increasingly integrated into daily life across various sectors such as banking, healthcare, tourism, and education. This research aims to investigate science teacher candidates' opinions on using ChatGPT in education and their approaches to preparing questions with this artificial intelligence tool. Specifically, it aims to elucidate the role of ChatGPT in question preparation processes and its potential applications in education. A case study methodology was employed, focusing on 17 fourth-year science teacher candidates and 6 graduate students in a science education master's program during the fall semester of 2023-2024. Data were collected using an interview form and images of participants' conversations with ChatGPT. Content analysis of the data reveals that most participants intend to use ChatGPT in their teaching process for research and question creation. Participants provided specific details in their prompts to ChatGPT, including grade level, unit, subject area, learning outcomes, question type, number, and difficulty level. This study highlights the potential of ChatGPT to enhance educational practices and support teachers in personalizing learning experiences.*

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Introduction

THE RAPID integration of advancing technology in our daily lives is evident in many fields such as health, banking, industry, logistics, and education (Tekin, 2023; Yalçın-Çelik & Çoban, 2023). The increasing digitalization with advancing technology has increased the value of artificial intelligence studies (Yalçın-Çelik & Çoban, 2023; Cooper, 2023). Artificial intelligence technologies are technologies that mimic human intelligence, possessing abilities such as thinking, reasoning, analyzing, and concluding, similar to human intelligence (Cooper, 2023; Aktay et al., 2023). These technologies, along with artificial neural networks and machine learning, with the help of computers and algorithms to process information, learn, generalize, problem-solve, and process language, can perform many human cognitive skills (Cooper, 2023).

Today, as in many fields, the use of artificial intelligence technologies is increasingly intensifying in the field of education (Tekin, 2023; Aktay et al., 2023). Artificial intelligence in educational areas is being utilized in many educational processes such as tracing educational steps towards everywhere-accessibility in the field of education. Artificial intelligence provides speed and convenience in analyzing, evaluating, and providing feedback on learning outcomes for teachers and students; by offering personalized educational programs tailored to individual needs, it enables students to progress at their own learning pace, ensures that students who are unable to attend formal education for any reason have access to an educational environment 24/7, prevents interruptions in their educational lives, and increases efficiency in the education process by enabling them to receive additional support in areas where they struggle (Yalçın-Çelik & Çoban, 2023; Mogavi et al., 2024). The utilization of artificial intelligence in the educational area is expanding from web-based content to online smart learning systems and chatbots which are getting more popular today (Aktay et al., 2023). A chatbot, which is a tool for conversation, is defined as an artificial intelligence program that is used to answer questions from users via text-based dialogue with the user (Meço & Coştu, 2022).

When the literature is inspected, it is obvious that several studies on artificial intelligence and chatbots in education have also been beginning to increase recently, as well as in all other areas (Mogavi et al., 2024; Tekin, 2023; Yalçın-Çelik & Çoban, 2023; Cooper, 2023; Doğru, 2023; Aktay et al., 2023; Darayseh, 2023; Meço & Coştu, 2022; Wu & Yang, 2022; Chai et al., 2021). ChatGPT is seen as one of the chatbot technologies that has become more and more widespread. ChatGPT, an abbreviation for Chat Generative Pre-trained Transformer, is an advanced chatbot technology that is developed and trained using a massive-scale word database and is capable of producing coherent and context-oriented answers to miscellaneous questions of humans with the help of Natural Language Processing (NLP) algorithms (Mogavi et al., 2024). Artificial intelligence applications, such as ChatGPT, which include massive-scale language models themselves depend on prompt engineering which is a systematic approach designed to provide effective communication (Heston & Khun, 2023).

Prompt engineering states a skill set that is used for applying certain rules over massive-scale language models, automatizing processes, and making obtained outputs provide certain qualifications (White et al., 2023). Heston and Khun (2023) mention prompt engineering in medical education in their studies. According to Heston and Khun (2023), prompt engineering is defined as including designing needed input for a model to produce the desired output. It is witnessed that this way, in the medical education field, realistic patient scenarios can be created and more effective results can be obtained in explaining medical concepts. Also in that study, it is emphasized that prompt engineering has a crucial role in the optimization of effective interaction with massive-scale language models and outputs (Heston & Khun, 2023). Henrickson and Meroño Peñuela (2023) mention polarized controversies on improvements in Natural Language Generation (NLG) and social effects of technologic developments, especially as ChatGPT, in their studies. According to Henrickson and Meroño Peñuela (2023), prompt engineering is defined as a technique that ensures the direction of the natural language generation system's output by setting inputs that the user gives into the system. Additionally, in their study, they state that prompt engineering has significant importance for artificial intelligence technologies and as artificial intelligence is not unbiased, it is influenced by human interactions (Henrickson & Meroño Peñuela, 2023). Lee et al. (2023) remark on the effects of prompt engineering in English education and also investigate prompt engineering usage in the development of Automatic Question Generation (AQG) systems, in their study. According to Lee et al. (2023), prompt engineering is described as utilizing certain instructions to help a language model yield requested results. In their study, they also declare that thanks to prompt engineering techniques, the validation and reliability of the questions are increased (Lee et al., 2023).

With the assistance of prompt usage in the educational field, Automatic Question Generation (AQG) systems ensure obtaining more effective desired results through language models such as ChatGPT. By using effective and appropriate prompt usage in language models, students' comprehension levels of taught topics can be evaluated, questions for teachers to ask students can be generated, and also the quality of those questions may be interpreted. Additionally, teachers can be given opportunities to develop different lecture materials (Lee et al., 2023). Taking these advantages into account, it is clear that the usage of language models in education may increase the quality of education, integration of current technologies into the education field, and thus functionality of education.

In education and many other fields, language models provide opportunities like easing people's lives, reducing their workloads, and assisting rapid and simple access to information. Some leading technological development examples in this field may be ChatGPT which is created by OpenAI, or Bard.ai and Gemini developed by Google Inc. Among the aforementioned language models, Turkey's national language model MAIN GPT, which is developed by Havelsan Inc. The model which has its name as an abbreviation of the words "Multifunctional Artificial Intelligence Network" is a language model that is trained by Turkish content exclusively (Havelsan, 2023). It is predicted that this national language model will be able to analyze resources written in the native Turkish language and upon those analyses yield more fulfilling answers in the native Turkish language compared to counterpart models that are trained in foreign languages when released publicly. It will contribute to the students who are creating content in their native language and also allow teachers who are preparing educational materials to utilize the Turkish language's richness maximally.

This study aims to determine undergraduate and postgraduate students' opinions about ChatGPT itself and its usage in the educational field, also prompt structures they use when they are generating questions through ChatGPT.

Method

Research Model

As the research model, a case study, which is one of the qualitative research methods, was preferred. The result of the case study is important for revealing the problem situation with a holistic approach without making a generalization and providing ideas for future research (Yıldırım & Şimşek, 2021).

Research Group

The research was conducted with 17 science teacher candidates in the 4th grade of the science education undergraduate program of a state university's faculty of education in the Central Anatolia Region and 6 master's students studying in the graduate program during the fall semester of the 2023-2024 academic year. The participants of the research were selected using the convenience sampling method. The demographic information of the participants (age, gender, grade level) is included in **Table 1**.

Table 1. Demographic Information of the Participants.

Code names of the Participants	Gender	Age (yr)	Grade Level
KL1	Male	22	4th Grade
KL2	Male	23	4th Grade
KL3	Female	21	4th Grade
KL4	Female	22	4th Grade
KL5	Female	21	4th Grade
KL6	Female	22	4th Grade
KL7	Female	21	4th Grade
KL8	Female	22	4th Grade
KL9	Female	23	4th Grade
KL10	Female	22	4th Grade
KL11	Male	21	4th Grade
KL12	Female	21	4th Grade
KL13	Female	22	4th Grade
KL14	Female	22	4th Grade
KL15	Female	21	4th Grade
KL16	Female	21	4th Grade
KL17	Female	23	4th Grade
KY1	Female	23	Postgraduate
KY2	Female	25	Postgraduate
KY3	Female	30	Postgraduate
KY4	Female	32	Postgraduate
KY5	Female	24	Postgraduate
KY6	Female	25	Postgraduate

Implementation Process

The implementation consists of three weeks with two hours per week for both undergraduate and graduate students. A class was created on Google Classroom for monitoring the implementation process, and the weekly activities were uploaded to this platform. During the first week of the implementation process, the participants were informed about the definition of artificial intelligence, the application areas of artificial intelligence, the definition of ChatGPT, and the application areas of ChatGPT. They were also encouraged to conduct research using ChatGPT by selecting one of the environmental issues as a topic. They uploaded their research to the Google Classroom platform until the next class. In the second week, the research conducted by the participants in the previous week was discussed in the class.

Then, the participants worked on creating lesson plans and stories about environmental issues. The work was uploaded to the platform. In the last week, the participants were informed about the definition of prompt engineering, the importance of prompt engineering, and its place in ChatGPT. Then, an activity of question generation using prompts was conducted and the participants were given an assignment to generate questions about an environmental issue they had chosen. The assignments were uploaded to the Google Classroom platform and reviewed.

Data Collecting Tools

In the research, the "Interview Form for ChatGPT and Its Use in Education" prepared by the researchers was used as the data collection tool and the data consisted of the conversations the participants had with ChatGPT-3.5. To enhance the credibility (validity) and consistency (reliability) of the qualitative research, several measures were taken. These include credibility (long-term engagement, depth-focused data collection, diversification, participant verification, expert review), transferability (detailed description, purposive sampling), consistency (consistency examination), and confirmability (confirmability examination) (Yıldırım & Şimşek, 2021). The semi-structured interview form prepared by the researchers is a questionnaire consisting of 10 open-ended questions aimed at determining participants' views on ChatGPT and its use in education. After initially creating the interview form, the researchers sought the opinions of two experts on ChatGPT and its application in education. Subsequently, the questions posed by the researchers were revised based on the experts' suggestions.

Collecting the Data

The data for the study was obtained through a semi-structured written interview form and screenshots of the conversations participants had with ChatGPT-3.5, after a 3-week implementation process.

Analysis of Data

The data collected in the study was analyzed using the content analysis method. In the content analysis method, categories and codes defined by the researcher are established. These categories and codes will contribute to other researchers in determining categories in line with similar results (Silverman, 2001). Firstly, for the analysis of the study, a code according to their grade levels was assigned to each participant who attended the study. Afterward, similar answers provided by the participants were grouped by the researchers under the same codes. The codes, which were examined based on their similarities and differences, were presented in table format to ease the analysis.

Table 2. Distribution of Participants According to Their Demographic Information.

Parameter		f	%
Gender	Male	3	13.1
	Female	20	86.9
Distribution of Ages	21	7	30.4
	22	7	30.4
	23	4	17.3
	24	1	4.4
	25	2	8.7
	30	1	4.4
	32	1	4.4
Grades	4th Grade (Undergraduate)	17	73.9
	Postgraduate	6	26.1

Table 3. Distributions According to First Resources of Information About ChatGPT.

