Alignment Between Senior High School Physics Content Standard and Academic Achievement Test: A Case Report from China

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Abstract: *Alignment between Senior High School Academic Content Standards and achievement tests is significant for achieving the new curriculum objectives in deepening the reform of curriculum, instruction and assessments. In this paper, both Content Standards and achievement tests are represented with a two-dimensional matrix (content subjects and cognitive levels). And the results is reported with the Porter's Alignment Index. It is found that there is not a statistically significant alignment between Content Standards and achievement tests. Compared with Content Standards, the test paper increases the amount of " Description of Movement", "Interaction and Moving Rule" and "Projectile Motion and Circular Motion". Besides, they reduce the amount of "Achievements and Limitations of Classical Mechanics", "Electromagnetic Phenomena and Laws" and "Electromagnetic Technology and Social Development". However, there exist a balance on the amount of "Mechanical Energy and Energy". Meanwhile, the test paper more emphasizes the cognitive levels of "Recognize" and "Understand", but deemphasizes "Know" and "Apply". Therefore, it is critical to build academic assessment standards and professional assessment system in order to improve the alignment between Content Standards and achievement tests. Further study of the alignment between content standards and achievement tests is necessary.*

Keywords: *physics content standard; academic achievement test; alignment*

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I. Introduction:

Introduction Many countries place the curriculum standards in a prominent important position in the elementary education reform since the late 1980s, universally implementing the curriculum reform based on the curriculum standards. The alignment between the academic evaluation and curriculum standards has attracted worldwide attention under this background. Chinese ordinary high school proficiency test is a large-scale education examination system with the establishment of the new high school curriculum reform. Theoretically, proficiency test and curriculum standard should have remarkable consistency.

From the perspective of literature in China, this research on “Alignment” started late with relatively less academic papers focused on introducing and summarizing the research achievements of foreign scholars. The first study on the alignment between curriculum standards and evaluation was put forward by Liu Xuezhi in his paper The Construction of Consistency between Evaluation and Curriculum Standards: American Experience. He first introduced the background and origin of the standard of the alignment, then explored the experience of constructing the alignment to meet the needs of educational practice and introduced the main models and analysis methods of alignment analysis(Liu, 2006).

In addition, Shao Chaoyou (2011) delivered the paper Alignment between Students' Academic Achievement Evaluation and Curriculum Standard . He argued that the alignment was the core content to measure the relationship between curriculum standards, student, and evaluation. And he introduced and estimated eight different analysis frameworks. According to his theory, the consistency was studied from the perspective of the scope of testing, the quantity of the questions, the difficulty of the test paper and other aspects. And he put forward a series of strategies to ensure consistency. In summary, it is not difficult to find out that most of the researches are drawing on some foreign analysis models.

However, scholars in China are aware of the differences between other countries and China. Therefore, in the construction of consistency analysis model, it is requested to study the localization of consistency according to the actual situation in China.

Ordinary high school proficiency test is in accordance with the provisions of the national curriculum standard for senior high school, organized and implemented by the provincial education administrative departments.

As an important system to ensure the quality of education and teaching, it mainly measures whether students meet the state requirements of learning (MOE, 2014). The National Medium and Long-term Education Reform and Development Plan Outline (2010-2020) (2010) made it clear that we should establish scientific evaluation system of educational quality and implement high school proficiency test and the overall quality evaluation comprehensively.

With the start of a new round of comprehensive reform of the college entrance examination, the State Council made it clear that academic proficiency test is an important basis for students to graduate and further education， whose authority and application have been further strengthened.

In 2012 the Ministry of Education (2012) promulgated Guidance On the Implementation of the Ordinary High School Proficiency Test System (hereinafter referred to as Guidance) made a clear definition of the nature of academic proficiency test. Ordinary high school proficiency test is under the guidance of the Ministry of Education, organized and implemented by the provincial education administrative departments, which is based on the ordinary high school curriculum standard and fully reflect academic level that the senior high school students has achieved.

At the same time, the Guidance also stipulates the contents and methods of academic proficiency test and the proposition basis---academic proficiency test should be strictly on the basis of the curriculum standards. Therefore, high school academic proficiency test on physics subject, a kind of educational examination based on the curriculum standards, should be consistent with the curriculum standards.

