A Fuzzy Expert System on College Program Suggestion

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The research is about developing an expert system that can help and guide students on what college program are suitable for them using the student's interest and aptitude test results. The research aims to make a reliable system through determining the process in suggesting a college program from a human expert that uses the same parameters that the research uses. The research also aims to determine if fuzzy expert system is an efficient expert system for the given problem. The fuzzy expert system uses fuzzy logic that can handle complex reasoning of a human expert. Fuzzy expert system also uses IF-THEN language as the main component that is non-procedural and can do parallel firing. The scope of this research is undergraduate programs of universities in Davao City, applicable for upcoming college students.

1. INTRODUCTION

1.1 Background of the Study

The problem is common to all upcoming college students, the problem of choosing the right course for them to pursue. Generally students have a hard time choosing their course because of factors like interests, peer pressure, parents' choice, and etc. Many of the students' decision later in their life have become regretful. Majority of them have failed their course majors and decided to shift onto another course, a course in which it's easier and enough that they can handle. Another cause of shifting to another course is the lack of interest of the students in their course that their parents have decided for themselves. Only few are really fortunate to have stayed and pursued the course. But After many years some of them are still on college due to several courses they have shifted. Some have graduated and have found an occupation that they seem to dislike due to the same routine they undergo every day (Sabao, 2010).

Shifting onto another course can really time wasting to the student's life. Also it will really have an effect on your financial state because here in the Philippines going to a university is really expensive. The need to finish the course in an early state is really important because going to college is just the beginning, getting a job is not an easy thing. But getting the job you always wanted is another story.

This research was conducted in order to assist the upcoming college students to decide what college program to pursue; having this kind of research in choosing a course is a good thing because it is for them to be guided in what and what not to take. Given detailed information about a course, this gives the opportunity to choose a certain course with details, by then can decide on what to take up without doubt. Upcoming College students really need to choose wisely in picking up a course for their future to be successful.

This research was form in order to minimize the problem of the upcoming college students. The reaching is about building an expert system for them to use. This expert system goal is to help the upcoming college students to decide on what course is more appropriate to them, giving them suggestions on courses based on their personality, interests, skills, and aptitude. The approach of the expert system is using the fuzzy theory. Having their answers in the system provided tests as

the input, after which, the results of the tests will be then used in the manipulation of variables in the system then will have an output which is the suggested course/s for the student to choose.

This research is a big help to those students who have difficulties on choosing their course. It aims to help them in a way that the suggested course/s is efficient for the student's skills and capabilities.

1.2. Problem Statement

The goal of the research is to accomplish an expert system to suggest a certain college program pursue based on the student's information like the student's interest, personality, and aptitude test scores.

Specifically, the study aims to answer the following questions:

- What college program/s is could be suggested for the upcoming college students?
- How the classification of the college program works?
- How to use the student's interest and aptitude test scores in the system?
- Is the fuzzy expert system appropriate for the given problem?
- Does the system suggest course like the expert?

1.3. Research Objectives

The study has the following general objective:

- To develop a fuzzy expert system that can help students decide a college program.

The study has the following specific objectives:

- To determine the process in suggesting a college program
- To put the process base from the expert into the fuzzy expert system
- To determine if fuzzy expert system is efficient to the given problem
- To use the student's interest and aptitude test scores as fuzzy sets

1.4. Significance of the study

Many people ended up in misery simply because of making a wrong decision on the course they have taken and choosing a course is very difficult for an upcoming college student.

It is very common for college students to shift after 1 year in their college studies due to lack of interest and knowledge about the course they have first taken. Some have shifted to another course more than two times.

After ten years some people are still on college due to several course shifting and have wasted financial assets and time. Some of them are employed but unsatisfied of their occupations due to the endless cycle of their routine. Some have retired from their disliked occupation and tries to chase their original dream but ended up having difficulties due to lack of required knowledge and skills (Sabao, 2010).

The proposed system's goal is to avoid the multiple times of course shifting. To avoid ending up in an occupation that you don't like due to the repetitive routine slowly takes away your morale. To avoid being miserable in the future due to dream job that have become unattainable because of lack of required skills and knowledge.

The significance of the system is to make choosing a course the best suits you much easier. It can reduce wasted time on thinking of a course and also the time you studied before you shifted and money you've spent. The system simply is developed for the user to have a fulfilling course and occupation for the user.

1.5. Scope and Limitations

The system covers the undergraduate courses base on the data gathered from the expert. The system is intended for the upcoming college students. The system's functions are not dependent on internet availability.

The approach that has been chosen for implementing the expert system is using the Fuzzy theory. The tests are based on the user's interests, aptitude and skills.

2. REVIEW OF RELATED WORKS

2.1. College Program Suggestion

The existing Web-based system of the Griffith University presents some number of limitations which results to misleading students in their enrollment. The system does not give verification if a student may enroll to a certain subject regarding some University policies. The system gives out confusing descriptions of subjects and courses for forthcoming students (Noran, 2003).

Based on consultations, the present system is proposed to provide guidance and assistance to forthcoming postgraduates. This will provide them a customized assessments, requirements and expectations for a certain student; this concludes in helping the enrolment errors done by students (Noran, 2003).

