An Investigation and Analysis on the Improvement of Primary School Students' Learning Accomplishment by Attending Innovation Course, Based on the SOLO Taxonomy and Analytic Hierarchy Process

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Abstract: Scientific literacy is particularly important for primary school students. The textbook "play with science" made by the second affiliated primary school of Shandong university is a pilot teaching of science and innovation. To examine the course degree to the promotion of students' learning quality, our students was divided into the experimental group and the contrast group.
Based on the Solo taxonomy, we designed a questionnaire to evaluate students' knowledge ability, and we also used Ahp analytic hierarchy process to evaluate students' non-knowledge ability. According to the results of training, class that have taken innovation courses has better knowledge ability and non-knowledge ability than the contrast class, suggests that science and technology innovation course plays an important role on primary school students' all-round development, which is worth popularizing in the classroom.

1. Introduction

There are a lot of present research of innovation education, but their objects were mostly the young children, not only lack of intensive analysis for group of elementary school students, but few people choose in-classroom research direction. Our survey mainly aimed at primary school students, and set the experimental group and the contrast group. we evaluated their learning qualities from both knowledge and non-knowledge competence respectively.

As for the evaluation of students' knowledge ability, we adopted Solo classification evaluation method. Students' thinking level from low to high was divided into five different levels, namely the former structure, single structure, multiple structure, link structure, and the development of abstract structure[1-3]. Different levels have different scores. These five levels, respectively, represent students' mastery of a certain knowledge. we can quantify students' learning quality from their scores, which can also be used as the basis for end evaluation[4].

As for the assessment of students' emotions, there is no recognized authority scale for reference. By referring to relevant literature and discussing with relevant teachers, we obtained ten evaluation criterion. Different evaluation criterion have different importance, it is unfair to use the same proportion to score different criterion. Therefore, we innovatively adopted Ahp analytic hierarchy process to evaluate the non-knowledge ability. Firstly, we calculated the proportion of the evaluation criterion in students' quality. After that, based on the actual score, we did a liner weighting of the evaluation criterion. Thus, we obtained a accurate and reliable evaluation result[5].

2. Objects

In this study, our research object was students in fourth grade of second affiliated primary school of Shandong university, who were divided into the contrast group and the experimental group , with 45

people in each group. The experimental group students had taken one academic years' science and technology innovation training course; None of the contrast group students had participated in similar courses.

In the assessment of knowledge ability, two groups of students were given questionnaire who contents of nine single selections. The questionnaire was made up of the knowledge points of the class and its extension. We would grade them after they finished the questionnaire. The non-knowledge competence evaluation was carried out in a group discussion, in which each of the contrast group and the experimental group was divided into 5 groups to discuss opening questions. We scored in groups according to the performance of the members and the result of the discussion.

3. Methods

3.1. Design of the Knowledge Ability Evaluation Questionnaire Based on Solo Classification

The evaluation of the knowledge ability of this research was carried out through the questionnaire,whose content was the expand of the class learning knowledge. The question of the questionnaire was choice question with four options. The design of the options were based on the theory of solo classification, that is, these four choices are not right or wrong, only good or bad, which represent different levels of solo classification. Compared the scores of the two classes by average value,and used matlab program to calculate.

3.2. Design of the Scale Based on AHP Analytic Hierarchy Process

After consulting relevant information, the evaluation standard of the students' thinking ability was obtained, and the level structure model was formed based on the evaluation standard. (Figure1)

