Quantitative comparison on the difficulty of manual books used in Chinese and Romanian primary schools
——Based on the Bao’s Difficulty Model

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Abstract: In study before, we found that the mathematics scores of Romanian primary and secondary school students were not satisfactory compared with the children of the same age in China. The reason may be multifaceted, and this study start from the most objective material, the textbooks, to compare the difficulty, and try to find the truth hidden behind.

Keywords: Difficult model, textbook, Romanian, Chinese

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1. Research review

In the study of the difficulty of teaching materials or courses, the following models emerged: Professor Shi Ningzhong and others in the "Course Difficulties Model: Comparison of the Geometric Difficulties of Compulsory Education in China", starting from the three factors affecting the curriculum difficulty, constructing a quantitative model \( N = a \frac{S}{T} + (1-a) \frac{G}{T} \), the model "rationalizes change from experience evaluation to quantitative evaluation".[1]

Dr. Li Shuwen's "Comparative Study of the Difficulty of Chinese and Japanese School Geometry Curricula", used two difficulty models to compare the textbooks of the third grade in junior school from China and Japan, and then compared the difficulty of the entrance examination to high school, and then analyzed the impact of the differences between the two countries.[2]

Cai Qingyou's "Study on the Difficulty Model of Primary School Mathematics Textbook", based on the model proposed by Professor Shi Ningzhong, assisted in the use of expert interviews, questionnaires, etc., and modified the aforementioned models from difficulty of the content, the example and the exercise, and constructed a new linear difficulty model: \( N = 0.30C + 0.36W + 0.34E \); Where N represents the difficulty of the textbook, C represents the difficulty of the content, W represents the difficulty of the example, and E represents the difficulty of the exercise.[3]

Dr. Bao Jiansheng's comprehensive difficulty model, based on doctor Nohara’s difficulty model[4], captured the main form of mathematical activities—solving problems to measure the difficulty of mathematics curriculum, and chose investigation, Context, Computation, reasoning, and Topic coverage content as decisive five difficulty factors. Five factors were divided horizontally, and the pentagon visual model was used to describe the mathematical difficulty.[3]

These studies have broadened people's horizons, opened up people's ideas, and brought people enlightenment and more thinking about mathematics research.

However, there are few comparisons between Chinese and Romanian mathematics textbooks. This study focuses on primary school mathematics education in China and Romania, using textbooks as research objects to conduct comparative research.

2. Introduction to the difficulty model

This study based on Bao Jiansheng's curriculum difficulty model, which was suitable for the comparison of current Chinese and Romanian research materials. The model includes five latitudes such as "Context, Investigation, Computation, Reasoning and Topic coverage",...
as shown in Figure 1:

![Figure 1 Composite difficulty model](image)

**Figure 1** Composite difficulty model

Based the above five difficulty factors, with small improvement because of the textbook they can be divided into the following levels:

**Table 1** Difficult levels of composite difficulty factors

<table>
<thead>
<tr>
<th>Difficulty factors</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Context</td>
<td>None, Personal, Public, Scientific</td>
</tr>
<tr>
<td>Investigation</td>
<td>Knowing, Understanding, Application, Investigating</td>
</tr>
<tr>
<td>Computation</td>
<td>Non, Simple operation, Complex computation, High-complexity computation</td>
</tr>
<tr>
<td>Reasoning</td>
<td>None, Simple Reasoning, Complex reasoning, High-complexity Reasoning</td>
</tr>
<tr>
<td>Topic coverage</td>
<td>Single Topic coverage, Two Topic coverages, Three Topic coverages, Above 3 Topic coverages</td>
</tr>
</tbody>
</table>

The division of each level is defined as follows:

**2.1 Context**

None: The exercise is a purely mathematical and doesn’t involve any actual context.

Personal: Exercises closely related to students’ families, schools, and other daily life.

Public: An exercise that has little to do with student life, but has a relationship with social life and historical phenomena.

Scientific: There is a distance from the student life, but related to the development of human science and technology, or natural phenomena, archaeological discoveries, astronomical sciences, sports competitions, etc.

**2.2 Investigation**

Knowing: Only need to know related concepts or rules, and you can answer correctly without other skills. It is the initial level of learning.

Understanding: As long as students understand concepts, rule or a certain Topic coverage, they can answer correctly.

Application: These requires flexibly use the concepts, rules, to solve problems. The exercise may or may not have a relevant application context.

Investigating: In addition to asking students to understand what they have learned, they need to be able to make divergent thinking, ask some valuable questions, or make meaningful thinking. This type of question is generally an open topic without fixed answers or patterns.