Category	Code	Participant Code	f	%
First Resources of Information	Circle of Friends	KL1, KL3, KL7, KL11, KL13, KL16, KY 2	7	30.5
	Lectures	KL4, KL12, KL14	3	13.0
	Social Media	KL2, KL5, KL6, KL8, KL9, KL10, KL15, KY1, KY5	9	39.1
	Haven't Heard	KL17, KY3, KY4, KY6	4	17.4

Results

This chapter covers the presentation of findings obtained from participants' answers to the questionnaire in the form of a table and an examination of prompt structures they used while generating questions. Firstly, the demographic information of research participants is examined. In this context, the distribution of participants according to their demographic information is in **Table 2**.

Participants are asked, *"Have you ever heard of ChatGPT? If so, where have you heard? (Circle of friends, social media, etc.),*" and their answers to those questions are analyzed (**Table 3**). In **Table 3**, similar answers from the participants about where they first had been informed of ChatGPT were summed and examined.

Table 4. Distributions Upon Purposes of Usage of ChatGPT before the Research.

Category	Code	Participant Code	f	%
Purposes of Usage	Researching	KL4, KL8, KL15, KY1	4	17.4
	Chatting	KL10, KL11, KL14	3	13.0
	Homework	KL1, KL2, KL3, K5, KL9, KY5	6	26.1
	Haven't Used	KL6, KL7, KL12, KL13, KL16, KL17, KY2, KY3, KY4, KY6	10	43.5

When **Table 3** is viewed, participants' answers about first resources of information on ChatGPT are analyzed by dividing them into 4 subtitles. It is determined that most of the participants (19 participants, 82.6%) had already been informed about ChatGPT before this field research and also that the "Social Media" code has the widest (9 participants, 39.1%) share amongst the information resources. Also, it is seen that amongst the first information resources, there are other codes such as circle of friends and lectures. Lastly, some of the participants stated they had never heard of ChatGPT. Some of the opinions obtained from the research which belong to the participants are given below:

"Yes, I've heard it first in a circle of friends." (KL1).

"Yes, I've heard it first from social media platforms." (KL6).

"Yes, I've heard it first in a lecture." (KL14).

"No, I haven't heard it before." (KY4)

The participants are asked, "*Have you ever utilized ChatGPT before this field research? If yes, for which purpose have you utilized? Please explain*." Their answers are examined as frequency and percentage. In **Table 4**, similar answers of participants about whether they had ever used ChatGPT before this study and, if they had, which purpose they had aimed at are categorized under the same subtitles.

When **Table 4** is viewed, participants' answers about usage areas of ChatGPT before this research are examined broadly under 4 subtitles. It shows that before the research, most of the participants of this research had used ChatGPT for areas like researching, chatting, and preparing homework (13 participants, 56.5%). Some opinions of the participants obtained from this study about usage areas of ChatGPT are given below:

"I have used it for it to help my homework." (KL3).

"I have used it to chat with it." (KL10).

Table 5. Distributions Upon Purposes of Usage of ChatGPT before the Research.

Category	Code	Participant Code	f	%
Emotions while using ChatGPT	Astonished	KL2, KL9, KL13, KL17, KY2	5	21.8
	Excited	KL1, KL7, KL10	3	13.0
	Relaxed	KL3, KL11, KL12, KL15, KY3, KY5	6	26.1
	Happy	KL5, KL8, KL14, KY1, KY4, KY6	6	26.1

> *"No, I haven't used it before." (KL17).*
>
> *"I have used it to find answers to questions that caught up to my mind while doing research." (KY1).*

The participants are asked, *"How did using ChatGPT, which is an artificial intelligence program, make you feel?"*. Similar answers the participants had given are categorized under the same codes. The research participants' answers about emotions they felt while using ChatGPT are summed under the same subtitles and examined in **Table 5**.

When **Table 5** is viewed, answers of the research participants about emotions they had felt during the usage of ChatGPT are analyzed under 5 subtitles. Answers given are seemingly gathered under "Relaxed" (6 participants, 26.1%) and "Happy" (6 participants, 26.1%) codes. Also, other participants in the research are dispersed towards "Excitement," "Astonishment," and "Unease/Anxiety" codes. Some opinions about the participants' emotions, which are obtained from the research, are given below:

> *"This excited me." (KL1).*
>
> *"Not sure but I felt a bit uncomfortable." (KL6).*
>
> *"I realized flaws and inadequacies of artificial intelligence, and this surprised me." (KL13).*
>
> *"Ability of easy access to information is time saving and this gladdened me." (KY1)*
>
> *"I'm amazed and astonished." (KY2).*

The participants who attended the research were asked, "*Have you ever utilized an artificial intelligence program similar to ChatGPT? If yes, what was its name, and what was the purpose of your usage? Please explain.*" **Table 6** answers the research participants' questions about whether they had

Table 6. Distribution of ChatGPT-like AI Utilization.

Category	Code	Participant Code	f	%
ChatGPT-like AI programs	Diffit.me	KL1, KL10, KL13, KL14, KL17	5	21.8
	Gamma.app	KL4, KY6	2	8.7
	Magicschool.ai	KY1	1	4.3
	Bard	KY2, KY3, KY4	3	13.1
	Monica.im	KY5	1	4.3
	Popai.pro	KL3	1	4.3
	Haven't used before	KL2, KL5, KL6, KL7, KL8, KL9, KL11, KL12, KL15, KL16	10	43.5

Table 7. Distribution of Positive and Negative Opinions on ChatGPT and ChatGPT-like AI Programs.

Category	Theme	Code	Participant Code	f	%
Positive and Negative Opinions	Positive	Convenience	KL1, KL4, KL5, KL8, KY4	5	21.8
		Productivity	KL2, KL3, KL11, KL13, KL14, KL16, KL17, KY1, KY5	9	39.1
		Time saving	KL6, KL7, KL9, KL10, KL12, KL15, KY2, KY3, KY6	9	39.1
	Negative	Self-Repetition	KL5, KL7, KL17, KY6	4	17.3
		Unreliability	KL10, KL11, KL12, KL14, KY1, KY4, KY5	7	30.5
		Laze	KL6, KL16, KY2, KY3, KY4	5	21.7
		Misinformation	KL1, KL2, KL4, KL8, KL9, KL13, KL15	7	30.5

used any artificial intelligence program similar to ChatGPT or not and, if they had, which ones. Those programs are summed under the same subtitles based on the similarities.

When **Table 6** is viewed, participants' answers about the utilization of any ChatGPT-like AI programs are examined under 7 subtitles. The participants that had used an AI program other than ChatGPT mostly gathered in the "Diffit.me" code (5 participants, 21.8%), seemingly. Additionally, the fact "Gamma.App", "Magicschool.ai," "Bard," "Monica.im," and "Popai.pro" programs were also used is determined. Some opinions belonging to the participants that are obtained from the research are given below:

"I had used Popai application." (KL3).

"No, I haven't used any." (KL8).

"I haven't used before." (KL9).

"I had used Diffit.me application for generating questions." (KL14).

"I had used Google Bard application to try it." (KY3).

"I had used Gamma.app application to prepare a presentation." (KY6).

The research participants are asked, "*What are the positive and negative aspects of ChatGPT and ChatGPT-like artificial intelligent programs when used in the educational field? Please explain*." Similar answers of the participants telling their positive and negative opinions on ChatGPT and similar AI programs are summed and examined on **Table 7** based on resemblances.

When **Table 7** is viewed, answers to the participant's opinions on ChatGPT and ChatGPT-like programs are grouped into 2 categories, "positive" and "negative" ones. 3 subtitles are under the "positive" category, and 4 are under the "negative" category. Positive opinions of the participants are gathered under "Convenience," "Productivity," and "Timesaving" codes, whereas negative opinions are gathered under "Self-Repetition," "Unreliability," "Laze," and "Misinformation" codes. Some opinions that are obtained from the research about the positive/negative thoughts of the participants are given below:

"To me, the greatest good of it is that it provides ease while researching, not necessarily it gives the most correct results, and it does the job." (KL5, positive).

"Using it, we end up doing similar homeworks with friends." (KL5, negative).

"When I am stuck at some point, it can be consulted to get an idea." (KL11, positive).

"It isn't always reliable." (KL11, negative).

"It significantly decreases the time a research takes, this is quite useful." (KL15, positive).

"It may offer incorrect information. Using without verification may give rise to problems." (KL15, negative).

"It may ease up the job while generating questions. It can be utilized in order to make introductions of lectures more interesting." (KY4, positive).

"Since students would extensively rely on these programs while doing homework, they will use the information they get as is, without verification. This will lead them to laze and prevent the instinct of curiosity and researching in them." (KY4, negative)

Table 8. Distribution According to the Opinions of the Participants on Lectures Taught Using ChatGPT.

Category	Code	Participant Code	f	%
Opinions on lectures taught using ChatGPT	Different	KL3, KL5, KL6, KL7, KL8, KL9, KL10, KL11, KL13, KL14, KL15, KL16, KL17, KY1, KY3, KY4, KY5	18	78.3
	Not different	KL1, KL2, KL4, KL12, KY2	5	21.7

Table 9. Distribution According to Intended Purposes of ChatGPT After Once Using It.

Category	Code	Participant Code	f	%
Intended Purposes of ChatGPT after Once Using It	Creating Texts	KL1, KL16	2	8.7
	Designing of Lesson Plans and Experiments	KL8, KL10, KY1	3	13.1
	Researching	KL4, KL11, KL14, KL15, KL17, KY4, KY6	7	30.4
	Question Generation	KL5, KL6, KL9, KL12, KY3, KY5	6	26.1
	I wouldn’t use	KL2, KL3, KL7, KL13, KL17	5	21.7

The research participants are asked, “*Do you think a lecture taught using ChatGPT or conventional methods are different? If yes, which differences are there in your opinion? Please explain*.” In **Table 8**, similar answers of the research participants about opinions on the differences between lectures taught using ChatGPT or conventional methods are summed and analyzed based on similarities.

In **Table 8**, answers the participants gave on whether there is any difference between lectures taught using ChatGPT or conventional methods are examined. Most of the participants (18 participants, 78.3%) stated lectures taught using ChatGPT have differences. Some opinions of the research participants are given below:

> *“Yes, it will be different. Because this way we incorporate technology into the lecture more.” (KL7).*
>
> *“Yes, it will be different. It will be useful in the aspect of learning new knowledge and practices in lectures.” (KL10).*
>
> *“Sometimes, AI programs may have an error, apart from that there won’t be any differences.” (KL12).*

> *"To me, there would be difference. In conventional methods we are given the knowledge directly but using ChatGPT, we can investigate and question the knowledge." (KL16).*
>
> *"I don't think there would be any difference." (KY2).*
>
> *The research participants are asked, "Would you use ChatGPT, an artificial intelligence program, as an educational tool again? If yes, what would be the reason? Please explain."*

In **Table 9**, similar answers of the research participants about whether they would use ChatGPT for educational purposes again and what purposes they would aim for are summed and examined under the same subtitles based on similarities.

