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Teaching Experiment and Effect Analysis on Geospatial Thinking Cultivation among Senior High School Students under the Concept of Core Literacy

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Abstract: Spatial thinking is the core thinking in geography discipline and also the necessary prerequisite for regional cognition, comprehensive thinking and geographical practice. Cultivating geospatial thinking among senior high school students plays an important role in developing the core discipline literacy. This study investigates a variety of geospatial thinking cultivation strategies including mental map, mind mapping, Project-based learning and VR technology, and verifies the implementation effect of these strategies through teaching experiments. We find that appropriate use of geospatial thinking cultivation strategies in teaching can significantly improve senior high school students' geospatial thinking ability, which can also narrow the gender difference in geospatial thinking ability between male and female students to a certain extent.

1. Introduction

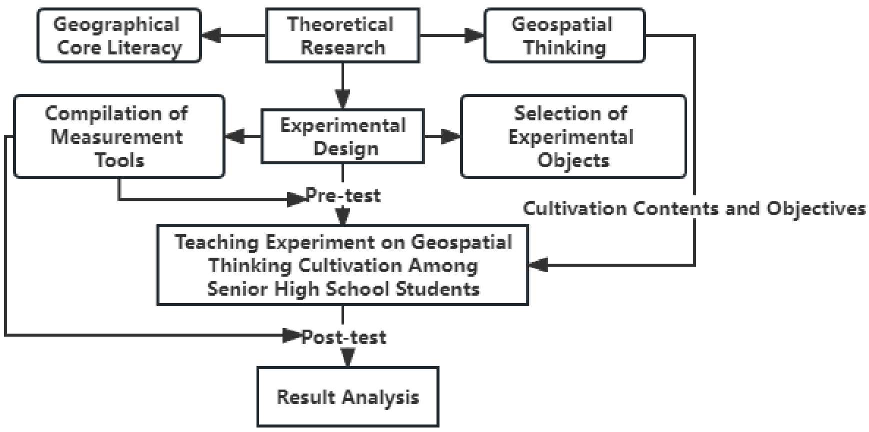

Figure 1: Teaching experiment flow of geospatial thinking cultivation among senior high school students

In order to test the implementation effect of geospatial thinking cultivation strategy in geography teaching of senior high school students under the concept of core literacy, this study selected more than 110 students from two classes in senior grade one of Jianyang Middle School as research objects to carry out a comparative teaching experiment on geospatial thinking cultivation. Through the investigation and analysis of students' geospatial thinking before and after the implementation of the cultivation strategy, the implementation effect of the geospatial thinking cultivation strategy is learned to point out the direction of geospatial thinking cultivation among senior high school students in the future. The main process of this teaching experiment is shown in Figure 1.

2. Teaching Experiment of Geospatial Thinking Cultivation among Senior High School Students

2.1. Teaching Experiment Design

In order to facilitate the observation and analysis of the teaching experiment effect, this study only adopted paper and pencil test to evaluate the geospatial thinking cultivation effect. Two classes with the closest pre-test results were selected from the senior grade one of Jianyang Middle School as the research objects, both of which were taught by the same teacher of the research group to maximally guarantee insignificant difference in the pretest conditions of this experiment. Class A with 54 students (male 25, female 29) was used as the experimental group. For it, various strategies were adopted in daily geography teaching to cultivate geospatial thinking. Class B with 57 students (male 28, female 29) was used as the control group. For it, geography was taught in the traditional way without special cultivation of geospatial thinking.

2.2. Teaching Experiment Conditions

Jianyang Middle School is not only equipped with special facilities for geography teaching, such as a multi-purpose geography laboratory, an astronomical telescope, and a geography park, but also supports multi-media and networking of all classrooms. The natural and socio-economic conditions around the school are very suitable for the implementation of spatial thinking cultivation strategies such as visual geography teaching and project-based learning. In addition, a high proportion of the senior teachers and backbone teachers in the geography group have postgraduate degree, who have participated in a number of provincial, municipal and county-level projects, and have strong teaching and research ability. Therefore, the school fully meets the conditions for teaching experiments on geospatial thinking cultivation strategy.