According to Raihiemie Binti Razak(2006), students from Sijil Tinggi Pelajaran Malaysia (STPM) usually apply for further studies in the university. Most students don't really know about any details on a particular program that they should apply except for other students who have a little bit of idea of the program. Some programs are not applicable for other students because the tendency of students might have lack of knowledge about certain programs and are not quite proper for them.

Another situation which cited by Raihiemie Binti Razak(2006), there are other students which dislike the program they took due to a misunderstanding of the program. Some student has a talent on a certain program and is given a program that is not fit for the student's skills and capabilities. Razak made used of the users personality to match up the students and to their program.

According to Zhang(1998) personalities can match certain programmes the teachers, The Guidance Office, and educational counselors should help students match their personalities by identifying their interests, abilities, temperaments, limitations, etc. with programme' requirements. By these statements the proponents can formulate very important variables for an Expert System- the individual, the programme, and the relationship between the two (Razak, 2006).

According to Carl Gustav Jung there are 4 functions of people to deal with the world; First is sensing, a sensing Person is good at looking and listening and generally getting to know the world. Second is thinking, it involves decision making or judging not just taking information. Third is intuiting, it is a kind of perception that works outside of the usual conscious processes. It looks at large amounts of information. Fourth is feeling, like thinking, it evaluates information. It includes emotional response.

Katherine Briggs and her Daughter Isabel Briggs made a test called the Myers-Briggs Type Indicator using Carl Jung's Function to classify people's personalities in types. There are four scales in this test, first is Extroversion – introversion (E-I), second is sensing – Intuiting (S-N), third is Thinking – Feeling (T-F), fourth is Judging – Perceiving (J-P). Each Type is identified by four letters like ENFJ. There are 16 Types in all for the Briggs (Boeree, 2006).

2.2. Approaches

The case study of Noran(2003) is about developing a knowledge-based expert system to provide preliminary assistance and advice for postgraduates. The current knowledge base from their consultation session was used. Noran developed a Conventional Expert System (CES) that uses a boolean logic.

The user presents occupation that they have interest in and their knowledge about it. The system will use this information to find a study course for the user to pursue. The system can also suggest correction about their preferred occupation depending in the information provided.

The system also uses constraints in order to have more accurate results. Examples of their constraints are as follows: the outcomes of a module must be distinct and two modules should not produce the same outcome. More constraints such as the maximum duration of the modules and the maximum number of modules per year can be added while using the system.

For the approach used by Razak(2006) the project is about making an expert system to advise the students from Matriculation, STPM, and Diploma to choose a bachelor's degree in the Fakulti Teknologi Maklumat & Sains Kuantiatif using the fuzzy systems theory like fuzzy logic and fuzzy sets. The system also uses student information like their programming skills, programming interests, and personality types (Razak, 2006).

For the study of Goodarzi ang Hassani (2012) they designed a decision support system (Student Consulting Expert System) base on the fuzzy system theory which; first determines and fuzzifies the inputs to the system by using a fuzzy rule and then determines the degree of membership of linguistic terms. When the data is obtained after they are fuzzified, there are certain rules that will be the result of the negotiations which is if the system can or cannot solve the given problem. Then, it goes to a data centralization process where it defines if the profiles of students are available.

Goodarzi and Hassani applied their expert system in the web for the users to gain access outside the campus. Since fuzzy sets are used, the process of inference should be done on the client so that the processing time of the server can be reduced. Student then are checked, those that should be excluded should be prevented in the registration for the next semester.

The three projects presented developed an expert system to solve their problems statements. The first project developed a CES that used a boolean logic and handles constraints. The other two used Fuzzy Expert System (FES) that uses the fuzzy system theory.

Expert systems are computer programs that think and decide like a human expert. The most popular approach for an expert system is the used of boolean logic (Cox, 2005). Boolean logic refers to the logical relationships among search terms. It compares bits that represent true or false values to derive an answer of true of false value.

The other kind of expert system is called the Fuzzy Expert System that uses fuzzy logic instead of boolean logic. Fuzzy logic is a type or system of logic. Similar to Boolean logic, fuzzy logic is based on the theory of sets. From a modeling perspective, fuzzy logic is logic of continuous variables. Its complement, Boolean logic, is logic of discrete variables. With fuzzy logic we can deal with inaccurate concepts as high risk, a long duration, and a large transaction volume. It can also evaluate certain process factors in a model. For example, dealing with certain cases like Is X decreasing? Is A close to B? In these cases fuzzy logic gives a way of finding the degree to which a

state is representative of a method. These degrees play a delicate but critical role in the process of evaluating of fuzzy models and fuzzy systems. They serve as modeling concepts as supporting evidence, numeric elasticity, and semantic ambiguity (Cox, 2005).

