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Evaluating Student Grades Using Analytic Network Process

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Abstract: With an increase in number of students, universities and other academic institutions are facing the problem of designing a student grade evaluation system which is fair, transparent and efficient. Grades are equally important for students, teachers, and academic institutions as they represent the learning outcome of the student as well as the education system. The benefits of using computer technology in this regard are obvious. This paper suggests an analytic network process (ANP) based technique to evaluate students' grades. For testing purpose the technique is used for grades evaluation of the students of the undergraduate computer science program offered by a university. The calculations in the proposed method are done by using super decision software.

Keywords:: Analytic Network Process, Fuzzy Logic, Student Grade Evaluation

1. INTRODUCTION

Student grade evaluation is an important aspect of any teaching and education institute. Having confidence upon the correctness of an answer the student provides for a question is also a skill (Reed, 2012). Evaluation of students' work further enhances this confidence; hence it is more than simply assigning grades. On the other hand low grades repeatedly cause nervousness for students in their course performance. Some students consider it as partial appraisal. So grading and evaluation must be done reasonably and professionally. Keeping in view some general principles, grading become easy for teachers to evaluate their students. The ultimate goal of grades should be to give confidence to students and not to give them unsympathetic response which decreases their basic inspirations.

Due to the sensitivity of this matter, several diverse approaches have been devised and used for grading the students. Some of approaches evaluate and judge the behavior of the students and some of them are used for the academic purpose of the students. David Love and Matthew Kotchen have developed a grading model which shows how the institution incentives affect the student and teacher manners. The results of the method show that stressing on course evaluation can decrease teaching effort of the teacher (Love & Kotchen, 2010). C. Nowell used student evaluation of teaching (SET) for the association of grades and rating. The results shows an indirect relationship of SET and grade performance average (Nowell, 2007). Spoorena and Van Loon discusses a non-response analysis of online student evaluation teaching by the help of multilevel logistic model (Spooren & Van Loon, 2012). Pilten evaluated mathematical abilities of 5th grade primary students. He collected quantitative data using observation and interview techniques. Mathematical problems were given to students and then evaluated for their performance (Pilten, 2010). Pulkka and Niemivirta determine the predictive relations of adult students, course evaluation and performance. The data was collected from 88 Finnish National Defense University students (Pulkka & Niemivirta, 2013).

Spoorena discussed the results of cross-classified multilevel analysis of the student evaluation of teaching in Flemish university. This is a cross-classified multilevel analysis based on different attributes concerning students and the courses taken by them. (Spooren, 2010). Struyven, et al. discussed examination evaluation and judgment from the view of students. This research exposes the student view about assessment for learning and studying. On the other hand, the student view about study controls the evaluation and assessment which the student observes. The results recommend that student hold strong view about diverse evaluation and assessment (Struyven & Janssens, 2005).

This paper presents technique for student grade evaluation based analytic network process (ANP) (Saaty, 1999). ANP is the extended version of analytic hierarchy process (AHP) in which dependencies are resolved. The method of ANP is quite efficient in situations where there is a complex structure among nodes. ANP structures the grades of students along with their subjects in a cluster of network and determine the pair wise comparison of student's subjects with other students. Eigen vector (Saaty, 1999) of the pair wise comparison are find and then plotted all the E.V. in weighted matrix. The weighted matrix is then converted to final limit matrix and the final decision is made. The proposed method is used for the academic purpose of the student, evaluates the students' grades and resulting the top most student.

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The organization of the paper is as follows. In section 2 materials and method relating to student grades evaluations are presented. Next, the results and discussion section provides a test case for the proposed technique by applying it on a real life data taken from the results of computer science graduate students. Sensitivity analysis is discussed in section 4. Section 5 provides a conclusion for the paper.

2. MATERIALS AND METHOD

2.1 Student Grades Evaluation

Evaluating students' grades are the important part of the student academic career. Student grade evaluation is the assessment of a student talent and position in the class. In the proposed method undergraduate semester program of a public sector university was followed in the evaluation of students' grades in the class. Subjects of first semester were taken which are shown in Table 1.

Table 1: First semester course details

Course ID	Course title
BCS111	Fundamentals of Computers.
BCS112	Mathematics-I
BCS113	Probability and Statistics
BCS114	Functional English
BCS115	Programming Concepts

2.2 ANP method

Analytic network process developed by Saaty (saaty, 1999) has been used for student grades evaluation. It applies dependencies and feedback with structure of network. In ANP elements are grouped in different clusters which are goal, criteria and alternatives. The clusters consist of different elements connected to each other. ANP uses pair wise comparison of elements in different stages for different attributes. The ANP is best approach for weight comparison. This method can also be applied on the remaining semesters of the program. Details of ANP can be found in Saaty (Saaty, 1999), however the following main steps were followed in the proposed process of student grade evaluation.

