Research on the Inhibitory Mechanism of Transactive Memory Systems and Group Characteristics on High School Students' Creative Thinking Capacity: A Fuzzy-Set Qualitative Comparative Analysis Approach

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Abstract. *Our country's policy documents have put forward new requirements for the cultivation of students' creative thinking in high school education, especially for the cultivation of creative thinking ability of students in the chemistry subject, which is a field of scientific education. In this context, this study introduces the concept of transactive memory system based on the research logic of educational psychology, and analyzes the configuration effect that inhibits the formation of creative thinking ability of high school students in the chemistry subject from the perspective of "transactive memory system-group characteristics". Through the qualitative comparative analysis of fuzzy sets, it is found that the matching of transactive memory system and group characteristics sometimes inhibits the formation of creative thinking ability of high school students in the chemistry subject. Through the data analysis results of 179 high school student groups, it is found that there are two configurations that inhibit the formation of creative thinking ability of high school students in the chemistry subject, and low transactive memory system credibility and low group heterogeneity play a core role. The research results provide effective guidance for the theory and practice of high school chemistry education.*

Keywords: transactive memory system, group heterogeneity, group reflexivity, creative thinking capacity.

Introduction

With the development of society, scientific and technological progress and the changes of the times, high school students face great growth pressure and increasing pressure to enter higher education in the process of development (Sun et al., 2013; Tian et al., 2019). In the rapidly changing social and educational environment, students with creative thinking can better adapt to changes and discover new learning and lifestyles, thereby reducing the uncertainty and pressure caused by changes. In addition, the "Outline of the National Medium- and Long-Term Education Reform and Development Plan (2010-2020)" (the "Outline") pointed out that "my country is in a critical stage of reform and development. Economic construction, political construction, cultural construction, social construction and ecological civilization construction are being promoted in an all-round way. Industrialization, informatization, urbanization, marketization and internationalization are developing in depth. The pressure on population, resources and environment is increasing. The

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transformation of economic development mode is accelerating, which highlights the importance and urgency of improving the quality of the nation and cultivating innovative talents." In the new era, cultivating innovative talents has become an important mission of education at all levels and types. High school education is a transitional stage between basic education and higher education, and plays a very key role in cultivating innovative talents. The Outline further points out that "high school education is a critical period for the formation of students' personality and independent development, and it is of special significance for improving the quality of the nation and cultivating innovative talents" (Rich et al., 2012). It can be seen that policies and practices have put forward new requirements for improving the creative thinking ability of high school students.

Existing research on creative thinking ability is mainly concentrated on the level of college student education, focusing on exploring the development of college students' creative thinking ability scale (Fields et al., 2014) and the construction mechanism of college students' creative thinking ability (Wu et al., 2014), while rarely taking high school students as research objects. In addition, the only research on the creative thinking ability of high school students is mainly concentrated on English teaching (Sehic, 2017), mathematics teaching (Siswono et al., 2011; Suherman et al., 2022) and biology teaching (Zubaidah et al., 2021), lacking the cultivation of creative thinking ability of high school chemistry students. The only research applied to high school chemistry is also mainly conducted through theoretical research rather than empirical research (Fisher et al., 1991).

Transactive memory system (TMS) is a mechanism and method that reflects the use of each other's knowledge among group members (Lewis, 2003). It is the research focus of organizational behavior, knowledge management and other fields, and is also widely used in educational psychology research (Jackson et al., 2009). The role of transactive memory system in promoting ability performance has been widely recognized by the academic community (Argote, 2012). However, in the research of educational psychology, there is a lack of research on the influence of the configuration matching of transactive memory system and group characteristic factors on students' creative thinking ability and the consideration of configuration factors that inhibit creative thinking ability. In chemistry teaching, while cultivating the construction of group transactive memory system, by forming students from different backgrounds into a group and requiring students to have reflective ability, students' creative thinking ability in the process of chemistry learning can be gradually cultivated. On the contrary, it may inhibit the formation of students' creative thinking ability. Qualitative comparative analysis (QCA) is a supplement to traditional symmetric analysis tools. It considers the possibility of interdependence of all antecedent conditions and reveals sufficient combinations of conditions for the outcome variable, thereby enhancing a more refined understanding of chemical education phenomena and providing an empirical basis for building new theories about these phenomena.