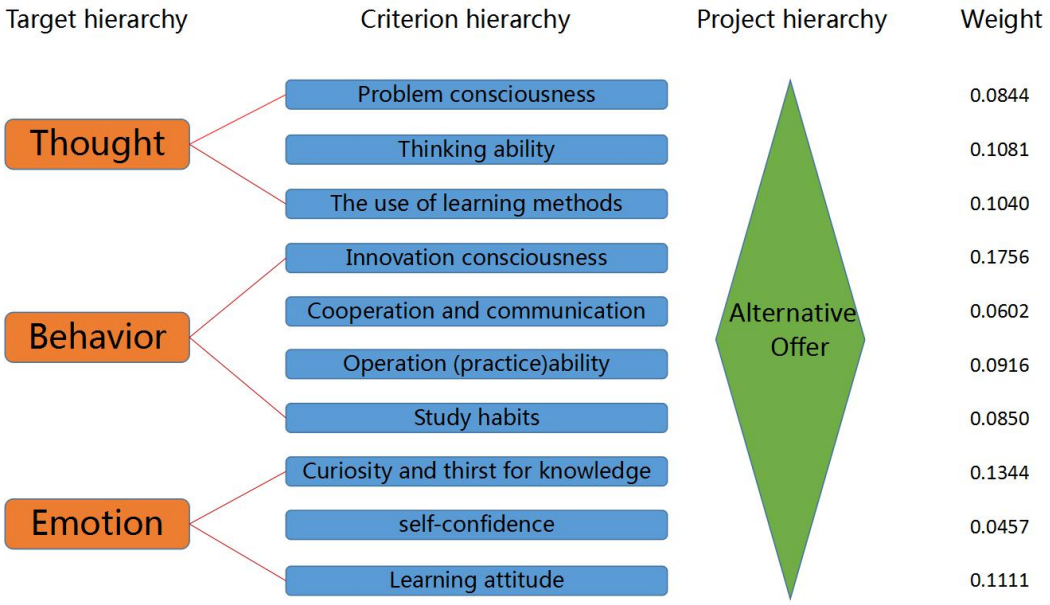

Figure 1 Level Model

Used consistent matrix method to analyse the importance of indicators in hierarchical models. That was, did not put all the factors together, but analyzed the results of questionnaires filled by people and experts,and got the importance of each factor[6-8]. At this time, the relative scale was adopted to minimize the difficulties of comparing factors with different properties and to improve accuracy [9]. (table 1, table 2)

Table 1 Structure Judgment Matrix

	C 5	C 3	C 9	C 7	C 1	C 6	C 8	C 4	C 2	C10
C 5	1	1/2	1/2	1/3	1	2	1	1	3	1/2
C 3	2	1	1/2	1/3	2	2	1	1	3	1
C 9	2	2	1	1/3	2	1	1	1/2	2	1
C 7	3	3	3	1	2	2	1	1	4	1
C 1	1	1/2	1/2	1/2	1	1/3	1	1/3	2	1/2
C 6	1/2	1/2	1	1/2	3	1	1	1	2	1
C 8	1	1	1	1	1	1	1	1/3	1	1
C 4	1	1	2	1	3	1	3	1	2	1
C 2	1/3	1/3	1/2	1/4	1/2	1/2	1	1/2	1	1/2
C 10	2	1	1	1	2	1	1	1	2	1

Table 2 Evaluation Scale

Scaling	Meaning
1	It means that these two factors has equal importance.
3	It means that compared with each other, one factor is slightly important than the other.
5	It means that compared with each other, one factor is fairly important than the other.
7	It means that compared with each other, one factor is specially important than the other.
9	It means that compared with each other, one factor is extremely important than the other.
2、4、6、8	The intermediate value of the two adjacent judgments above.
Reciprocal	The judgement of the comparation of factor i and factor j is aij, so the judgement of the comparation of factor j and factor i is aji=1/aij.

The maximum eigenvalue of a comparative judgement matrix was solved by MATLAB, and the following is as follows:

Call the eig function:

[V,D]=eig(A);

%Find the eigenvalues and eigenvectors of the matrix,V eigenvalue,D eigenvectors;

The maximum eigenvalue of the solution λ=10.7166, corresponding eigenvector C =[0.2520, 0.3228, 0.3104, 0.5243, 0.1799, 0.2736, 0.2537, 0.4012, 0.1363, 0.3316]^T.

Since$\lambda$was continuously dependent on aij, the more$\lambda$was greater than n, the greater the inconsistency of A. Using the eigenvector corresponding to the maximum eigenvalue as the weight vector of the influence degree of comparative factors on a certain factor of the upper level. The greater the degree of inconsistency, the greater the judgment error [10].So we could measure the inconsistency of A by the magnitude ofλ-n.

