DESIGN AND DEVELOPMENT OF A MULTI-CRITERIA DECISION SUPPORT SYSTEM FOR INTERNATIONAL STUDENTS

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ABSTRACT

This research aims to support international student decision making in the context of university’s selection. The research investigates and analyses the key factors affecting students’ decisions when selecting a suitable university using personal interview and questionnaire survey methods. The research developed and tested a decision support system that can facilitate students’ multi-criteria decision making process. A Decision Support System (DSS-US) is developed using Analytic Hierarchy Process (AHP) method. The system was tested with students and their feedback was analysed. The system evaluation results show that DSS-US was perceived to be effective, efficient and useful.

Keyword: Personal decision support system, Multi-criteria decision making, Analytical Hierarchy Process (AHP), Higher education, University selection

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INTRODUCTION

Effective decision making is a complex process and can be affected by many factors. For example, people who have to make a decision cannot deal with the volume and complexity of information effectively with limited cognitive ability. The emergence of the Decision Support Systems (DSS) was to help people make effective and informed decisions in the 1970s. The systems have been widely used and enhanced with internet technologies in recent years. One of them is Multi-criteria decision support systems (MCDSS). MCDSS aims to aid the decision makers to handle semi-structured decisions with multiple criteria (Siskos & Spyridakos, 1999).

University selection is one of the most important decisions that many international students have to make when they try to find a suitable university to continue their graduate education. When choosing a university to study, the key challenge for students is how to get useful information and how to use it to make effective and informed decisions. There are several problems, such as information overload, lack of information, or inaccurate information. It can be a time consuming process for a student to make the decision, especially for international students. The problem they encountered mostly is due to the lack of knowledge on culture, region, and custom, etc. Students may get confused by university’s league tables, fees, living costs, locations, job prospects, facilities, etc. So, developing a multi-criteria decision making tool for students can help them make better decisions and save their time.

This research aims to help individuals understand the decision making process, especially the multi-criteria decision making process, and develop and test a personal Decision Support System (DSS-US) to help individuals make better decisions in the context of university selection by overseas students. To achieve the research objectives, this research develops a decision support system for students. Extensive literature review was conducted to establish initial understanding of decision support process. To investigate the key criteria for students on university selection, semi-structured interviews and questionnaires were carried out. This research used Chinese students as an example to demonstrate the benefit of the proposed system.

LITERATURE REVIEW

DSS has been a major research area in the Information Systems (IS) field focus on supporting and improving managerial decision-making for almost forty years. A number of scholars have contributed to the decision making process. For example, Simon (Simon, 1977) provided a decision making process as a most notable and classic model. He proposed a three phase decision making process that follows intelligence-design-choice phases. Individuals who have to make a decision follow this three phases process and they have to face many challenges in each phase.

Multi-Criteria Decision Making (MCDM) is one of the most active, widely used,
and interdisciplinary fields of research in management science and operations research in business and engineering world. A MCDM method can help individuals to make a better decision, and one of the most well-known and widely used multi-criteria methods is Analytic Hierarchy Process (AHP). AHP has been used successfully to help people make better decisions when faced with unfamiliar problems involving value-based trade-offs between the advantages and disadvantages of two or more options (Docampo, 2011).

Literature review on DSS revealed that many studies have been conducted on developing decision support systems for enterprise or managers. Some DSSs were developed for individuals in the business area, such as personal banking decision support system. It is found that current decision support systems are widely used in various fields by experts, managers, and business people. However, limited systems are developed to support individuals who are not managers or decision makers in business organisations. Although there are studies focusing on the method of ranking universities, analysing the advantages and disadvantages of each ranking method, and how to improve the method for university ranking (Lari, 2002, Van Den Haak, 2003). It is believed that limited research has been done on how to help international students to make better decision on university selection. Therefore, it is necessary to help students to deal with the information overload and avoid the influence from the commercial university ranking information when selecting a university to study.

**DESIGN METHODS OF DSS-US**

This research aims to understand the decision support needs of international students, to develop and test a decision support system for international students to select the most suitable university for their postgraduate study in the UK. To achieve the aims, the research investigated and analysed the key factors affecting students’ decisions of selecting a university, and to collect relevant data from UK universities and select suitable multi-criteria decision making methods for developing the DSS. This section discusses the key decision criteria that students are concerned with, and design methods and database collection and data normalization.

**AHP Decision Hierarchy and Data Collection**

DSS-US aims to using AHP help individuals make a better decision on university selection. AHP is based on a hierarchical framework of criteria (Mamat & Daniel, 2007). In order to find out the key criteria of university selection to set up the AHP decision hierarchy, semi-interviews and questionnaire surveys have been adopted. We find out six key criteria on university selection by Chinese students from the results of questionnaires. According to the results, AHP decision hierarchy can be built as shown in Figure 1.
Many relevant data was collected, including the data of six criteria in UK universities. All data collected from universities website, Guardian ranking (one of the most famous league tables in the UK) and Google Map (Location). We choose Business and Management as the Subject area to match the sample group students’ needs. The DSS-US chooses six cities in UK as samples for location criterion as the six cities are dispersed throughout UK. They are London, Liverpool, Birmingham, Leeds, Plymouth, and Edinburgh.