However, the in-depth analysis of the current academic proficiency test shows that the test objectives can not be matched with three-dimensional target (including knowledge and skills, processes and methods, emotional attitudes and values) in the curriculum standards.

The main reason is that the level of theory of performance evaluation in China is not perfect and that the practical foundation is blank. Besides, another two significant factors not developing the corresponding performance standards according to are the curriculum standards and not develop the examination criteria according to the academic standards.

At present, the quantitative research on the academic level examination in China is mainly based on the analysis of the quality of the test paper, such as reliability, difficulty and differentiation. Nevertheless, the foreign countries have developed a variety of analytic models, such as Webb Mode (Webb,2007), Curriculum Implementation Survey (Surveys of Enacted Curriculum) Mode (Porter,A.C.2002) and Successful Mode etc (http://research.cse.ucla.edu /Reports/TR566.pdf.2002.). Comparatively speaking, the SEC model can be characteristic of simple computation and wide use(Fulmer, G. W., 2011), which can be used to analyze multiple factors of curriculum system, the consistency between curriculum, teaching and evaluation.

Moreover, it can provide useful information for the improvement of teaching and evaluation and revision of standards. Accordingly, this paper focuses on the consistency and difference between high school physics academic proficiency exam papers and Curriculum Standard of Ordinary High School Physics (draft) (MOE, 2003) (hereinafter referred to as Standard) , so as to provide good reference for China to further improve high school science academic proficiency test and also promotes the development of the worldwide research on consistency and international comparative research in the future.

2.Methods

2.1. Alignment Measures

Consistency is defined as the agreement between the national curriculum standard of a specific subject and the test to measure student academic achievement (Bhola, D. S., Impara, J. S., &Buckendahl, C. W. 2003). Rothman (2003) examined eight independent alignment studies and explored possible advantages and disadvantages of using different alignment methods.

Among those studies examined, Porter's model (2002) caught the attention. To determine alignment between curriculum standards and tests, for instance, Porter creates two tables (one representing the curriculum standards and the other a test), each using a two-dimensional matrix in which the rows represent topics and columns represent levels of cognitive demand.

In this study, we adopted the SEC model to examine the consistency between the physical content standard and the test paper from two dimensions: content subjects and cognitive levels.

Based on this model, it is necessary, first of all, to transform the physical content standard and test paper into the same structure of the coding matrix form. One dimension is the content subject, and the other one is the cognitive level. Secondly, all the data in the table are normalized to form two ratio tables, which is convenient to compare the coincidence degree of the corresponding values of the two tables. Finally, we calculate the alignment index by substituting the cell values into the formula, which is defined as follows:

$$P = 1 - \frac{\sum_{i-1}^{n} \left| (X_i - Y_i) \right|}{2}$$

In this formula, n is the total number of cells in a table, and I represents a specific value in the table, ranging from 1 to n. Xi refers to the ith cell of Table X (e.g., the content standard table) , while Yi is the ith cell in Table Y(e.g., the standardized test table). The Porter alignment index ranges from 0 to 1, where 0 means the largest difference between the test and the content standard, and 1 was perfect equal.

2.2. Analyzing Process

According to the content of the test papers, the researchers need to analyze the Compulsory Module 1, Compulsory Module 2 and Elective Module1-1. In order to make the classification of cognitive level well consistent with the content standard, the researchers adopt four cognitive levels of Know, Cognitive, Understand and Apply in the Standard.

Through in-depth study on the content of the standard, the researchers establish a framework of Content Subject×Cognitive Level, and then analyze the papers separately in accordance with the content subject and cognitive level, encoding the content standard and the test paper. The analysis process is shown in Figure 1(Guo, & Wang, 2015).