2.3. Teaching Experiment Method

This study took Compulsory Geography 1 of the PEP Edition as the teaching content. Both the experimental group and the control group carried out teaching activities according to the curriculum standard requirements and textbook contents. The difference was whether the geospatial thinking cultivation strategy was used. The control group was taught in the traditional way with the help of traditional maps, globes, PPT and other conventional teaching tools. The experimental group implemented different geospatial thinking cultivation strategies according to chapter contents in daily teaching [1]. For example, when teaching the chapter of longitude and latitude grid line, the experimental group made use of Marble, Google Earth [2], Quick Understanding of Geography APP and other cutting-edge multimedia technologies to visually display and explain the connotation and distribution characteristics of longitude and latitude grid lines, so as to help students observe and think about the longitude and latitude grid line from different perspectives. Meanwhile, in the control group, globes were combined with PPT and atlas in explanation. Limited by the globe size and flat map, it was difficult for students to convert between the spatial dimension and spatial perspective of the longitude and latitude grid line. For another example, when interpreting surface contour maps, the experimental group can use 3D models or software to improve students' geospatial thinking ability [3], experience the conversion between contour maps and three-dimensional terrain with the help of VR equipment, and even go to a mountain park near the school under the guidance of geography teachers to observe mountain terrain such as ridge, valley, saddle and steep cliff on the spot. However, in the control group, contour line interpretation law was mainly taught through PPT, failing to fully cultivate the students' geospatial thinking of spatial transformation and spatial perception.

3. Analysis of the Geospatial Thinking Cultivation Effect on Senior High School Students

3.1. Compile a Geospatial Thinking Scale for Senior High School Students

In order to test the geospatial thinking ability of senior high school students, this study compiled a geospatial thinking scale for senior high school students by referring to the investigation direction and form of geospatial thinking in geography curriculum standards and college entrance examination questions, and conducted pre-and post-test on the geospatial positioning, spatial conversion, spatial reasoning and spatial perception ability of senior high school students.

The design of the geospatial thinking scale for senior high school students should be rigorous and scientific. The design and use steps are shown in Figure 2.

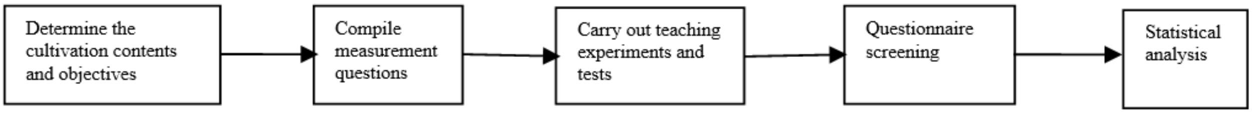

Figure 2: Design and application of geospatial thinking scale

First, after studying course standards, teaching materials and college entrance examination questions, clarify the geospatial thinking cultivation objectives and contents for senior high school students based on teaching practice.

The second step was to draw on the relevant research of Huynh and Niem Tu [4] and organize senior teachers and experts to jointly compile the measurement scale according to the geospatial thinking cultivation objectives and contents for senior high school students. Finally, 10 questions were selected to form a brief table, and each question was assigned 1 point out of a total of 10 points. The measurement scale mainly involves geospatial positioning, spatial reasoning, spatial transformation, spatial perception and so on [5].

The third step was to carry out the teaching experiment of geospatial thinking cultivation. From September to December 2022, the two classes in senior grade one with the closest pre-test results in geospatial thinking were selected for the teaching experiment. The experimental group (Class A) integrated VR, GE, PBL [6] and other geospatial thinking cultivation strategies in daily teaching, while the control group (Class B) did not carry out special geospatial thinking cultivation. At the end of December, the geospatial thinking of students in the two classes was post-tested.