The fuzzy logic has an advantage over boolean logic in handling the complex human reasoning in order to arrive at realistic conclusions about the imprecise and often fuzzy nature of reality (Openshaw, 1997). This is possible because fuzzy logic does not only deal with true or false value, but rather deals how high the truth value is or high the falseness is. This is also the reason why fuzzy expert system in more appropriate to use in dealing with the capabilities of a student. The capabilities of a student can be graded into low, medium or high.
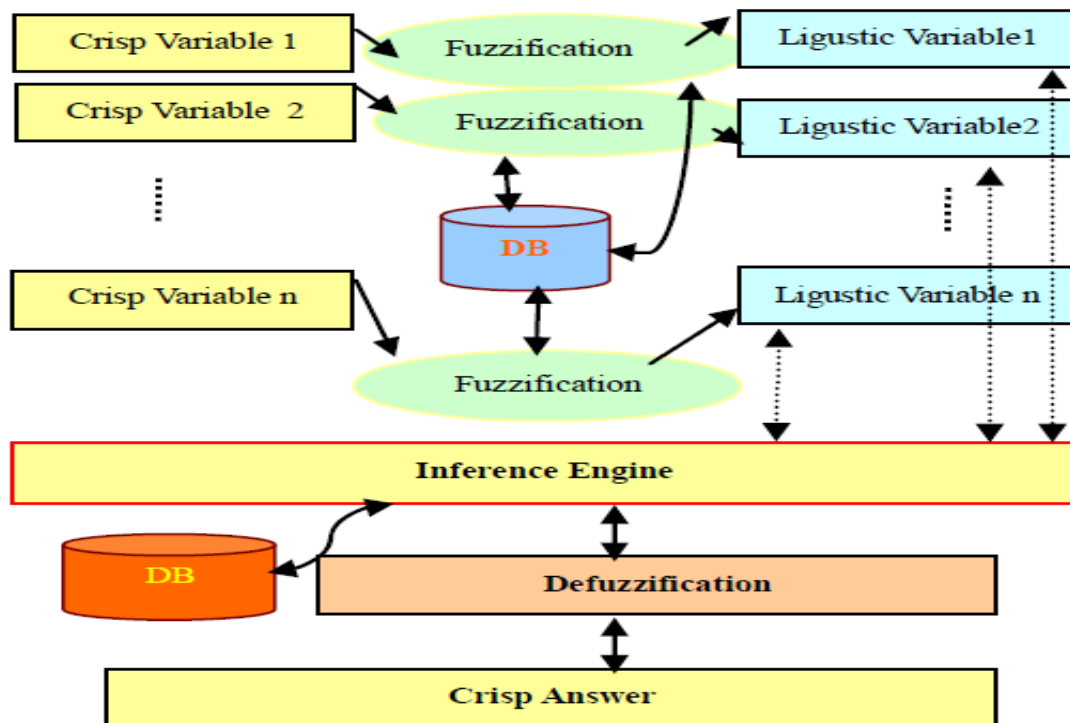
2.3. Theoretical Framework

Figure 2.3: Theoretical Framework

A type of session is selected and crisp data will also be entered by the user in a web application layer. Inputs will now be managed by the business facade and business rules layer. Then a request for fuzzification of crisp variables and rules generation will be send to the system by data access layer by ADO.NET. Some of the fuzzy sets in the system are: Grade Point Average (GPA), passed courses, marks for passed courses and many more. In the GPA, the students are categorized into groups like A, B, C, D and E. After the fuzzification the system then generates the linguistic variables with database functions, which defines this section as the one who controls the SQL-injection and database abstraction. The linguistic variables generated in the Fuzzy sets for the GPA are expressed in terms like Excellent, Good, Middle, Weak, Very Weak. Then linguistic

variables will now be sending to the inference engine and will be processed by their system. An example rule for getting the answer from the fuzzified variables is:

> **If** The GPA is Middle **And** The number of semesters
>   which the student is small **And**
>   The courses that are not passed can be taken and passed in one semester **And**
>   The student hasn't given any pledges **And**
>   The student hasn't received any disciplinary notices **And** The student hasn't reached the
>   maximum time period for his/her studies **And**
>   The student has 5 marks between 10 - 12 **And**
>   Some other student has had conditions similar to this Student
> **Then**
>   To a large degree, it is possible that the student is allowed to continue his/her studies in the
>   university by giving an Official pledge of achieving a GPA over 12 in the next semester.
> **Else**
>   The Expert System cannot solve your problem.

Then fuzzy answers will be defuzzified and the generation of output crisp values will happen. This section is accomplished by a function used in the database. Finally the system will output answers to the user (Goodarzi and Hassani, 2012).

