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Interaction between field cognitive tendencies and academic performance in geography among high school students

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Abstract: *Field cognitive tendency refers to an individual's tendency to choose a reference point in cognitive activities. Hermann Witkin classified them as field-independent and field-dependent. Field-independent individuals tend to use their own internal frameworks and criteria to understand and evaluate information, whereas field-dependent individuals are more inclined to form perceptions and make decisions based on cues from the external environment. This study found that there is a correlation between field cognitive tendencies and academic achievement in geography, i.e., field-independent students are more likely to achieve excellent geography grades, but this correlation is limited and not a determining factor. On the other hand, field-independent students' achievement in physical geography had a more significant positive correlation with their cognitive tendency, while field-dependent students' achievement in human geography showed a stronger positive correlation. Not only that, the presence or absence of maps on geography questions had different effects on students with different cognitive dispositions, with field-dependent students having an increased ability to score on questions with maps, whereas field-independent students relied less on visual aids. Based on this, geography teachers should recognise that total geography achievement is affected by a variety of factors, and adopt diverse measures to improve students' geography achievement. In addition, they should respect students' individual differences and use differentiated teaching strategies to promote students' all-round development. At the same time, assessment experts should take into account differences in cognitive tendencies when designing geography test questions, so as to ensure that students' mastery of geography knowledge and skills is measured more accurately and objectively.*

Keywords: *field cognitive tendencies; geography academic achievement; correlation; high school geography; differentiated instruction*

1. Introduction

In the contemporary education system, students' academic performance in geography is one of the important concerns of geography education, which not only reflects students' geography learning, but also has a profound impact on students' self-confidence, learning interest and future career development path. Therefore, an in-depth discussion of the factors affecting senior high school students' academic performance in geography is of great practical significance for improving the quality of geography education and promoting students' better development. Geography learning as a cognitive processing activity, to a certain extent, will be affected by the cognitive style, Herman Witkin based on the root person in cognitive processing on the objective environment to provide clues to the different degree of reliance on the cognitive style is divided into field dependent and field independent. Field-independent individuals tend to use internal normative perceptual cues and are less influenced by the external environment, whereas field-dependent individuals rely more on external environmental references for judgement. Geography, as a subject with both arts and sciences, both regional and integrative, and with human-earth relationship as the research theme, is reasonably suspected to be an important factor affecting students' academic performance in geography, and based on this, a related study is conducted. The present study is divided into three main research questions.1. What is the correlation between field cognitive tendency and overall academic performance in geography.2. What is the correlation between field cognitive tendency and performance in physical geography and human geography respectively.3. What is the effect of field cognitive tendency on students' ability to solve geography problems with and

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without maps.4. What is the effect of field cognitive tendency on students' performance in geography?

2. Literature review

2.1 Field cognitive tendencies

Field cognitive tendency, as an important basis for the division of individual cognitive styles, has been a hotspot of psychological and pedagogical research since it was proposed by Hermann Witkin. As of June 2024, there have been as many as 600 related academic articles included in CNKI. In the field of education and teaching, most of the related studies focus on foreign language learning. For example, Dai Yuncai investigated the relationship between English learners' field independence/field dependence cognitive styles and second language acquisition through a combination of quantitative and qualitative methods. The results of the study showed that field independence had no substantial effect on the overall academic performance of English learners at the elementary level, but it was significantly positively correlated with the English performance of female learners; and for learners at the intermediate level, it had no significant relationship with other test scores, except for a positive correlation with listening scores in the Grade 4 exam, especially for male students.[1] In the field of psychology, the study mainly focuses on the correlation between field cognitive tendency and its thinking quality and life behaviour. For example, Guo Cicada Yu and Zhuang Kaixiang explored the link between field-independent and field-dependent cognitive styles and creative thinking in terms of the functional basis of the brain. Using functional magnetic resonance techniques, they found that there are positively correlated brain regions between creative thinking and the centrality of the brain's resting attitudes, and that the degree centrality of some of these brain regions partially mediates the effect on cognitive style and creative thinking. This suggests that field-independent-field-dependent cognitive styles may influence creative thinking through cognitive control, i.e., individuals with cognitive styles that are more oriented towards field-independence may have better cognitive control, be able to exclude extraneous information more efficiently, focus their attention, and show higher cognitive flexibility.[2] The study by Sun Linhui and Yang Lu explored the effect of cognitive style on the efficiency of online shopping information search from the perspective of consumer behaviour. Through eye-tracking experiments, they found that task complexity and cognitive style had a significant effect on the response time of consumers searching for information in the simulation interface of online shopping. The average reaction times of field-independent consumers were all lower than those of field-dependent consumers, indicating that field-independent consumers have some advantages in information search efficiency. In summary, it is easy to see that field cognitive tendency has an important influence on the cognitive behaviour of individuals.[3] Thus, it is reasonable to link the field cognitive tendency with students' academic performance in geography, and to discover the inherent rules by quantifying the relationship between the two, so as to optimise teaching and improve teaching efficiency.