**2.3 Computation**

None: no Computations, such as readings, writing numbers, or formulating without getting the answer, just giving idea.

Simple Computation: with two or less operation symbols, or the oral Computation.

Complex computation: Operators are 3 or more, or equation with one variables.

High complexity Computation: involve solving problems in an easier ways, multiple symbolic operations, or binary or multivariate linear equations.

**2.4 Reasoning**

None: This type of topic does not involve Reasoning, such as purely computational problems.

Simple Reasoning: You can find a solution to a problem with just one-step-reasoning.

Complex Reasoning: You can find a way to solve the problem by two-step reasoning.

High-difficulty Reasoning: After three-steps or more reasoning, you can find a solution to the problem. For example, the problem of "rex rabbit cage" in Chinese exercises.

There is no need to explain more about the Topic coverage.

In this study, the Chinese textbooks were published by the PEP (People’s Education Publishing House)\(^6\). It is the most authoritative textbook publisher in China, and more than 70% of primary and secondary schools use the textbooks from them.

The Romanian textbooks were uniformly approved by the Ministry of Education and published by private publishing companies, which are selected by each school. Currently, six versions of Romania have been reviewed by the Ministry of Education. This
study selected textbooks\textsuperscript{[7]} published by the most influential textbook publishers, Aramis, which is used by most schools.

When counting the amount of exercises, follow the rules below:

In Chinese sample textbooks, the first numbering of items is all by 1, 2, 3, . . . , which are called "big items". And the second numbering of items is by (1), (2), (3), ..., which are called "sub items" are numbered (1), (2), (3)... The amount of exercises were calculated by sub items. The total number was calculated on the second level. If under the level of the "sub items", there are more levels of items, still counting as 1; and if one big item has multiple sub items without numbering, according to the number of sub items.

Romanian exercises, are also numbered with 1, 2, 3... , and the sub items (a), (b), (c)... Similar with China, were counted with the same rule.

In this study, only after-class exercises and review exercises were counted in Chinese textbooks. These exercises were only used for homework. They have titles such as "练习－" (Exercise 1) or "整理与复习 " (sorting & revision), not including examples, the class exercises or some exercises with title "做一做 ",(Do it), etc.; Romanian mathematics textbooks we only count exercise titled "Exercitii" and "sunt Campion", which does not include classroom exercises, examples and some exercise with the "Aplic" title.

From the content point of view, Chinese textbooks have more content, more extensive, more topic coverages; from the catalogue, Chinese textbooks contain two volumes, total 17 chapters; Romanian mathematics textbooks also have two volumes, but only 9 chapters totally; in the total number of exercises, there are 1407 in Chinese textbook, and 1189 in Romanian textbooks.

It can be seen that the Romanian exercises were more concentrated. As for the difficulty of the exercises, this study characterized the exercises through comprehensive difficulty. The difficulty was measured by the following formula\textsuperscript{[8]}:

\[
d = \frac{\sum n_i d_i}{n} (\sum n_i=n, i=1,2,3,4,5, j=1,2,\cdots)
\]

Among them, \(d_i\) represents the value of the five difficulty factors, "Context", "Investigation", "Computation", "Reasoning" and "Topic coverage" sequentially ; \(d_i\) indicating the weight of the \(j\)th level of the \(i\)th difficulty factor, where the weight is taken according to the difficulty level with the values 1, 2, 3, 4; \(n_i\) is the number of exercise in the \(j\)th level of the \(i\)th difficulty factor in the group.

3. Findings

According to the above classification rule and difficulty computation formula, the exercises of the two sample textbooks were identified one by one, and the following quantitative indicator table is obtained:

The following five difficulty factors were also compared separately, and then the difficulty analysis was carried out.

3.1 Context

Statistics show that in the textbooks of China and Romania, the exercises that do not involve the actual Context are 73% and 74% respectively; the exercises related to "personal" account for 14% and 22% respectively; the exercises belonging to "pulic" are respectively 6% and 4%; the exercises belonging to the "Scientific context" account for 6% and 1% respectively. See the figure below.

**Figure 2** Comparison of Chinese and Romanian textbooks post-class exercises on context

It can be seen from the figure that the overall difference between the textbooks in China and Romania is not large. On the "personal" level, the Chinese textbooks were 8 percentage points lower than the Romanian textbooks, while on "public" and "scientific" level, it was higher than Romanian textbooks by 2 and 5 percentage. It can be seen that the connection between Chinese mathematics textbooks and scientific knowledge is more profound, and Romanian textbooks are closer to students' personal life. Chinese and Romanian textbooks in the "Context" latitude, the difficulty coefficients were 1.46 and 1.32 respectively.