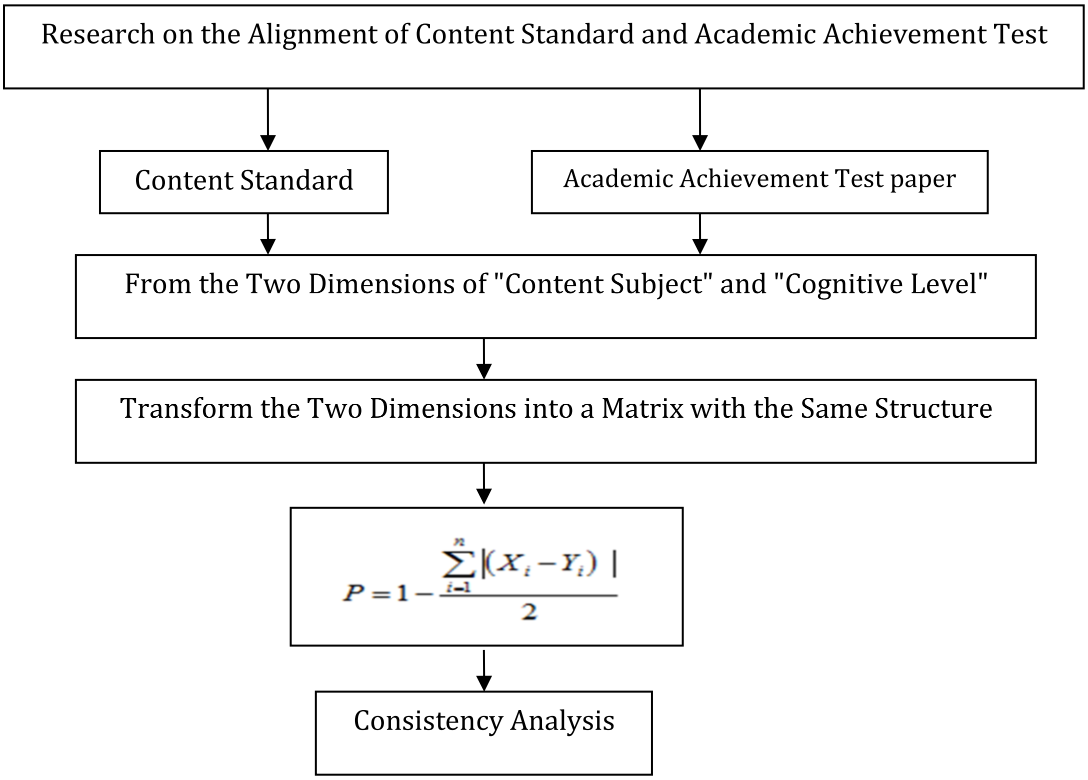

Figure 1. Analysis Process Flow Chart

3.Results

3.1. Classification of Content Subject and Cognitive Level

The classification of content subject and cognitive level in the Content Standard is based on a wide range of international comparisons and full consideration of China's educational reality, which experiences the test of more than 10 years of practice and has sufficient scientific basis. Therefore, in this study, the reaearchers build the framework of consistency analysis according to the Standard.

To compare the consistency between the test paper and the physical content standard, the researchers need a common coding framework, which is defined as Content Subject ×Cognitive Level. This paper mainly includes the physical content of the Compulsory Module 1, Compulsory Module 2 and Elective Module 1-1. The content subjects are as follows: Description of Movement, Interaction and Moving Rule, Mechanical Energy and Energy, Projectile Motion and Circular Motion, Achievements and Limitations of Classical Mechanics, Electromagnetic Phenomena and Laws, Electromagnetic Technology and Social Development, and Home Appliances and the Daily Life. And four cognitive levels are Know, Recognize, Understand and Apply. Accordingly, the matrix for coding content subject and cognitive level is an 8 × 4 table. That is, eight main category topics by 4 cognitive levels.

3.2. Coding of Content Standard and Academic Achievement Test

3.2.1 Coding of Content Standard

In this study, the researchers analyze the physical knowledge and cognitive level of the specific items (40 items) according to the content in the Standard, which is the common requirement of the high school physics. In order to ensure the reliability of the study, three coders respectively divide the content subject and the cognitive level of the Standard using the content analysis method. The encoders assign each cell in the Content Subject×Cognitive Level matrix according to the number of the knowledge points in the specific items in the physical content standards. Then, on the basis of the order of the content subject, the encoders systematically make appropriate recording and obtain the results of their analysis. The internal consistency reliability coefficient of the analysis results is 0.958, which shows super internal consistency. Where there are differences in coding, there is a consensus between the participants and the final agreement is reached through consultation, which is shown in Table 1. In order to compare with the coding matrix of the test paper, Table 1 is standardized and the results are shown in Table 2.