The fourth step was to eliminate invalid questionnaires such as blank papers and similar papers. In the pre-test, 54 questionnaires were issued to the experimental group (Class A), 54 were recovered with a recovery rate of 100%, 52 questionnaires were valid, with a validity rate of 96.3%; 57 questionnaires were issued to the control group (Class B), 56 were recovered with a recovery rate of 98.2%, 53 questionnaires were valid, with a validity rate of 94.6%. In the post-test, 54 papers were issued to Class A and 53 were recovered, with a recovery rate of 98.1%, 51 questionnaires were valid, with a validity rate of 96.2%; 57 papers were issued to Class B and 54 were recovered, with a recovery rate of 94.7%, 52 questionnaires were valid, with a validity rate of 96.3% (see Table 1).

Table 1: Selection of teaching experiment samples

	Pre-test			post-test			remarks
group	issued	recovered	valid	issued	recovered	valid	The paper is invalid if the number of questions answered is less than 7.
A	54	54	52	54	53	51	
B	57	56	53	57	54	52	

The fifth step is statistics and analysis of data to draw conclusions.

3.2. Reliability and Validity of Geospatial Thinking Scale for Senior High School Students

3.2.1 Reliability of Measurement Scale

Generally speaking, reliability refers to the degree of consistency of the results obtained by repeated measurement of the same object using the same method. In this paper, SPSS22.0 was used to test the self-designed geospatial thinking scale with Cronbach α method, and the results are as follows (see Table 2):

Table 2: Reliability analysis of geospatial thinking scale

Reliability statistics	
Cronbach's Alpha	number of projects
.851	10

The Klonbach α coefficient of the scale reached 0.851, indicating that the different items of the scale had a high degree of consistency, with certain stability and reliability, which met the reliability requirements of the measurement scale.

3.2.2 Validity of the Measurement Scale

Validity refers to the effectiveness of the measurement results, which means the degree to which the measurement tool or means can accurately measure the objects to be measured, or the degree to which the measured results are consistent with the results to be measured. Since this study used a self-developed measurement scale, the validity analysis mainly focused on content validity. The author invited senior geography teachers and researchers to judge the degree of consistency between the measurement questions and the original purpose of the survey by logical analysis. It was concluded that the scale has high content validity.

3.3. Evaluation on Geospatial Thinking Cultivation Effect

In order to determine whether there is a difference in the geospatial thinking measurement results between the experimental group and the control group, the independent sample T-test was performed in this study. The results show that in the pre-test of geospatial thinking, the average scores and score distributions of the experimental group and the control group are very similar (see Table 3, 4 and Figure 3), and P=0.453 in Table 3 indicates that there is insignificant difference between the experimental group and the control group in the pre-test of geospatial thinking, so teaching experiments can be carried out.

Table 3: Pre-test results of independent sample T-test in geospatial thinking teaching experiment

Group	N	average score	standard deviation	df	t	p
Experimental group (Class A)	52	6.08	1.545	103	-0.754	0.453
Control group (Class B)	53	6.30	1.514			

Table 4: Comparison of interval distribution of pre-test scores in geospatial thinking teaching experiment

Pre-test	experimental group (Class A)				Control group (Class B)			
score	frequency	percentage	valid percentage	cumulative percentage	frequency	percentage	valid percentage	cumulative percentage
3	4	7.7	7.7	7.7	2	3.8	3.8	3.8
4	4	7.7	7.7	15.4	5	9.4	9.4	13.2
5	10	19.2	19.2	34.6	9	17.0	17.0	30.2
6	12	23.1	23.1	57.7	11	20.8	20.8	50.9
7	11	21.2	21.2	78.8	14	26.4	26.4	77.4
8	10	19.2	19.2	98.1	9	17.0	17.0	94.3
9	1	1.9	1.9	100.0	3	5.7	5.7	100.0
Total	52	100.0	100.0		53	100.0	100.0	