When **Table 9** is viewed, the answers of the participants, asking if they would use ChatGPT for educational purposes again and if they would, what the purposes would be, are divided under 5 subtitles. Most research participants (18 participants, 78.3%) stated they would use ChatGPT as an educational tool again. Also, the participants who stated they would use it again mentioned that they would have intended purposes such as "Creating Texts," "Designing Lesson Plans and Experiments," "Researching," and "Question Generation." Some opinions of the participants obtained from the research are given below:

> *"I would use it again to make it create texts." (KL1).*
>
> *"I would use it again in order to get opinions when I got stuck while creating questions and educational contents." (KL6).*
>
> *"I would use it to get help while preparing lesson plans or educational contents or studying for an exam." (KL10).*
>
> *"No, I wouldn't use it." (KL17).*
>
> *"Yes, I would use it again. I think it ensures more active participation to the lecture since it engages attentions of students. Students researching and trying to reach to the information rather than being given the knowledge directly to them in lecture times makes the learning process more yielding." (KY1).*
>
> *"I would use it even as a regular search engine." (KY6).*

The research participants are asked, "*What are the prompt structures you have used while asking ChatGPT to generate questions? Please share an example conversation screen of yours"*. The participants' answers are

Table 10. Distribution of the Prompt Structures the Participants Had Used While Asking ChatGPT to Generate Questions.

Category	Code	Participant Code	f
The Prompt Structures Used While Asking ChatGPT to Generate Questions	Grade Level	KL3, KL5, KL6, KL8, KL9, KL10, KL11, KL14, KL15, KL16, K17, KY1, KY3, KY4 , KY6	15
	Unit	KL10, KL13, KY2	3
	Subject Area	KL1, KL2, KL3, KL4, KL5, KL6, KL8, KL9, KL10, KL11, KL13, KL14, KL15, KL16, KL17, KY1, KY2, KY3, KY5	19
	Learning Outcomes	KL9, KL10, KY2	3
	Type of Question	KL1, KL2, KL3, KL4, KL9, KL10, KL11, KL13, KL15, KL16, KL17, KY3, KY4, KY5, KY6	14
	Number of Questions	KL3, KL4, KL8, KL9, KL10, KL11, KL13, KL17, KY1, KY2, KY6	11
	Difficulty Level of Question	KL6, KL9, KL10, KY 4, KY5	5

summed under similar codes, and conversation screens are inspected. In **Table 10**, similar answers the research participants gave about the prompt structures they had used while asking ChatGPT to generate questions are gathered and inspected under the same subtitles based on similarities.

When **Table 10** is viewed, similar to each other, phrases about the prompt structures the participants had used while asking ChatGPT to generate questions are analyzed. When the aforementioned prompt structures are inspected, “Grade Level,” “Unit,” “Subject Area,” “Learning Outcomes,” “Type of Question,” “Number of Questions,” and “Difficulty Level of Question” are indicated in them, seemingly. Additionally, when the conversation screens of the participants were inspected, they hadn’t indicated several options for the questions they asked ChatGPT to generate.

Based on the participants’ conversation screens, it is clear that several options for ChatGPT’s questions have to differ on grade level. Some conversation screens of the participants showing the dialogue with ChatGPT are given below:

When the prompt structure the participant used while asking ChatGPT to generate questions is inspected, the prompt structure above includes “Grade Level” and “Subject Area” codes (**Figure 1**.).

When the prompt structure the participant used while asking ChatGPT to generate questions is inspected, the prompt structure above includes all the codes in the category (**Figure 2**.).

When the prompt structure the participant used while asking ChatGPT to generate questions is inspected, the prompt structure above includes “Grade Level”, “Subject Area” and “Type of Question” codes (**Figure 3**.)

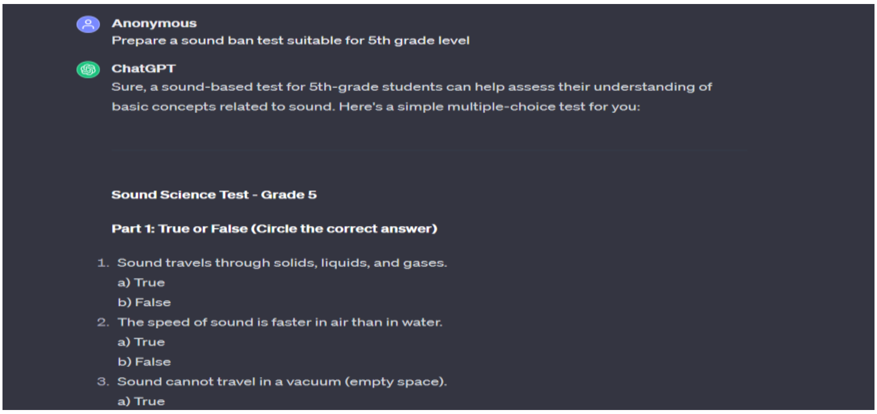

Figure 1. Conversation Screen of the Participant and ChatGPT's Dialogue Belongs to KL5 [18].

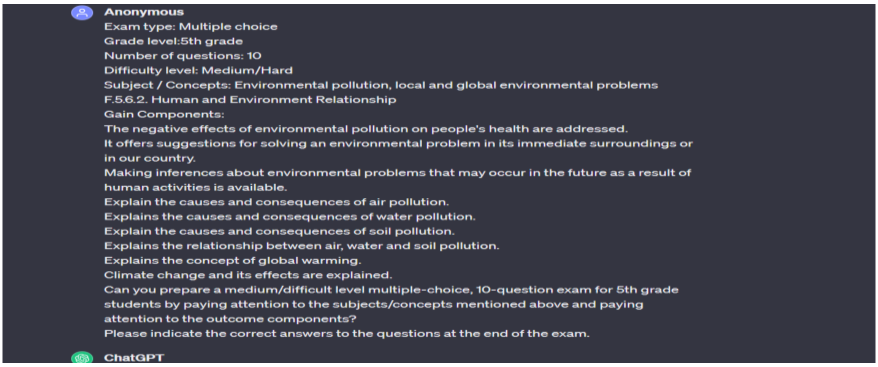

Figure 2. Conversation Screen of the Participant and ChatGPT's Dialogue Belongs to KL10 [18].

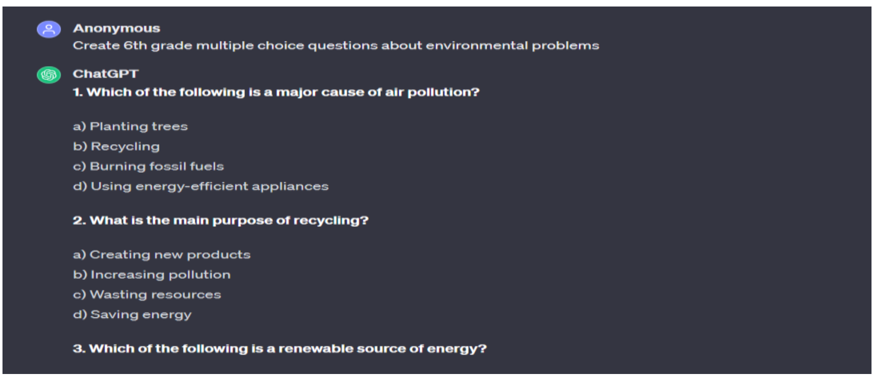

Figure 3. Conversation Screen of the Participant and ChatGPT's Dialogue Belongs to KL16 [18].

Discussion and Conclusion

The purpose of this research is to determine the opinions of undergraduate and graduate students on ChatGPT and its use in education, as well as the prompt structures they use when creating questions with ChatGPT. For this purpose, undergraduate and graduate students were asked about their opinions on ChatGPT and conversation screenshots showing the prompt structures they used when generating questions with ChatGPT were requested. The answers given by the participants were gathered under similar titles and analyzed. The opinions of the participants on ChatGPT were examined under 8 categories. It was determined that the sources from which the participants were first informed about ChatGPT were environments such as friends, classes, and social media. In the research, it was found that the most selected code as the first source of information for the participants was "Social Media" (9 participants, 39.1%). In comparison, the least selected code was "Classes" (3 participants, 13.0%). The reason for the participants choosing the "Class" code less as one of the first information resources is thought to be that integrating tools such as language learning models into educational environments is still relatively new.

Additionally, when the purposes of the participants' ChatGPT usage activities before this research were examined, it was determined that they had used it for purposes such as researching, chatting, and preparing homework. As an important finding, in addition to the fact that a limited number of participants (4 participants, 17.4%) have not heard of ChatGPT, the number of people who have not used it before the application (10 participants, 43.5%) is significant. As a reason for this situation, it can be argued that participants' perceptions of risk related to artificial intelligence technologies are influential. In a study created by Çağal and Keskin (2023), one of the studies on this subject, the opinions of 15 participants with different demographic characteristics were collected, and the data obtained were analyzed using the descriptive analysis method. According to the results obtained in the study, it was determined that participants felt risk from the advancement of artificial intelligence robot technology (Çağal & Keskin, 2023). In another study created in this field, Benzer and Benzer (2023) examined the concerns of university students towards artificial intelligence, and as a result of the research, it was determined that the anxieties of university students arise from the thoughts of that artificial intelligence will make people lazy and take away their jobs (Benzer & Benzer, 2023). Another category of the research has focused on the emotions experienced by the participants during the usage of ChatGPT. In this regard, it was identified that the participants expressed emotions such as astonishment, excitement, comfort, happiness, and unease. It was considered that the emotions experienced by the participants while using the application could be related to their positive and negative views about the application. In this context, positive evaluations of the participants on using ChatGPT were classified under the codes of convenience, productivity, and time-saving. On the other hand, negative evaluations were classified under codes such as self-repetition, unreliability, laze, and misinformation. The positive emotions felt by the participants during the usage may be due to the convenience, time-saving, and productivity they experienced while using. Montenegro-Rueda et al. (2023) created a systematic review study that included the advantages and disadvantages of using ChatGPT in education. In their study, they found that the use of ChatGPT in educational settings enriches the learning experience but, at the same time, can lead to ethical issues with long-term use (Montenegro-Rueda et al., 2023). Similarly, Adeshola and Adepodoju (2023) examined the opportunities and challenges created by using ChatGPT in education in their study. In the research, while the usability of ChatGPT in different fields and its ability to quickly solve problems were evaluated as positive, the idea that using it for assignments would threaten academic integrity and harm the development of critical thinking skills was considered a negative view (Adeshola & Adepodoju, 2023). Therefore, it can undoubtedly be concluded that while benefiting from the productivity and speed of ChatGPT, the accuracy of the answers ChatGPT gives should not be unquestionably accepted, and they should be evaluated with a critical eye.