2.2 Achievements in geography

Improving students' academic performance in geography is one of the important aims of research on geography teaching and learning, but the number of studies on geography academic performance itself is relatively small, with a total of more than 100 related articles on CNKI as of June 24th. It comes down to two categories, one is the analysis of factors affecting geography achievement and the other is the research on the evaluation programme of geography achievement. In comparison, there are fewer studies on the analysis of influencing factors. In 2017, Zeng Xiaodan had selected six classes of students in Dongshan Middle School of Meizhou City as the survey object to explore the influence of four non-intellectual factors, namely, motivation, interest in learning, self-efficacy, and study habits, on the geography achievement of senior students. Through the correlation analysis of each factor with geography achievement, it was found that the four non-intellectual factors of motivation, interest in learning, self-efficacy and study habits were positively correlated with the geography achievement of the first year high school students, with self-efficacy having the most significant effect. In addition, there were slight differences in gender performance, with learning interest and self-efficacy having a significant effect on both male and female students' geography achievement, while motivation and study habits had a more pronounced effect on male students' achievement than on female students'.[4] 2016 Lu Xiaoxu conducted a study on the relationship between geography note-taking and geography academic achievement, first of all, Lu Xiaoxu, Gübeni et al. constructed a geography note-taking evaluation index system including two first-level indexes of note-taking quality and note-taking process, as well as eight second-level indexes of completeness, uniqueness, neatness, selectivity, format, as well as awareness,

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method, and utilisation. The weights of the indicators were set through the hierarchical analysis method, and the note quality evaluation criteria and note process measurement tools were established. It was found that students' geography note-taking level had an extremely significant correlation with geography academic performance, with a correlation coefficient as high as 0.934, and a logarithmic regression equation with excellent goodness-of-fit was established for performance prediction and learning early warning. In terms of the strength of influence, note-taking quality is more important than note-taking process in the primary indicators, with format, completeness, selectivity, neatness and uniqueness having a decreasing strength of influence on achievement in the five secondary indicators of note-taking quality; and methodology, awareness and utilisation having a decreasing strength of influence in the three secondary indicators of note-taking process.[5]

It can be seen that existing studies have not fully explored the potential impact of field cognitive tendencies on academic performance in geography. Field cognitive tendencies, as differences in individuals' reliance on internal references or external environmental cues in processing information, may affect students' spatial thinking ability and their understanding and application of geographical knowledge. Considering the regional and integrative nature of geography, field cognitive tendency may affect students' academic performance by influencing their spatial analysis, map interpretation and conceptual application in geography learning. Therefore, research on the factors influencing academic performance in geography needs to incorporate field cognitive tendencies into the scope of the study with a view to discovering new associations and mechanisms of action. This will enable educators to better understand the variability of students' geography learning, design personalised teaching methods, and promote students' deeper understanding and competence in the subject.