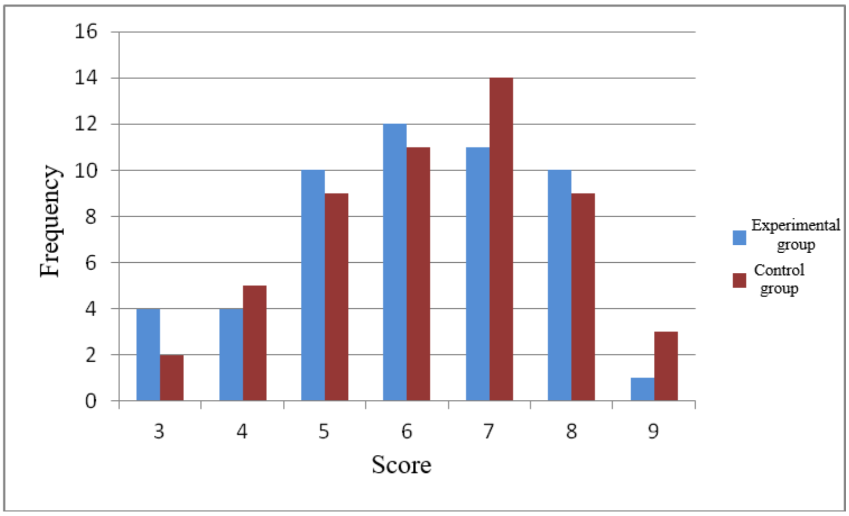

Figure 3: Histogram of pre-test results distribution between experimental group and control group

After nearly a semester of teaching experiments, the post-test results of geospatial thinking cultivation showed that, compared with the control group, the number of people in the experimental group increased significantly in the high score section and decreased significantly in the low score section (see Table 6 and Figure 4). The average score of the experimental group was 1.04 points higher than that of the control group, P<0.01 (see Table 5), reaching a significant difference. This indicates that students' geospatial thinking ability can be significantly improved by using the geospatial thinking cultivation strategies in daily teaching [7, 8].

Table 5: Post-test results of independent sample-T test in geography teaching experiment

Group	N	average score	standard deviation	df	t	p
Experimental group (Class A)	51	7.37	1.612	101	3.315	0.002
Control group (Class B)	52	6.33	1.768			

Table 6: Comparison of interval distribution of post-test scores in geospatial thinking

Post-test	experimental group (Class A)				Control group (Class B)			
score	frequency	percentage	valid percentage	cumulative percentage	frequency	percentage	valid percentage	cumulative percentage
2	0	0	0	0	1	1.9	1.9	1.9
3	0	0	0	0	1	1.9	1.9	3.8
4	3	5.9	5.9	5.9	7	13.5	13.5	17.3
5	3	5.9	5.9	11.8	8	15.4	15.4	32.7
6	9	17.6	17.6	29.4	10	19.2	19.2	51.9
7	12	23.5	23.5	52.9	12	23.1	23.1	75.0
8	9	17.6	17.6	70.6	5	9.6	9.6	84.6
9	11	21.6	21.6	92.2	8	15.4	15.4	100.0
10	4	7.8	7.8	100.0	0	0	0	100.0
Total	51	100.0	100.0		52	100.0	100.0	