This defines the consistency index: $CI = \frac{\lambda - n}{n-1}$, while CI=0, there is complete consistency; While CI close to 0, there is satisfactory consistency; The greater the CI, the greater the inconsistency.

According to the results, we got the consistency index CI=0.0796.

Contrast random average random consistency index table (below).

Table 3 Contrast random average random consistency index

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.32	1.41	1.45	1.49	1.51

RI=1.51 while N=10, The consistency ratio was RC<0.1, which showed that the matrix had good consistency.

4. Results

4.1. T Test to Detect the Division of Two Grades

The results of the experimental group and the contrast group were approximately normal distribution and the variance of the experimental group and the control group was similar,which prerequisited for meeting T test [11,12]. So we could assume that the mean of c1 was less than the mean of c2.

Type the following function in matlab:

[h,p,ci]=ttest2(c1,c2,0.05,-1);

% c1 and c2 represent the scores of the two class students. -1 represents the hypothesis that the mean of c1 is less than the mean of c2.

The result was: h= 0, which meant the hypothesis that the mean of c1 was less than the mean of c2 was valid. That was, the total grade of class that had attended the science and innovation course was better than the contrast class.

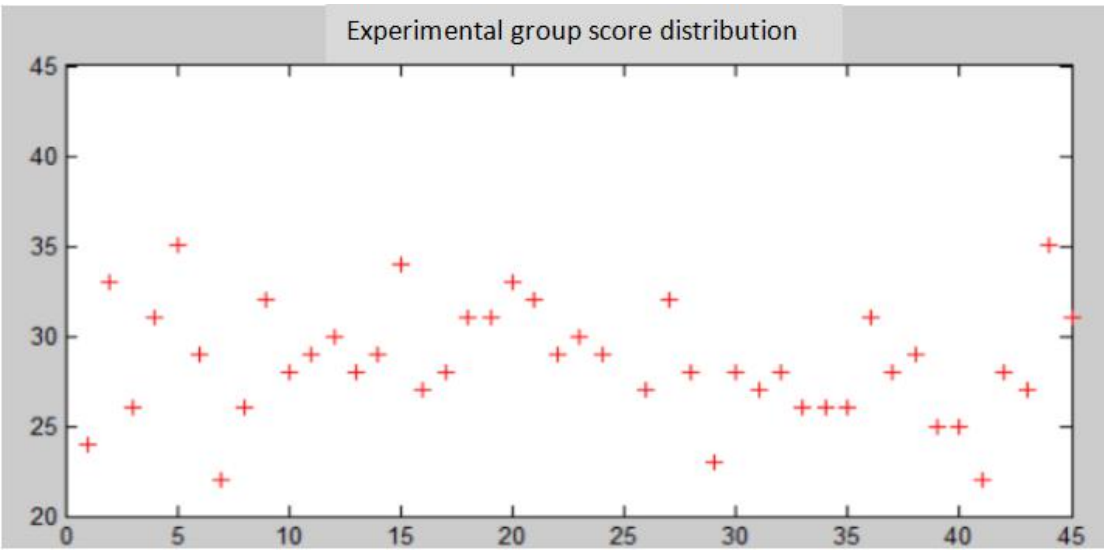

Figure 2a Scatter plot of experimental group score distribution

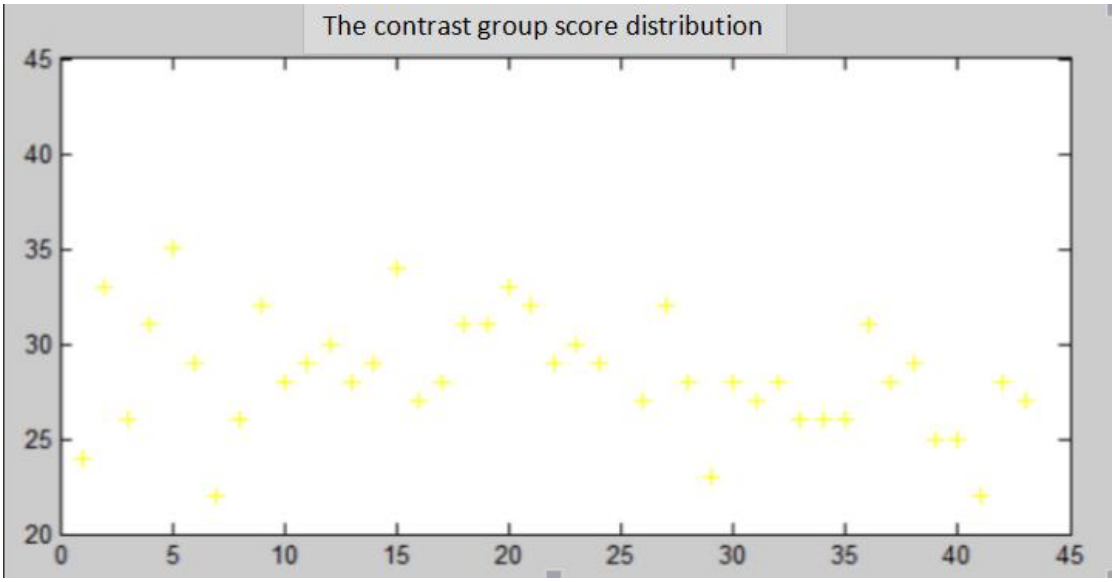

Figure 2b Scatter plot of contrast group score distribution

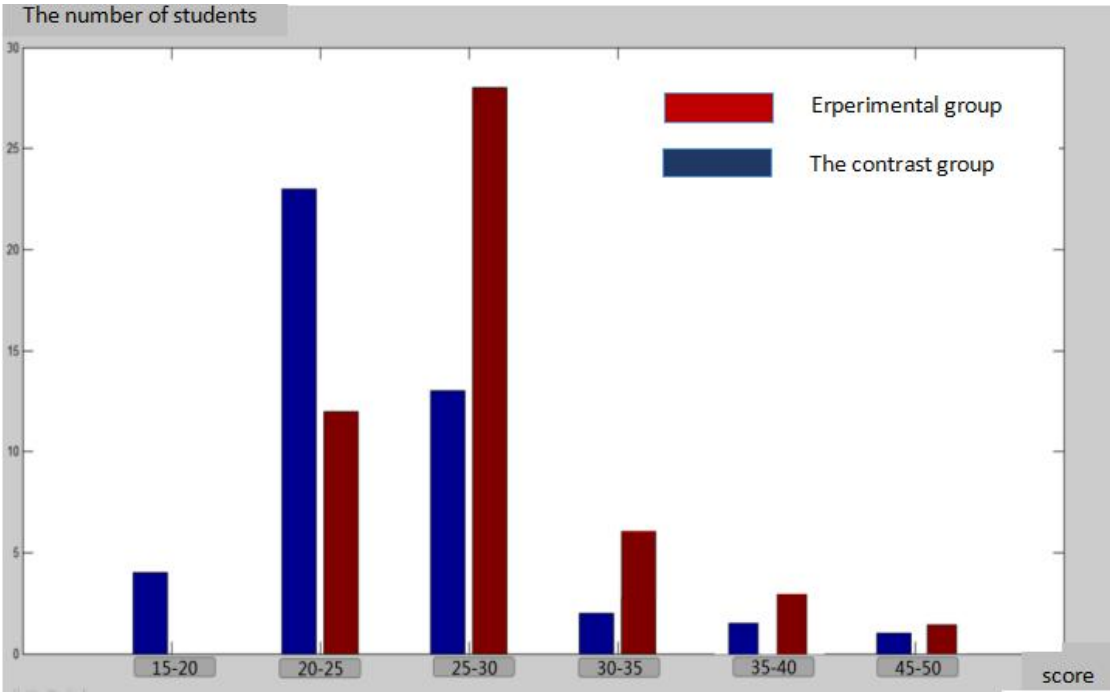

Figure 3 Experimental group and control group score distribution histogram

4.2. The Index Weight and Scale Design of Analytic Hierarchy Process

According to the AHP calculation results, the specific weights of each evaluation index could be obtained (Figure 4), and the evaluation scale was designed accordingly (Table 4).