3. Research design

3.1 Research tools

(1) Revised Mosaic Graphic Test, Department of Psychology, Beijing Normal University

The test is an inherited and optimised version of the original Mosaic Graphics Test developed by Witkin in 1972, which quantifies subjects' field cognitive tendencies by asking them to identify and depict specific simple shapes among complex shapes. The design of the test paper ensures operational simplicity and scientific rigour, with high internal consistency (reliability of 0.9) and reasonable validity (0.49), and is able to effectively differentiate between individuals of different cognitive style types.[6] Meng Qingmao and Chang Jianhua set the evaluation criteria in 1988, in which a score of 12 serves as the cut-off point between field-independent and field-dependent cognitive styles in a test with a total score of 24. Above 12, the higher the score the more prominent the field-independent characteristics, and below 12, the lower the score the more prominent the field-dependent characteristics. This provides a clear categorisation for the study of field cognitive tendencies.[7]

(2) L City 2023-2024 school year second semester final test

The Geography end-of-term quality test questions are carefully developed by L Geography teachers and researchers as an assessment tool based on the content of the Humanities version of the Geography textbooks for Compulsory I and II and the New Curriculum Standards. After repeated polishing, as well as expert review, has a high degree of reliability and validity. The questions are worth 100 marks and are divided into two modules, namely natural geography and human geography, with natural geography accounting for 55 marks and human geography 45 marks. The questions were divided into those with and without maps, of which 68 were questions with maps and 32 were questions without maps. The questions with maps were designed to examine students' ability to interpret maps, spatial analysis skills and their ability to solve geographical problems by combining graphical information. On the whole, the questions were well structured and of moderate difficulty, covering the basic geography knowledge that students should master in the first year of senior secondary education, as well as reflecting the examination of students' comprehensive analytical and practical skills in geography, which can be used to assess students' achievements in geography in the previous semester in a more comprehensive manner.

3.2 Research methodology

Firstly, participants' field cognitive styles were assessed using the Mosaic Graphics Test, which was scheduled to take place during non-teaching hours and with the consent of the class teacher. Prior to the test, invigilators were trained and the purpose of the test was made clear to the students, emphasising that

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the results only reflected individual cognitive styles and had nothing to do with learning ability, thus ensuring standardisation and fairness of the test. Upon completion of the test, valid scripts were collected and collated, and non-compliant scripts were excluded to ensure the accuracy of the data. Subsequently, the final geography scores of all participants were collected, including the total score and each sub-score. Finally, the correlation between field cognitive tendencies and academic performance in geography was quantitatively analysed using SPSS 23.0 software. The results of the analysis aimed to reveal the extent of the influence of different field cognitive styles on geography academic performance and, based on this, to help geography teachers optimise their teaching and improve the relevance and scientificity of their teaching, so as to enhance students' geography academic performance.

3.3 Research Objects

In this study, 200 students in the first year of L No. 5 Higher Secondary School were randomly selected as respondents. L No. 5 Higher Secondary School, founded in 1993, is a provincial demonstration high school, with enrolment in H Province and neighbouring provinces, and a wide range of student levels, making it highly representative. The students in the first year of high school are usually in the initial stage of deepening their understanding of geography, and their attitudes and methods of learning are in the stage of formation and solidification, which provides a pure window for the study, and to a certain extent, it can exclude the interference of some irrelevant factors, so as to better reflect the relationship between students' cognitive tendency in the field and their performance in geography. In addition, the male-to-female ratio in the study population is close to 1:1, thus avoiding the bias caused by the difference in the number of males and females. In addition, the school has perfect teaching facilities and standardised teaching management, which provides good external conditions for the study.

3.4 Data Acquisition

In July 2024, we obtained the geography final grade data of the 200 students who participated in the test from the teaching office of L Fifth Senior High School. 178 questionnaires were returned to the students who participated in the test (questionnaire survey) in June 2024, the recovery rate of the questionnaires was 89%, and 18 out of the 178 questionnaires were found to be invalid, with 160 valid questionnaires, which is an effective rate of 90%. The validity rate of the questionnaire was 90%. The descriptive statistics of the data are shown in Table 1.