Based on the above analysis, this study introduces the core variable of transactive memory system. From the perspective of team characteristics, the fuzzy set qualitative comparative analysis method (fsQCA) is used to explore the linkage effect between transactive memory system and group characteristics, and to discover the configuration mechanism that inhibits the formation of creative thinking ability in high school students' chemistry discipline. The research results have an important guiding role in the theory and practice of high school chemistry education.

Literature review and analytical framework

Group Transactive Memory Systems

The concept transactive memory system was proposed based on the concept of external memory. In the past, psychological research on memory focused on the encoding, storage and retrieval process of individual memory, while ignoring the tendency of humans to use external storage media to keep records, such as phone books, memos, archival materials, etc. (Brandon et al., 2004).

Wegner (1985) was the first person to propose the concept of transactive memory. He observed through experimental methods that individuals in a group rely on each other to remember certain information, which greatly increases the information and knowledge capacity of each person. In other words, the amount of information possessed by group members depends not only on the members' own memory capacity, but also on the information that can be obtained from the memory systems of other members, that is, the information that individual members can use is greater than their own memory capacity (Bachrach and Mullins, 2019). In a student group, when students learn about the expertise of other classmates, the responsibility for obtaining and encoding information related to the expertise will be implicitly or explicitly assigned to the most suitable classmate, and then transactive memory will be generated (Zhang et al., 2007). Wegner defines the transactive memory system as the sum of the knowledge possessed by each member (knowledge stock) and the collective consciousness of who knows what. In a student group, the effective use of the transactive memory system is crucial for the learning and effective mastery of knowledge (Ren et al., 2011). Classes are usually important units of student groups. In a class, students enhance their own memories through mutual communication, thereby sharing two types of information, namely: the knowledge possessed by individual students and the knowledge possessed by other members of the class group. As a result, the cognitive burden of each student is reduced, and they can also obtain far more professional knowledge and information than any individual can master alone. At the same time, their mutual dependence will also produce a group knowledge management system, enhancing the knowledge processing ability of the class group. The transactive memory system is a mutually dependent cooperative division of labor system formed between classmates in the class to obtain, store, and use information and knowledge from different fields. It is a mechanism to explain the group knowledge processing process. Lewis (2003)'s dimensional division of the transactive memory system and the scale he developed are the most widely used in subsequent studies of the transactive memory system. He believes that the transactive memory system contains three dimensions: (1) expertise, that is, the effectiveness of the knowledge division of group members; (2) credibility, that is, the group members' understanding of knowledge distribution and the degree of knowledge sharing; (3) coordination, that is, the effectiveness of the knowledge interactive retrieval process among group members.

The innovative thinking ability of high school students in chemistry is extremely important for students, because it directly affects how students understand and use chemical knowledge to solve new problems, discover unknown phenomena, and promote the frontier progress of science. This ability cultivates students' curiosity and spirit of exploration, inspires their love for chemistry and science, and lays a solid foundation for students to continue their studies or enter the workplace in the future. In the transactive memory system constructed by the class group, students use discussion and collaborative problem solving to transfer and transform chemical knowledge among different students, which promotes the in-depth understanding and application of knowledge (Lo et al., 2020). If there is a lack of discussion and cooperation, the formation of students' creative thinking ability will be inhibited. Therefore, the lack of construction of an interactive memory system among high school students may inhibit the improvement of students' creative thinking ability in chemistry.

Group Characteristics

Group heterogeneity

Group heterogeneity reflects the degree of difference in the characteristics and attributes of group members and is the most basic and broadest indicator for understanding group characteristics (Leitc et al., 2017). Due to differences in family background and life experience, student group members have different cognitive abilities. They differ in learning autonomy and their ability to accept and adapt to things. They may also have different internalization abilities of external values and normative constraints (Ackerman et al., 2006). For example, for high school students with higher cognitive abilities, they have stronger autonomy in learning chemistry and their ability to accept new things, while for high school students with average cognitive abilities, they may have relatively poor ability to contact new things. Therefore, group heterogeneity is an important factor affecting the creative thinking ability of high school students in chemistry.

Group Reflexivity

Scholars have defined the connotation of self-reflection from different levels. Petzold defined the connotation of self-reflection from the individual level, emphasizing that self-reflection is the embodiment and representation of individual cognitive style. Swift et al. (1998) and Shi Jintao et al. (2008) defined the connotation of self-reflection from the group level, believing that group self-reflection is the public reflection of group members on the existing group vision, operation process, goals, ideas, plans, etc., and on the basis of public reflection, take corresponding plans and actions to enable the team vision, goals, rules and regulations, ideas, strategies, etc. to quickly adapt to the dynamically changing and competitive learning environment. Group self-reflection mainly includes three elements: reflection (core element), planning and action (Von et al., 1993).

