A Model for Students’ Key Mathematical Competency Training in the Age of Internet+

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Abstract

As a discipline that studies quantity, structure, change, space, information and other concepts, mathematics plays an irreplaceable role in the continuous development of human society. In the digital era, the functions assumed by mathematics are increasingly significant. Higher degree of emphasis is attached on mathematical education. How to cultivate students’ key competency skills and train more excellent math talents has become a research focus that receives wide attention from educational workers. However, under the traditional teaching mode, subject to a variety of subjective or objective factors, more emphasis tends to be laid on cultivating students’ ability to solve math problems and key mathematical competency has not been taken seriously, which leads to students’ general lack of math application and research ability and the difficulty to realize the purpose of training mathematical talents. For this purpose, this paper mainly studies the status quo and cultivation strategies of students’ key mathematical competency in the era of Internet+ and provides a reference for mathematical education reform.

Keywords: Internet+, Key Mathematical Competency, Educational Reform.

1. RESEARCH OVERVIEW

1.1 Research background

1.1.1 Background of Internet+

Internet+ is a new type of operation of Internet development under Innovation 2.0, a further practical achievement of Internet thinking and a product of in-depth integration between the Internet and various traditional industries, which can create a new development ecology for each traditional industry and become an inevitable trend of social development. In the field of education, Internet+ can provide people of all levels with various forms of education such as primary school, junior high school, high school, university, occupation, etc., and supply open courses with registration and enrollment, so that students can participate in the national unified examination on the Internet like the normal situation, study and obtain a diploma and certificate at home. In the advanced development stage of Internet+Education, the traditional teaching mode will be replaced by Internet education. Both teachers and students carry out teaching activities on the Internet and offline activities supplement education. The development of Internet+ symbolizes that education in China is advancing towards the stage of 4.0. Internet+Education has become an inevitable trend of the development of education system in China.

1.1.2 Background of key mathematical competency

Guided by the idea of quality-oriented education, China attaches vital importance to the cultivation of key mathematical competency. As early as 1992, mathematical competency was mentioned in the Mathematics Teaching Syllabus of Junior Middle School, which was regarded as a major direction of mathematical education. The study on key mathematical competency has received widespread attention of educators. In 2003, Mathematics Curriculum Standards for Regular High Schools (Experimental Draft) clearly put forward that students’ key mathematical competencies should be trained in mathematical education. The beginning of Mathematics Curriculum Standards for Compulsory Education (2011 Edition) emphatically explained that the key objective of mathematics education at this stage was to cultivate the core mathematics qualities of students. This has been incorporated into Outline of National Medium-and-long-term Program for Education Reform and Development (2010-2020), reflecting China’s attention to cultivating students’ key mathematical competencies.
1.2 Literature review

In essence, key mathematical competency is the ability to adopt mathematics knowledge to solve practical problems, and it involves the following characteristics. First, in view of a problem, it emphasizes more on its conditions and concepts. Secondly, in the observation of a problem, it tends to attach more attention to the relationship among various elements and extend it to the whole space through the study on a certain local space. In the end, when understanding a problem, some strict mathematical concepts are often mobilized including random, periodicity, duality and other description problems. For example, the price of a particular product is the duality of the product (Kong and Shi, 2017). At present, the key mathematical competency of students in China is generally low. A substantial amount of students have a solid foundation of mathematics knowledge, the ability to solve problems, but the poor ability to solve practical problems. It is difficult for them to express and communicate through mathematics, thus impossible to construct models through mathematical knowledge. According to relevant surveys, students’ key mathematical competency is not affected by gender and other factors. When solving the problems appearing in the real life, students show poor problem-solving abilities. In the course of mathematics learning, students lack the necessary reflection and sentiment, and their mathematics knowledge is superficial and forms no complete knowledge framework (Ning et al., 2017). The training of students’ key mathematical competency is a vital target in mathematics teaching in China. However, in practical teaching, subject to numerous subjective or objective factors, a quantity of teachers mistakenly regard students’ mathematics knowledge and problem solving ability as the key mathematical competencies, and take students’ grades as the only criterion for evaluating the level of students’ key mathematical competency. As a consequence, the traditional teaching mode often focuses on cultivating students’ ability to solve problems without playing the significance of key mathematical competency, which is not conducive to the continuous improvement of mathematics teaching (Shen and Fu, 2016).