3.2 Investigation

Statistics show that Chinese and Romanian textbooks, the "knowing" had 4% and 14% respectively. And the
Table 2. Quantitative index on the difficulty factors of the post-class exercises

<table>
<thead>
<tr>
<th>Factors</th>
<th>Level</th>
<th>Number of Exercises</th>
<th>Percentage</th>
<th>Weighted mean</th>
<th>Ch</th>
<th>Ro</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ch¹</td>
<td>Ro²</td>
<td>Ch</td>
<td>Ro</td>
<td></td>
</tr>
<tr>
<td>Context</td>
<td>Non</td>
<td>1026</td>
<td>875</td>
<td>73.00</td>
<td>74.00</td>
<td>1.46</td>
</tr>
<tr>
<td></td>
<td>Personal</td>
<td>204</td>
<td>260</td>
<td>14.00</td>
<td>22.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Public</td>
<td>89</td>
<td>43</td>
<td>6.00</td>
<td>4.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scientific</td>
<td>88</td>
<td>11</td>
<td>6.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Knowing</td>
<td>61</td>
<td>168</td>
<td>4.00</td>
<td>14.00</td>
<td>2.55</td>
</tr>
<tr>
<td></td>
<td>Understanding</td>
<td>579</td>
<td>464</td>
<td>41.00</td>
<td>39.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Application</td>
<td>695</td>
<td>525</td>
<td>49.00</td>
<td>44.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Investigating</td>
<td>72</td>
<td>32</td>
<td>5.00</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non</td>
<td>577</td>
<td>408</td>
<td>41.00</td>
<td>34.00</td>
<td>1.69</td>
</tr>
<tr>
<td></td>
<td>Number Computation</td>
<td>714</td>
<td>520</td>
<td>51.00</td>
<td>44.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complex Computation</td>
<td>96</td>
<td>243</td>
<td>7.00</td>
<td>20.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High-difficulty operation</td>
<td>20</td>
<td>18</td>
<td>1.00</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>Reasoning</td>
<td>Non</td>
<td>749</td>
<td>690</td>
<td>53.00</td>
<td>58.00</td>
<td>1.54</td>
</tr>
<tr>
<td></td>
<td>Simple Reasoning</td>
<td>491</td>
<td>373</td>
<td>35.00</td>
<td>31.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complex Reasoning</td>
<td>129</td>
<td>113</td>
<td>9.00</td>
<td>10.00</td>
<td>1.61</td>
</tr>
<tr>
<td></td>
<td>High difficulty Reasoning</td>
<td>38</td>
<td>13</td>
<td>3.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Topic coverage</td>
<td>Single Topic coverage</td>
<td>1206</td>
<td>1027</td>
<td>86.00</td>
<td>86.00</td>
<td>1.14</td>
</tr>
<tr>
<td></td>
<td>Two Topic coverages</td>
<td>200</td>
<td>161</td>
<td>14.00</td>
<td>14.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Three Topic coverages</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Above 3 Topic coverages</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1407</td>
<td>1189</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Ch¹, Chinese; Ro², Romanian.

proportions of "understanding" were 41% and 39% respectively. On the "application", they were 49% and 44% respectively; on "Investigating", they were 5% and 3%, as shown in the following figure.

Figure 3 Comparison of Chinese and Romanian textbooks post-class exercises on investigation

As can be seen from the figure, Romania had a relatively high level on "knowing", 10 percentage points more than China; on "understanding", "application" and "Investigating" the percentages were lower than those of Chinese textbooks, which were 2, 5 and 2 percentage points lower. It can be seen that Chinese textbooks were higher in the investigation requirement. The difficulty coefficients were 2.55 and 2.35 respectively.

3.3 Computation

Statistics show that, the non-computation exercises of Chinese and Romanian textbooks accounted 41% and 34%; the "simple computation" accounted 51% and 44% respectively; on the "complex computation", Chinese textbooks accounted for 7%, and Romania textbooks accounted 20%; on the "high difficulty computation", Chinese and Romanian textbooks accounted for 1% and 2% separately, as shown below.

Figure 4 Comparison of Chinese and Romanian textbooks post-class exercises on computation
It can be seen that, there were more exercises with less computational difficulty in Chinese textbooks; and more complex exercises, Romanian textbooks accounted for more. However, it should be noted that the Romanian textbooks had involved simple linear equation with one unknowns in the fourth grade. The computation of equations in China only be studied in the middle school. However, the linear equation with one unknowns was divided into "complex computations" according the rule, which raises the difficulty index of Romanian. The coefficients of Chinese and Romanian textbooks on "computation" difficulty were 1.69 and 1.89 respectively.