Table 1: Descriptive statistics of field cognitive style scores as well as final geography grades

	Number of cases	minimum value	maximum values	average value	standard deviation
Graphic mosaics results	160	5.0	24.0	15.0	4.7
Final geography results	160	35	93	72	11.9
Field Independent Tendency Geography Scores	88	35	93	73.3	10.3
Field Dependency Tendency Geography Scores	72	39	92	70.4	15.6

4. Data analysis

4.1 Correlation analysis between field cognitive tendency and overall geography performance

Pearson's correlation was used to investigate the correlation between students' field cognitive tendencies and their academic performance in geography. As shown in Table 2. The correlation coefficient between field cognitive tendency scores and geography academic achievement is 0.21, and the correlation coefficient indicates that there is some linear relationship between the two. The probability of significance p-value is 0.038, which just meets the criteria for statistical significance.

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Table 2: Correlation statistics between field cognitive styles and overall geography scores

		cognitive tendency	totals
cognitive tendency	Pearson Correlation	1	
	Significance (two-tailed)		
	Number of cases	160	
totals	Pearson Correlation	0.21	1
	Significance (two-tailed)	.038	
	Number of cases	160	160

4.2 Analysis of the correlation between cognitive dispositions and academic achievement in geography with different content types

To further explore how different field cognitive dispositions correlate with different content types of geography academic performance, Pearson correlation analyses were next conducted on the final grades of field-independent and field-dependent students in the areas of physical and human geography, respectively, in order to make clear the links between these cognitive dispositions and their associations. As shown in Tables 3 and 4. The results show that there is a relatively significant positive correlation between cognitive disposition of field independence and performance in natural geography ($r= 0.568$, $p=0.025<0.05$), indicating that students with higher field independence also perform relatively better in natural geography. However, the correlation between field independence and achievement in human geography was not significant ($r= 0.015$, $p=0.886>0.05$) and did not reach the level of statistical significance, which may imply that the effect of field independence on the achievement in human geography is small or not generalisable. Also, the correlation between field dependence and physical geography achievement was not significant ($r= 0.223$, $p=0.227>0.05$). In contrast, there was a negative correlation between field dependence and human geography achievement ($r= -0.235$, $p= 0.029<0.05$),which suggests that students with higher field dependence have relatively higher human geography achievement.

Table 3: Correlation statistics between field-independent cognitive styles and geography scores across content types

		Field independent	Physical Geography Score	Human Geography Score
Field independent	Pearson Correlation	1		
	Significance (two-tailed)			
	Number of cases	88		
Physical geography Score	Pearson Correlation	.568*	1	
	Significance (two-tailed)	.025		
	Number of cases	88	88	
Human Geography Score	Pearson Correlation	.015	.758**	1
	Significance (two-tailed)	.886	.000	
	Number of cases	88	88	88

Table 4: Correlation statistics between field dependent cognitive styles and geography scores across content types

		Field dependent	Physical Geography Score	Human Geography Score
Field dependent	Pearson Correlation	1		
	Significance (two-tailed)			
	Number of cases	72		
Physical Geography Score	Pearson Correlation	.223	1	
	Significance (two-tailed)	.227		
	Number of cases	72	72	
Human Geography Score	Pearson Correlation	-.235*	.678**	1
	Significance (two-tailed)	.029	.000	
	Number of cases	72	72	72

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4.3 Correlation analysis between cognitive tendency and the scoring of questions with or without pictures

Pearson's correlation analysis of the scores of field-independent and field-dependent students on the questions with and without matching diagrams can be obtained in Tables 5 and 6. The structure shows that the presence or absence of matching diagrams has little effect on the field-independent students, and that there is no significant correlation between their scores on both question types and their cognitive tendencies. On the contrary, for the field-dependent students, the scores on the questions with matching diagrams showed some negative correlation with their cognitive tendencies ($r=-0.474$, $P=0.042<0.05$).