Group self-reflection reflects the degree to which group members publicly reflect on the group learning goals, action plans and processes, and make adaptive adjustments based on the results of reflection (Wiedow et al., 2011). Highly self-reflective groups emphasize the cycle of reflection-planning-action. The group is keen to reflect, actively examine changes in the learning environment, seize opportunities that are conducive to their own development, and identify the information extracted from the reflection link through planning and action for their own use (Ohlsson et al., 2013). Domestic and foreign scholars have explored the positive role of group self-reflection in promoting group learning ability from the perspective of quantitative research. Shin et al. (2017) believed that highly self-reflective groups are easy to reflect and discuss problems together, actively carry out group reform actions and knowledge innovation, and improve group learning ability. Gibson et al. (2003) believed that reflective communication and experimental exploration are important factors affecting group learning ability. Creative thinking ability is an important manifestation of learning ability. Therefore, if the class group lacks group reflection, it may inhibit the thinking ability of high school students in chemistry.

Creative thinking capacity

Learning ability generally refers to the combination of various abilities required for students to successfully complete learning activities and achieve learning goals (Mohammed et al., 2018). Creative thinking ability is an important factor in learning ability and is the key to determining whether innovative learning outcomes can be produced in the process of deep learning (Hong et al., 2010). The OECT expert group deconstructed it into three dimensions: "generating diverse ideas, generating creative ideas, and evaluating and improving ideas." A special test for creative thinking was also conducted in PISA2022. American ACT experts further proposed a new model of creative thinking for the future, in which the core cognitive skills include "conventional thinking, divergent thinking, unconventional thinking, and evaluation and improvement of ideas" (Ni et al., 2014). High school students' chemistry learning requires students to have creative thinking such as divergent thinking and imagination. Cultivating students' creative thinking ability in chemistry has become a focus in the field of chemistry education. Therefore, this study focuses on the creative thinking ability of high school students in chemistry.

Analytical Framework

Through the above analysis, it is found that the transactive memory system, group self-reflection and group heterogeneity have a positive impact on the creative thinking ability of high school students in chemistry. However, most previous studies have focused on the impact of a single factor on students' learning ability, ignoring the exploration of the linkage effect of matching multiple factors. Based on this, this paper attempts to incorporate the different characteristics of the group into the same framework, and constructs an analytical framework of "transactive memory system-group characteristics" from a diversified perspective, considering the comprehensive effect of the two levels of group knowledge management (transactive memory system) and group characteristics (group self-reflection and heterogeneity). Through the QCA method, the interaction mechanism between the five antecedent conditions of expertise, credibility and coordination of the transactive memory system and self-reflection and heterogeneity of group characteristics is explored, and the possible paths for the creative thinking ability of non-high-level high school students in chemistry are identified, as well as what kind of interactive combination can produce substitution, complementary (synergistic) effects. Based on the above analytical ideas, the analytical framework of this study is constructed as shown in Figure 1:

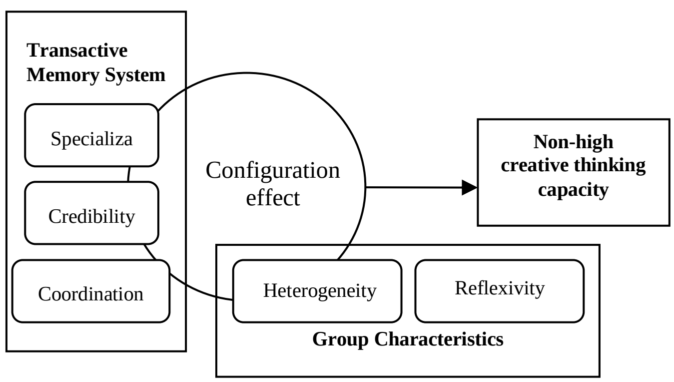

Figure 1. Framework for analyzing the study

Source: Authors' own research.

Measurement and sample

Variable Measurement

The study obtained data through questionnaire surveys. The measurement of the concepts involved was borrowed or adapted from mature scales: (1) The measurement tool of the group interactive memory system was borrowed from Lewis's (2003) scale on the team level, and was measured from three aspects: expertise, credibility, and coordination, with a total of 15 questions; (2) Group characteristics include group heterogeneity and group self-reflection. The measurement tool for group heterogeneity was adapted from Jackson et al.'s (2003) scale, and the measurement of group self-reflection was borrowed from Schippers et al.'s (2015) tool, with a total of 8 questions; the measurement of creative thinking ability was borrowed from Shen Xiajuan et al.'s (2023) measurement, with a total of 3 questions.