2.3 Proposed approach using decision software

All the calculations are done using super decision software ("http://www.superdecisions.com/,"). The three main parts of the **Fig. are 1**) goal, 2) criteria and 3) alternatives. Criteria of subjects along with an alternative (different students') are given. The goal is to find the topmost student obtained high grade. The following figure visually shows the network structure of students' with their subjects.

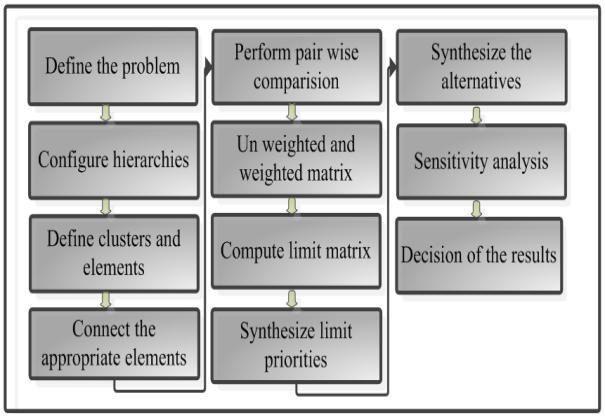


Fig. 1. Steps of analytic network process

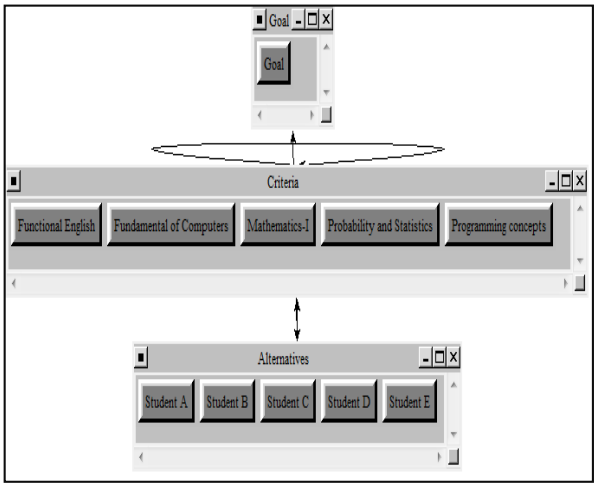


Fig. 2. Structure of the proposed model for student's grade evaluation

3. RESULTS AND DISCUSSIONS

The appropriate weights from experts were given to the students'. The following **(Fig. 3- 7)** show a pairwise comparison of students' along with their relative subjects. The consistency matrix is also calculated and according to Saaty it is less than 0.1 in each pairwise comparison.