Table 5: Correlation statistics between field dependent cognitive styles and the scoring of geography questions with and without maps

		Field dependent	with pictures	unillustrated
Field dependent	Pearson Correlation	1		
	Significance (two-tailed)			
	Number of cases	72		
with pictures	Pearson Correlation	-.474*	1	
	Significance (two-tailed)	.042		
	Number of cases	72	72	
unillustrated	Pearson Correlation	.343	.735**	1
	Significance (two-tailed)	.829	.000	
	Number of cases	72	72	72

Table 6: Correlation statistics between field independent cognitive styles and scores gained on geography questions with and without maps

		Field independent	with pictures	unillustrated
Field independent	Pearson Correlation	1		
	Significance (two-tailed)			
	Number of cases	88		
with pictures	Pearson Correlation	-.435	1	
	Significance (two-tailed)	.772		
	Number of cases	88	88	
unillustrated	Pearson Correlation	.353	.629**	1
	Significance (two-tailed)	.739	.000	
	Number of cases	88	88	88

5. Conclusions and discussion of the study

5.1 Field cognitive tendencies have limited impact on overall geography performance

Although field cognitive tendency is recognised in educational psychology as an important factor influencing students' learning styles, its impact on overall geography achievement is relatively limited. A Pearson correlation analysis revealed a correlation coefficient of 0.21 between field cognitive tendency scores and academic achievement in geography, a value that, while showing a positive trend, had a probability of significance p-value of 0.038, which is only slightly below the commonly accepted threshold of statistical significance of 0.05. This suggests that, while field cognitive tendency may have an impact on students' learning in geography, this impact is not decisive. Simply put the higher the cognitive style test scores (the more inclined to field independence) the higher the students' geography scores, but not to an extremely high degree. That is to say, both types of students have the opportunity to become better learners in geography. An in-depth analysis of the descriptive statistics also leads to the corresponding conclusions. In a sample of 160 first-year students, field-independent students had an average overall geography score of 73.3, while field-dependent students had an average score of 70.4, a difference of 2.9 points, with field-independent students slightly outperforming field-dependent students. However, this difference does not mean that field-independent students have an insurmountable advantage in geography, as field-dependent students have the same opportunity to excel. In fact, the range of geography scores for field-independent students ranged from 35 to 93, and the range of scores for field-dependent students ranged from 39 to 92, demonstrating large fluctuations and individual differences in geography scores for students of both cognitive styles. The comprehensive and complex nature of geography requires students to possess not only a wealth of knowledge, but also spatial analysis and logical reasoning. Therefore, students' overall performance in geography may be affected by a

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combination of factors such as learning strategies, teaching methods, course content, personal interests and motivation. Together, these factors shape students' academic performance, not just their cognitive tendencies. In summary, while there is some correlation between field cognitive dispositions and academic performance in geography, this correlation is not strong and does not reach a statistically significant level. Students' overall performance in geography is affected by a combination of factors, and geography teachers should recognise this and take appropriate measures to promote the holistic development of their students. For example, geography teachers implement differentiated teaching strategies that respect individual differences in students and provide teaching methods that accommodate different fields of cognitive styles in order to help all students find the right learning methods to improve their performance in geography. At the same time, students should also realise that through hard work and appropriate learning strategies, it is possible for students with different cognitive styles to excel in the subject of Geography.