In addition, the participants were asked whether there would be a difference between the lectures in which ChatGPT was involved and the conventional lectures. Most participants (18 participants, 78.3%) were found to believe that the lectures ChatGPT would involve would be different. This is due to positive evaluations based on factors such as quick and easy access to information or increased productivity during usage.

One other question of the study is whether the participants will use ChatGPT again for educational purposes after this research and what their intended uses would be. It is determined that the participants using it would have purposes such as researching, generating questions, designing lesson plans and experiments, and creating text. Reasons for the participants who will not use it include negative experiences related to ChatGPT providing repetitive answers and incorrect information during usage.

The prompt structures used by the participants while generating questions in the research were also asked to the participants. When the prompt structures used by the participants while generating questions in ChatGPT were examined; it is observed that the participants specify the grade level, unit, subject area, learning outcomes, question type, number of questions, and question difficulty levels in the prompt structures they used. However, it was observed that none of the participants in the research specified the number of options for the question they would create in their prompt structure. Since this parameter was not specified, the ChatGPT algorithm determined the number of options in a non-standardized way, left to the algorithm to decide, while generating questions. This scene that emerges shows us that the importance and sensitivity of the prompt structure, which is the essential interface while ensuring seamless communication and harmony between human and the artificial intelligence that aims to assist human consciousness, cannot be denied. The role of creating an optimal prompt structure emphasizes the importance of prompt engineering concepts in artificial intelligence-human interaction. In a study by Lee et al. (2023), an automatic question generation (AQG) system developed using massive-scale language models like ChatGPT for English education was designed. At the forefront of the inputs examined in this study comes the contribution of prompt engineering in the effectiveness of questions generated by AQG and the feasibility of creating a prompt engineering protocol based on these contributions (Lee et al., 2023). Research has shown that prompt engineering has positively influenced the quality of the work created on language models. Similar results have been achieved by Heston and Khun (2023) in their study examining the use of massive-scale language models in medical education and the importance of prompt engineering in those models. The research has shown that prompt engineering is effective in massive-scale language models and that the models are used to achieve effective results in medical education (Heston & Khun, 2023).

In this regard, it is concluded that participants should use appropriate prompt structures and receive training on prompt engineering to achieve the desired outcome when using massive-scale language models. The studies by Lee et al. (2023) and Heston and Khun (2023) highlight the importance of prompt engineering in language models. Therefore, it can be concluded that more focus should be placed on prompt engineering in training programs and guidelines related to language model usage. This way, by ensuring the effective and efficient use of language models, teachers, and teacher candidates can achieve the results they desire.

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REVIEW

The Application of Cooperative Learning in Chinese Education: A Systematic Review

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***Abstract**: Cooperative learning has been applied in Chinese education for decades, and an overview of its implementation in China is warranted for further improvements. This study seeks to survey the current application of cooperative learning at various education levels in China based on an analysis of 50 prior studies. The survey finds that comparable cooperative learning procedures and methods have been adopted by educators in different education phases and those teachers and students have encountered many challenges in enacting cooperative learning. We also put forward several suggestions in response to these challenges for improving instructional outcomes of this teaching approach.*

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Introduction

THE CONCEPT of cooperative learning (CL) was advanced in the 1970s and subsequently evolved into an established instructional modality. Deemed a potent strategy for fostering students' key competencies, including critical thinking, interpersonal communication, and collaboration abilities (Loh & Ang, 2020), CL has been widely adopted in the global educational community. It was introduced to China in the 1980s and used as a major pedagogical paradigm to change the traditional education style in China. Chinese researchers put a high value on CL, claiming that the promotive effects of CL on the student's academic success and social development as well as the improvement of the learning environment are of vital significance for the growth of the individual and the achievement of the national educational goals (Han, 2018). Governmental interest in cooperative learning in China finds expression in the "Opinions on Intensifying the Curriculum Reform and Implementing All-Round Education as the Core Mission," which advocates advancing instructional reform by popularizing relatively novel learning methods, such as cooperative learning, inquiry-based learning, and self-directed learning (Ministry of Education of China, 2014).

Global research on CL in the last few decades has substantiated its positive effects on student learning outcomes. In their review of 84 studies, Trung and Truong (2023) discovered that CL was beneficial for enhancing the student's learning motivation, academic performance, and practical skills. CL is also acclaimed to have positive effects on students' learning of specific subjects. For example, Xu & Yang's (2023) study suggests that it is effective in increasing the student's language acquisition in foreign language instruction and empirically verifies its effectiveness in improving their language accuracy, enhancing their learning motivation and confidence, boosting their engagement in learning, and reducing their anxiety in foreign language learning. In the area of physical education, research has demonstrated that the improved interpersonal relationships brought by CL are conducive to the student's physical, academic, social, and emotional development (Bores-García et al., 2023; Casey & Goodyear, 2015). Recent meta-analytic studies of CL have verified that it can generate better learning outcomes than traditional teaching methods. At the same time, these studies also point out that factors such as the method and intensity of teacher intervention, grouping method, cooperation intensity, and group size can have significant impacts on CL's outcomes, which are likely to be neglected by teachers or researchers. Therefore, to optimize the effects of CL, it is necessary to look more thoroughly into its implementation processes. This study, based on a review of 50 relevant studies, aims to survey the application of CL in Chinese education at all levels and critically examine prior experiences in this regard with the view to providing implications for more efficacious use of this instructional approach.

Literature Review

Conceptualization of Cooperative Learning

CL is an instructional strategy with which the teacher organizes the students to work toward a common learning goal or outcome or solve a common problem or task in groups, making sure that they complete their work through interdependent behavior but with each individual student being held accountable for their contributions and efforts (Brody & Davidson, 1998). The study group in CL is typically made up of a certain number of students with varying levels of competence, and group members are not only responsible for their own mastery of learning substances but also for helping each other to reach the shared learning objectives (Slavin, 1987). In CL, the student learns how to maximize their own and the team’s achievements by means of information sharing, knowledge co-construction, and more (Johnson & Johnson, 1989). According to Sharan (2018), CL is not a rigid teaching and learning approach with prescribed procedures but does show certain consistent features: (i) small-group interaction surrounding the learning task; (ii) mutually supportive cooperation behavior among students; (iii) positive interdependence in working towards learning objectives; (iv) individual accountability and responsibility for group work outcomes (Sharan, 2014).

Education researchers in China claim that the idea of CL is deep-rooted in Chinese ancient educational philosophy. Statements in archaic Chinese like “Learning alone without peers leads to ignorance and prejudice” and “A cultured man gets along with others, though he may not always agree with them on learning” represent the educational wisdom of ancient Chinese on CL (Han, 2018). That is why CL, as a foreign pedagogical approach, can easily garner attention in Chinese academia. Wang (2002), one of the earliest Chinese researchers in the CL studies, defines CL learning as a teaching process in which students are grouped on the principle of “intra-group heterogeneity” to increase the interactions between classroom actors, with the group achievements being treated as the assessment criterion to motivate team efforts to reach the common instructional objectives. Compared to their foreign peers, Chinese researchers place a heavier weight on the teacher’s role in CL by emphasizing the importance of their “inspiration and guidance” (Han, 2018), albeit also stressing the central position of students in CL (Li & Ham, 2013; Wang et al., 2020).

CP's Core Elements

The study group is the most fundamental organizational structure for implementing CL. Nevertheless, the presence of a study group does not necessarily mean the occurrence of CL. Students in a group working on their respective learning tasks without substantive inter-peer communication is not seen as CL. Integral to CL are certain essential elements (Ma, 2003), despite the fact that there is currently no conclusive definition of CL's core components. The five-element CL pattern, advanced by American researchers Johnson and Johnson (1989, 2009), has been the most referenced, which includes: (1) Positive Interdependence—meaning that group members rely on each other for the goal achievement, with each of them making a unique contribution to the collective endeavor. (2) Individual Accountability—stressing the necessity of a clear division of responsibility, with which each group member is held accountable for a specific section of the assigned task. (3) Promotive Interaction—highlighting the importance of inter-peer interaction for completing the learning task, including providing feedback to group members, posing questions to each other's reasoning and conclusions, and assisting each other in achieving the group's outcomes in an efficient manner. (4) Appropriate Use of Social Skills—emphasizing that the teacher has the responsibility to urge students to use legitimate social skills to solve problems to practice and develop interpersonal communication abilities, including trust-building, leadership, decision-making, and conflict management. (5) Group Processing—entailing the collective efforts to build the team, including setting shared learning objectives, evaluating the team performance regularly, and setting forth improvements to be made in order to enhance the efficiency and effectiveness of the group operation.

CL Implementation Methods

As per Slavin (1980), CP's in-class implementation entails three structures: the task, reward, and authority structures. The task structure is about the configuration of various learning tasks and the organization of study groups (e.g., the grouping method and the availability of teacher supervision). The reward structure exerts impacts on student performance and group cohesion. The authoritative structure concerns the students' power over their learning activities instead of the teacher's control of the learning process. The three structures, particularly the reward structure, are dynamic changes in the process of in-class CL implementation (Slavin, 1980) and hence deserve careful consideration by the teacher when they make the preparations for CL-based instruction.

Over the years, the researchers have developed many distinctive methods for executing CL, among which the most widely adopted are Student Teams Achievement Divisions (STAD), Team Games Tournament (TGT), Jigsaw, Learning Together (LT), and Small-group Teaching. STAD is featured by the following procedures: First, the students are grouped on the principle of intra-group heterogeneity, with each group consisting of members with differential academic levels. Second, an assessment is administered to the students after they complete a learning task in groups. The scores of individual members are combined to calculate the average scores of the group according to prescribed rules that ensure the equal weight of the contribution of each student. Third, the score ranking is not conducted within the whole class, but instead, the class is divided into several layers, and the student is only compared with their peers in the same layer (Wittrock, 1978; Slavin, 1980). The basic procedures of TGT are comparable to those of STAD, except that in TGT, the competition replaces the assessment and takes place every week among students in the same academic layer from different groups (Stevens et al., 1991; Wang, 2002). "Jigsaw" adopts the same grouping method as the above two models. On top of that, it divides the teaching materials for a certain subject into several sections and has the students in a group address different sections separately. The students studying the same section make up a specialty study group, who work together to delve deeper into the content and subsequently teach their knowledge of the delegated section to peers in their respective groups (Slavin, 1994). Comparatively, LT has simpler procedures. The students with varying academic levels work together in a group, and the teacher gives feedback on the overall performance of the group. This model pays more attention to the group organization before the enactment of CL and the regular evaluation of the performance of group members (Wang, 2002). Small-group Teaching is a more general method with a special emphasis on the size of the study group, which should be ideally composed of two to six people. With this method, the group needs to establish a research project based on the learning materials available to the whole class and split it up into several separate tasks, assigning them to individual members, who later put together their work results and formulate the group report. Each group needs to make a representation of their research findings to the class, and the teacher and other groups give comments on their report (Slavin, 1980).