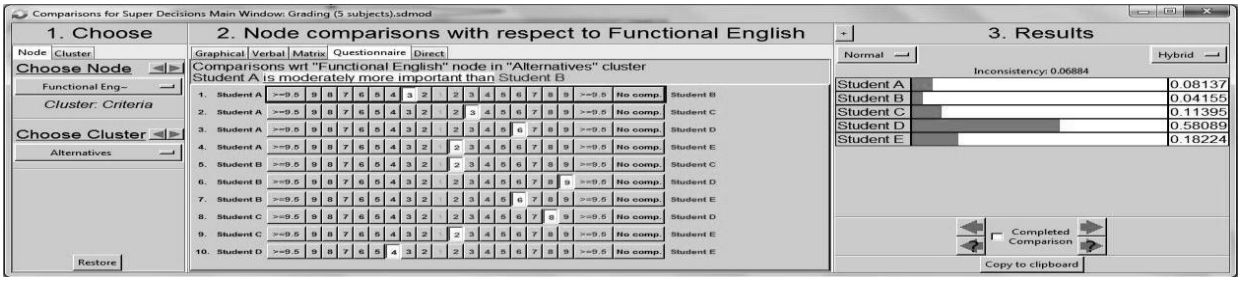


Fig. 3. Comparison w.r.t. Functional English

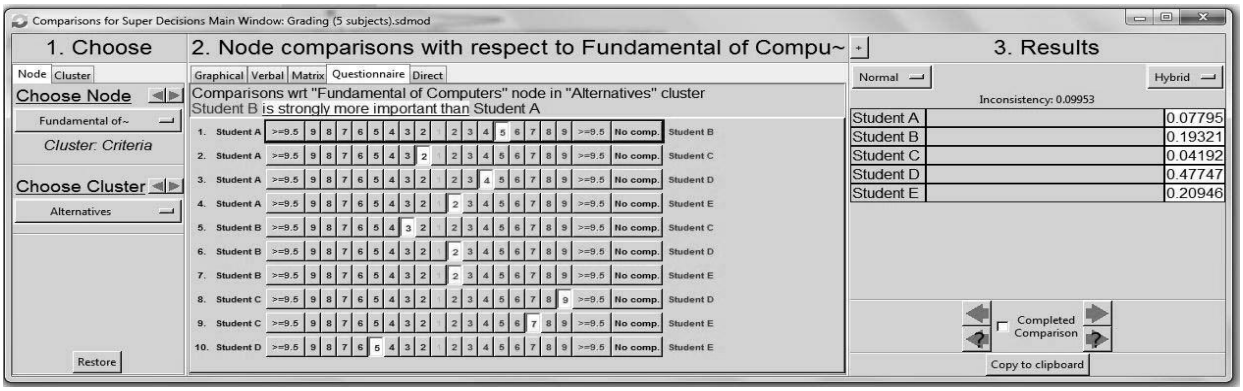


Fig. 4. Comparison w.r.t. fundamental of computer science

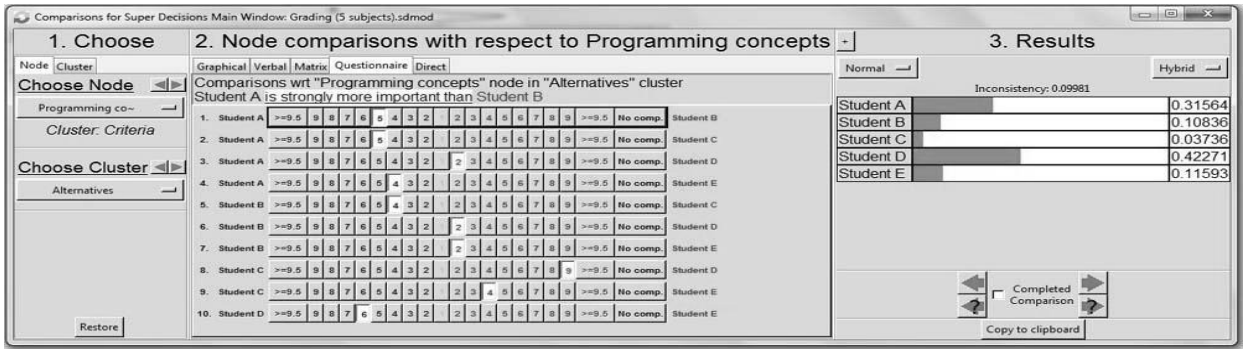


Fig. 5. Comparison w.r.t. programming concepts

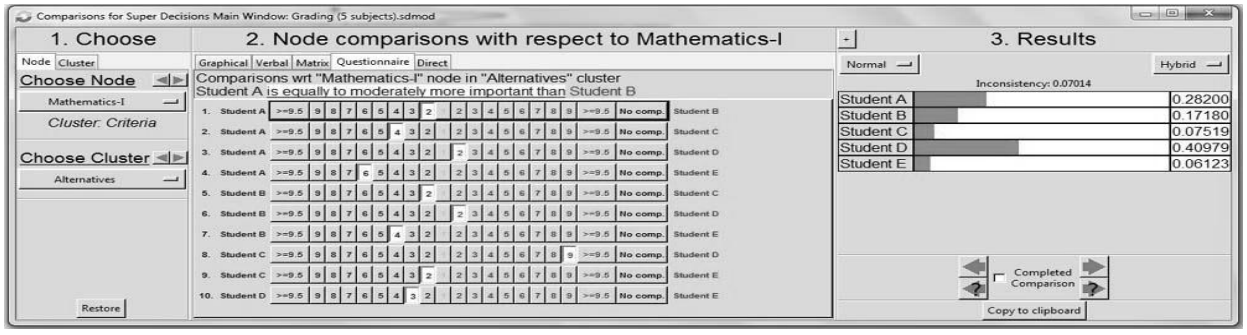


Fig. 6. Comparison w.r.t. mathematics

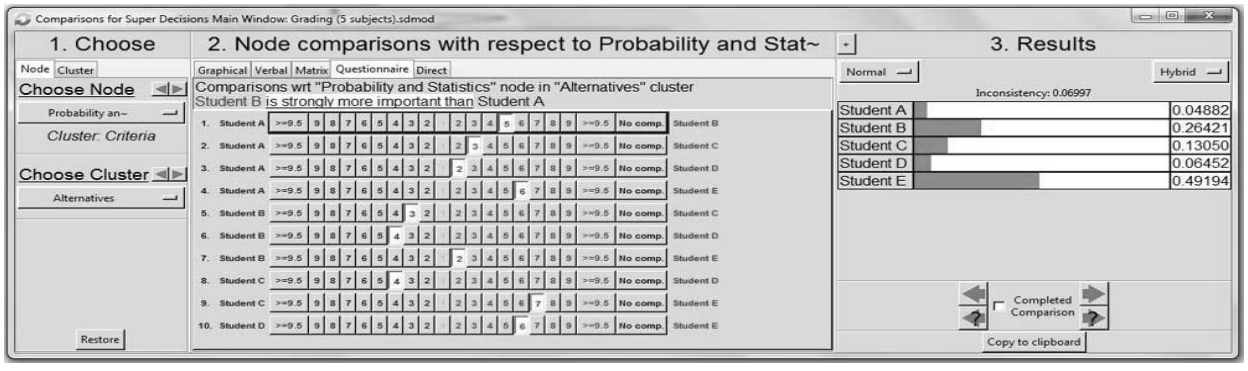


Fig.7. Comparison w.r.t. probability and statistics

A. Unweighted super matrix

This is the summarized matrix of all pairwise comparison of elements. The elements are placed in rows and columns. In this matrix if the sum of column values are greater than 1 then it should be normalized till its sum equal to or less than 1. In normalization it is converted to a weighted super matrix.

Table 2. Unweighted super matrix

	StudentA	Student B	StudentC	StudentD	StudentE	Functional English	Fundamentals of Computers	Mathematics-I	Probability and Statistics	Programming Concepts
Student A	0.000	0.000	0.000	0.000	0.000	0.081	0.078	0.282	0.049	0.316
Student B	0.000	0.000	0.000	0.000	0.000	0.042	0.193	0.172	0.264	0.108
Student C	0.000	0.000	0.000	0.000	0.000	0.114	0.042	0.075	0.131	0.037
Student D	0.000	0.000	0.000	0.000	0.000	0.581	0.477	0.410	0.065	0.423
Student E	0.000	0.000	0.000	0.000	0.000	0.182	0.209	0.061	0.492	0.116
Functional English	0.183	0.449	0.039	0.049	0.501	1.000	0.000	0.000	0.000	0.000
Fundamentals of Computers	0.393	0.349	0.413	0.062	0.314	0.000	1.000	0.000	0.000	0.000
Mathematics-I	0.097	0.081	0.147	0.190	0.078	0.000	0.000	1.000	0.000	0.000