This study conducted a preliminary survey in a high school in Tianshui City, Gansu Province to improve and revise the initial questionnaire. A total of 40 questionnaires were distributed in the pre-survey. Through statistical analysis of the survey data, the CITC coefficient (corrected total correlation coefficient of questions) was less than 0.4 and the SMC (squared correlation coefficient) was less than 0.5. The items that did not meet the standards were deleted to achieve the purpose of correcting the measurement tool. In addition, the wording of the questions was modified based on the feedback from the pre-survey process to form a final questionnaire containing 18 measurement questions. The measurement questions of all concepts used the Likert 7-point scale (1 for strongly disagree and 7 for strongly agree).

Table 1. Measurement Scales of This Study

Variable	Dimension	Items
Transactive Memory System (TMS)	Specialization	Classmates have professional knowledge related to the chemistry learning tasks
		The professional knowledge of chemistry that the classmates have is all that is needed to complete the learning tasks
		Classmates know which specific areas of chemistry other students are good at
	Credibility	Willing to accept suggestions from classmates on chemistry learning
		Believe that the chemical knowledge provided by other students in the discussion is reliable
		I always want to double-check the chemical knowledge provided by other students
	Coordination	Classmates work well together when studying chemistry
		Classmates can complete the learning tasks of chemistry smoothly and efficiently
		Classmates feel confused about how to complete chemistry learning tasks.
Group Characteristics	Heterogeneity	The educational background knowledge of classmates before high school varies greatly
		The behavior styles of classmates vary greatly
		The thinking styles of classmates are very different
	Reflexivity	Classmates will often discuss learning methods in order to complete learning tasks efficiently
		Classmates can identify areas where they need to improve in their learning process
		Classmates clearly understand the importance of continuous improvement
Creative thinking capacity		I like to think of original solutions to problems
		I can come up with ideas that are different from others
		When I encounter learning difficulties, I can find new solutions

Source: Authors' own research.

Data Collection and Sample Overview

The data collection of this study is mainly focused on high schools in Qinzhou District, Tianshui City, Gansu Province. The steps include: ① Obtain the list of high schools in Qinzhou District, Tianshui City on the official website of the Tianshui Municipal Education Bureau, and contact relevant schools and students to inquire whether they are willing to participate in the survey. ② The questionnaires are mainly collected in the form of paper questionnaires, and the questions that students do not understand are explained and explained. ③ The questionnaire data are sorted and screened to form the data set of this study. In order to avoid common method bias and make the measurement more effective, the questionnaires are not only filled by students, but also invited to be filled by chemistry teachers.

The survey lasted for three months, contacted eligible students and teachers, and distributed 260 questionnaires. 192 questionnaires were collected, of which 179 were valid questionnaires, and the effective recovery rate was 68.85%. Since the data collection was carried out with the help of the school and the opinions of students and teachers were consulted in advance, the questionnaire recovery rate was relatively ideal. The basic information of the sample is shown in Table 2.

Table 2. Sample students (N=179)

Index	Category	Frequency	Per (%)
Gender	Male	84	46.93
	Female	95	53.07
Grade Level	Grade 10	33	18.43
	Grade 11	107	59.78
	Grade 12	39	21.79
Class Size (Students)	<40	31	17.32
	40–60	123	68.71
	>60	25	13.97

Source: Authors' own research.

FsQCA analysis

Variable Calibration

According to the suggestions of Fiss (2011), the five conditional variables and the outcome variable in the study were recalibrated into sets by setting three critical values, which are 75%, 50%, and 25% of the distribution of the sample data, corresponding to complete membership, intersection, and complete non-membership, respectively. This transformation makes the set membership range between 0 and 1. The fsQCA3.0 software was used to assign membership. For the variable of low creative thinking ability, the calibration rule is exactly the opposite of that of high creative ability, that is, the 75%, 50%, and 25% values of the data are marked as complete non-membership, intersection, and complete membership, respectively, to calculate the membership set of the non-set (see Table 3).