A Comparison of Cooperative Learning and Collaborative Learning

The two concepts, cooperative learning and collaborative learning, emerged almost at the same time. Initially, they were deemed two distinct approaches, with collaborative learning focusing more on the techniques involved in inter-student interaction and cooperative learning more on the process of the inter-student interaction under the direction and supervision of the teacher (Panitz, 1999; McInnerney & Roberts, 2004). Yet, amid the advances in theoretical and practical research on them and increasing integration of technology, the distinction between the two has become blurred (Yang, 2023). Currently, the researchers tend to agree that there are no fundamental differences between them and that they are both student-centered instructional methods with the potential to help teachers and students shape new learning environments (Jacobs, 2015). This study acknowledges the subtle differences between cooperative learning and collaborative learning but contends that there are no significantly mutually contradictory elements between the two concepts and that they basically coexist in practical teaching. Hence, in this survey, the two terms are virtually interchangeable, both pointing to a learning approach that requires students to learn and practice disciplinary knowledge, fulfill learning tasks, and reach educational objectives primarily via intra-group interactions (Li & Ham, 2013).

Research Questions

Based on a survey of existing research on CL in the Chinese context, this study addresses the following questions:

Q 1: What are the conceptions of CL among Chinese educators and education researchers?
Q 2: How has CL been implemented in Chinese classrooms?
Q 3: What are the challenges of CL application in Chinese education?

Research Methodology and Process

We sourced literature from China National Knowledge Infrastructure (CNKI), Web of Science, EBSCO, and Scopus, using "cooperative learning," "group cooperative learning," "collaborative learning," and "China" as search terms. To obtain high-quality papers in Chinese from the CNKI, only journals listed in "A Guide to the Core Journals of China" and the "Chinese Social Science Citation Index" were selected as literature sources. As of August 2024, a total of 1876 journal articles were retrieved, with 797 in Chinese and 1079 in English.

Rayyan, a systematic literature review tool, was adopted to remove duplicate and irrelevant studies. We further screen the records using the following criteria: (1) including studies with a research topic on the practical application of CL but excluding theoretical studies and literature review-based studies; (2) including studies in the context of Chinese education; (3) including studies with a detailed description of the implementation procedures of CL (CL implementation schemes, grouping methods, types of learning tasks, etc.) but excluding those skipping this step or only reporting research findings; (4) including studies accessible in full text to avoid misunderstandings due to incomplete information. Based on these criteria, 50 papers were obtained, with 34 in Chinese and 16 in English. Their publication years range from 2007 to 2023.

Research Results

Our review shows that existing literature on CL application in China has covered all of its education levels, from basic to tertiary education. Among the 50 studies, five address CL applications in primary schooling, 12 concern secondary education, and 33 concentrate on its application in tertiary education. Regarding their disciplinary scope, CL studies targeting the primary level mostly address the effectiveness of CL in multiple subjects (N=4), whereas research on CL applications in secondary and tertiary education typically focuses on a single discipline. As to the specific subjects involved, research at the primary level shows parallel interest in the mathematics-dominated natural science education (N=5) and Chinese language-centered humanities education (N=4). Studies at the secondary level focus more on natural science subjects (N=10), with less attention paid to humanities (N=1) and social sciences (N=1). Comparatively, research at the tertiary education level covers a wide range of subjects, such as physics, chemistry, medicine, computer science, and more from the domain of natural sciences (N=12); language education in the domain of humanities (N=12); and education-related disciplines in the domain of social sciences (N=6), with additional four studies specializing in CL in physical education (PE). In analyzing CL’s effects on student development, all these studies, no matter which education level they target, have highlighted its positive roles in promoting student cognitive and non-cognitive abilities. In addition, classroom teaching remains the primary setting for CL (N=41). CL application in the online and mobile learning scenarios is also researched (N=9), particularly at the tertiary education level (N=7). The active implementation of online CL in higher education institutions is perhaps due to their richer education resources and more flexible teaching environments.

The above breakdown of literature indicates a widespread adoption of CL in all levels of Chinese education. The ensuing section is devoted to a more in-depth analysis of the following three dimensions: the perceptions of CL in Chinese researchers and educators, CL implementation patterns in various education phases, and challenges of CL application in China.

Perceptions of CL in Chinese Researchers

The researchers' perceptions of CL derive from their understanding of the purpose of CL. A sizable portion of them claimed that their adoption of CL was a reaction to new requirements from the national curriculum program or education policies (e.g., Lin, 2007; Tan, 2015; Yan, 2023). Some treated CL as an educational idea rather than simply a learning model, emphasizing the importance of students' agency in the learning process and the necessity of their use of their initiatives in completing learning tasks (Chen & Qin, 2013). On top of its role in enhancing student academic performance, CL is also acclaimed as a humanistic and pro-social modality of education (Pan & Wu, 2013), with the potential to lower the student's anxiety level in learning and classroom interaction, to boost their self-esteem, and improve their quality of interpersonal relationships (Jiang & Tan, 2007; Jiang, 2007). Certain researchers adopted a comparatively simple understanding of CL, viewing it as a mutually supportive learning modality that facilitates students working together to complete specific training activities according to established procedures and rules, and therefore, introduced it into physical education or vocational skills training (e.g., Zhang, 2009; Gao & Zhu, 2014).

In the Chinese historical context of collective culture, it is easy for the researchers to be identified with CL's core elements, claiming they were in conformity with Confucian ideas (Chan, 2014), and gave their own interpretations. For example, according to Peng et al. (2020), "positive interdependence" is most effectively realized through division of responsibility and sharing of resources; "promotive interaction" is not just about inter-student interaction but also involves teacher-student communication; when encouraging "appropriate use of social skills," the teacher should place a special emphasis on teamwork ability development in students. Moreover, the division of roles in CL is underlined in the literature. Zhang (2014) argued that the division of roles among group members was aimed at defining the accountability of everyone in the process of CL and that there was a need to give the learners necessary prompts on how to perform their respective roles for a successful completion of the common learning task. In addition, the classroom environment is also deemed an essential factor affecting the outcomes of CL. A digital learning environment facilitating interaction and timely feedback can help students solve problems more effectively in the group study (Xu et al., 2017).

To sum up, our review finds that under the influence of the national education policy and traditional culture, Chinese researchers and educators exhibit open and receptive attitudes towards CL. They have developed their own conceptions of CL's essential elements and realized that CL can bridge the gaps in the traditional educational modalities.

CL Implementation Patterns

The literature in review shows that there are primarily three CL implementation patterns in Chinese schools. (1) Using one single CL-execution method. For example, Liu and Zhao (2012) focused on STAD, and Luo (2020) on TGT in their studies. Among the aforementioned CL execution methods, LT was the most used, adopted by 16 studies, as opposed to the Jigsaw method, which was the least applied (Song Yi, 2012), possibly due to its entailing the organization of additional "specialty study groups," an extra burden for the teacher. In effect, the Jigsaw method is not quite applicable in a class with many study groups. (2) Mixing several CL-execution methods together. For instance, Jing (2007) and Li (2017) grouped the students according to STAD's grouping procedure before the students were required to carry out CL activities following the small-group teaching method. Each CL-execution method has its own limitations, whereas the mixed-methods-based pattern can make up for the inadequacies of any single method, which is evidenced by Ning's (2010) and Hornby's (2013) practices. They incorporated the Numbered-Heads-Together (NHT) method into STAD, numbering the groups and students first and assigning the learning tasks or representation opportunities to them by randomly drawing the numbers to avoid uneven task distribution. (3) Combining CL with other learning models, such as project-based learning (Chang & Song, 2023), mobile learning (Huang et al., 2020), and the flipped classroom (Jiang et al., 2016; Huang et al., 2021). Some researchers integrated these learning models into CL to improve the latter's learning outcomes. In the past, a portion of teachers assigned CL tasks to students before class and had them present their group study results in class, resulting in the latter's focus on the representation rather than the group learning process. To address this issue, Cao and Bai (2018) experimented with CL in a flipped classroom setting, making students engage in CL activity in the classroom and complete learning tasks under the supervision of the teacher to increase in-class interactions and the teacher's oversight of the students' group work process. At the same time, other researchers have tried to utilize CL to compensate for the shortcomings of other learning models. For example, Cao (2014) discovered in her interpretation classes that self-directed learning did not work well without effective supervision and therefore, introduced group-based CL to optimize the engagement of every student.

In addition, some researchers have examined the differences in CL's effects between various subjects. In their survey on students' perceptions of three CL-based courses, Guo and Zhang (2008) found that students tended to increase CL behavior in courses involving open-ended learning content. This finding is corroborated by research by Zhang et al. (2011), who compared task-specific CL and open-ended question-based CL to draw the conclusion that the latter elicited better performance and lower cognitive load in the students. In most studies included in our review, CP was enacted within one class, with several exceptions where the researchers examined the effects of CL in interdisciplinary study. For example, Cheng et al. (2022) organized preschool education and digital media majors into groups to develop digital teaching resources for young children.

To delve into CL's implementation in China in more detail, this study further examines the composition of the study group, the types of learning tasks and cooperation behaviors, the assessment methods, and the roles of the teacher in CL discussed in the literature.

The Grouping Methods and Division of Roles

Most studies in the included literature organized CL study groups on the principle of homogeneity between groups and heterogeneity within the group to ensure that each group includes students with different characteristics and that the overall competence levels of groups are comparable. Only very few studies adopted the random grouping method or left the grouping to the students' discretion (e.g., Xu, 2016). Furthermore, most researchers employed the "static grouping" mode, where the composition of the group remains stable for a certain period, with only several of them choosing to regroup the class in the middle of the semester (e.g., Jiang & Tan, 2007; Jiang, 2007). Realizing that "static grouping" might cause issues like low motivation or the "bystander" effect, fixed role assignment, intra-group fatigue, etc., Zhong and Huang (2022) advanced the "dynamic grouping" mode, in which the teacher divides the learning task into several sub-tasks, administers assessment and interviews to students after the completion of each sub-task, adjusts the composition of the group in consideration of factors like group cohesion, group cooperation smoothness, and student academic achievements as indicated by the results of assessment and interviews, and, after that, advances the students to the next sub-task in reorganized groups. Yet, they also noted that "dynamic grouping" might compromise the student's attachment to group efforts (Zhong & Huang, 2022).

The majority of researchers grouped the students in light of their academic results and competence levels to ensure that each group contained both high- and low-performers. Nevertheless, this grouping method is not without its challenges, which will be discussed later in a separate section. Moreover, gender, personality traits, interests, and the learning style of the student are also the chief factors that researchers considered in grouping the students (e.g., Zhang & Zhao, 2009; He & Jing, 2019). The plurality-valued grouping method is aimed at enabling mutual complementation in group members. In most studies, a group of four to six is the common size of group (e.g., Cai & Zhang, 2008; Meng, 2017). Zhang (2013) noted that a group of over eight would have difficulty splitting responsibilities properly among its members, leading to some students being marginalized with low levels of participation.