5.2 Different field cognitive dispositions manifest themselves differently in different content areas of the geography discipline

According to the results of the correlation analysis, the achievement of field-independent students in the field of natural geography shows a more significant positive correlation with their cognitive tendencies. This implies that field-independent students may be able to better use their ability to think independently and synthesise and analyse when dealing with abstract concepts and theories in natural geography, leading to better performance in this area. In contrast, field-dependent students showed a positive correlation in human geography, suggesting that they may be better at understanding and remembering knowledge related to human geography. However, field-dependent students showed a negative correlation in physical geography performance with a correlation coefficient of 0.223 and a significance level of P=0.027, which reflects that they may face some challenges in dealing with abstract geographic concepts. In summary, the reasons for these differences may be related to the essential characteristics of the two cognitive styles. Field-independent students are more inclined to use a logical and analytical approach to process information, which may be more effective in the learning and understanding of physical geography. Field-dependent students, on the other hand, prefer to use an intuitive and holistic approach to learning, which may be more favourable in the field of human geography, a field that usually involves a large number of case studies and cultural contexts. This finding, is also in line with the current mainstream view that field independence is better at learning science subjects and field dependency is better at learning arts subjects. Geography teachers, therefore, should design differentiated teaching methods to accommodate students with different cognitive styles, and can engage in adaptive teaching, providing more independent research and analysis tasks for field-independent students, and more guidance and case studies for field-dependent students, to build on students' strengths. It can also be reversed, with mismatch teaching, to make up for students' shortcomings through exercise. All in all, teachers need to enhance the relevance of their teaching and targeting.

5.3 The presence or absence of maps in geography questions has different effects on students with different cognitive tendencies

For field-dependent students, the question design with accompanying diagrams seems to provide an effective aid to help them better understand and answer geography questions. In the correlation analysis above, the scores on the questions with illustrations were negatively correlated with the cognitive tendencies of the field-dependent students ($r = 0.474$, $P = -0.042$), suggesting that their scoring ability was enhanced with the aid of visual information. In contrast, there was no significant correlation between field-independent students' scores on questions with and without matching pictures and their cognitive tendencies. This may imply that field-independent students are less reliant on visually assisted information when dealing with geography problems and are more inclined to use their own internal cognitive resources and analytical skills to solve problems. This difference may stem from the fact that field-independent students have strong information screening and abstract thinking skills, enabling them to effectively extract key information from problems without additional visual cues. Therefore, assessment experts should take into account this difference in cognitive tendencies when designing geography examination questions to ensure that all students can demonstrate their knowledge and skills in a way that best suits them, and thus ensure that the assessment is scientific, accurate and fair.

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6. Conclusions

This study explored the interrelationship between field cognitive tendency and high school students' academic achievement in geography through quantitative analysis. It was found that although field cognitive tendency has a certain influence on total geography achievement, it is not a decisive factor, which indicates that the acquisition of geography academic achievement is the result of a multidimensional and multifactorial combination. In addition, students with different cognitive dispositions showed different learning strengths in different areas of geography, with field-independent students performing better in the area of physical geography, while field-dependent students performed more prominently in the area of humanistic geography. Therefore, geography educators need to pay attention to the diversity of students' cognitive styles in instructional design and adopt differentiated teaching strategies to accommodate the learning needs of different students. In addition, this study also explored the effects of the presence or absence of accompanying maps in geography topics on students with different cognitive tendencies. The results showed that field-dependent students improved their ability to score on questions assisted by accompanying maps, while field-independent students relied less on visual information. Therefore, geography test questions should also be designed with students' cognitive tendencies in mind to ensure that the assessment is scientific and fair, so that all students can demonstrate their knowledge and skills in a way that best suits them. In summary, this study provides a new perspective for geography education research, pointing out the potential role of cognitive dispositions in geography learning and providing a theoretical basis for personalised teaching and assessment. Future research can further explore how to optimise students' cognitive dispositions through pedagogical interventions, thereby improving the effectiveness of teaching and learning in geography. Educators and assessment specialists are also encouraged to apply the findings of this study in practice to facilitate deeper student learning in the subject of geography. Finally, this study calls for greater collaboration between the education and psychology communities in exploring the application of cognitive dispositions in education to provide more personalised and effective learning support for students to help them achieve their maximum learning potential.

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