Probability and Statistics	0.291	0.037	0.179	0.121	0.064	0.000	0.000	0.000	1.000	0.000
Programming Concepts	0.036	0.084	0.223	0.577	0.043	0.000	0.000	0.000	0.000	1.000

B. Weighted super matrix

In this matrix the sum of column values is less than or equal to 1. This matrix is finally converted to limit matrix.

Table 3. Weighted super matrix

	Student A	**Student B**	**StudentC**	**StudentD**	**Student E**	**Functional English**	**Fundamentals of Computers**	**Mathematics-I**	**Probability and Statistics**	**Programming Concepts**
StudentA	0.000	0.000	0.000	0.000	0.000	0.054	0.052	0.188	0.033	0.210
StudentB	0.000	0.000	0.000	0.000	0.000	0.028	0.129	0.115	0.176	0.072
StudentC	0.000	0.000	0.000	0.000	0.000	0.076	0.028	0.050	0.087	0.025
StudentD	0.000	0.000	0.000	0.000	0.000	0.387	0.318	0.273	0.043	0.282
StudentE	0.000	0.000	0.000	0.000	0.000	0.121	0.140	0.041	0.328	0.077
Functional English	0.061	0.150	0.013	0.016	0.167	0.333	0.000	0.000	0.000	0.000
Fundamentals of Computers	0.131	0.116	0.138	0.021	0.105	0.000	0.333	0.000	0.000	0.000
Mathematics-I	0.032	0.027	0.049	0.063	0.026	0.000	0.000	0.333	0.000	0.000
Probability and Statistics	0.097	0.012	0.060	0.040	0.021	0.000	0.000	0.000	0.333	0.000
Programming Concepts	0.012	0.028	0.074	0.192	0.014	0.000	0.000	0.000	0.000	0.333

C. Limit matrix

This matrix is obtained by raising the power of weighted super matrix till its row values become same and stable. This is the final matrix from which the decision about results can be made.