A portion of studies have explicitly specified the division of roles within the group. Common among these roles are the group leader, responsible for organizing, managing, and coordinating the group activities; the recorder, for documenting learning materials, the group inquiry process, and group study results; the spokesperson, for representing group learning outcomes to the class; and the information collector, for searching and organizing learning resources (e.g., Chen & Qin, 2013; Liu et al., 2022). Certain studies prescribed the roles of group members to suit the needs of the learning task. For example, in teaching a rehabilitation course, You (2016) required each student in the group to take on a specific role essential for a rehabilitation therapy group, such as the rehabilitation assessor, exercise therapist, occupational therapist, physical therapist, and speech therapist. In most cases, there was a rotation of roles among the group members, who took turns trying different responsibilities (Tan, 2015; Meng, 2017). However, in some studies, there was no purposeful specification of the division of responsibility among group members (Chan, 2014; Xiao & Chongda, 2014), or the teacher simply designated the best-performing student as the group leader, who had the responsibility to organize learning activities and assign specific duties to group members (Yin & Shen, 2016).

The Type of Learning Tasks and Cooperation Behavior in CL

Learning tasks for CL vary by education level. In CL at the primary education level, students typically work together in groups to solve problems using worksheets or assignment cards (Jiang & Tan, 2007; Jiang, 2007; Huang et al., 2020). On top of problem-solving, secondary school students have more challenging CL tasks to complete, such as theme-based group representation and creation tasks that require substantial hands-on manipulation skills from the group members. To make a thematic group representation, the students need to gather materials, discuss with each other, and prepare a representation based on the selected theme (Zhao, 2023); to complete a creation task, they must give full play to their creativity, designing and producing an artifact in collaboration (Tan, 2015). In addition, the students can review for exams more effectively via group work (Chen & Qin, 2013). University students have more complex CL tasks to address, such as project development, project-based research, and specialty-related practical study, which challenge their comprehensive competencies (Jiang, 2014; Zhang, 2014; Chang & Song, 2023).

Analyses of student cooperation behaviors are beneficial for revealing how CL is enacted. Regretfully, the literature in review has paid inadequate attention to student cooperation behavior. Only a small number of studies gave concrete descriptions of students' interaction behaviors, including information sharing, idea exchange, and brainstorming, and their communication devices, such as summary, inference, commenting, analysis, and reasoning (Ning & Hornby, 2010, 2013; Cao & Bai, 2018; Cheng et al., 2022). Most studies used more general terms like group discussion and group work to describe intra-group cooperation behaviors without providing details, such as interaction patterns and tactics, as well as their impact on CL outcomes, resulting in our limited knowledge about CL enactment procedures. Hence, CL may appear a "black box" in most situations, into which we input learning tasks, grouping methods, and teacher interventions, and from which we get group representations and student performance as outputs (Cao & Bai, 2018). Yet, little is known about the key information inside the box, such as cognitive interaction and cognitive flow that occur during the CL process.

Evaluation Methods for CL

According to our analysis results, the teacher is the chief evaluator of student CL outcomes at the primary education level. This may be because self-reflection and inter-peer evaluation skills are not fully developed in primary school students, who are not sufficiently mature to make independent and objective judgments on their own learning outcomes or group performance. In secondary schools and universities, both the teacher and students act as the evaluators for the results of CL, jointly assessing the performance of the individual and the group. The most pervasive CL evaluation method in these education phases is the "intra-group evaluation + inter-group evaluation + teacher assessment + tests" pattern (e.g., Zhang & Zhao, 2009; Huang et al., 2021), which is also well-accepted by students as a multi-actor evaluation method (Guo & Zhang, 2008). The teacher is often held responsible for finalizing the evaluation criteria (Gao & Zhu, 2014), which cover not only student academic performance but also their collaboration and communication skills such as oral representation (Yin & Shen, 2016). Furthermore, researchers like Li (2017) highlighted the individual's contribution to the group work as a core component of the CL evaluation system. It is also noteworthy that studies focusing on CL at the secondary education level place an exceptional emphasis on the proper wording of the teacher's evaluation, as adolescent students tend to be more sensitive to external stimuli, particularly more concerned about others' comments. Therefore, the teacher's appraisal must be objective as well as inspiring for this group (Zhao, 2023). In addition, some researchers highly emphasized the importance of regular collective reflections on CL activities (e.g., Tan, 2015; He & Jing, 2019), claiming that they could help boost the engagement of the students and the teacher, stimulate thorough discussion on the issues encountered in the CL process, and continuously optimize the CL implementation strategies.

The Teacher’s Roles in CL

No matter which education phase they teach, the educator plays their roles in student group CL as the designer, director, assistant, and promoter, providing students with a learning environment that facilitates their CL enactment (Wu & He, 2014). In the initial stage, the teacher needs to fulfill three duties: student grouping, CP orientation, and lesson preparation (Jiang & Tan, 2007). First off, to strengthen positive interdependence between group members, most researchers designed certain supporting activities for the students, such as naming the group and establishing shared goals for the group (e.g., Zhang & Zhao, 2009). Second, a portion of researchers provided CP orientation for students. The majority of them only inform students of the learning objectives and evaluation criteria in advance (e.g., Jian, 2019; Li et al., 2019); a small number of them chose to give students sufficient time for knowing each other and practicing cooperation skills (Pan & Wu, 2013; He & Jing, 2019). Third, the lesson preparation work of the teacher typically focused on selecting appropriate learning materials and reorganizing them to suit the CL learning environment (e.g., Zhang & Zhao, 2009; Song, 2012; Gao & Zhu, 2014).

In the process of CL enactment, the teacher often acted as the supervisor without significant interference in actual group activities (e.g., Chan, 2014; Liu, 2022). Some researchers conducted class-based introductory instruction before students’ group study, providing them with relevant basic knowledge and background information to ensure their group CL was informed by practices (e.g., Jing, 2007; You, 2016). In addition, after students’ completion of each CL task, the teacher needs to give a summary, answer queries from the students, and offer directions to individuals who want extra instruction. This step has been emphasized in most studies included in our review (e.g., Pan & Wu, 2013; Liu et al., 2022).

Challenges of CL

Research on CL implementation has also revealed a variety of issues. The misconceptions of CL among Chinese educators are pronounced ones. Some teachers simply equated CL to group discussion (Tan, 2015) or assumed that CL would naturally take place after learning tasks were assigned to the group (Wang, 2007). Some treated CL as a rigid procedure (Yan, 2023), an established combination of processes including grouping, learning task assignment, task completion, group discussion, and group representation

(Guo & Zhang, 2008). Others failed to make necessary preparations for CL enactment: for example, their neglect of the division of roles in group members might lead to disorderly CL execution and low learning efficacy (Wang, 2007); the absence of well-designed learning objectives was an impediment to eliciting the dedication of all group members (Hsiung, 2011)—an overly unitary learning objective could be easily achieved by the high-performing members without involving teamwork; the lack of provision of CL skill training by the teacher was unfavorable for ensuring student CL outcomes (Chan, 2014). Furthermore, a portion of educators misunderstood teacher supervision of the CL process as the teacher's absolute control of student group work, disregarding the significance of team building and the cultivation of self-regulation ability in students (Wang, 2007).

Additionally, the educator may encounter certain practical challenges in implementing CL. Han (2015) noted that it was difficult for the teacher to seek out learning resources and methods that cater to the needs of students at distinct academic levels. The choice of the assessment method is also not easy. The two alternatives, evaluating student academic achievement based on group performance or evaluating group performance with test scores of individual students, can both have a negative impact on student motivation levels in CL (Song, 2012). Also, in the Chinese context of prevalent large-sized classes, the relatively big number of study groups in a CL classroom complicates class management. With finite classroom or laboratory space, mutual disruptions between groups are unavoidable (You, 2016).

In the meantime, the students also experience additional complications in a CL classroom. There are significant disparities in the CL engagement level between high- and low-achieving students. Low-achieving students have low intention of engaging in CL because of the following reasons: their ideas are often disregarded by peers during the group work (Zhang & Zhao, 2009); they are primarily to blame when the group fails to reach the learning objective (Jiang & Tan, 2007); and they have few chances to exhibit their ability as the high-achieving students are the chief actors in dealing with the learning task (Wang, 2007). On the other hand, high-achieving students have their own complaints. They may feel "exploited" because their low-achieving peers are seemingly taking a "free ride" (Jiang, 2007). When facing the pressures of high-stakes examinations, this group is more willing to work independently (Meng, 2017). Furthermore, there are individual differences in group discussion behavior (Chen & Qin, 2013), showing two extremes. Some students are not interested in speaking openly to a group of people (Tan, 2015); some, on the other hand, show a strong propensity for being the center of attention, who may purposefully interrupt others' speeches or initiate casual conversations to attract peer attention (Jiang et al., 2016). Worse still, the students typically feel helpless in dealing with disputes due to a lack of coping tactics (Chan, 2014). They are likely to be intolerant of inter-peer disagreements or to get emotional over the disputes (Yan, 2023), which poses serious barriers to the smooth enactment of CL.

Discussion

Basically, CL implementation at various education levels in China follows broadly similar procedures: grouping, learning task assignment and provision of learning resources, group CL enactment, CL outcome representation, and multi-dimensional evaluation, summary, and reflections, despite the minor adaptations due to the variations in the cognitive characteristics between different age groups and the disparities in the education resources and environment between different levels of education. Aside from the conventional CL methods, Chinese researchers have also experimented with other approaches, including integrating CL into the flipped classroom model to combine self-directed learning with group study (Li et al., 2019) and leveraging educational technology (such as the smart classroom) to enhance teacher management efficiency and student CL outcomes (e.g., Xu et al., 2017). Nevertheless, there is currently a lack of in-depth research into student cooperation behaviors in CL and their effects on student learning results. The challenges encountered by educators in their practical application of CL underscore the necessity of strengthening research in this area.

Issues with students' CL enactment are largely due to the teacher's less-ideal organization of CL activities. The unclear division of roles leads to unbalanced contributions to group work results among group members. Explicit division of roles within a group is crucial for maintaining students' CL engagement intention as it ensures each group member can perceive their value to the team (Liu, 2013). Although the students are allowed autonomy in dividing the specific responsibilities, the teacher must be substantively involved in the division of roles in a group. At the same time, the absence of division of roles also reflects the illegitimate design of CL learning objectives and tasks. When the learning task has an overly simple structure, focusing on a single skill, it can be easily finished off by more competent students in the group, making the division of responsibility unnecessary. To make students engage in genuine group cooperation, the teacher must develop well-structured CL tasks that are challenging and demand team efforts as well. In addition, the students' low consciousness of cooperation and poor collaboration skills also contribute to their difficulty conducting CL, which are, to some extent, associated with the inadequacies in intervention and guidance on the part of the teacher. To help students develop sound awareness of cooperation, the teacher needs to formulate legitimate incentives for cooperative behaviors while also teaching them how to balance cooperation and competition. Also, it is important for the teacher to provide essential CL skills training to students beforehand to ensure the students are well prepared for CL implementation.