2. AN AHP-BASED EVALUATION INDEX MODEL FOR MATHEMATICAL EDUCATION QUALITY

Analytic hierarchy process (AHP), proposed by A.L. Satie, an American operation strategist in the 1970s, is a method combines quantitative analysis and qualitative analysis. Mathematics teaching quality evaluation is affected by a variety of factors. In the application of traditional evaluation methods, numerous indexes can not be quantified, leading to some errors in the calculations. AHP combines quantitative with qualitative analysis, has stronger adaptability, and is able to solve many a problem that cannot be solved by traditional methods (Ye, 2017). Therefore, an evaluation index model for mathematics teaching quality is established by the AHP, and the steps are as follows.

2.1 Design evaluation indexes

First of all, based on the investigation on experts, scholars and front-line teachers, the main indexes that affect the quality of mathematics teaching are sorted out and constructed into the evaluation system table, as illustrated in Table 1:

<table>
<thead>
<tr>
<th>Target layer U</th>
<th>Criterion layer B</th>
<th>Scheme layer C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom teaching quality</td>
<td>Teaching attitude</td>
<td>Full of mind, conscientious and responsible</td>
</tr>
<tr>
<td></td>
<td>Content of courses</td>
<td>Clear thinking and accurate expression</td>
</tr>
<tr>
<td></td>
<td>teaching method</td>
<td>Give prominence to key points</td>
</tr>
<tr>
<td></td>
<td>Teaching organization</td>
<td>Cultivating students’ innovative thinking</td>
</tr>
<tr>
<td></td>
<td>teaching effectiveness</td>
<td>Discussion heuristic teaching</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Information education</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Strict requirements, regular attendance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Good discipline in class</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Teaching plan and scheme are clear</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stimulate students’ interest in learning</td>
</tr>
</tbody>
</table>

Secondly, a comparison judge matrix is constructed. As indicated by Table 1, each of the influencing factors has a subordinate relationship and a certain relevance. In order to judge the influence of the factor in a certain layer on the upper layer, it is necessary to apply the importance index to quantify the difference between the two
influencing factors in this layer (Shi, 2017). Assume that this layer is \( x \); there are \( n \) influencing indexes in total; the proportion between certain two influencing factors is \( w \), the formula is:

\[
 w_{ij} = \frac{x_i}{x_j}
\]  

(1)

In view of the above formula, the matrix could be derived as follows:

\[
 A = \begin{bmatrix}
 w_{11} & w_{12} & \cdots & w_{1n} \\
 w_{21} & w_{22} & \cdots & w_{2n} \\
 \cdots & \cdots & \cdots & \cdots \\
 w_{n1} & w_{n2} & \cdots & w_{nn}
\end{bmatrix}
\]  

(2)

Among them, the value of \( w_{ij} \) is the difference of the importance, represented by the scale of 1 to 9, as shown in Table 2:

<table>
<thead>
<tr>
<th>Scaling</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Indicates that two indicators, 1, are of equal importance compared to indicator ( J )</td>
</tr>
<tr>
<td>3</td>
<td>indicates that an indicator is a little more important than another in comparison to the two indicators</td>
</tr>
<tr>
<td>5</td>
<td>compared to the two indicators, one indicator is obviously more important than the other</td>
</tr>
<tr>
<td>7</td>
<td>compared to two indicators, an indicator is much more important than the other</td>
</tr>
<tr>
<td>9</td>
<td>indicates that compared to the two indicators, one index is more important than the other</td>
</tr>
<tr>
<td>2, 4, 6, 8</td>
<td>The median value of two adjacent degrees</td>
</tr>
</tbody>
</table>

The influencing factors of mathematical teaching quality are hierarchically ordered in accord with the importance. After the comparison, the scale value of the result is determined by the coincidence degree of its conclusion. As indicated by Table 2, 1 is denoted if two influencing factors are equally important; 3 represents where one index is slightly more important than the other index; 5 is adopted when one index is significantly more important than the other one; 7 refers to that one index is strongly more important than the other one; 9 means that one index is extremely more important than the other one; 2, 4, 6 and 8 stand for the level of importance between these two factors (Chen and Chen, 2016).

### 2.2 Maximum eigenvalue and eigenvector calculation

In the process of index judgment, we must pay attention to calculating the maximum eigenvalue and eigenvector. The largest eigenvalue is \( \lambda_{\max} \) and the eigenvector is \( W = [w_1, w_2, w_3, \ldots w_n]^T \). Because \( AW = \lambda_{\max}W \), the final eigenvector can be derived. When calculating eigenvectors, the contents of each row in matrix \( A \) should be multiplied by the following formula:

\[
 \prod_{j=1}^{n} a_{ij} \quad (i = 1, 2, 3L)
\]  

(3)

Open calculations are conducted on the results of the formula, which are substituted into the formula, \( \bar{w}_i = \frac{n}{\sqrt{\prod_{j=1}^{n} a_{ij}}} \). The obtained results are normalized to derive the final eigenvector (Zhu, 2016). The result is:

\[
 w_i = \frac{\bar{w}_i}{\sum_{j=1}^{n} \bar{w}_j}, W = [w_1, w_2, w_3, \ldots, w_n]
\]  

(4)

### 2.3 Consistency test

In the end, the reliability of the results should be analyzed by consistency test, and its formula is as follows:

\[
 CI = \frac{\lambda_{\max}-n}{n-1}
\]  

(5)
where CI represents the consistency index, and the solution is as below:

\[ CR = \frac{CI}{RI} \]  

(6)

In the above formula, RI represents the consistency index, and its value range has a certain limitation (Table 3).