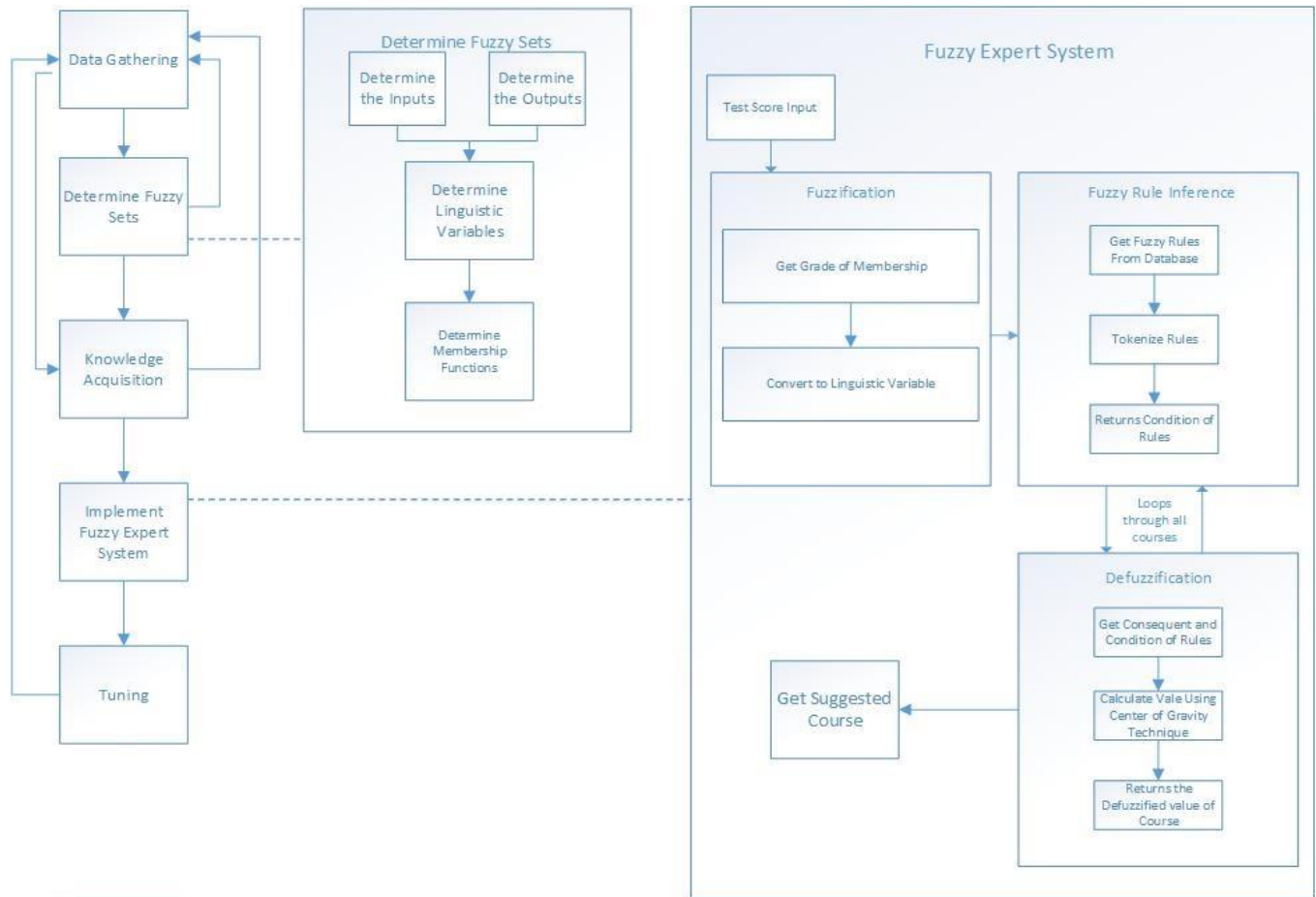3. RESEARCH DESIGN AND METHODOLOGY

3.1. Conceptual Framework

Figure 3.1: Conceptual Framework

3.2. Methodology

The following are the phases that the proponents will undergo regarding the study.

3.2.1. Data Gathering

Data gathering is conducted in order to successfully develop an expert system that conducts suggestions on courses for the users. Data like approach to use and variables to utilize.

3.2.2. Determine Fuzzy Sets

   Identify and construct fuzzy sets and fuzzy numbers based on the gathered data for the fuzzy expert system to use. It acts as the variable for the fuzzy rule to process.

3.2.2.1. Determine the Input & Output

   Input and Output are prerequisites in determining the Linguistic variables and Membership functions for the Fuzzy set to be functional.

3.2.2.2. Determine Linguistic Variables

   Linguistic variables are used to help the expressions of rules and facts which have a certain value that helps determine a variable more. When used, these variables are managed by certain functions for the fuzzification.

3.2.1.3. Determine Membership Functions

   Membership Functions represents degrees of truth for certain values. It is a generalization of the function of the set.

3.2.3. Knowledge Acquisition

   This phase is to extract the knowledge of a human expert/s to make proper rules for the system.

3.2.4. Implement Fuzzy Expert System

   In the implementation of the fuzzy expert system the previous phases' data should be based. The following are phases of fuzzy expert system to generate a suggested course for the user.

3.2.4.1. Fuzzification

   Gets the fuzzy sets which have the linguistic variable and membership function. Through this fuzzy objects the system will turn the input data or test score into a fuzzy data which will be sent to the fuzzy rule to process.

3.2.4.2. Fuzzy Rule Inference

   Fires all the rules and get the truth values of the THEN part of the rules using the fuzzified values. All the values that is somehow true will be combined and sent to the defuzzification method.

3.2.4.3. Defuzzification

Using the truth values from the Fuzzy Rule inference the defuzzification method will then get the exact crisp value of the Then part. Using the Center of Gravity defuzzification

3.2.5. Tuning

Tuning is conducted in order to check the outputs of the system using a sample data. Testing and experimentation is part in this process. This process makes sure that the system's output are like of the expert.

4.   THEORETICAL BACKGROUND

4.1. Expert System

Expert systems are computer programs that are designed to put the skills and expertise of a person to the system and emulate the thinking pattern of the person (Siler & Buckley, 2005). The first expert system *Dendral* was developed on 1965 by the AI researcher Edward Feigenbaum and the genetics Joshua Lederberg. Dendral was design to analyze chemical-compound and would make a hypothesis about the compound's structure (Kumar, 2009).

A production system is a type of expert system that uses boolean logic employs the rules of IF THEN. According to the UXL encyclopedia of science boolean logic is a kind of algebra that describes and manipulates logical statements and classify them as true or false.