Table 3. Variable calibration points

Variable		Anchor					Fuzzy-set Descriptive Statistics			
		Mean	SD	Full membership	Crossover point	Full non-membership	Fuzzy mean	Fuzzy SD	Min	Max
Transactive Memory System	Specialization	5.15	1.460	7.00	5.00	4.00	0.4860	0.38707	0	0.95
	Credibility	4.71	1.275	6.33	4.67	3.67	0.4901	0.36082	0	0.92
	Coordination	5.12	1.405	6.33	5.00	4.00	0.5016	0.40028	0	0.99
Group Characteristics	Heterogeneity	5.14	1.394	6.33	5.00	4.00	0.5044	0.39622	0	0.99
	Reflexivity	5.05	1.296	6.00	5.00	4.00	0.4796	0.39826	0	1.00
Creative thinking capacity		5.18	1.348	6.33	5.00	4.00	0.5197	0.39630	0	0.99

Source: Authors' own research.

Data Analysis
The study used fsQCA3.0 software to analyze and identify the configurations that affect high school students' creative thinking ability. Following the suggestions of Fiss (2011), the consistency threshold of the solution was set to 0.8 and the frequency was selected as 1.

Necessity Analysis
Before entering the truth table analysis, it is an important step to conduct a necessity check. Necessary conditions can be regarded as a superset of the results. It is worth noting that if necessary conditions are considered in the truth table analysis, they may be excluded in the simplified solution containing the "logical remainder", that is, the necessary conditions may be eliminated in the simplification process. Therefore, it is necessary to conduct a necessity check. The analysis of necessary conditions for the creative thinking ability of high school students shows (see Table 4) that the consistency index of all single preconditions did not reach the standard of 0.9, indicating that these conditions do not constitute necessary conditions. This shows that the influence of these single preconditions on the creative thinking ability of high school students is limited. Based on this, this study uses fsQCA software to perform configuration analysis on the condition combination.

Table 4. Necessity test for sample variables

Condition variables		**Non-high Creative thinking capacity**	
		Consistency	**Coverage**
Transactive Memory System	Specialization	0.353571	0.349425
	~Specialization	0.877413	0.820000
	Credibility	0.354502	0.347470
	~Credibility	0.833566	0.785166
	Coordination	0.344848	0.330215
	~Coordination	0.886253	0.854164
Group Characteristics	Heterogeneity	0.350082	0.333407
	~Heterogeneity	0.887648	0.860234
	Reflexivity	0.303559	0.304019
	~Reflexivity	0.940684	0.868277

Source: Authors' own research.

The Necessary Conditions Analysis (NCA) method was used to identify the factors that are necessary for a particular outcome and to assess the effect size of the necessary conditions. This method is versatile and can accommodate both continuous and discrete variables, and the size of the effect is quantified as a "bottleneck level". This measure ranges from 0 to 1, where higher values indicate a larger effect of the necessary condition and values closer to 0.1 indicate a smaller effect size. For cases where both variables are continuous or defined as categorical variables with five or more levels, ceiling regression (CR) is the analysis method of choice. In contrast, for examining binary variables or categorical variables with fewer than five levels, ceiling envelope analysis (CE) is used in order to fully assess the effect size of the necessary conditions on the outcome and their importance to the outcome.

The results of the Necessary Conditions Analysis (NCA) study are detailed in Table 4, where the NCA method combines two estimation techniques—ceiling regression (CR) and ceiling envelope analysis (CE)—to measure the effect size of individual conditions on the desired outcome. Identifying a necessary condition depends on two key criteria: first, the effect size must meet or exceed a threshold of 0.1 (Dul, 2016), and second, the significance of this effect size must be verified by a Monte Carlo permutation test (Dul et al., 2020). The analysis showed that while DR was statistically significant, its effect was not large enough to classify it as a necessary condition for creative thinking ability success consistent with Dul (2016). Investigation of the other conditions found them to be statistically insignificant, indicating that they did not have a necessary effect on the creative thinking ability outcome. The bottleneck analysis is further detailed in Table 5. The bottleneck level (%) represents the value of the level that must be met within the maximum observed range of the outcome and the maximum observed range of the necessary condition (%).

Table 5. The need to analyze creative thinking capacity using NCA

Antecedent Condition	**Approach**	**C-accuracy**	**Ceiling zone**	**Scope**	**Effect size[b]**	**p-value[c]**
Specialization	CR	100%	0.000	0.94	0.000	1.000
	CE	100%	0.000	0.94	0.000	1.000
Credibility	CR	100%	0.000	0.91	0.000	1.000
	CE	100%	0.000	0.91	0.000	1.000
Coordination	CR	100%	0.000	0.98	0.000	1.000
	CE	100%	0.000	0.98	0.000	1.000
Heterogeneity	CR	100%	0.000	0.98	0.000	1.000
	CE	100%	0.000	0.98	0.000	1.000
Reflexivity	CR	98.9%	0.073	0.99	0.074	0.000
	CE	100%	0.060	0.99	0.061	0.000

Notes: a. Calibrated fuzzy set membership values. b. 0.0≤d < 0.1: “Low level”; 0.1≤ d < 0.3: “Moderate level”. c. Permutation tests in NCA, with 10,000 repetitions.