### Table 3 RI

<table>
<thead>
<tr>
<th>Order number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI</td>
<td>0</td>
<td>0</td>
<td>0.58</td>
<td>0.90</td>
<td>1.12</td>
<td>1.24</td>
<td>1.32</td>
<td>1.41</td>
<td>1.45</td>
</tr>
</tbody>
</table>

The value of RI was substituted into the above formula to derive the final CR value. If CR<0.1, the accuracy of the result is proved to be within the acceptable range, and the result can effectively reflect the quality of mathematical education. However, if CR>0.1, the resulting error is proved to be fairly large and it needs to be recalculated (Sun, 2016).

### 3. STUDENTS’ KEY MATHEMATICAL COMPETENCY TEST

#### 3.1 PISA test

The test on students’ key mathematical competency mainly adopts the PISA method which takes examination paper as the main form and tests students’ key mathematical competency from multiple dimensions. PISA exams are divided into three types, including multiple choice questions, closed construct answer questions and open construct answer questions (Li et al., 2016). This study mainly adopts examination questions of open constructs, which can better test students’ ability to solve practical problems. Its details are listed in Table 4:

### Table 4 Distribution of Mathematical Competency Test Items

<table>
<thead>
<tr>
<th>Subject</th>
<th>Field</th>
<th>Situation</th>
<th>Process</th>
<th>Questions</th>
<th>Difficulty level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclist (1)</td>
<td>Change and relation</td>
<td>personal</td>
<td>Application</td>
<td>Multiple choice questions</td>
<td>2</td>
</tr>
<tr>
<td>Cyclist (2)</td>
<td>Change and relation</td>
<td>personal</td>
<td>Application</td>
<td>Multiple choice questions</td>
<td>3</td>
</tr>
<tr>
<td>Cyclist (3)</td>
<td>Change and relation</td>
<td>personal</td>
<td>Application</td>
<td>Construct answer questions</td>
<td>6</td>
</tr>
<tr>
<td>bookshelf</td>
<td>Number</td>
<td>Occupation</td>
<td>formulation</td>
<td>Construct answer questions</td>
<td>3</td>
</tr>
<tr>
<td>Navigation (1)</td>
<td>Number</td>
<td>science</td>
<td>Application</td>
<td>Multiple choice questions</td>
<td>2</td>
</tr>
<tr>
<td>Navigation (2)</td>
<td>Space and shape</td>
<td>science</td>
<td>Application</td>
<td>Multiple choice questions</td>
<td>3</td>
</tr>
<tr>
<td>Navigation (3)</td>
<td>Change and relation</td>
<td>science</td>
<td>explain</td>
<td>Construct answer questions</td>
<td>4</td>
</tr>
<tr>
<td>Graphical</td>
<td>Space and shape</td>
<td>science</td>
<td>formulation</td>
<td>Construct answer questions</td>
<td>5</td>
</tr>
<tr>
<td>The president's approval rating</td>
<td>Uncertainty and data</td>
<td>Sociology</td>
<td>explain</td>
<td>Construct answer questions</td>
<td>5</td>
</tr>
<tr>
<td>Garage (1)</td>
<td>Space and shape</td>
<td>Occupation</td>
<td>explain</td>
<td>Multiple choice questions</td>
<td>1</td>
</tr>
<tr>
<td>Garage (2)</td>
<td>Space and shape</td>
<td>Occupation</td>
<td>Application</td>
<td>Construct answer questions</td>
<td>6</td>
</tr>
<tr>
<td>Robbery</td>
<td>Uncertainty and data</td>
<td>personal</td>
<td>Application</td>
<td>Construct answer questions</td>
<td>6</td>
</tr>
<tr>
<td>Resort Hotel (1)</td>
<td>Number</td>
<td>Sociology</td>
<td>Application</td>
<td>Construct answer questions</td>
<td>2</td>
</tr>
<tr>
<td>Resort Hotel (2)</td>
<td>Uncertainty and data</td>
<td>Sociology</td>
<td>explain</td>
<td>Construct answer questions</td>
<td>5</td>
</tr>
</tbody>
</table>
3.2 PISA test results analysis

This new testing method lets students solve practical problems based on their own knowledge, skills, solution approaches or mathematical experience in a real environment by means of examination, and the level of students’ key mathematical competency is evaluated on basis of the derived results. The PISA approach takes a binary evaluation methodology including two options: points and no points (Li and Wang, 2016). Six levels are classified according to the level of student scores.