Table 1. Content Standard Based on Number of Knowledge Points

Module	Content Subject	Know	Recognize	Understand	Apply	Subtotal
Compulsory Module 1	Description of Movement	3	2	3	0	8
	Interaction and Moving Rule	4	3	2	5	14
Compulsory Module 2	Mechanical Energy and Energy	6	2	4	2	14
	Projectile Motion and Circular Motion	2	0	3	2	7
	Achievements and Limitations of Classical Mechanics	11	1	1	0	13
Elective Module 1-1	Electromagnetic Phenomena and Laws	9	4	1	6	20
	Electromagnetic Technology and Social Development	5	1	0	0	6
	Home Appliances and the Daily Life	7	0	0	0	7
Subtotal		47	13	14	15	89

Table 2 .Content Standard Based on Ratios of Knowledge Points

Module	Content Subject	Know	Recognize	Understand	Apply	Subtotal
Compulsory Module 1	Description of Movement	0.034	0.022	0.034	0.000	0.090
	Interaction and Moving Rule	0.045	0.034	0.022	0.056	0.157
	Mechanical Energy and Energy	0.067	0.022	0.045	0.022	0.157
Compulsory Module 2	Projectile Motion and Circular Motion	0.022	0.000	0.034	0.022	0.079
	Achievements and Limitations of Classical Mechanics	0.124	0.011	0.011	0.000	0.146
	Electromagnetic Phenomena and Laws	0.101	0.045	0.011	0.067	0.225
Elective Module 1-1	Electromagnetic Technology and Social Development	0.056	0.011	0.000	0.000	0.067
	Home Appliances and the Daily Life	0.079	0.000	0.000	0.000	0.079
Subtotal		0.528	0.146	0.157	0.169	1.000

3.2.2 Coding of Academic Achievement Test Paper

It is very important to accurately determine the physical knowledge and cognitive level in the test paper for the reliability of this study. Therefore, three coders respectively divide the content subject and the cognitive level in the test paper using the content analysis method. To increase the objectivity, they first determine the knowledge points of a question (more detailed than content subjects). Then they try to find out the score points through the refinement process of solving problems and determine the cognitive level which the students need to solve the problem. According to the order of each question, they fill the matrix defined as Content Subject × Cognitive Level with the content subject and the cognitive level examined in the paper. Next, they work out the score corresponding to each cell and sum up each content subject and cognitive level (Subtotal in Table 3). The internal consistency reliability coefficient of the analysis results is 0.900, which also shows super internal consistency. Where there are differences in coding, there is a consensus between the participants and the final agreement is reached through consultation, which is shown in Table 3. In order to compare this coding matrix with the coding matrix of the physical content standard, the Table 3 is standardized and the results are shown in Table 4.

Table 3. Test Paper Based on Scores

Module	Content Subject	Know	Recognize	Understand	Apply	Subtotal
Compulsory Module 1	Description of Movement	9	3	6	3	21
	Interaction and Moving Rule	8.75	4	6	0	18.75
	Mechanical Energy and Energy	1	9	2	4	16
Compulsory Module 2	Projectile Motion and Circular Motion	3	0	3	3	9
	Achievements and Limitations of Classical Mechanics	2.25	0	3	0	5.25
Elective Module 1-1	Electromagnetic Phenomena and Laws	3	3	15	0	21
	Electromagnetic Technology and Social Development	0	3	0	0	3
	Home Appliances and the Daily Life	4	0	2	0	6
Subtotal		31	22	37	10	100

Table 4. Test Paper Based on Score Ratio

Module	Content Subject	Know	Recognize	Understand	Apply	Subtotal
Compulsory Module 1	Description of Movement	0.090	0.030	0.060	0.030	0.210
	Interaction and Moving Rule	0.088	0.040	0.060	0.000	0.188
	Mechanical Energy and Energy	0.010	0.090	0.020	0.040	0.160
Compulsory Module 2	Projectile Motion and Circular Motion	0.030	0.000	0.030	0.030	0.090
	Achievements and Limitations of Classical Mechanics	0.023	0.000	0.030	0.000	0.053
	Electromagnetic Phenomena and Laws	0.030	0.030	0.150	0.000	0.210
Elective Module 1-1						