Once the hierarchy structure is established, the decision maker need to do the pair-wise comparison between every two criteria. These comparisons are the basis for calculation of the relative weight of each criterion. In this research, it can be seen from the formula $N*(N-1)/2$ ($N=6$, $N$ means the number of criteria) that users need to compare 15 times. Users derive ratio-scale priorities reflecting the relative preference of alternatives relative to each objective. After that, compare matrix is formed in computer and then calculate the weight of each criterion. To ensure that the pair wise made by users are acceptable, consistency has to be checked. Thus the consistency ratio (C.R.) is set to be less than or in the neighbourhood of 0.10. Otherwise the decision maker needs to re-judge or re-evaluate the judgments in a pair wise comparison matrix.

**Weight Sum Model**

To provide more choices and different results for compare purpose for users, another simple method, Weighted Sum Model (WSM). WSM is the best known and simplest multi-criteria decision making method for evaluating a number of alternatives in terms of a number of decision criteria (Triantaphyllou, 2000).
higher the weight is the more important the criterion.

Let \( A_i \) be the weighted sum value, \( w_i \) as the weight of each criteria, and \( a_i \) as the value of each criteria. The formula is

\[
A_i = \sum_{i=1}^{n} w_i \times a_i \quad (i = 1, 2, ... n)
\]  

(1)

In this research, the system implement WSM to calculate the value of each criterion, then generate a university ranking to an exact user.

**Default Weight Model**

The study uses the results of questionnaires to calculate the default weights. Denote \( c_i \) as the score of each criterion, and \( W_i \) as the weight of each criterion. The calculate formula is

\[
W_i = \frac{c_i}{\sum_{i=1}^{n} c_i} \times 100\% \quad (i = 1, 2, ... n), \quad \sum_{i=1}^{n} W_i
\]  

(2)

According to the results of questionnaires, there are six key criteria and two restricted conditions, so the value of \( n \) is 6 in this research. Table 1 shows the weight results based on questionnaires’ result.

**TABLE 1. THE KE CRITERIA ON UNIVERSITY SELECTION AND DEFAULT WEIGHT**

<table>
<thead>
<tr>
<th>No.</th>
<th>Key Criteria</th>
<th>Weights</th>
<th>Restricted Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>University ranking</td>
<td>25%</td>
<td>1 Degree class demand</td>
</tr>
<tr>
<td>2</td>
<td>Subject ranking</td>
<td>24%</td>
<td>2 IELTS demand</td>
</tr>
<tr>
<td>3</td>
<td>Completion rate</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Location</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Living costs</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Accommodation costs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Tuition fees</td>
<td>12%</td>
<td></td>
</tr>
</tbody>
</table>

It should be emphasized that the default weights change with the number of users. That means the more users that use the system, the more accurate the weight value of the system according to the collection of more data. As a result, the value of default weights becomes more and more precise based on default weights. This is one of the characteristics of this research.

**Data Normalization Model**

In this research, all data including University Ranking, Subject Ranking,
Completion Rate, Location, Accommodation Fee, and Tuition Fee need to be normalization. Min–max normalization is best suited for the case where the bounds (maximum and minimum values) of the scores produced by a matcher are known (Jain et.al, 2005). Suppose that Min and Max are the minimum and the maximum values for a given set of \( \{a_k\} \), \( k=1, 2...n \). Max-min normalization maps a value \( a_k \) of \( \{a_k\} \) to \( a_k' \) in the range \((\text{Min}', \text{Max}')\) by computing:

\[
a_k' = \frac{a_k - \text{min}}{\text{max} - \text{min}} (\text{max}' - \text{min}') + \text{min}'
\]  

(3)

**Database Design**

The DSS-US system requires universities information and also stores user’s results. To achieve this aim, the DSS-US system uses MySQL relational database server to design the database.

The database has three parts. The first part is universities information, including universities’ name and ranking, subject ranking in business area, tuition fees, costs, completion rate, location (distance between the five selected cities), degree requirement and IELTS requirement. The second part is users’ information, including username, password, email address, IELTS Score, Degree Class, etc. The third part is the weights of each criterion and the university ranking results of each user. That could help to update the value of the default weights. The system could provide the user with information on these universities and subjects URL and local information when the user obtained the results of university ranking.