Source: Authors’ own research.

Table 6. Analyzing bottleneck levels using NCA

Creative thinking capacity	Specialization	Credibility	Coordination	Heterogeneity	Reflexivity
0	NN	NN	NN	NN	NN
10	NN	NN	NN	NN	NN
20	NN	NN	NN	NN	NN
30	NN	NN	NN	NN	NN
40	NN	NN	NN	NN	NN
50	NN	NN	NN	NN	NN
60	NN	NN	NN	NN	NN
70	NN	NN	NN	NN	2.2
80	NN	NN	NN	NN	17.1
90	NN	NN	NN	NN	32.1
100	NN	NN	NN	NN	47.0

Notes: NN=Non necessity.

Source: Authors’ own research.

Configurational Analysis

Using fsQCA analysis, three types of solutions are obtained: complex solutions, simple solutions, and intermediate solutions. Among them, complex solutions do not include "logical remainders"; simple solutions include "logical remainders", but their rationality is not evaluated; intermediate solutions are limited to incorporating "logical remainders" that conform to theoretical and practical knowledge into the solution. An important advantage of intermediate solutions is that they do not allow the elimination of necessary conditions. Generally speaking, intermediate solutions are better than the other two solutions, so this study chooses intermediate solutions for analysis.

According to the analytical convention of fsQCA, the core conditions and marginal conditions of the configuration are judged according to the simple solution and the intermediate solution: if a causal condition appears in both the simple solution and the intermediate solution, it is the core condition, which plays a leading and driving role; if this condition only appears in the intermediate solution, it is recorded as a marginal condition (auxiliary condition), that is, an auxiliary contribution condition. Using fsQCA3.0 software analysis, it can be seen that there are two configurations (i.e., condition combinations) of factors affecting the production of non-high-level creative thinking ability, namely, configuration 1: ~AA*~BB*~CC*~DD*~EE; configuration 2: AA*BB*~CC*~DD*~EE. The consistency rate of the solutions of the above three configurations reached 0.936161 (greater than 0.8), indicating that the solutions are meaningful. The coverage of the model solution is 0.803327, indicating that this configuration explains about 80% of the reasons for the generation of high-level creative thinking ability.

Following the approach outlined by Fiss (2011), the results are presented using the following symbols: ● Indicates that the core condition appears; ⊗ Indicates that the core condition does not appear; • Indicates that the edge condition appears; ⊗ Indicates that the edge condition does not appear; a space indicates that the variable is optional. The results of the configurations influencing creative thinking capacity are summarized in Table 7.

Table 7. The configuration result of creative thinking capacity

	Non-high creative thinking capacity	
	NH1	NH2
Specialization	⊗	●
Credibility	⊗	●
Coordination	⊗	⊗
Heterogeneity	⊗	⊗
Reflexivity	⊗	⊗
Consistency	0.945914	0.908524
Coverage	0.752617	0.203303
Unique coverage	0.600023	0.0507094
Solution consistency	0.936161	
Solution coverage	0.803327	

Source: Authors' own research.

Conclusions

Findings

The conclusion of the study shows that there is no single core condition that will inhibit the formation of creative thinking ability in high school students' chemistry, but the core role of the coordination of the transactive memory system and the heterogeneity of high school students in inhibiting the formation of creative thinking ability in high school students' chemistry has been fully demonstrated. The main results include:

First, when high school students learn chemical knowledge together, the combination of a lower transactive memory system (expertise, credibility and coordination) and lower group characteristics (group introspection and group heterogeneity) established between them will inhibit the formation of creative thinking ability in high school students' chemistry. Among them, the lower coordination of the transactive memory system and the lower group heterogeneity play a core role, and the lower expertise and credibility of the transactive memory system and the group introspection play an auxiliary role.

Second, when high school students learn chemical knowledge together, the combination of expertise and credibility of the transactive memory system established between them and the lower coordination and lower group characteristics (group heterogeneity and group introspection) will inhibit the formation of creative thinking ability in high school students' chemistry. Among them, the lower coordination of the transactive memory system and the lower group heterogeneity play a core role, and the expertise and credibility of the transactive memory system and the lower group introspection play an auxiliary role.