The first level indicates scores above 669.3 where the obtained information is conceptualized, summarized and utilized, and different sources of information are connected, flexibly transformed and applied based on the study and modeling of complex situations. Students at this level are equipped with advanced mathematics thinking and mathematical reasoning ability, the ability of adopting insight and understanding skills to master symbols, formulas and mathematical operations, the ability of applying methods and strategies to solve new problems, as well as concise and accurate mathematical concepts to find, understand and demonstrate mathematical problems.

At the second level, scores lie between 607.0 and 669.3, where students can establish and employ the model for complex problems, identify their constraint conditions and assumed conditions, select, compare and evaluate the solving strategies for problems, apply extensive and mature mathematical thinking and reasoning skills, connect symbols, formulas and calculations, have an insight into real-world problems, and think, express, communicate, explain and reason about their own behaviours (Zhang, 2015).

The third level involves scores between 544.7 and 607.0, where students are able to effectively take advantage of models for specific complex problems, to identify constraints and assumed condition of the models, to select different statements to establish the connection with real-life situations, to flexibly employ practical skills, reasoning ability and insight, and to establish, express and explain based on understanding, argumentation and ability.

Scores between 482.4 and 544.7 fall into the fourth level, where students are capable of executing well-defined procedures, selecting and using problem-solving strategies, understanding and applying statements based on different sources of information, and directly conducting mathematical inference to communicate, understand and reason the results.

At the fifth level, scores are between 420.1 and 482.4, students can understand and identify problems that require no inference, extract and present information from simple situational material resources, make a direct inference using basic algorithms, formulas and procedures, and literally interpret the mathematical results (Huang, 2013).

The sixth level concerns scores between 357.8 and 420.1, students are able to answer clear and legible questions, to perform routine operations based on explicit instruction, and to complete corresponding actions based on obvious and given stimuli.

4. TRAINING STRATEGY OF STUDENTS’ KEY MATHEMATICS COMPETENCY FROM THE PERSPECTIVE OF INTERNET+

4.1 Implement mathematical activities

Mathematical activities are mainly divided into reproduction activities and real-life activities. Reproduction activities refer to placing students in the contradictions or problems that arose during the development of mathematics and producing their own knowledge. In real-life activities, an environment is constructed or questions are put forward in the real life, and students seek solutions based on their own mathematical knowledge.

From the perspective of reproduction activities, many of the mathematical concepts come from life practice and they are also a high-level summary of practical problems. In mathematical teaching, because of the high abstraction and the theoretical property of mathematical knowledge, it is difficult for students to understand the deep meaning involved. Consequently, numerous students lose their confidence in mathematics learning and can not solve practical problems by using mathematics. To this end, in mathematical teaching, emphasis should be laid on extending the mathematical concept so that students can understand the core meaning of mathematics.
In light of real-life activities, teachers can guide students to analyze and solve problems in the practical life. Available information is extracted from problems and transformed into a mathematical model. Based on this, teachers can carry out thematic events, organize students to conduct collective seminars, write relevant essays, hold exchange reports, etc., so that students can better integrate mathematics knowledge with real life. In this way, students’ key mathematical competencies are effectively enhanced (Yang, 2013).

4.2 Construct a benign learning atmosphere

Learning atmosphere can exert a subtle influence on students’ learning level. Indicated by teaching experience and relevant research results, a benign learning atmosphere can effectively stimulate students’ learning enthusiasm. Hence, in mathematical teaching, teachers should organize students to make an in-depth exploration of mathematical knowledge by means of group discussion, deskmate discussion, practical investigation, etc. and should give students adequate space for expression in the classroom, which can cultivate students’ mathematics research ability and also improve students’ enthusiasm in maths learning. In addition, teachers should pay attention to situation construction in mathematics teaching. Only by staying in the situation can education demonstrate its vitality and reflect its actual significance. For this purpose, questions raised by teachers should be vivid, interesting and in line with the actual situation, so that students can be better integrated into the situation. In situational teaching, it is of vital significance for teachers to guide students to enter the situation. For example, students are arranged to play the role of protagonist in the situation and to analyze from the angle of the protagonist, which not only can effectively stimulate students’ enthusiasm for learning, but also can guide them to think (Rao and Liu, 2011).

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