4.2. Fuzzy Expert System

According to Siler and Buckley a fuzzy expert system is a kind of expert system that uses the fuzzy systems theory; It uses fuzzy logic instead of the boolean logic that conventional expert systems uses. Fuzzy expert system does not deal with the actual yes or no answers. It deals with the possibility of the events. It can handle cases like not completely true or false.

In constructing a FES the most important things to learn and to keep in mind are:

- Fuzzy expert system's primary element of language is the IF-THEN rules.
- Conducts data-driven non-procedural language
- Sequential and parallel language execution
- Uses fuzzy systems theory: Fuzzy logic, fuzzy sets and fuzzy numbers.

4.2.1.   Knowledge Base IF-THEN

The most important aspect of an expert system is the if-then rules that are based on the knowledge acquisitions and the rules that have been formulated through the means of a fuzzy set and fuzzy number based on fuzzy logic.

The IF part of the language is also known as the antecedent and the THEN part is the consequent. An antecedent is a logical proposition whose truth value can be determined. Antecedents can be made more complex by combining individual truth values by the connective AND, OR, NOT.

The antecedent of a FES differs to the antecedent of the conventional ES. In the ES that antecedent has an exact value while in the FES the antecedent are more on possibility and has an additional data type.

Differences of Antecedents	
Conventional Expert System	**Fuzzy Expert System**
-IF X is 100	-IF distance is about 100
-IF Y is 7	-IF height is about 7
-IF material is leather	-IF age is young
-IF name is James	-IF speed is very fast

Figure 4.2.1: Difference of
Antecedents

4.3. Fuzzy Systems Theory

The fuzzy systems theory was created by Lotfi A. Zadeh on 1965. According to Zadeh there are many possibilities that are limited to the simple propositional logic. He made the function of the true and false values operate over the range of real numbers [0.0, 1.0] where 0.0 represents absolutely false and 1.0 represents absolutely false. The basics of the fuzzy system theories are: Fuzzy Logic, Fuzzy Sets, and Fuzzy numbers.

4.3.1. Fuzzy Logic

Fuzzy Logic is based on the classical logic and propositional calculus. Like the classical logic, fuzzy logic is concerned with the truth of propositions and handles the ambiguity of the value. To handle the ambiguity the truth values should be in the interval of [0,1] not just 0 or 1.

Difference of Logic	
Boolean Conventional Logic	**Fuzzy Logic**
-Uses sharp distinctions	-No distinct values
-has only two values -Possibility of having TRUE of False only	-has values range of 0 and 1 -Possibility of having a little Truth in False

Figure 4.3.1: Difference of Logic

4.3.2. Fuzzy Sets

According to Earl Cox in his book Fuzzy Modeling and Genetic Algorithm for Data Mining and Exploration, Fuzzy sets are distinct from a crisp or Boolean set in that it allows its elements to have a degree of membership. The center of fuzzy sets is the membership function it has; Membership functions are the ones that determine the relationship in between a certain value in the sets domain and its degree of membership.

Fuzzy sets provides helps determine the series of overlapping concepts, thus allowing rules to address the condition in terms of these fuzzy set names; these names are called Linguistic Variables, they permit fuzzy sets to represent the underlying semantics of a variable (Cox, 2005).

Linguistic Variables are used in fuzzy rules as part of a fuzzy relation. For example, a rule is being constructed: if *height* is *Short* then *weight* is *Light,* then both *Short* and *Light* are Linguistic variables representing one of the possible partitions of height and weight.

4.3.3. Fuzzy Numbers

Fuzzy numbers are an extension to a regular number that it does not refer to only one value but to a series of possible values, it adds the sense of robustness and flexibility. Every fuzzy set represents a central value, which is in essence the Fuzzy Number.

4.4. Course Suggestion Basis

In the research the basis of the suggestion of course/s are the user's scores on personality, aptitude, skills, and interest base on a provided tests.

4.4.1. Aptitude

According to Merriam Webster Dictionary Aptitude is a natural ability, a capacity for learning, a general suitability of a person. The need of knowing a person's abilities is very important because the output which is the suggested course needs to be related to the person for him/her to apply his/her abilities.

4.4.2. Skills

A skill is proficiency, facility, or dexterity that is acquired or developed through training or experience. This is needed because for the suggested course to be appropriate for the student/s skills.

4.4.3. Interests

An interest is a state of curiosity or concern about or attention to something. The results of a test of this is needed because in order for the system to know what is the student/s interest and for the suggested course/s to be related in the interests of the student.

5. RESULTS AND DISCUSSIONS

5.1. Gathering of Data

The proponents had to know first what these data are, which are the type of test that the Teachers conduct to the students, the test results of each student in all of the test, and the basis of determining the course that is suggested.

For more assurance and a clear basis of rules and data, the proponents needs to conduct an interview with the experts of the Student Development Center in Ateneo de Davao University High School Campus and in order to make this possible.

The proponents were given test scores per student and test scores per group. There were also manuals given on how to interpret the scores as the basis of the suggested output of the experts. (Insert process on how to interpret the scores).

5.1.1. Type of Test

CEM (Center for Educational Measurement, Inc.) is a nongovernment institution which serves the valuation needs of public and private sectors of education. Through the institution's website there were files uploaded that contains manuals, sample test results per respondent and per group.