Research Significance and Implications

This study aims to explore the mechanism that inhibits the formation of creative thinking ability in high school students' chemistry discipline from a configuration perspective, focusing on the matching of group transactive memory systems with important factors of group characteristics.

The theoretical value of the study is mainly reflected in: (1) This study expands the application of transactive memory system theory in the field of education, especially in the understanding of creative thinking in collective learning environments. The study proves that in addition to traditional cognitive abilities, trust and reliable information exchange systems are also crucial for disciplinary creative thinking. The study emphasizes the importance of building and maintaining high-quality transactive memory systems in teaching practice, especially in collective learning environments. This finding encourages educators to design and implement teaching strategies aimed at enhancing trust, information sharing, and inter-group collaboration; (2) Secondly, this study analyzes the configuration that affects the creative thinking ability of high school students in chemistry discipline from a configuration perspective, providing a new analytical perspective and analytical ideas for chemical education research, and providing theoretical and methodological guidance for chemical education research; (3) This study mainly explores the configuration that inhibits the formation of creative thinking ability in high school students' chemistry discipline, enriches the analytical perspective of research in the field of chemical education, and can more effectively guide chemical education practice, helping teachers to use positive configurations and avoid negative configurations in chemical education.

At the same time, the conclusions of the study provide several management implications for cultivating high school students' creative thinking ability: This study emphasizes how to influence students' creative thinking ability by improving the coordination of the transactive memory system and enhancing the heterogeneity of the student group in high school chemistry education. Studies have shown that low coordination and group heterogeneity are key factors that inhibit the formation of creative thinking. Therefore, teachers should design teaching activities and learning environments to encourage effective communication and cooperation among students and ensure that information and knowledge flow reliably and evenly in the group. At the same time, the diversity of the group should be increased by mixing students with different backgrounds and abilities, thereby stimulating new thinking and problem-solving methods. In addition, educators should also encourage students to conduct regular self-reflection to help them understand their roles and contributions in the learning process, thereby further improving the collaborative efficiency and creative results of the entire group. Through these strategies, the creative thinking ability of high school students in the chemistry subject can be effectively cultivated and improved.

Research Limitations and Recommendations

Although this study has made useful explorations in the formation mechanism of creative thinking ability in high school students' chemistry, there are still some shortcomings, mainly including: (1) This study only explored and studied the creative thinking ability in high school students' chemistry learning ability, but high school students' chemistry learning ability also includes other important dimensions, such as critical thinking ability and autonomous learning ability. Therefore, future research should explore other types of learning abilities. (2) The group characteristics involved in this study (group heterogeneity and group introspection) are internal factors that affect high school students' creative thinking ability in chemistry, while the formation of creative thinking ability is also affected by other external factors, such as the complexity of the school examination system. Subsequent research can add external factors to the group to explore how the transactive memory system matches internal and external factors to form the creative thinking ability of high school students in chemistry.

References

Ackerman, J.M., Shapiro, J.R., Neuberg, S.L., et al. (2006). They all look the same to me (unless they're angry): From out-group homogeneity to out-group heterogeneity. *Psychological Science*, 17(10), 836-840.

Argote, L., & Ren, Y. (2012). Transactive memory systems: A microfoundation of dynamic capabilities. *Journal of Management Studies*, 49(8), 1375-1382.

Bachrach, G., & Mullins, R. (2019). A dual-process contingency model of leadership, transactive memory systems and team performance. *Journal of Business Research*, 96(1), 297-308.

Brandon, D.P., & Hollingshead, A.B. (2004). Transactive memory systems in organizations: Matching tasks, expertise, and people. *Organization Science*, 15(6), 633-644.

Dul, J., Van der Laan, E., & Kuik, R. (2020). A statistical significance test for necessary condition analysis. *Organizational Research Methods*, 23(2), 385-395.

Dul, J. (2016). Necessary condition analysis (NCA) logic and methodology of "necessary but not sufficient" causality. *Organizational Research Methods*, 19(1), 10-52.

Fields, Z., & Bisschoff, C.A. (2014). Developing and assessing a tool to measure the creativity of university students. *Journal of Social Sciences*, 38(1), 23-31.

Fisher, D.L., & Fraser, B.J. (1991). School climate and teacher professional development. *South Pacific Journal of Teacher Education*, 19(1), 17-32.

