
Chao-Yen Wu¹, Min-Chuan Huang²

¹ Department of Information Management
I-Shou University
No.1, Sec. 1, Syuecheng Rd., Dashu District, Kaohsiung City 84001,Taiwan, R.O.C.
cywu@isu.edu.tw

² Department of Information Engineering
I-Shou University
No.1, Sec. 1, Syuecheng Rd., Dashu District, Kaohsiung City 84001,Taiwan, R.O.C.
hmc307@gmail.com

ABSTRACT. We use the fuzzy theory to evaluate the defense education curriculum teaching material for high schools towards improved policy-making. Our study sorts the obtained results in descending weighted order, and subsequently, we evaluate and arrive at the best curriculum teaching material. The study uses the fuzzy multi-criterion decision method as its foundation, and empirical analysis is applied in the group decision model. The evaluation of the teaching material is set in a systematized pattern based on the preference of the teaching material by the schools in which the evaluation was carried out.

Upon evaluating the current teaching material available in the market, that by the Young Lion publishing house was considered as the material of highest quality. This was based on multi-criterion appraisal and group decision-making. The fuzzy theory provides objectivity, a systematic evaluation method, and overcomes the limits set by traditional mathematics. The best or optimal solution is thus obtained. Further, the method reduces the subjective, arbitrary cognition of the small number of people involved in the decision-making process, and perfect decision-making can be arrived at in terms of reaching uniform consensus within the group.

Keywords: Defense education program teaching material, Fuzzy theory, Fuzzy multi-criterion decision-making

1. Introduction. In this study, we obtain and evaluate the teaching material of the national defense education curriculum’s training section as applicable to high schools (public and private). By applying fuzzy logic, we use the fuzzy number in the solution to obtain the evaluation scores of the teaching material, and sort these scores in descending order. Subsequently, we evaluate the best methods to implement the training to all concerned participants. Our study uses the fuzzy multi-criterion decision method as its foundation, and we apply empirical analysis in the group decision model. Further, we consider and include the inputs of the concerned faculty for the training section of the
national defense education program, and create a systematized quality evaluation pattern for the training material (books). Further, we use inputs from public and private schools and obtain information about their preferred teaching material.

Taiwan's defense education program covers the following topics: mobilization in administration, house combat readiness, economic construction, establishment of responsibility and safety bodies by the national populace, disaster recognition and mitigation, and the inculcation of national defense as the highest ideal in all people. This program includes both military and civil education as the minimum standard. At present, although the program has been accepted as part of the high school curriculum, we believe that the impact of the defense education program merits observation for the following reasons: The program was implemented from the academic school year 1998, and in 2008, it was revised based on the Ministry of Education's notification making defense education compulsory as part of the high school curriculum. However, the implementation of the curriculum over the past two years has not shown any significant effects. Further, there has been no uniformity in the reports and examination of records in this regard; therefore, the test results are awaited. From the 1999 school year, changes to the school curriculum with respect to defense education included one-hour classes per week for a semester; this led to difficulties in the achievement of significant results. Students were found to be interested in the curriculum, and it was debated whether the possibility of higher studies in this direction could be provided as an elective in the curriculum (in a manner similar to the program in Canada). The factors influencing the quality of the program include the teaching aid resources for the textbook teaching material and the teachers.

Since Professor Zadeh’s studies in 1965, significant advances have been made in fuzzy theory. Fuzzy theory has since been utilized for its ability to deal with uncertainty and fuzzy alternative schemes for multi-policy-making and other such complex issues. Professor Zadeh's work was based on the premise that humans’ understanding of their environment through sensation is essentially subjective, i.e., there is a suitable degree of fuzziness in reasoning. Fuzzy logical concepts use a truth value range to describe the “truth” or “falsity” of a situation, as opposed to the traditional set theory that uses two-valued logic (binary logic) to describe the truth values. The fuzzy number of the so-called fuzzy set is a standardization (normality) for the raised (convex set) fuzzy set. The fuzzy multi-criterion decision method introduced by Wang and Chang (1995) and Wang, T. J., Zhang, Z. H., and Wang, S. H. (2004) proposes that the application of the multi-criterion decision model may anticipate actual results. Further, the method uses mechanical evaluation steps in the process of application.

Lin Yang (2009) researched the business management training tables in the teaching material evaluation and quantified the research. Wang Y. X. (1996) evaluated teaching curriculum using the Delphi technique. Revisions of the Delphi technique were used for research material collection and analysis. The five selected targets from the business management training evaluation table may be subdivided into 36 evaluation projects. The game nature target altogether has 10 evaluation projects, the game rule target altogether has 8 evaluation projects, the target which the game participation altogether has 7 evaluation projects, the game and the curriculum compatible target altogether has 6 evaluation projects, the curriculum participant's target altogether has 5 evaluation projects.
Wang L. Y. (2004) studied the open English textbook idea in the evaluation of teaching material, and he used the concept of nature research orientation. His research concluded that three factors were important in teaching—a native English teacher, teaching experience, and the level of participation allowed by the textbook. Liu K. M. (2010) used aggregated analysis, level analysis, and fuzzy theory research for commodity recommendation, and he considered recommendation of the commodity as a factor along with the goal of selling the commodity. The techniques of aggregated analysis (clustering), level analytic method, and analytic hierarchy process (AHP) have also used fuzzy theory. Our study comprises the following steps:

Step 1: The evaluation criteria, based on the study by Wang and Chang (1995), are the following: “very unimportant (VL)” fuzzy numbers corresponding to the set (0, 0, 0, 0.3), “unimportant (L)” fuzzy numbers corresponding to the set (0, 0.3, 0.3, 0.5), “ordinary important (M)” fuzzy numbers corresponding to the set (0.2, 0.5, 0.5, 0.8), “important (H)” fuzzy numbers corresponding to the set (0.5, 0.7, 0.7, 1), and “very important (VH)” fuzzy numbers corresponding to the set (0.7, 1, 1, 1). Table 1 lists these values.

Step 2: The variable fuzzy numbers as proposed by Wang and Chang (1995) are as follows: “very bad (Worse)” fuzzy numbers corresponding to the set of values (0, 0, 0, 0.3), “difference (Poor)” fuzzy numbers corresponding to the set (0, 0.3, 0.3, 0.5), “medium (Fair)” fuzzy numbers corresponding to the set (0.2, 0.5, 0.5, 0.8), “good (Good)” fuzzy numbers corresponding to the set (0.5, 0.7, 0.7, 1), and “very good (Best)” fuzzy numbers corresponding to the set (0.7, 1, 1, 1). Table 2 lists these variable fuzzy numbers.

Table 1 Important variable fuzzy numbers

<table>
<thead>
<tr>
<th>VL</th>
<th>L</th>
<th>M</th>
<th>H</th>
<th>VH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Step 3: The decision evaluation criterion collects the inputs of all n policy-makers for weight comparison. We used the method by Chen (1985) that (maximizing set and minimizing set method) allows the ranking of the fuzzy number based on the smallest grouping value, and we obtained the solution fuzzy.
2. Organization of Text Material

Current Situation in Taipei high schools as regards teaching material: There are a total of 65 high schools in the 99th Taipei area, Taiwan. The schools in the area currently impart the defense education curriculum to first-graders using various editions of the national defense curriculum teaching material. We collected the percentage value of the most popular five editions used, and we found the Young Lion publication version that is used in 39 schools to be the most used version, followed by the To Nurture publishing house version used in 18 schools, the US publication version used in 4 schools, the Peaceful Space publication version used in 3 schools, and the All Phenomena on Earth publishing house version used in 1 school. Fig. 1 shows this statistic for the Taipei 99th schools.

![National defense curriculum teaching material](image)

Fig. 1 Numbers of different teaching material editions used in Taipei 99th area schools

Empirical analysis: Our empirical analysis is based on the work by Wang, T. J., Zhang, Z. H., and Wang, S. H. (2004) in terms of data research; this study is the first related literature that reorganizes the national defense education program based on teaching material supplier evaluation. The evaluation criteria include 22 attributes that comprise the questionnaire regarding the material. The committee of five sets of evaluators who filled the questionnaire include those who have served for 15 years and above as military officers. Other responses include those by the faculty of the education department for the national defense education classes for graduate students in Taiwan Teachers University. In the second round, after recycling the obtained answers, the respondents included two officers on active duty in the office of National Defense University, Army Education Ministry, and the army directing staff media teachers (formerly Lieutenant Colonel Lu and Lieutenant Colonel Cao). Other respondents have been engaged in military training teaching for many years (Lieutenant Colonel Ruan, Lieutenant Colonel Huang). One of the respondents included the military training manager on active duty in universities, colleges, and institutes (Colonel Zhou). He was formerly the high school vocational school area director on special duty. We evaluated the inputs of all faculty in the national defense education program by using the fuzzy multi-criterion decision theory. We studied the weight relations for the teaching material suppliers and manufacturers for comparison. By sorting the obtained results, we determined the most suitable manufacturer of the teaching material for the national defense education program.
Appraisal of results of the weight criterion for the five valuators

The average weight was computed using the following formula:

\[ w_i = \frac{1}{5} \sum [0.5 \cdot 0.7 \cdot 0.7 \cdot 1] \oplus [0.7 \cdot 1 \cdot 1 \cdot 1] \oplus [0.5 \cdot 0.7 \cdot 0.7 \cdot 1] \oplus [0.7 \cdot 1 \cdot 1 \cdot 1] \]

\[ = (0.62, 0.68, 0.68, 1) \]  \hspace{1cm} (1)

**Criterion weight fuzzy number**: The education department mandated 5 valuators in the Taiwan Teachers University serving as officers, special class to collect the average weighted fuzzy numbers for the 22 criteria. Table 3 lists the criterion weight fuzzy numbers.