The DepEd (Department of Education) is the executive department of the Philippine government responsible for ensuring access to, promoting equity in, and improving the quality of basic education.

5.1.1.1 POIS (Philippine Occupational Interest Survey)

The POIS (Philippine Occupational Interest Survey) is a survey that measures the preferences for different types of occupation. It has questions wherein a respondent answers them to know the degree of interest in various occupational fields. It is paired up with an aptitude test, these test helps brighten the decision making in what career the respondent will pursue. It contains occupational fields which contains occupations in every field.

The Figure is an examinee report in a school which consists of the Occupational fields given with Quality Index Score. Occupational fields are which the point of specialty of a student. Quality Index Score are the scores that a student receives; it can be Very Low, Low, Medium, Strong or Very Strong.

There 7 factors in the Occupational fields located at Figure 5.1.1.1. Examinee Report; (1) Math, Physical & Tech (2) Outdoor Physical (3) Social/Personal (4) Business/Clerical (5) Administrative (6) Life & Health Sciences (7) Arts & Humanities.

Appendix B
Sample Examinee Report

POISH-ER0207
Tracer 9998881A

Center for
Educational
Measurement, Inc.
The test of excellence

Philippine Occupational Interest Survey
(High School)

EXAMINEE REPORT

NAME   : EXAMINEE 3   STUDENT NO.   : 484335
SCHOOL   : ABCD SCHOOL   TEST DATE   : 04/24/2007
YEAR LEVEL   : B.S. NURSING
COURSE CHOICE : LITERATURE

OCCUPATIONAL FIELD	CODE	STANDARD SCORE (SS)			QUALITY INDEX (QI)				
		200	500	800	VL	L	M	S	VS
• Math, Physical Sciences & Tech	OF01	470						✔	
• Outdoor/Physical	OF02	444					✔		
• Social/Personal	OF03	443					✔		
• Business/Clerical	OF04	335				✔			
• Administrative	OF05	333				✔			
• Life & Health Sciences	OF06	505							✔
• Arts & Humanities	OF07	615							✔

Figure 5.1.1.1: POIS Sample
Examinee Report

5.1.1.2. PACT (Philippine Aptitude Classification Test)

The PACT (Philippine Aptitude Classification Test) is a test that measures the abilities of a respondent that are significant for the accomplishment of different courses. It is design to measure a student's strengths and abilities in the 8 aptitude factors and 9 educational programs. With every of these aptitude factors and educational programs comes along with sample courses.

This is an examinee report of a student wherein it comprises the Aptitude factors and Educational programs and given test scores of each field. Educational Programs are programs where a student can be good at. The Quality Index Score can be Very Low, Low, Average, High, or Very High.

There are 8 factors in the Aptitude factor in the PACT at Figure 5.1.1.2 A. Examinee Report 1; (1) Perceptual Speed (2) Verbal English (3) General Reasoning (4) Flexibility of Closure (5) Verbal Filipino (6) Spiritual Closure (7) Visualization (8) Perceptual Acuity.

Appendix C
Sample Examinee Report

Figure 5.1.1.2 A: PACT Sample
Examinee Report

The 9 factors in the Educational Program in PACT located at Figure 5.1.1.2 B Examinee Report 2; (1) Service (2) Agriculture (3) Humanities and Arts (4) Social Science, business, and law (5) Education (6) Engineering (7) Trades and Crafts (8) Health and Welfare (9) Science.

EDUCATIONAL PROGRAM	CODE	QUALITY INDEX (QI)				
		VL	L	A	H	VH
• **Services:** Includes courses on hotel and catering, travel and tourism, seamanship and other transport services, environmental conservation, and protection of property and persons	E01					✓
• **Agriculture:** Includes courses on agriculture, forestry, and fishery in areas of research, data analysis, and management in large-scale enterprises, as well as veterinary medicine	E02			✓		
• **Humanities and Arts:** Includes courses on religion and theology, languages and literature, fine arts, performing arts, graphic and audio-visual arts, and design	E03				✓	
• **Social Sciences, Business, and Law:** Includes courses on political science, sociology, anthropology, psychology, geography, economics, as well as journalism and information, business and administration, and law	E04			✓		
• **Education:** Includes courses on teacher training for preschool, kindergarten, elementary, secondary, vocational, adult education, and for handicapped children, as well as education science on areas of assessment, measurement, and research	E05				✓	
• **Engineering:** Includes courses on engineering, manufacturing and processing as well as architecture and building	E06			✓		
• **Trades and Craft:** Includes non-degree programs dealing with mechanical repair trades involving the assembly, fitting, repair, and maintenance of all types of machineries	E07			✓		
• **Health and Welfare:** Includes courses on medicine, nursing, midwifery, medical technology, dentistry, optometry, pharmacy, as well as physical and occupational therapy	E08			✓		
• **Science:** Includes courses on natural and biological sciences such as general biology, zoology, botany, chemistry, physics, geological sciences, astronomy, meteorology and oceanography, as well as mathematics and statistics and computer sciences	E09			✓		

Figure 5.1.1.2 B: PACT Sample
Examinee Report

5.1.1.3. NCAE (National Career Assessment Examination)

The NCAE (National Career Assessment Examination) is an aptitude test geared to giving information through test result for self-assessment, career guidance and career awareness of high-school students.