3.4 Reasoning
Statistics show that, the number of non-reasoning in Chinese and Romanian textbooks accounted 53% and 58% respectively. For simple-reasoning exercises, the proportion of Chinese and Romanian textbooks was 35% and 31% respectively. Romanian and Chinese textbooks accounted for 10% and 9% respectively on the complex reasoning; High-difficulty-Reasoning exercises, the proportions of Chinese textbooks and Romanian textbook were 3% and 1% respectively. As shown below.

![Figure 5](image1)

**Figure 5** Comparison of Chinese and Romanian textbooks post-class exercises on reasoning

As can be seen from Figure 4, there was fewer non-reasoning in Romanian textbooks; simple-Reasoning exercises account 4% higher in Romanian textbooks than Chinese textbooks; and on complex-reasoning, the proportions of textbooks in the two countries were equal; On the high-difficulty, the proportion of Chinese textbooks was slightly higher. That is to say, Romanian textbooks had higher requirements for simple reasoning than Chinese textbooks, while Chinese textbooks were more intensive in high-level reasoning. For Chinese and Romanian textbooks, the difficulty index were 1.61 and 1.54 respectively on "reasoning".

3.5 Topic coverage
Statistics show that the textbooks of Chinese and Romanian countries have no more than three topic coverages. The exercises containing one and two topic coverages account for 86% and 14% separately in Chinese and Romania textbooks.

However, it is worth noting that the content of the textbooks in the two countries differs greatly in the total topic coverages. The two volumes of Chinese textbooks cover a total of 38 topic coverages, while Romania had a total of 8 topic coverages. So it can be seen that Romanian textbook exercises, had more repeats in a smaller range.

![Figure 6](image2)

**Figure 6** Comparison of Chinese and Romanian textbooks post-class exercises on topic coverage

Comprehensive difficulty

In the above five aspects, the difficulty of the textbooks of China and Romania at each latitude was delineated separately. However, the measurement of difficulty cannot be described by unilateral. Therefore, based on the quantitative indicators of the difficulty of each latitude, this study gave comprehensive difficulty by the radar chart as following:

![Figure 7](image3)

**Figure 7** Comparison of Comprehensive Difficulties between Chinese and Romanian Textbooks

As can be seen from the above figure, except for calculation, the difficulty level of Romanian textbooks,
Chinese textbooks in the "Context" "Investigation" "Reasoning" "Topic coverage" were higher than or equal to the difficulty level of Romanian textbooks.

4. Conclusion

This study uses Chinese and Romanian elementary school textbooks as samples, and compared the five latitudes from the "Context", "Investigation", "Computation", "Reasoning" and "Topic coverage". Some results were obtained, which were summarized as follows:

(1) On the total number of Topic coverages, Chinese textbooks far more than Romanian textbooks.

(2) On the difficulty of the sample, due to the arrangement of the textbook content, the Chinese textbook was much difficult than the Romanian textbook except for the "Computation" latitude. The comprehensive difficulty of Chinese sample textbooks was higher than that of Romanian textbooks.

5. Limitation

It should be noted that there are many different methods for comparing the difficulty of textbooks. But no one model or method is perfect. There are always some defects. This research is not exception, and some of them will affect the process and methods of research. For example:

The division of 5 latitudes of comprehensive difficulty is not comprehensive enough.

For instance, in some practical operations, such as requiring space imagination, or examining the hands-on skills, are difficult should be covered in the division of these five latitudes.

In the division of each level of difficulty factors, it is inevitable that there were some subjectivity.

For example, on "Context", some exercises can be attributable to "public" or to "scientific", which is difficult to define and can only be judged by the subjective judgment of the researcher.

At each difficulty level, the weight distribution has a certain degree of subjectivity; for example, the problem with a topic coverage of 2, the difficulty weight is assigned to 2, and the topic coverage is 1 with a difficulty weight of 1. But must be the former twice as difficult as the latter? There is no objective standard.

The model has certain defects in the overall difficulty of the whole textbook.

For example, in terms of "Topic coverage", what we get is the Topic coverage of each exercise, and never consider whether they are repeated. If the whole textbook has only a few limited number of Topic coverages, the extreme case: only one Topic coverage, but it was repeated in 20 exercises; while in another textbook, there are 20 Topic coverages, appear in 20 exercises separately. After counting, the difficulties on the "Topic coverage" of the two books are same. But in fact, we can see that the latter difficulty is obviously higher.

Therefore, we hope that these aspects can attract the attention of other researchers, to make the model more comprehensive and objectively on reflecting the difficulty of the textbooks.

References


