Research on the Gray Hierarchy Evaluation Model Based on Multimedia System and English Teaching Evaluation

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Abstract

Network technology and multimedia are gaining momentum. They accelerate the reform of the educational sector. Traditional educational mode is integrated with new technology and a multimedia network education system is taking shape. As a result, traditional English teaching system has experienced a progressed reform. The evaluation of English teaching system in multimedia network is for the purpose of measuring the level and efficacy of the integrated new multimedia technology. This paper studies the English teaching system in multimedia network, adopts Analytic Hierarchy Process (AHP) to conclude 1 first-class index, 5 second-class indexes and 21 three-class indexes. It employs the Grey Evaluation and Matlab software for the comprehensive evaluation of 30 teaching systems and classifies the results by gray classes. By studying the evaluation principle of English teaching system in multimedia network, this paper intends to provide the algorithm with theoretical foundations so that the system can better serve students.

Keywords: AHP (Analytic Hierarchy Process); Gray Evaluation method; Matrix; Realization of MATLAB

1. Introduction

In the foreseeable future, classroom teaching will still be a mainstream. But the class structure, materials, method and hardware will be different from those of traditional classroom teaching. Multimedia and tradition way of teaching will be complementary and lead the new trend of teaching [1]. Multimedia teaching aboard is derived from audio-visual instruction, or named audio-visual education programme domestically. This later developed into computer aided instruction and computer teaching. With the development of technology, there has emerged multimedia technology with computer at its core and multimedia-aided teaching.

In traditional way of teaching, knowledge in textbooks and coaching materials is developed in a linear way with a logic order. In the course of teaching, students are passive and dependent on teachers and lack the flexibility of self-study. In contrast, multimedia teaching is organized in a way that fits human perception. It can make up for the weaknesses in traditional teaching. This paper studies the English teaching system in multimedia network and provides a Gray Hierarchy Evaluation model based on Matlab to have an all-round evaluation on teaching systems. It hopes to provide scientific analytical method for the improvement of the new teaching system.

Many people pay efforts to study the teaching system in multimedia network and Gray Hierarchy Evaluation method that enables a successful combination of method and technology, laying a solid foundation for the development of multimedia English teaching. Xiao Dejun (2009) and some others from the Foundation Department of Changzhou Institute of Light Industry Technology, propose that the mode of English teaching and learning in multimedia network has charted the correct direction. And an integrated scientific evaluation
system to measure its quality is necessary. They also discuss the theory and idea of the evaluation index system based on the “Task-based” English teaching theories and practices, and constructs a proper evaluation system that focuses on subject, interaction and development of English teaching [2].

Feng Lixia (2009), from College of Mathematics and Information Science of Northwest Normal University, targets at the lack of full-time teaching of the second-class evaluation index in the existing evaluation index system, constructs models by AHP and tests its consistency. She gives out reasonable references values to teaching evaluation index of all classes. Based on her effort, this paper constructs a teaching evaluation index model based on AHP and finds it useful [3]. Zhang Hui (2008) from China University of Petroleum combines fuzzy comprehensive evaluation method and the Gray theory, suggests a new quantitative comprehensive evaluation method, namely, Fuzzy Analytic Hierarchy Process of Gray Correlation Clustering Analysis. He applies it to oil and gas drilling technology and yields good results [4].

Wang Kai (2006) from Foreign Language Department of Huainan Normal University targets at how to use multimedia courseware for evaluation to promote the English teaching aided software. He bases his discussion from the position of English multimedia courseware, characteristics of courseware teaching, technique features and the economic utility of courseware [5]. Chai Zhengyi from College of Information Science and Technology of Henan University of Technology and Li Yalun from Zhengzhou Furun Foreign Language School (2006) analyze the poor quality of multimedia courseware teaching and problems of teachers blindly using multimedia technology. They provide reasonable advice and references for the use of multimedia technology in teaching [6]. Deng Xianglin and Luo Yan (2009), librarians of Hunan University of Science Technology adopts questionnaires and quantitative mathematical method based on system evaluation principle and Fuzzy Analytic Hierarchy Process, point out that performance management is available in the library. They have proved that the evaluation indexes are scientific, reasonable and accessible by empirical analysis on library performance management.

This paper stands on the shoulder of previous researches and uses Fuzzy Analytic Hierarchy Process to evaluate 27 indexes of 30 systems in multimedia network and gets the algorithm by Matlab software. It hopes to provide suggestions to the multimedia teaching system and theoretical foundations for the algorithm.