This is an examinee report in a school which consists of the areas of occupational interest, charts based on the score ranges.

There are 8 factors in the aptitude test in NCAE located at Figure 5.1.1.3 A. Examinee Report 1; (1) Scientific Ability (2) Reading Comprehension (3) Verbal Ability (4) Mathematical Ability (5) Clerical Ability (6) Manipulative Skill (7) Nonverbal Ability (8) Entrepreneurial Skill.

AREAS	STANDARD SCORE	PERCENTILE RANK
GENERAL SCHOLASTIC APTITUDE (GSA)		
SCIENTIFIC ABILITY (SA)	456.23	33
READING COMPREHENSION (RC)	523.94	59
VERBAL ABILITY (VA)	543.79	67
MATHEMATICAL ABILITY (MA)	562.55	74
OVERALL GSA	531.79	63
TECHNICAL-VOCATIONAL APTITUDE (TVA)		
CLERICAL ABILITY (CA)	626.85	90
VISUAL MANIPULATIVE SKILLS (VMS)	504.03	52
OVERALL TVA	578.84	79
NON VERBAL ABILITY (NVA)	512.22	55
LOGICAL REASONING ABILITY (LRA)	617.80	88
ENTREPRENEURIAL SKILL (ES)		
PLANNING & DECISION MAKING (PD)	499.65	50
BUDGETING, MARKETING & FORECASTING (BMF)	563.74	74
CREATIVITY (C)	468.59	38
OVERALL ES	527.72	61

Figure 5.1.1.3 A: NCAE Sample
Examinee Report

There are 11 factors in the Interest test in NCAE located at Figure 5.1.1.3 B. Examinee Report 2; (1) Sciences (2) Engineering (3) Commerce (4) Professional Services (5) Personal Services (6) Cyberservices (7) Aesthetics (8) Environment (9) Military training (10) Spiritual Vocation (11) Agriculture & Fishery.

AREAS OF OCCUPATIONAL INTEREST	PERCENTAGE SCORE	PREFERENCE LEVEL	RANK OVERALL
A. Sciences	64.50	MP	2
B. Engineering	56.94	MP	5
C. Commerce	50.00	LP	9.25
D. Professional Services	70.00	MP	1
E. Personal Services	52.56	MP	6
F. Cyberservices	62.50	MP	3
G. Aesthetics	60.63	MP	4
H. Environment	50.00	LP	9.25
I. Military Training	51.04	MP	7
J. Spiritual Vocation	50.00	LP	9.25
K. Agriculture & Fishery			

Figure 5.1.1.3 B: NCAE Sample
Examinee Report

Based on the interview, membership functions of the linguistic variables in the aptitude test have been formulated by the experts.

Linguistic Variable	Range
Very Low	[0,20]
Low	[15,50]
Medium	[41,85]
High	[61,97]
Very High	[80,99]

Figure 5.1.1.3 C: Aptitude Score Range

5.1.2. Possible Outputs

After determining and setting the inputs, the outputs then are set. The proponents based it on the common courses located in the three type of test. Approximately there are 50 common college program found in the three different tests.

| Criminology Environmental Science Home Economics Management Marine Transportation Tourism Culinary Arts Agriculture Fine Arts Interior Design | Philosophy Accountancy Business Administration Commerce Financial Management Information Science Marketing Management Mass Communications Psychology Technology Management | Entrepreneurship Education Elementary Education Secondary Education Agricultural Engineering Architecture Chemical Engineering Civil Engineering Computer Engineering Electrical Engineering | Food Technology Industrial Engineering Mechanical Engineering Automotive Technology Dressmaking Electrical Technology Electronics Technology Mechanical Technology Dentistry Medical Technology | Medicine Nursing Pharmacy Physical Therapy Biology Computer Science Information Technology Mathematics Chemistry Physics |

Figure 5.1.2: Possible College Programs

5.2. Determining the Fuzzy Rules

In determining the rules, the proponents based it on the fuzzy set that have constructed using the factors and the quality index score per factor that the students received of the three different type of test found in section 5.1.1.

The Quality Index Score per factor of the three different types of tests are used as the Linguistic Variable and the Ranges in determining the Quality Index Score are used as Grade of Membership in the Fuzzy Sets.

The Fuzzy rules are defined as conditions in the form, where A & B are linguistic values; x and y are linguistic variables defined by fuzzy sets.

IF *x* is A THEN *y* is B

Figure 5.2 A: Rule
Form

After the determining of linguistic variables, they will be now used in the building of fuzzy rule, which in Figure 5.2 points out the pseudo code of the fuzzy rule.

IF [(Factor) is (Quality Index)] THEN [(Course) is (Quality Index)]

Figure 5.2 B: Pseudo code of
the Fuzzy Rule

After gathering all of the variables, they will be then use to build the final fuzzy rule which an example would be;

IF [(Business/Clerical) is (Very Low)] THEN [(Accountancy) is (Very Low)]

Figure 5.2 C: Sample
Fuzzy Rule

5.3. Knowledge Acquisition

Throughout the process, the proponents have been coming back to the experts because of the assurance of rules. As defined, the expert system is a system that relies on what the expert is doing or saying thus frequent interviews with the expert are important because of the assurance of the rules; it helps the determining and building of rules.