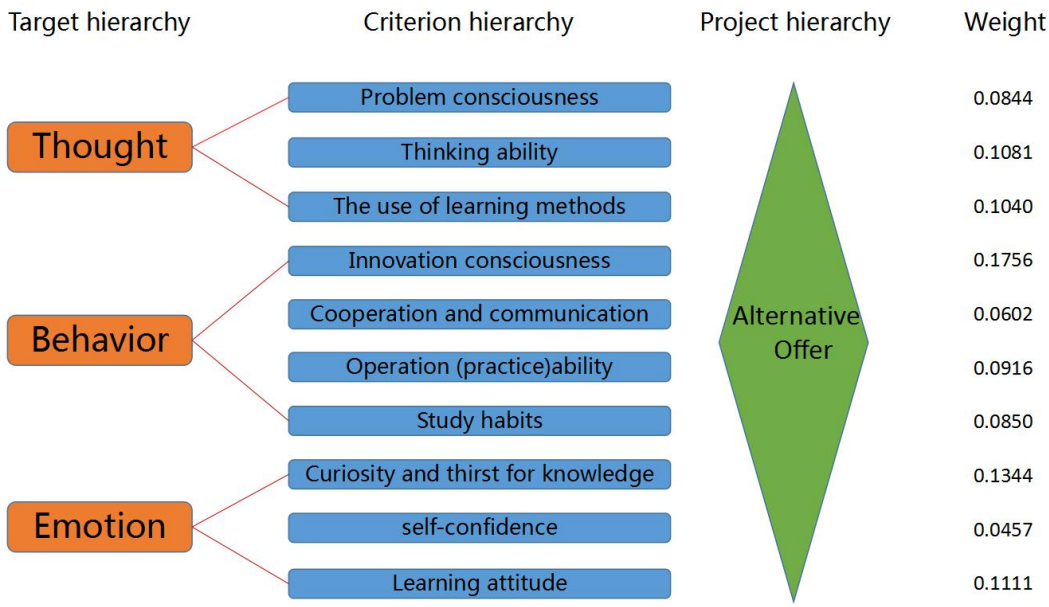

Figure 4 Weight of each evaluation indicator

Table 4 The evaluation scale

The first dimension	The second dimension	The third dimension	Score	Weight	Score*Weight
Thought	Put forward a question	Problem consciousness		0.0844	
	Analysis the question	Thinking ability		0.1081	
		The use of learning methods		0.1040	
Behavior	Solve the question	Innovation consciousness		0.1756	
		Cooperation and communication		0.0602	
		Operation (practice)ability		0.0916	
	Study habits	Study habits		0.0850	
Emotion	Learning literacy	Curiosity and thirst for knowledge		0.1344	
		self-confidence		0.0457	
	Learning attitude	Learning attitude		0.1111	

4.3. The Scale Results Analysis of Linear Weight Method

Linear weighting and method is an evaluation function method. It is a method for solving multi-objective programming problems with linear combination of targets and gives the corresponding weight coefficient according to the importance of each objective[13-15].

In the process of research, students of the experimental group and the contrast group were divided into 5 groups, each group with 8-10 people. Let the team members discuss and analyze several problems and scored the group according to their performance, then multiplied the original score with the weight to get the end score of each group.

In this experiment, we accumulated the value of multiplying by the original score with the weight. The end score of the contrast group was 16.94, which was less than the score of the experimental group of 17.88. So we could conclude that students who had taken science and technology innovation course had better learning cability than the other students.

5. Discussion

At present, there are a lot of evaluation and Research on primary school students' learning ability, but they are mostly limited to knowledge or emotional awareness alone, and fail to combine them effectively. In this paper, the comprehensive evaluation of the two is made, which makes the result more objective.

We used Ahp analytic hierarchy process to complete the design of the scale, did it for the first time to distinguish between different indicators according to their importance, and calculate the corresponding weight, which made the research of the abstract question more accurate and convincing.

The research has carried on the comprehensive consideration from two aspects of knowledge and non-knowledge ability, but we still need further discussion of how to reasonable integrate the results of the two aspects, this remains to be improved.

The final result of the research shows that the science and technology innovation course plays an important role in the development of the pupils' thinking. It should appear more in primary school classroom, and educators should pay attention to it.

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