2. Establishment of the Evaluation Index System

With the rapid development of scientific technology, multimedia network classroom emerged in campuses of all levels. This paper studies the English teaching system in multimedia network, establishes the evaluation index system for multimedia teaching. By doing so, it hopes to evaluate the quality of the system in a proper and effective way.

The teaching system in multimedia network can be simplified as the following model in Figure 1.
The indexes are divided into three categories, namely, first-class index, second-class index and third-class index. First-class index is referred to by A.

There are five second-class indexes: student B1, teacher B2, teaching task B3, teaching courseware and multimedia resources B4 and multimedia network teaching platform B5.

There are three third-class indexes. Under the student index, there are studying condition C1, studying way C2, studying effect C3. Under the teacher index, there are role position C4, humanistic concern C5, environment building C6, technology application C7, habit concern C8 and teaching creativity C9. Under the teaching task, there are task design C10, task presentation C11, task completion and tactics C12, report and summary C13, task effect C14. Under the teaching courseware and multimedia resources index, there are content C15, effectiveness C16, interaction C17 and technological level C18. Under the multimedia network teaching platform index, there are openness C19, interaction C20, performance and effectiveness C21.

The hierarchy index system is shown in Figure 2.

Figure 2. Index Hierarchy System

3. Mathematical model of Gray Hierarchy Evaluation

Based on the English teaching evaluation index system in multimedia network, we should also confirm the weight of indexes in order to learn about the proportion of every index. Many methods are available, including AHP, experience method, expert estimation method, weighted statistical method and statistical method of frequency. This paper adopts the Gray Hierarchy Evaluation that divides the results into five classes: Best, Better, Normal, Worse and Worst. This paper will start by illustrating the second-class indexes B1, B2, B3, B4 and B5. The set of the first-class evaluation index A is known as (1)

\[ U_A = \{U_{B_1}, U_{B_2}, \ldots, U_{B_5}\} \]  

The corresponding weigh of indexes in (1) is shown as in (2)

\[ A = \{A_1, A_2, \ldots, A_5\} \]
The set consisted of the second-class indexes is expressed by (3)

\[
U_m = \{ U_{m1}, U_{m2}, \cdots, U_{m\nu} \} \tag{3}
\]

The corresponding weigh of indexes in (3) is expressed by (4)

\[
A_i = \{ A_{i1}, A_{i2}, \cdots, A_{im} \} \tag{4}
\]

The process of Gray Hierarchy Evaluation includes confirming the gray class of evaluation, working out evaluation class, calculating sampling matrix, calculating gray evaluation coefficient, constructing gray evaluation weight matrix, checking results and indicating the gray class of indexes.

3.1. Confirming the Gray Class of Evaluation.

This paper classifies 5 gray classes, namely, \( \varepsilon = 1, 2, 3, 4, 5 \), Best, Better, Normal, Worse and Worst. The gray and whitening weight functions are shown as follows.

For Best or \( \varepsilon = 1 \), there is \( x \in [x_1, x_2, x_3] \), the whitening weight function \( f_1 \) is expressed by (5).

\[
f_1 = \begin{cases} 
0 & x \not\in [x_1, x_2] \\
\frac{x - x_1}{x_3 - x_1} & x \in [x_1, x_2] \\
1 & x \in [x_2, x_3] 
\end{cases} \tag{5}
\]

For Better or \( \varepsilon = 2 \), there is \( x \in [x_1, x_2, x_3, x_4] \), the whitening weight function \( f_2 \) is expressed by (6).

\[
f_2 = \begin{cases} 
0 & x \not\in [x_1, x_3] \\
\frac{x - x_1}{x_4 - x_1} & x \in [x_1, x_3] \\
\frac{x_3 - x_1}{x_4 - x_1} & x \in [x_3, x_2] \\
1 & x \in [x_2, x_3] 
\end{cases} \tag{6}
\]

For Normal or \( \varepsilon = 3 \), there is \( x \in [x_1, x_2, x_3, x_4] \), the whitening weight function \( f_3 \) is expressed by (7).

\[
f_3 = \begin{cases} 
0 & x \not\in [x_1, x_4] \\
\frac{x - x_1}{x_4 - x_1} & x \in [x_1, x_4] \\
\frac{x_4 - x_1}{x_4 - x_1} & x \in [x_4, x_3] \\
1 & x \in [x_3, x_2] 
\end{cases} \tag{7}
\]