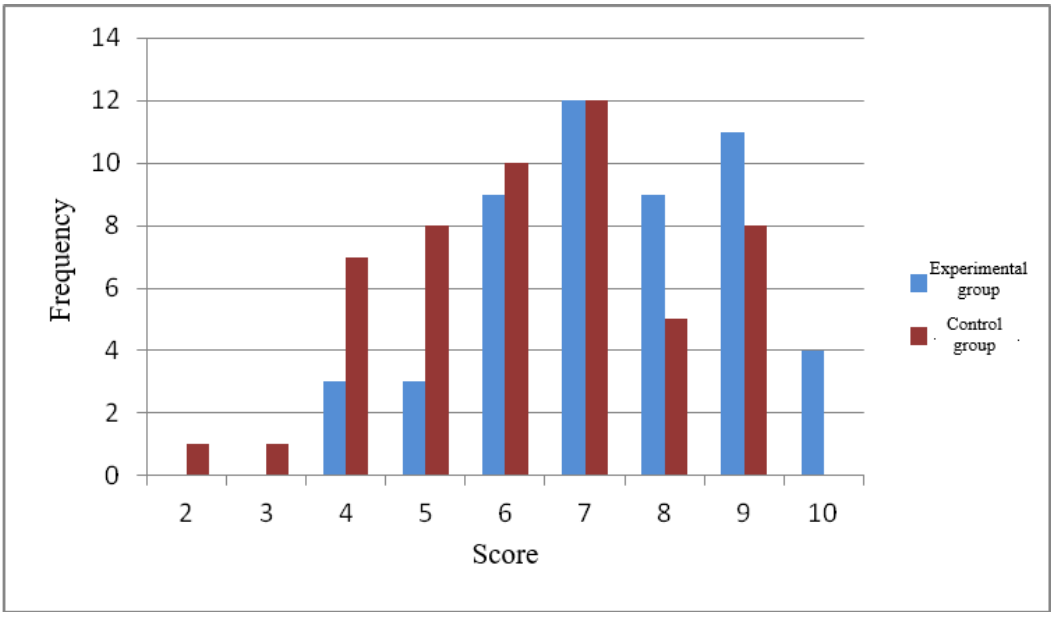

Figure 4: Histogram of post-test results distribution between experimental group and control group

The geography teaching experiment not only changed the average score and score distribution of geospatial thinking between the experimental group and the control group, but also had a certain impact on the gender difference in geospatial thinking of senior high school students [9, 10]. As shown in Table 7, both male and female students in the experimental group and the control group achieved a significant difference of 0.05 in the geospatial thinking measurement results in the pre-test. In the experimental group, the average score of male and female students in the post-test was significantly increased and the gender score difference was reduced to 0.23, showing insignificant difference (P>0.05), while the gender difference of male and female students was still significant in the control group (P<0.05). Therefore, this study believes that special geospatial thinking cultivation among senior high school students can narrow the gender differences in geospatial thinking to a certain extent.

Table 7: Gender differences in geospatial thinking of senior high school students

		Pre-test				post-test			
group	gender	number	Average score	standard deviation	P	number	Average score	standard deviation	P
Experimental group (Class A)	male	24	6.45	1.857	0.005	24	7.49	1.729	0.223
	Female	28	5.76	1.453		27	7.26	1.548	
Control group (Class B)	male	28	6.71	1.436	0.031	24	7.23	1.911	0.01
	Female	25	5.84	1.818		28	5.56	1.472	

In conclusion, the geospatial thinking cultivation strategy for senior high school students based on the development of core discipline literacy can significantly improve senior high school students' geospatial thinking ability.

4. Conclusion and Discussion

In the teaching experiment of geospatial thinking in senior grade one of Jianyang Middle School, the experimental group (Class A) used VR, Project-based learning, GE, mind mapping and other geospatial thinking cultivation strategies for teaching, while the control group carried out geography teaching according to conventional methods. The experimental results show that appropriate use of geospatial thinking cultivation strategies in teaching can significantly improve senior high school students' geospatial thinking ability. At the same time, geospatial thinking cultivation can narrow the gender difference in geospatial thinking ability between male and female students to a certain extent.

Although this study has made some achievements, there are still some areas for improvement:

1) Since there is no universally recognized geospatial thinking scale in the academic field, the differentiation and application scope of the self-compiled geospatial thinking scale for senior high school students in this study require further study.

2) Limited by conditions, the sample coverage of this study is small, and whether the research results can be applied to other places needs to be further studied.

3) In this study, the geospatial thinking of senior high school students was measured only by paper and pencil test, which had single evaluation method and incomplete evaluation content. How to make a scientific and comprehensive evaluation of senor high school students' geospatial thinking? This is worthy of further contemplation.

It is hoped that this study can provide some references for the geospatial thinking cultivation among senior high school students, and it is believed that through our joint efforts, the geospatial literacy of senior high school students will surely be valued and developed.

Acknowledgements

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