Challenges of CL faced by the teachers are also attributable to the following two reasons. First off, a sizable portion of teachers do not have a complete understanding of the concept of CL and may fail to comprehensively consider the five key elements of CL: positive interdependence, individual accountability, promotive interaction, appropriate use of social skills, and group processing. The absence of any of these components may directly negatively affect the effectiveness of CL (Dyson et al., 2022). Meanwhile, the manipulation of in-class CL is complicated and demanding, necessitating a thorough comprehension of the diverse ability levels of the students and the characteristics of current teaching materials on the part of the teacher. It entails considerable additional burdens of lesson preparation and classroom management. To address these issues, it is imperative to supply the teachers with comprehensive guidelines on CL implementation and promote the use of educational technology in CL-based teaching.

Our analysis results suggest that more successful CL implementation in Chinese education warrants a systematic framework for CL practice, which should cover an overarching concept of CL, an interpretation of its core elements, concrete execution steps, and coping tactics for common issues. The teacher needs such a framework to develop knowledge about CL and establish CL instruction paths in an efficient manner.

Conclusion

Based on a review of relevant research over the last more than 10 years, this study gives an overview of CP's application in Chinese education, with a focus on exploring the challenges of CL implementation in China and their causes. Pertinent suggestions for improving student CL enactment are also proposed. The survey finds that the Chinese education world shows strong interest in CP as an instructional strategy, whereas a lack of systematic CL implementation guidelines for Chinese teachers negatively affects its effectiveness.

The limitations of this study should be acknowledged. The limited literature search scope may lead to an insufficient inclusion of prior studies. It is suggested that future research, on the basis of this survey, delve more thoroughly into factors that potentially influence CL's outcomes, such as the use of educational technology in CL in the context of digital transformation in education. Also, comparisons with overseas CP research should be increased to provide a more comprehensive reference framework for Chinese CL studies and practice.

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REVIEW

The Application of Big Data-Based Precision Teaching in Chinese Education: Using Xichuan Experimental School in Chengdu City as an Example

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***Abstract**: In the era of big data, technology is a catalyst for change in teaching modalities. Although the notion of precision teaching is not new to the education world, its application has faced a variety of constraints due to technical issues. The advent of big data technology and the proliferation of educational data are vital factors in diminishing these constraints. Based on a review of relevant research, this study encapsulates popular application patterns of big data-based precision teaching in China and expounds on its implementation procedures, citing the practice of Xichuan Experimental School as a case study. It also discusses the challenges arising in the integration of big data into precision teaching in order to provide a broader perspective on this teaching method.*

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Introduction

IN THE CONTEXT of the accelerated development of information technology like the internet, mobile communication, and cloud computing, the amount of digital data related to human behaviors has increased exponentially, marking the entry of human society into the era of big data. Big data technology has the potential to assist people in reaching scientific decision-making, providing valuable information via analysis of datasets containing colossal amounts of data (Liu, 2014). It is also an impactful technology in the field of education. In 2012, the U.S. Department of Education's Office of Educational Technology (2012) released the report "*Enhancing Teaching and Learning Through Educational Data Mining and Learning Analytics: An Issue Brief*," which describes how data analytics and data mining were starting to be applied in education and examines the potential of such efforts for improving student outcomes and the productivity of K–12 education systems as well as the challenges being encountered. This issue brief provoked more intense interest in the educational application of big data in other countries as well. For instance, the Action Plan for Promoting Big Data Development, issued by the Chinese government in 2015, calls for actively advancing the development of educational big data to support the educational reform in China (Chen, 2015).

Recent years saw a significant increase in educational big data research. For example, Baig et al. (2020) conducted a review of 40 studies in English on educational big data, published between 2014 and 2019, to find the four primary research themes in this area: the learners' behavior and performance, modeling and educational data warehouses, improvement in the educational system, and integration of big data into the curriculum. According to Bai et al.'s (2021) study, educational big data has positive effects in realizing intelligent management of the school, optimizing teaching methods, and increasing the outcomes of educational resources. It can also play other, more specific roles, including making projections of student academic performance, giving recommendations on employment, and planning economic support for low-income students. Some researchers emphasized the significance of educational big data for the development of equitable, high-quality education (Yang, 2024). In this context, the topic of how to leverage educational big data to support precision teaching (PT) has attracted a lot of interest in the education research community. However, there is a dearth of in-depth research into the specific patterns and implementation procedures of big data-based PT. Hence, this study focuses on:

1. *Encapsulating common big data-based PT modalities in China by reviewing the existing literature.*

2. *Expounding on its implementation procedures by analyzing the experimentation of Xichuan Experimental School in this area.*

Literature Review

The concept of "precision teaching" was first advanced by Ogden Lindsley in the 1960s, under the influence of Skinner's behaviorist learning theory and procedural teaching theory (Wu, 2020; Evans et al., 2021; An, 2021). Some researchers made the observation that the method of PT was based on three ideas from Skinner's research: student behavior being treated as the variable; the frequency of the behavior in question being adopted as an indicator of behavioral change; and the Standard Celeration Chart (SCC) being used as a tool for data display (Vargas, 2003; Wu, 2020). The initial purpose of this teaching technique was to help students identify the improvements to make and to enable their teachers to have a clear understanding of their mastery of a skill or body of knowledge (Binder, 1998; Wu, 2020). In PT, fluent responding, characterized by accuracy and speed, is often used as a mastery criterion. Fluent behavior includes enhanced skill retention and maintenance, endurance, stability, and easy application to novel settings and stimuli (Binder, 1998; Ramey et al., 2016). Over the years, the concept of PT has undergone certain modifications. Based on their review of PT's evolution and prior definitions of this teaching method, Evans et al. (2021) conceptualized it as a system for precisely defining and continuously measuring the student's learning behavior in multiple dimensions and analyzing behavioral data via the SCC for the purpose of facilitating the teacher making timely, data-driven decisions and accelerating the recurrence of desirable behaviors in students. They also gave a summary of PT's core features, including accelerating behavioral repertoires, precise behavior definitions, continuous observation, dimensional measurement, the SCC, and timely and effective data-based decisions. On the other hand, despite it being considered an effective teaching method, particularly in special education for children with developmental disabilities (Ramey et al., 2016), PT has exhibited limitations due to a lack of technological support, such as the inability to track and measure student learning behavior as accurately as expected (with capabilities being limited to recording time spent on learning and frequency of certain learning behaviors) and the imposition of additional burdens on teachers and students caused by the manual manipulation of recording (Fu & Tang, 2017; An, 2021). This has hindered its widespread application.

PT began to garner the attention of Chinese academia around 2010. In 2016, Professor Zhu proposed the idea of leveraging IT to support precision teaching, an advocacy largely driving PT towards the direction of technological infusion (Zhu & Peng, 2016; Wu, 2020). The Chinese education community typically viewed PT as a technology-optimized teaching technique (Peng & Zhu, 2017), with the following capabilities: recording, tracking, and analyzing data on students' learning processes using IT-based devices; applying these data to directing the instructional design, teaching decision-making, and tailored instruction of the teacher; providing data-based learning remedies and improvement support to the students (An, 2021). In addition, the initiation of research on how to use IT to modify PT in China coincided with the time when technologies like big data and visualization were in accelerated development. In this context, it was natural for Chinese researchers to set about experimenting with integrating big data into PT. Their research findings reveal multiple benefits of big data-based PT, including tracking and recording data in more dimensions aside from the frequency of a certain learning behavior; using artificial intelligence to extract data that appeared unmeasurable in the past, such as the learner's emotions; and automating data collection, processing, and presentation to reduce manual labor (Guo et al., 2019). As a result of governmental promotion of digital education and the popularization of digital teaching platforms in recent years, digital educational data have expanded on an immense scale (Wan et al., 2019), providing a solid foundation for the development of big data-based PT. Driven by the advanced technologies and large-scale data resources, PT in China has matured considerably and has been accepted as a novel teaching approach (Shi et al., 2022). The relatively conclusive definition of big data-based PT in Chinese academia is that it is a teaching approach leveraging big data technology to precisely project teaching objectives, content, and activities; precisely evaluate students' performance; and make the teaching processes and outcomes quantifiable, traceable, and adjustable (Wang et al., 2018; Wan et al., 2019).

Common Big Data-Based PT Modalities in China

Based on the traditional PT method, Chinese researchers have developed various implementation patterns of big data-based PT. Despite the variations between them, underlying them are four principles, according to most researchers: focusing on measurable student learning behavior data (including overt and covert behavior); gauging the learner's performance with multiple indicators; applying learning analytics; and using student performance data to support instructional decision-making (Wang et al., 2018; Wu et al., 2022).

The IT-assisted PT modality advanced by Zhu and Peng (2016) is deemed a prototype of big data-based PT (Wu, 2020). It is a system characterized by the cycle of four steps: (1) precise goal setting; (2) development of pertinent teaching materials and teaching processes; (3) recording and visualization of student performance; (4) data-based decision-making. In the first step, the notion of recursion is applied to the setting of teaching or learning objectives. In the second, the uniform textbooks are adapted into digital textbooks that can be used for micro video-based, interactive learning, and the teaching is enacted with four tactics: stratified teaching within the class, group cooperative study, self-directed learning, and collectively interactive, generative learning. For the third step, statistics and visualization tools are used to present student learning behavior data in an efficient manner. For the fourth step, the PT analysis software is employed to assist the teacher in determining the effectiveness of the current teaching practice in reaching the expected teaching or learning objectives (Zhu & Peng, 2016).

Fu and Tang (2017) developed a PT model from the teachers' standpoint, which consists of three dimensions: the establishment of teaching objectives, the design of teaching processes, and teaching evaluation and projection. The developers of the model argued that establishing quantifiable teaching objectives was the primary process in PT, as explicit teaching objectives are the starting point of all teaching activities as well as the criteria for judging the outcomes of teaching. The teaching process framework of this model, based on the procedural teaching theory, includes the following processes: establishing a teaching resource library, measuring and recording students' performance as indicated by their completion of the exercises from the library, and providing targeted interventions in accordance with the student's learning circumstances. The model's teaching evaluation relies heavily on technological devices for collecting and analyzing data about students' learning progression and giving real-time feedback to students and teachers as well as keeping parents updated on their children's progress in learning. Teaching projection is about making predictions of the student's performance in the ensuing period based on the records of their performance in the preceding periods and other data and recommending pertinent improvement moves or learning strategies accordingly.