For Worse or \( \varepsilon = 4 \), there is \( x \in [x_4, x_1, x_2, x_3] \), the whitening weight function \( f_4 \) is expressed by (8).

\[
f_4 = \begin{cases} 
0 & x \not\in [x_4, x_3] \\
\frac{x - x_1}{x_4 - x_1} & x \in [x_4, x_3] \\
\frac{x_4 - x_1}{x_4 - x_1} & x \in [x_3, x_2] \\
1 & x \in [x_2, x_3] 
\end{cases} \tag{8}
\]
For Worst or $e = s$, there is $x \in [x_7, x_1, x_5]$, the whitening weight function $f_s$ is expressed by (9).

$$f_s = \begin{cases} 
0 & x \not\in [x_7, x_5] \\
1 & x \in [x_7, x_1] \\
\frac{x_7 - x}{x_5 - x_7} & x \in [x_1, x_5]
\end{cases} \quad (9)$$

### 3.2. Calculating the Sampling Matrix

According to the evaluation $U_i^p$ by the first commentator based on evaluation index $e_i^r$, we construct the sampling matrix $D$ of the system to $U_i$, The sampling matrix is expressed by (10).

$$D = \begin{bmatrix} 
d_{11} & d_{12} & \cdots & d_{1p} \\
d_{21} & d_{22} & \cdots & d_{2p} \\
\vdots & \vdots & \ddots & \vdots \\
d_{m1} & d_{m2} & \cdots & d_{mp}
\end{bmatrix} U_i
\quad (10)$$

### 3.3 Calculating the Gray Evaluation Coefficient

For the evaluation index $U_i$, the gray evaluation coefficient of the $e$ gray class of the commented object is expressed by $X_{i\omega}$ and the algorithm is expressed by (11).

$$X_{\omega} = \sum_{r=1}^{\omega} f_r (d_{\omega}) \quad (11)$$

For the evaluation index $U_i$, the overall gray evaluation coefficient of the commented object of all gray classes is expressed by $X_i$ and the algorithm is expressed by (12).

$$X_i = \sum_{s=1}^{S} (X_{i\omega}) \quad (12)$$

### 3.4. Constructing Gray Evaluation Weight Matrix

For the evaluation index $e_i^r$, the overall gray evaluation weight of the $e$ gray class of the commented object is expressed by $R_{i\omega}$ and the algorithm is expressed by (12).

$$R_{\omega} = \frac{X_{\omega}}{X_0} \quad (13)$$

Suppose there are $s$ evaluation gray classes, $R_{\omega}^g$ is used to refer to vector of $U_i$ of the commented object to gray evaluation weight vector of all gray classes. This vector is expressed by (14).

$$R_{\omega}^g = (r_{\omega1}, r_{\omega2}, \ldots, r_{\omega g}) \quad (14)$$

From all vectors, we can get the gray evaluation weight matrix $R_i$ of $U_i$ of the commented object, as is expressed by (15).

$$R_i = \begin{bmatrix} r_{i1} \\
r_{i2} \\
\vdots \\
r_{in}
\end{bmatrix} = \begin{bmatrix} r_{i11} & r_{i12} & \cdots & r_{i1p} \\
r_{i21} & r_{i22} & \cdots & r_{i2p} \\
\vdots & \vdots & \ddots & \vdots \\
r_{i1} & r_{i2} & \cdots & r_{in}
\end{bmatrix} \quad (15)$$
3.5. Comprehensive Evaluation

For the evaluation of the first-class index, suppose the evaluation result of index $U_i$ of the commented object is expressed by $\beta_i$, and the algorithm is known as (16).

$$B_i = A_i \cdot R_i = (b_{i1}, b_{i2}, \ldots, b_{i\gamma})$$  \hspace{1cm} (16)

For the evaluation of the second-class index, from the result $B_i$, we can get the index $U_i$ of the commented object $U$, the gray evaluation weight matrix $R$ of all gray classes is expressed by (17).

$$R = \begin{bmatrix}
B_1 \\
B_2 \\
\vdots \\
B_m
\end{bmatrix} = \begin{bmatrix}
b_{11} & b_{12} & \cdots & b_{1\gamma} \\
b_{21} & b_{22} & \cdots & b_{2\gamma} \\
\vdots & \vdots & \ddots & \vdots \\
b_{m1} & b_{m2} & \cdots & b_{m\gamma}
\end{bmatrix}$$ \hspace{1cm} (17)

Therefore, the comprehensive evaluation $B$ is expressed by (18).