<table>
<thead>
<tr>
<th>Training section uses the book suppliers’ special characteristics</th>
<th>Book content and editor</th>
<th>Multimedia and network resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>C_1 : (0.62, 0.68, 0.68, 1)</td>
<td>C_{10} : (0.44, 0.66, 0.66, 0.96)</td>
<td>C_{20} : (0.58, 0.82, 0.82, 1)</td>
</tr>
<tr>
<td>C_2 : (0.48, 0.72, 0.72, 0.96)</td>
<td>C_{11} : (0.44, 0.66, 0.66, 0.96)</td>
<td>C_{21} : (0.36, 0.66, 0.66, 0.82)</td>
</tr>
<tr>
<td>C_3 : (0.4, 0.7, 0.7, 0.88)</td>
<td>C_{12} : (0.5, 0.7, 0.7, 1)</td>
<td>C_{22} : (0.54, 0.76, 0.76, 1)</td>
</tr>
<tr>
<td>C_4 : (0.62, 0.88, 0.88, 1)</td>
<td>C_{13} : (0.36, 0.66, 0.66, 0.82)</td>
<td></td>
</tr>
<tr>
<td>C_5 : (0.5, 0.7, 0.7, 1)</td>
<td>C_{14} : (0.28, 0.54, 0.54, 0.82)</td>
<td></td>
</tr>
<tr>
<td>C_6 : (0.66, 0.94, 0.94, 1)</td>
<td>C_{15} : (0.5, 0.7, 0.7, 1)</td>
<td></td>
</tr>
<tr>
<td>C_7 : (0.58, 0.82, 0.82, 1)</td>
<td>C_{16} : (0.54, 0.76, 0.76, 1)</td>
<td></td>
</tr>
<tr>
<td>C_8 : (0.36, 0.66, 0.66, 0.82)</td>
<td>C_{17} : (0.52, 0.78, 0.78, 0.96)</td>
<td></td>
</tr>
<tr>
<td>C_9 : (0.54, 0.76, 0.76, 1)</td>
<td>C_{18} : (0.44, 0.66, 0.66, 0.96)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C_{19} : (0.44, 0.66, 0.66, 0.96)</td>
<td></td>
</tr>
</tbody>
</table>

Comparison results and carry on result of the evaluation: Young Lion, To Nurture Publishing, Peaceful Space publishing, US New publishing, and All Phenomena on Earth publishing are assigned as A1, A2, A3, A4, and A5, respectively.

\[ F_i = \frac{1}{n} \sum (R_i \odot \hat{W}_i) \]

\[ F_{A1} = \frac{1}{22} \left[ (0.3564, 0.7144, 0.7144, 1) \oplus (0.3080, 0.6600, 0.6600, 0.9600) \oplus (0.3960, 0.8460, 0.8460, 0.9600) \right] \]

\[ = \frac{1}{22} \oplus (0.3120, 0.8640, 0.6640, 0.9520) \]  \hspace{1cm} (2)

The comparison result score in descending order is A1 > A2 > A3 > A4 > A5. The candidate for the textbook publisher is obtained after comparison and sorting; the Young Lion version A1 is the primary consideration in this scenario. Table 4 lists the candidate publisher values of the fuzzy numbers.

<table>
<thead>
<tr>
<th>Candidate publisher</th>
<th>Value of the fuzzy number</th>
<th>U_m</th>
<th>U_s</th>
<th>U_i</th>
<th>Ranking Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>A_1</td>
<td>0.3120, 0.6640, 0.6640, 0.952</td>
<td>0.718</td>
<td>0.588</td>
<td>0.565</td>
<td>1</td>
</tr>
<tr>
<td>A_2</td>
<td>0.3030, 0.6500, 0.6500, 0.938</td>
<td>0.704</td>
<td>0.600</td>
<td>0.552</td>
<td>2</td>
</tr>
<tr>
<td>A_3</td>
<td>0.2340, 0.5350, 0.5350, 0.902</td>
<td>0.621</td>
<td>0.693</td>
<td>0.464</td>
<td>3</td>
</tr>
<tr>
<td>A_4</td>
<td>0.2250, 0.5180, 0.5180, 0.891</td>
<td>0.609</td>
<td>0.707</td>
<td>0.451</td>
<td>4</td>
</tr>
<tr>
<td>A_5</td>
<td>0.2170, 0.5050, 0.5050, 0.894</td>
<td>0.602</td>
<td>0.718</td>
<td>0.442</td>
<td>5</td>
</tr>
</tbody>
</table>
3. Conclusion and suggestions
From the point of view of utility, the faculty for the national defense education program selected the Young Lion publishing house for the best teaching material. The following conclusion can be drawn from our study:
Upon evaluation of the textbook publishers by experts, the Young Lion version was assigned as A1, the To Nurture version was assigned as A2, the Peaceful Space version was assigned as A3, the Beautiful Update version as A4, and the All Phenomena on Earth version as A5. The Young Lion version (A1) was ranked as the first in terms of providing quality teaching material. Based on our obtained results, we diagnosed that complete service, compiling experience, teacher's manual, network resources, and multimedia were the five primary criteria for evaluation of the five teaching material suppliers. Purchase cost or price was previously listed as the most important criterion; however, this study shows that the weight that price occupies is not the highest value; the root factor is the quality of the teaching material, followed by economic considerations.

REFERENCES