According to Zhang and Mou's (2018) observation, student learning would undergo a transition from the one-size-fits-all approach to a more individual needs-targeted, personalized learning method with the assistance of big data. Hence, they worked to develop a PT model aimed at personalized learning by integrating novel instructional approaches like the flipped classroom and new technologies such as big data, learning analytics, adaptive learning, and educational information processing. Central to this model are the students' profiles, based on which a PT procedure is established, including before-class learning protocol design and preliminary projection of learning outcomes, in-class teacher-student interaction and stratified directions, and after-class self-directed learning. The before-class process is meant to enable the student to master the basic knowledge that is in line with their individual cognitive levels through stratified learning materials and to help them set their own learning objectives according to the analysis results of their engagement levels and completion of these before-class activities. In the in-class process, the teacher selects the appropriate teaching method to suit the subject matter of the lesson and conducts stratified instruction in accordance with the previously established personalized learning objectives. In the after-class process, the students use the adaptive learning platform to perform autonomous practice and try to improve their mastery of relevant knowledge by utilizing the individualized learning resources and adopting the learning paths recommended by the platform. Other researchers, such as Jiang et al. (2020), Liu et al. (2020), Wang (2020), and Xing (2020), have also developed their own big data-based PT patterns with the before-class, in-class, and after-class teaching processes. Commonalities of these PT modalities include: (1) collecting basic data of students via the pre-test before class and creating their profiles to facilitate the teacher establishing individualized teaching objectives and materials (Ren, 2017; Liu et al., 2020); (2) implementing in-class teaching that suits the students' academic level based on the prior analysis of their learning foundations (Wang, 2020); (3) giving the students additional, customized learning materials in the form of after-class assignments to help them improve their weaknesses (Jiang et al., 2020).

In addition, certain researchers created their data-driven PT modalities by following the procedure of technological use of big data. For example, Wang, Gao, and Ye (2024) developed a PT model with five basic components, namely, educational data collection and screening, educational data mining and analysis, identification of student characteristics, intervention strategy selection, and intervention effect evaluation. Subsequently, drawing on Qin' and Zhang' (2019) research findings, Wang, Wang, and Fan (2024) simplified the model to retain four components: data collection, analysis of student prior knowledge repertoires and determination of teaching objectives, teaching implementation, and teaching intervention.

To recap, all these PT modalities enable the teachers to reach more scientific, precise instructional decisions through applying data mining and learning analytics and, in the meantime, support student learning by serving the different needs of the learners, posing differential teaching objectives, materials, and interventions to them. The validity of these PT patterns has been verified by empirical studies. For instance, Xing (2020) applied a big data-based PT model to the teaching of "advanced mathematics" to find it could improve the frequency of teacher-student interaction and the efficiency of student learning. According to Guo et al.'s (2021) two-year field study of PT's implementation in 51 experimental schools, the use of big data-based PT modalities produced ideal effects in all these schools across the board, significantly enhancing the teachers' senses of achievement and professional competence and heightening the students' learning satisfaction as well as improving their academic performance.

Implementation Procedures of Big Data-Based PT: Xichuan Experimental School's Practice of PT

Traditional PT is typically enacted in the sequence of the following six procedures: (i) Determine the types of learning behavior to be measured and set teaching objectives; (ii) prepare pertinent teaching materials and exercises; (iii) record the frequency of learning behaviors in students and their performance; (iv) represent the data in the form of SCC; (v) evaluate student performance using SCCs and make instructional decisions; (vi) adjust teaching objectives and teaching design according to the revised instructional decisions and initiate the next round of PT (Jiang et al., 2020; Evans et al., 2021). Big data-based PT basically follows this sequence, though with certain variations. This section is devoted to an analysis of implementation procedures of big data-based PT, using Xichuan Experimental School as an example.

To start with, it is necessary to look at the reasons for this school's adoption of big data-based PT in regular instruction. First off, behind this practice is the school's philosophy of teaching management, namely, "evidence-based decision-making." This policy emphasizes the importance of data collection and analysis for scientific teaching decision-making. Moreover, the school adopted PT to address the problems with the teachers' instruction as revealed by a survey of its classroom enactment. These problems include the teachers' lack of in-depth comprehension of the curriculum program and course standards, improper teaching behavior, and inadequate understanding of their students. The school strengthened its provision of in-service training for its teachers to improve their knowledge on curriculum standards. For the other issues, big data-based PT, it is believed, could be the judicious solution.

While the school's in-class PT includes those basic PT procedures, it has prominent advantages over the traditional PT pattern. First, it leverages big data-driven online classroom teaching platforms (e.g., Smart Study Companion) and terminal devices like the Classroom Feedback Machine (with the feature of recording students' answers to the teacher's questions) to gather and analyze data, as opposed to the traditional PT's reliance on manual manipulations on the part of the teachers and students. These platforms and devices can make real-time records and give statistical analyses of behavioral data of students, facilitating the teacher's timely knowledge of students' performance. Following the completion of a lesson, the digital systems will produce an overview of the class enactment to assist with the teacher's understanding of the overall progress of the class. Second, the data collected are not just about the student's performance in answering questions but also about the thinking process of the student. After the student gives the initial answer, the teacher will try to discern the reasons for their answers by asking follow-up questions and observe the changes in their thinking by asking them to represent their answers for the second time. In addition, the digital systems also record and analyze students' other in-class behaviors. Data on the duration of group discussions, group discussion findings, and student representations can help the teacher develop a more comprehensive picture of the students' personality traits, learning habits, and other details. Third, the digital systems also record behavioral data of the teachers. The teacher can correct their improper teaching behavior by examining their own classroom performance or discussing with other teachers' improvement measures through studying the replayed footage of the class.

Furthermore, Xichuan Experimental School extends big data-based PT to after-class assignment management, creating a digital homework management system spanning procedures from homework design to homework assignment, homework completion tracking and analysis, and teacher intervention. During homework design, the teacher needs to mark each question with the subject matter and academic level it involves and limit the questions for one assignment to a reasonable amount. On top of that, the format of homework is unified to make sure it is presented on A4-size paper with prescribed font and spacing, facilitating the collection of data as well as the management of homework. For the homework assignment, the school sets up a variety of templates for teachers teaching different subjects, each explicitly specifying the type of questions, number of questions, and level of difficulty. It also stipulates the provision of multiple configurations of questions with various levels of difficulty to cater to students in distinct academic strata. The provision of menu-based, tailored assignments is intended to enhance the role of homework in promoting knowledge development of each individual student.

The school adopts the method of "teacher marking followed by machine scanning" for the procedure of data collection, with which the teacher marks the students' homework first and has students correct the wrong answers before sending it for machine scanning so that the students' completion of homework and the teacher's marking work can both be transmitted to the school's central system. The teacher can read the collected data in the system at any time through apps on mobile phones, computers, and other terminals, and the student can receive feedback on their homework through apps on the said devices. Since its founding in 2018, the school has conducted nearly 6,000 times of homework data collection, with a total of 673.35 million data entries into the school system. The analysis results of these data serve as the groundwork of the teacher's interventions. There are mainly two types of interventions administered by the teachers. One is to correct the mistaken answers by the students and provide them with individualized supplementary exercises. To put it in a more specific way, the teacher focuses on expounding on those questions for which 60% of students gave wrong answers and gives the student extra learning materials targeted at their respective weaknesses as evidenced by the data from the school's homework management system. The second type of invention is about remedial instruction. The teacher classifies the students' mistakes based on the machine's statistical analysis of data on student wrong answers and gives additional tutoring and reinforcements in subsequent instruction to address the inadequacies in students.

The implementation of big data-based PT in Xichuan Experimental School's classroom instruction and homework management has endured for years and proves productive. The school's graduates have received higher grades in academic proficiency tests, physical fitness assessments, and comprehensive competence evaluations than their counterparts from other schools in Chengdu City.

Discussion

Our review of existing big data-based PT modalities and implementation procedures shows that big data-enabled educational technology applications have superseded the SCCs as PT tools. Typical big data processing procedures, including data collection, data processing and integration, data analysis, and data interpretation (Liu & Zhang, 2014), have posed a substantial impact on the PT implementation pattern. Although the integration of educational big data makes no difference to the essence of PT, that is, making evidence-based instructional decisions with the learners' behavioral data and paying attention to their individuality (Hao & Guo), big data-based PT outperforms traditional PT with its advantage of having higher efficiency in data collection and analysis. The automated data processing instruments enable teachers and students to reach improved outcomes without changing the basic classroom processes. Also, big data-based PT helps enhance the role of the teacher, making them more observant of the individual differences in their students and preventing them from administering homogeneous teaching interventions (Luo et al., 2019; Ji et al., 2020; Bai et al., 2022). In addition, the data collected in PT augment the students' understanding of their academic state and assist with their adjustment of learning behavior, which is unquestionably conducive to the realization of personalized learning.

Nevertheless, the challenges of big data-based PT should also be acknowledged. First, many researchers have raised the concern that this teaching approach may nurture the "technology-first" mentality in teachers and distort the normal instructional progression. Second, the policy of "assisting teaching and learning with assessments" in big data-based PT may magnify the existing emphasis on tests, skewing PT towards "precision practice of exercises." Third, the current use of big data technology remains focused on the overt behaviors of learners, which may mislead the teacher to pay attention only to their academic performance while disregarding their psychological and emotional development (Wang et al., 2021). Fourth, when the school adopts machine-generated data as criteria for gauging the performance of the teachers and students, they may face the temptation to adapt their behavior only for better data outcomes, sacrificing the real meaning of education. Last but not least, the application of educational big data puts the privacy of the educators and the educated at risk. A portion of schools deploy cameras in the classrooms to monitor the behavior of teachers and students, potentially threatening their privacy security.

Conclusion

Amid the ongoing advancement of digital education in China, schools at all education levels have worked to expeditiously improve their digital environments. As a result, new technologies, such as the learning platform, mobile app, digital terminal, and wearable device, become popular in Chinese primary and secondary schools. The regular application of digital technology in teaching activities has promoted the generation of educational big data. The adoption of data mining and learning analytics has made a significant difference to the teaching modalities, the education evaluation system, and educational decision-making of the school. This study encapsulates the explorations of big data-based PT modalities among Chinese researchers to find that this teaching method is effective in resolving issues with the traditional PT due to its ability to provide instant, more precise feedback while also being beneficial for the realization of personalized learning in students. In China, a portion of schools have introduced big data-based PT into their regular instruction and have achieved considerable outcomes, which potentially propels its popularization in the entire education world across the country. Yet, as a non-traditional teaching approach, it faces a lot of challenges. For instance, its implementation demands up-to-par digital competence in teachers, posing a new requirement to teacher education and training. In addition, the colossal workloads of data collection and processing associated with the large size of ordinary Chinese schools may hamper the long-term execution of this instructional method in China, calling for further improvement of relevant technological devices.

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