$$B = A \cdot R = A \begin{bmatrix}
A_1 \cdot R_1 \\
A_2 \cdot R_2 \\
\vdots \\
A_m \cdot R_m
\end{bmatrix} = (b_1, b_2, \ldots, b_\gamma)$$ \hspace{1cm} (18)

3.6. Indicating the Gray Class

The comprehensive evaluation results $\beta$ of the commented object are presented in vectors. These vectors describe the characteristics of all gray classes and can be used to indicate the gray class of the commented object. The normalized processing for vector $B$ results in a binary vector as is shown in (19). The algorithm of comprehensive evaluation value $z$ is expressed by (20).

$$D = [d_1, d_2, \ldots, d_\gamma]$$ \hspace{1cm} (19)

$$z = B \cdot D^T$$ \hspace{1cm} (20)

4. Empirical Research and Algorithm based on Matlab

4.1. Algorithm Process

The algorithm process based on Matlab is shown as Figure 3.
4.2. Index Data Editing

This paper conducts the evaluation on 30 English teaching systems in multimedia network. Table 1 shows the rating for 21 indexes with the full score being 100.

Table 1. Third-class Index Evaluation

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</tr>
<tr>
<td>4</td>
<td>86</td>
<td>98</td>
<td>47</td>
<td>52</td>
<td>84</td>
<td>77</td>
<td>92</td>
<td>99</td>
<td>75</td>
<td>58</td>
<td></td>
</tr>
</tbody>
</table>
4.3. Index Weight of Three Classes based on Matrix

The matrix of the second-class index is shown in (21).

\[
\begin{align*}
U & \quad B_1 & \quad B_2 & \quad B_3 & \quad B_4 & \quad B_5 \\
B_1 & \begin{bmatrix} 1 & 2 & 3 & 1 & 2 \\ 1/2 & 1 & 2 & 1 & 2 \\ 1/3 & 1/2 & 1 & 1/3 & 1/2 \\ 1 & 1 & 3 & 1 & 2 \\ 1/2 & 1/2 & 2 & 1/2 & 1 \\ \end{bmatrix} \\
\end{align*}
\]  

From (21) we can get the weight \( A_s \) of second-class index as in (22).

\[
A_s = \begin{bmatrix} 0.30 & 0.21 & 0.09 & 0.26 & 0.14 \end{bmatrix}
\]  

There are 5 matrixes of third-class index, as is shown from (23) to (27).
\[
\begin{align*}
\begin{bmatrix}
1 & 3/5 & 2 \\
5/3 & 1 & 9/5 \\
2 & 5/9 & 1 \\
\end{bmatrix} & \quad (23) \\
\begin{bmatrix}
1 & 1/2 & 6/7 & 3/5 & 1/6 & 3/5 \\
2 & 1 & 2 & 7/8 & 3/2 & 2/3 \\
7/6 & 1/2 & 1 & 3/5 & 1 & 2/3 \\
5/3 & 8/7 & 5/3 & 1 & 3/5 & 2/3 \\
6 & 2/3 & 1 & 5/3 & 1 & 7/8 \\
5/3 & 3/2 & 3/2 & 3/2 & 8/7 & 1 \\
\end{bmatrix} & \quad (24) \\
\begin{bmatrix}
1 & 5/2 & 5/8 & 7/8 & 1/2 \\
2/5 & 1 & 7/6 & 6/5 & 2/3 \\
8/5 & 6/7 & 1 & 5/4 & 2 \\
8/7 & 5/6 & 4/5 & 1 & 9/7 \\
2 & 3/2 & 1/2 & 7/9 & 1 \\
\end{bmatrix} & \quad (25) \\
\begin{bmatrix}
1 & 4/5 & 3/7 & 2/3 \\
5/4 & 1 & 1/2 & 3/5 \\
7/3 & 2 & 1 & 4/3 \\
3/2 & 5/3 & 3/4 & 1 \\
\end{bmatrix} & \quad (26) \\
\begin{bmatrix}
1 & 3/2 & 8/7 \\
2/3 & 1 & 3/5 \\
7/8 & 5/3 & 1 \\
\end{bmatrix} & \quad (27)
\end{align*}
\]

From (23) to (27) we can get the weight as is expressed in (28).