	Electromagnetic Technology and Social Development	0.000	0.030	0.000	0.000	0.030
	Home Appliances and the Daily Life	0.040	0.000	0.020	0.000	0.060
Subtotal		0.310	0.220	0.370	0.100	1.000

3.33. Calculating the Porter Consistency Coefficient and Comparing with the Critical Value

In the paper, the data in the test paper and the data in the physical content standard are put into the consistency coefficient formula, and the consistency coefficient of the test paper and the physical content standard is obtained. At this time, the total number of cells is 32.

However, to determine whether there is a statistically significant consistency between the test paper and the physical content standard, it is necessary to compare the consistency coefficient obtained and the corresponding critical value. A study shows that the critical value of the consistency coefficient corresponding to the 89 standard points is 0.8648 in order to achieve a significant consistency at the level of 0.05 in the two-sided test for a 8×4 matrix.

3.3.4. Drawing Topographic Maps and Histograms, Further Comparison and Analysis

The Porter Consistency Coefficient only uses the total standard deviation and shows the absolute difference between the test paper and the content standard. Furthermore, it does not indicate whether the proportion of the value of each content subject and the cognitive level in examination papers is much larger than that in the content standard. With the purpose of further comparative analysis, the researchers draw a topographic map and histogram according to the matrix data, from which the figures clearly tell what subject the content relatively focuses on and what level the cognition is mainly concentrated in.

4.Discussion

4.1. Comparison of the Consistency between the Physical Content Standard and the Test Paper

The topographic map is designed to express the portion of the content subject and cognitive level in order to compare the consistency of the test paper and the physical content standard. The significance of the scale has been marked in the figure. represents the portion less than or equal to 0.03. represents the portion between 0.03 and 0.06. represents the portion between 0.06 and 0.09. represents the portion between 0.09 and 0.12. represents the portion between 0.12 and 0.15. The drawing process and significance are as follows. Take the subject Electromagnetic Phenomena and Laws for an example, the ratio of knowledge points in the level Know is 0.101, falling in 0.09-0.12 expressed by in the topographic map. Correspondingly, to this subject, the ratio of knowledge points in the level Recognize is 0.045, falling in 0.03-0.06 expressed by in the topographic map. And the ratio of knowledge points in the level Understand is 0.011, falling in 0 -0.03 expressed by in the topographic map. And the ratio of knowledge points in the level Apply is 0.067, falling in 0.06-0.09 expressed by in the topographic map. Based on the same drawing scheme, we can get the topographic map of content standard according to the data in Table 2 (the left part in Figure 2) and the topographic map of the test paper according to the data in Table 4(the right part in Figure 2).

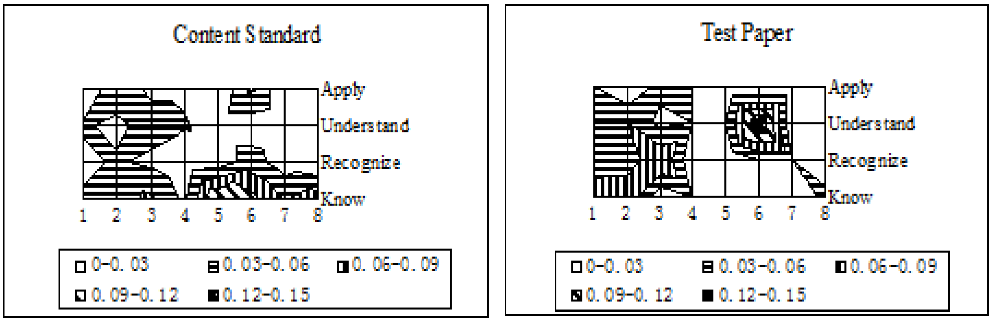

Figure2. Comparison of Topographic Maps between Content Standard and Test Paper

Notes: *In Figure 2, the number 1-8 in the horizontal ordinate respectively represents Description of Movement, Interaction and Moving Rule, Mechanical Energy and Energy, Projectile Motion and Circular Motion, Achievements and Limitations of Classical Mechanics, Electromagnetic Phenomena and Laws, Electromagnetic Technology and Social Development, Home Appliances and the Daily Life.*