Fiss, P.C. (2011). Building better causal theories: A fuzzy set approach to typologies in organization research. *Academy of Management Journal*, 54(2), 393-420.

Gibson, C., & Vermeulen, F. (2003). A healthy divide: Subgroups as a stimulus for team learning behavior. *Administrative Science Quarterly*, 48(2), 202-239.

Hong, E., & Milgram, R.M. (2010). Creative thinking ability: Domain generality and specificity. *Creativity Research Journal*, 22(3), 272-287.

Jackson, M., & Moreland, R.L. (2009). Transactive memory in the classroom. *Small Group Research*, 40(5), 508-534.

Jackson, S.E., Joshi, A., & Erhardt, N.L. (2003). Recent research on team and organizational diversity: SWOT analysis and implications. *Journal of Management*, 29(6), 801-830.

Leitc, C., & Volery, T. (2017). Entrepreneurial leadership: Insights and directions. *International Small Business Journal*, 35(2), 147-156.

Lewis, K. (2003). Measuring transactive memory systems in the field: Scale development and validation. *Journal of Applied Psychology*, 88(4), 587-604.

Lo, M.F., & Tian, F. (2020). Enhancing competitive advantage in Hong Kong higher education: Linking knowledge sharing, absorptive capacity, and innovation capability. *Higher Education Quarterly*, 74(4), 426-441.

Mohammed, G.S., Wakil, K., & Nawroly, S.S. (2018). The effectiveness of microlearning to improve students' learning ability. *International Journal of Educational Research Review*, 3(3), 32-38.

Ni, M., Yang, L., Chen, J., et al. (2014). How to improve divergent thinking capability by information technology and extenics. *Procedia Computer Science*, 31, 158-164.

Ohlsson, J. (2013). Team learning: Collective reflection processes in teacher teams. *Journal of Workplace Learning*, 25(5), 296-309.

Ren, Y., & Argote, L. (2011). Transactive memory systems 1985–2010: An integrative framework of key dimensions, antecedents, and consequences. *Academy of Management Annals*, 5(1), 189-229.

Rich, Y., & Schachter, E.P. (2012). High school identity climate and student identity development. *Contemporary Educational Psychology*, 37(3), 218-228.

Schippers, M.C., West, M.A., & Dawson, J.F. (2015). Team reflexivity and innovation: The moderating role of team context. *Journal of Management*, 41(3), 769-788.

Sehic, S. (2017). The effect of English language learning on creative thinking skills: A mixed methods case study. *English Language Teaching*, 10(3), 82-94.

Shin, Y., Kim, M., & Lee, S.H. (2017). Reflection toward creativity: Team reflexivity as a linking mechanism between team goal orientation and team creative performance. *Journal of Business and Psychology*, 32, 655-671.

Siswono, T.Y.E. (2011). Level of student's creative thinking in classroom mathematics. *Educational Research and Reviews*, 6(7), 548-553.

Suherman, S., & Vidákovich, T. (2022). Assessment of mathematical creative thinking: A systematic review. *Thinking Skills and Creativity*, 44, 101019.

Sun, J., Dunne, M.P., Hou, X., et al. (2013). Educational stress among Chinese adolescents: Individual, family, school and peer influences. *Educational Review*, 65(3), 284-302.

Swift, T.A., & West, M.A. (1998). *Reflexivity and group processes: Research and practice.* ESRC Centre for Organization and Innovation.

Tian, L., Jiang, S., & Huebner, E.S. (2019). The big two personality traits and adolescents' complete mental health: The mediation role of perceived school stress. *School Psychology*, 34(1), 32.

Von Wright, J. (1992). Reflections on reflection. *Learning and Instruction*, 2(1), 59-68.

Wiedow, A., & Konradt, U. (2011). Two-dimensional structure of team process improvement: Team reflection and team adaptation. *Small Group Research*, 42(1), 32-54.

Wu, H.Y., Wu, H.S., Chen, I.S., et al. (2014). Exploring the critical influential factors of creativity for college students: A multiple criteria decision-making approach. *Thinking Skills and Creativity*, 11, 1-21.

Zhang, Z.X., Hempel, P.S., Han, Y.L., et al. (2007). Transactive memory system links work team characteristics and performance. *Journal of Applied Psychology*, 92(6), 1722-1730.

Zubaidah, S., & Corebima, A.D. (2021). The effect size of different learning on critical and creative thinking skills of biology students. *International Journal of Instruction*, 14(3), 187-206.