Table 4. Limit matrix

	Student A	Student B	Student C	Student D	Student E	Functional English	Fundamentals of Computers	Mathematics-I	Probability and Statistics	Programming Concepts
StudentA	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
StudentB	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
StudentC	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
StudentD	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140
StudentE	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065
Functional English	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072
Fundamentals of Computers	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078
Mathematics-I	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Probability and Statistics	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044
Programming Concepts	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095

4. SENSITIVITY ANALYSIS

Sensitivity analysis has been done for the relative importance of different students' with subjects. Sensitivity analysis offer specialized insight to the results. In sensitivity analysis the weights of each criteria are exchanged with other criteria, while the weights of other criteria remain unchanged. Different calculations are done and different priorities are given. The decision maker can demote to sensitivity analysis for making the decision. The following figures show the sensitivity analysis for student grades.

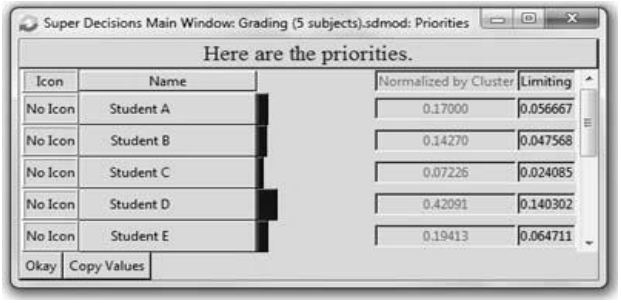


Fig. 8. Students' priority in different subjects

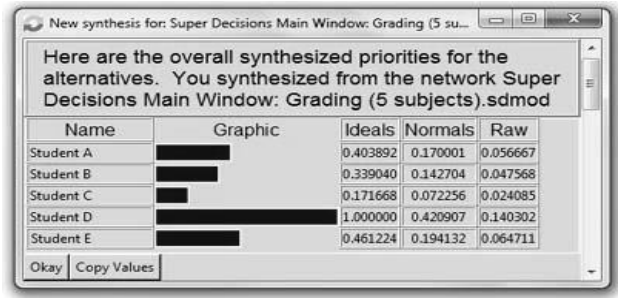


Fig. 9. Synthesized priority

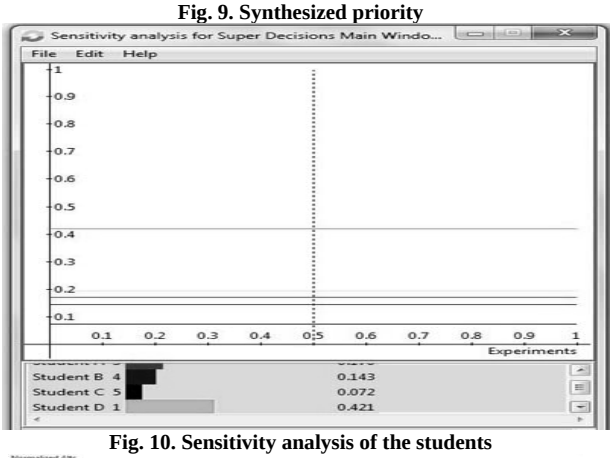


Fig. 10. Sensitivity analysis of the students

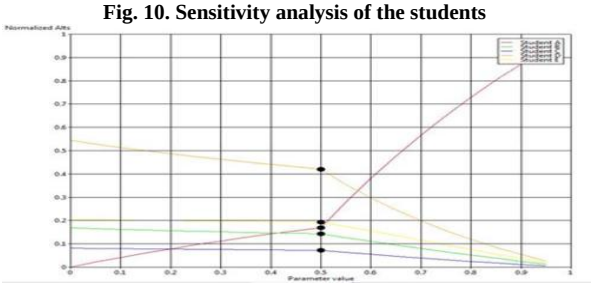


Fig. 11. Sensitivity for student grading

5. CONCLUSION

Student grade evaluation has become crucial and strenuous with an overall increase in student enrollment in educational institutions. Educationists and researchers are trying to find appropriate methods to evaluate student grades. The situation becomes more complicated when there is a need to calculate grades of students with many different subjects. The proposed ANP based method calculates pairwise comparison of subjects and students. The research shows that ANP technique provides accurate and efficient results, especially for grading students having different subjects within an academic program. The proposed method is easy to implement. It creates a network structure of subjects for students, which is easily understandable. This method can be applied to evaluate grades of students belonging to any academic level.

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