From the topographic map of the content standard and the data in Table 2, it is explicit to show that the Standard stresses Achievements and Limitations of Classical Mechanics(Know), Electromagnetic Phenomena and Laws(Know and Apply), Home Appliances and the Daily Life(Know) and Mechanical Energy and Energy(Know) ; then it focuses on Interaction and Moving Rule(Know and Apply), Mechanical Energy and Energy(Understand), Electromagnetic Phenomena and Laws(Recognize) and Electromagnetic Technology and Social Development(Know).

From the topographic map of test paper and the data in Table 4, the test paper mainly emphasize Electromagnetic Phenomena and Laws (Understand), Mechanical Energy and Energy (Know), Description of Movement(Know and Understand), Interaction and Moving Rule(Know and Understand); then it concentrates on Interaction and Moving Rule(Know), Mechanical Energy and Energy(Apply), Home Appliances and the Daily Life(Know).

Given the above analysis, it can be seen that there is a big difference between the topographic map of the content standard and the topographic map of the test paper, indicating that they do not have a significant consistency. When the data in Table 2 and Table 4 are put into the consistency coefficient formula, the consistency coefficient between test and physical content standard is 0.4960, lower than the critical value 0.8648. So, there is not remarkable statistical consistency between the test and the physical content standard.

4.2. Comparison of the Content Subject between the Physical Content Standard and the Test Paper

The data in Table 2 and Table 4 are represented in the form of a histogram, showing the content subject in the content standard and test paper, as shown in Figure 3.

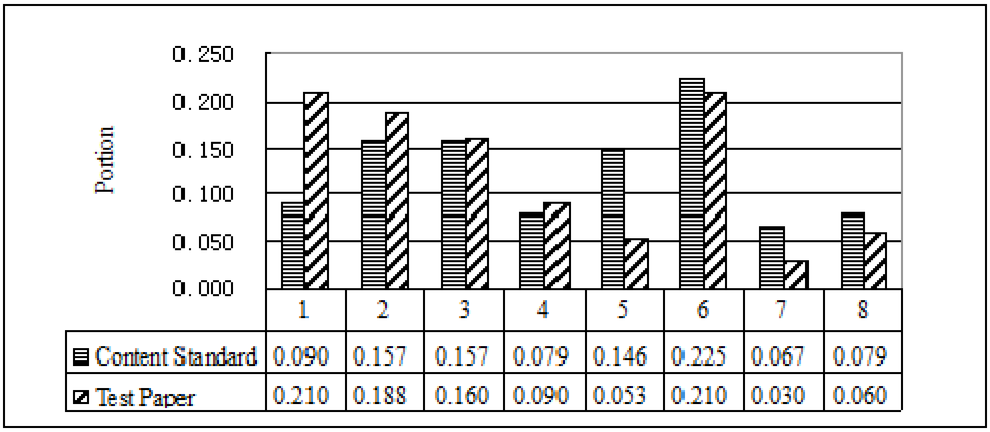

Figure 3. Comparison of Content Subject between Content Standard and Test Paper

Notes: *In Figure 2, the number 1-8 in the horizontal ordinate respectively represents Description of Movement, Interaction and Moving Rule, Mechanical Energy and Energy, Projectile Motion and Circular Motion, Achievements and Limitations of Classical Mechanics, Electromagnetic Phenomena and Laws, Electromagnetic Technology and Social Development, Home Appliances and the Daily Life.*

There is great difference of the content subject in the test paper and the content standard. The proportion of the knowledge points of each content in the content standard is as follows: Description of Movement (0.090), Interaction and Moving Rule (0.157), Mechanical Energy and Energy (0.157), Projectile Motion and Circular Motion(0.079), Achievements and Limitations of Classical Mechanics (0.146), Electromagnetic Phenomena and Laws (0.225), Electromagnetic Technology and Social Development (0.067), Home Appliances and the Daily Life (0.079). The proportion of the knowledge points of each content in the test paper is as follows: Description of Movement (0.210), Interaction and Moving Rule (0.188), Mechanical Energy and Energy (0.160), Projectile Motion and Circular Motion(0.090), Achievements and Limitations of Classical Mechanics (0.053), Electromagnetic Phenomena and Laws (0.210), Electromagnetic Technology and Social Development (0.030), Home Appliances and the Daily Life (0.060). By contrast, it can be found that the test paper has increased the intensity of " Description of Movement", "Interaction and Movement Law", "Projectile Motion and Circular Motion".