**DEVELOPMENT AND EVALUATION OF DSS-US**

**DSS-US Development**

A prototype Decision Support System for University Selection (DSS-US) has developed by Java language and Apache Tomacat, together with Hibernate and Model View Controller (MVC) design paradigm. Java language can run across different and diverse platforms such as Windows, Linux, Solaris, etc. It is a suitable characteristic for DSS-US because the system can be used widely without environment restrictions no matter whether the system is used on the internet or a personal computer only. The DSS-US used MySQL relational database server. The system runs on Tomcat 6.0.26, an open source JSP and Servlet container. It used to analytical JSP. Model tier has been used JavaBeans; View tier has been used JSP; and Controller tier has used Servlet.

Figure 2 shows the structure of the DSS-US. It is composed of a unit for university selection using three different methods, various databases of university data, users’ data, location data, selection results and other data used during process and calculation, and user interface. The DSS-US has the following functions:
Firstly, a user can obtain a list of suitable universities to help users make better decisions by the below three different methods.

- Weights generated by using AHP: users need to answer some questions (to fill in Matrix), and then the DSS-US calculates by using AHP method to provide a result of university ranking.
- Weights defined by User: users choose the criteria and input each criterion’s weight directly, then the DSS-US calculation a result of university ranking.
- Default Weights: the DSS-US result is calculated by default weights that come from a questionnaire result.

Secondly, the system can choose the location according to the user’s preference. When a user chooses different location, the results are different. It is able to personalize the system to meet the needs of users with different location priorities.

Thirdly, the system has self-learning function by collecting users’ results. They can try different weights to explore different results. The system records all results from users; then updates the default weight by doing the calculation automatically. If a user uses this system more than once, the system will choose the data that has the lowest consistency value to use from all the recorded results.

Fourth, users can see that the results are stored in the database easily and compare the different results from AHP and weight defined by themselves.

Fifth, the system could send the results of their personal university ranking to their Email address. In order to save time for the user and users can find further
information of the universities, the system can provide some useful information to users. For example, the result includes university ranking, university URL, subject URL and location information, etc.

**DSS-US Evaluation**

DSS-US system evaluation is based on user’s evaluation of system’s usability. There are different definitions about system usability evaluation. This study adopted the usability definition of ISO9241-11 (1994), which includes three quality components: effectiveness, efficiency and satisfaction.

Nielsen and Hackos (1993) give nine system evaluation methods. In this study, Think Aloud method will be used to evaluate DSS-US. All the evaluation participants were Chinese undergraduate students. Each test lasts forty minutes (minimum) to one hour (maximum). According to Jaspers (2009), the number of subjects should be limited to about eight for the reason that the Think Aloud method provides a rich source of data. That suffices to achieve a complete understanding of task behaviour (Ericsson and Simon, 1993) or to identify the main usability problems with a computer system (Nielsen and Hackos, 1993). The system evaluation involved seven participants. There are a number of important findings from the system evaluation.

First, the system is perceived as very useful by the students participated in the evaluation. All of seven system test participants were strongly agree to the system usability and effectiveness after using DSS-US. It can be concluded that DSS-US may have great potential on improving decision making for Chinese students who plan to study in UK to pursue postgraduate degree.

Second, AHP is perceived as a very useful and effective method to help users to define weight. According to the results of DSS-US system, AHP is able to generated weights that truly reflect the user’s personal preference as it is difficult for students to rank allocate weights to each criteria when there are many criteria to consider. When using Weight Defined by User method to decide the weight, users cannot provide an accurate answer by giving a numerical number. When using AHP method, it is easy for users to compare two criteria and using Linguistic Measures of Importance to represent their preferences. This is the reason why AHP is more accurate and effective than other methods.

Third, the university location can impact on the result. When a user chooses a different location, the results are different. It can be seen from that, this university selection system is able to personalize the system to meet the needs of users with different location priorities.

Fourth, there are some other very convenient functions in DSS-US. For example, DSS-US could send the result to users by their Email address. DSS-US could provide
links of each university’s official website on the results page so that users can find further information of the universities they are interested in more conveniently.

The system evaluation results show that DSS-US was perceived to be effective, efficient and usable. For effectiveness, users believed that DSS-US had the potential to help them make better decision through personalization in terms of decision making criteria and weight allocation. For efficiency, students found that the system could save them significant amount of time when making their decision by helping them access the necessary information and data.

The system functions should be further improved. For example, the system user interface can be more user friendly; the system can have provide an option for users to use the Chinese languages; instead of asking users to ensure their total weights is 100, the input method for the option of “Weight Defined by Users” should be able to show the users the total weights value automatically.

CONCLUSION

This research aims to explore a better way to design personal decision support systems for individuals to make effective multi-criteria decisions. To achieve the research objectives, this research developed a decision support system DSS-US for international students. The results of system evaluation show that the system was perceived as very useful by the students participated in the evaluation. AHP was a very useful and effective method to help users to define weight. It was also found that the effectiveness of the DSS-US was enhanced by the use of the university location criterion as the location could impact on the result. The future research should continue to explore the potential improvement of the DSS-US in terms of including non-quantifiable criteria and the ways to link the database to a wide range of sources with automatic data feeds.

REFERENCES