\[
\begin{align*}
A_{c_{1-3}} &= \begin{pmatrix}
0.30 & 0.41 & 0.29 \\
\end{pmatrix} \\
A_{c_{4-9}} &= \begin{pmatrix}
0.09 & 0.20 & 0.12 & 0.16 & 0.21 & 0.22 \\
\end{pmatrix} \\
A_{c_{10-14}} &= \begin{pmatrix}
0.18 & 0.16 & 0.25 & 0.20 & 0.21 \\
\end{pmatrix} \\
A_{c_{15-18}} &= \begin{pmatrix}
0.16 & 0.19 & 0.37 & 0.28 \\
\end{pmatrix} \\
A_{c_{19-21}} &= \begin{pmatrix}
0.36 & 0.30 & 0.34 \\
\end{pmatrix}
\end{align*}
\]

4.4. Research Results

From the above statement we can get the scores of each second-class index of 30 teaching systems, comprehensive scores and the grade gray cluster, as is shown in Table 2.
Table 2. Comprehensive Evaluation Results and the Grade Gray Cluster

<table>
<thead>
<tr>
<th>System number</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
<th>B5</th>
<th>A</th>
<th>The grade gray cluster</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>85.29</td>
<td>79.74</td>
<td>70.47</td>
<td>80.86</td>
<td>66.2</td>
<td>87.97</td>
<td>Best</td>
</tr>
<tr>
<td>2</td>
<td>69.75</td>
<td>58.97</td>
<td>62.23</td>
<td>76.05</td>
<td>73.02</td>
<td>57.91</td>
<td>Worse</td>
</tr>
<tr>
<td>3</td>
<td>50.55</td>
<td>73.12</td>
<td>84.62</td>
<td>76.17</td>
<td>52.68</td>
<td>77.32</td>
<td>Better</td>
</tr>
<tr>
<td>4</td>
<td>76.8</td>
<td>60.74</td>
<td>69.45</td>
<td>78.53</td>
<td>77.86</td>
<td>80.36</td>
<td>Better</td>
</tr>
<tr>
<td>5</td>
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<td>70.35</td>
<td>68.4</td>
<td>64.79</td>
<td>75.2</td>
<td>51.86</td>
<td>Worst</td>
</tr>
<tr>
<td>6</td>
<td>89.67</td>
<td>86.83</td>
<td>73.92</td>
<td>82.08</td>
<td>67.3</td>
<td>70.55</td>
<td>Normal</td>
</tr>
<tr>
<td>7</td>
<td>67.78</td>
<td>72.34</td>
<td>70.25</td>
<td>63.73</td>
<td>68.6</td>
<td>57.02</td>
<td>Worse</td>
</tr>
<tr>
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<td>74.09</td>
<td>72.16</td>
<td>77.05</td>
<td>74.32</td>
<td>48.3</td>
<td>60.40</td>
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<tr>
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<td>46.6</td>
<td>76.81</td>
<td>79.69</td>
<td>68.08</td>
<td>85.58</td>
<td>53.96</td>
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</tr>
<tr>
<td>10</td>
<td>72.95</td>
<td>69.98</td>
<td>73.26</td>
<td>72.91</td>
<td>61.96</td>
<td>60.81</td>
<td>Worse</td>
</tr>
<tr>
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<td>70.71</td>
<td>65.71</td>
<td>78.58</td>
<td>78.70</td>
<td>Better</td>
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<td>75.79</td>
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<tr>
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<td>71.47</td>
<td>65.68</td>
<td>81.86</td>
<td>84.16</td>
<td>92.14</td>
<td>Best</td>
</tr>
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<td>61.31</td>
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<td>71.62</td>
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<td>69.84</td>
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<td>77.94</td>
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<td>69.22</td>
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<td>95.52</td>
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<td>78.48</td>
<td>58.85</td>
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<td>73.56</td>
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<td>59.04</td>
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<td>75.44</td>
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<td>Normal</td>
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<td>62.06</td>
<td>81.88</td>
<td>85.96</td>
<td>92.91</td>
<td>Best</td>
</tr>
</tbody>
</table>

5. Conclusion

This paper uses Gray Hierarchy Evaluation method to evaluate 21 indexed of 30 teaching system in multimedia network and gets the gray classes of each system.

The evaluation algorithm proposed in this paper can function well in Matlab software. It provides a theoretical foundation for the evaluation system to be accessible.
References


Author

Xueyuan Zhang, She received her B.A. from the Shanxi Normal University in 2001 and a M.Sc. in Logistic Engineering from Nanjing University, China in 2012. She had been working as a university lecturer in English from 2003 to 2014 in Jinling Institute of Science and Technology. She teaches Business English courses in JIST. Her research area mainly includes Business English Writing and English Translation Theory.