Meanwhile, it weakens "Achievements and Limitations of Classical Mechanics", "Electromagnetic Phenomena and Laws", "Electromagnetic Technology and Social Development" and "Household Appliances and Daily Life". As for the "Mechanical Energy and Energy", it is exactly the same between the ratio of the knowledge points in the content standard and the score proportion in the test paper.

4.3. Comparison of the Cognitive Level between the Physical Content Standard and the Test Paper

The data in Table 2 and Table 4 are represented in the form of a histogram, showing the cognitive level in the content standard and test paper, as shown in Figure 4.

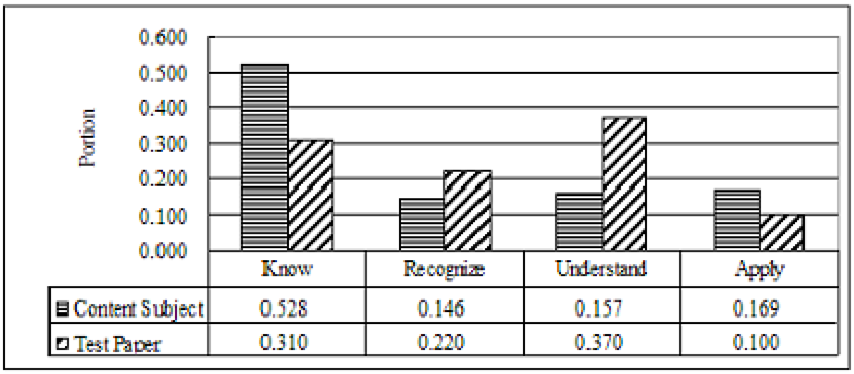

Figure 4. Comparison of the Cognitive Level between the Physical Content Standard and the Test Paper

With regard to the cognitive level, the test paper has a deviation compared with the content standard. The proportion of the cognitive level in the content standard is as follows: Know (0.528), Recognize (0.146), Understand (0.157) and Apply (0.100). However, the proportion of the cognitive level in the test paper is as follows: Know (0.310), Recognize (0.220), Understand (0.370) and Apply (0.100). It is obvious that the test paper increases the strength of the cognitive level of Know and Understand, and weakens the strength of Recognize and Apply.

Therefore, there is no statistically significant consistency between the physical content standard and the test paper.

5.Implications

The results show that there is a deviation between the test papers and content standard. That is, the quality of the test is not ideal and the design of the test should be improved. However, the conclusions of this study can only provide reference and should not be the merely judgment. Although the analysis is to assess the consistency based on the content standards, an important indicator of the quality, but consistency analysis is only a perspective for the quality of the test paper.

It is the basic requirement of the new curriculum reform of physics in senior high school to carry out the teaching goals in Standard, which is proved by evaluation finally. Only when the evaluation is consistent with the curriculum standards can the curriculum and teaching keep pace with the curriculum standards. If the physics academic proficiency test and the content standards are inconsistent, it will have a negative impact on physics teaching and students' learning.

First of all, the selection of the content narrows the range of students' learning. The Standard stipulates clearly that the students could choose any one from Elective Module 1-1, Elective Module 2-1 and Elective module 3-1 after completing the Compulsory Module1 and Compulsory Module2. But according to the above analysis, it can be seen that the papers do not contain Elective Module 2-1 and Elective Module 3-1, which actually already goes against the wide scope of students' study, not consistent with the theory advocated by the new curriculum reform.

Secondly, the deviation of examination content may have a negative effect on physics teaching. As for the content subject, the disagreement between the test paper and the content standard may lead the teacher to let the student repeatedly practice the knowledge defined as key points, neglecting non-key knowledge points.

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