5.4. Implement Fuzzy Expert System

Fuzzy Expert System is the basis for determining or getting the course base on the Data inputs which are tests scores of NCAE, PACT, and POIS. Fuzzy Expert System involves 3 important parts: Fuzzification, Fuzzy Rule Inference, and Defuzzification.

5.4.1 Fuzzification

The Fuzzification is to find grades of membership of linguistic values of a linguistic variable corresponding to an input number. When the test score is send to the

fuzzification method, the system first gets the grade of membership set in the code. The system will then calculate the membership grades and the input data to convert them into a fuzzified value base on the linguistic values of the. The linguistic value will later be used in the fuzzy inference engine for the firing of rules.

For example, let x be the test score for the fuzzy set Logical Reasoning Ability and y be the truth value. If we equate x as 83 then we could get the truth values of the linguistic variables Medium=0.14, High=1, Very High=0.42 as shown below in the graph below.
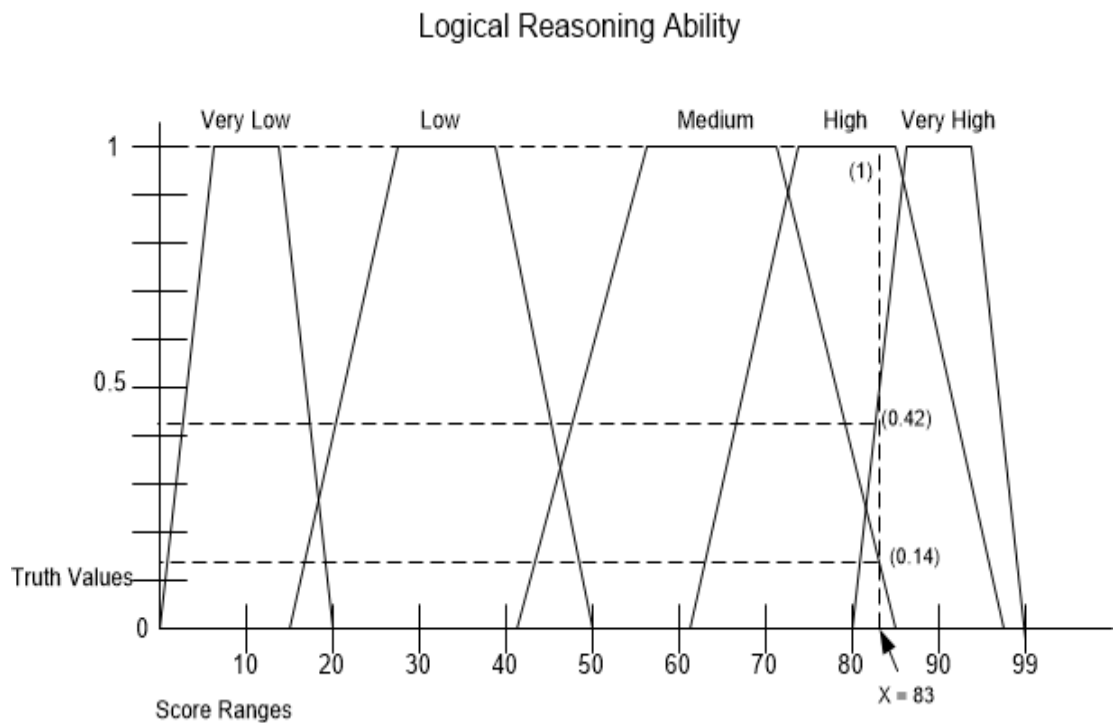

Figure 5.4.1: Logical Reasoning Ability

5.4.2 Fuzzy Rule Inference

The fuzzy rule inference is where the interpretation of the rules happens. In testing the code the proponents found out that the Fuzzy Engine got from an open source can only set one consequent at a time. In other words one course at a time can be evaluated using the rules in the fuzzy engine.

First the fuzzy inference will get all the rules per consequent. In this phase the antecedent of the rules has already been fuzzified thus having fuzzy values. All of the If we consider the course Criminology as the current consequent in the inference engine. In the example below the parameters were: Logical Reasoning Ability is 83, Personal Services is 75, Services is Medium, and Outdoor/Physical is Average.

```
Inference Engine.txt ☒
  1   Antecedent:                      Fuzzified Value     Consequent
  2   NCAE Aptitude
  3   IF Logic Reasoning Ability IS Very low  0            THEN Criminology IS Very low
  4   IF Logic Reasoning Ability IS Low       0            THEN Criminology IS Low
  5   IF Logic Reasoning Ability IS Medium    0.14         THEN Criminology IS Medium
  6   IF Logic Reasoning Ability IS High      1            THEN Criminology IS High
  7   IF Logic Reasoning Ability IS Very High 0.42         THEN Criminology IS Very High
  8
  9   PACT
 10   IF Services IS Medium                   1            THEN Criminology IS Medium
 11   IF Services IS High                     0            THEN Criminology IS High
 12   IF Services IS Low                      0            THEN Criminology IS Low
 13
 14   NCAE Interest
 15   IF Personal Services IS Very Low        0            THEN Criminology IS Very Low
 16   IF Personal Services IS Low             0            THEN Criminology IS Low
 17   IF Personal Services IS Medium          0            THEN Criminology IS Medium
 18   IF Personal Services IS High            1            THEN Criminology IS High
 19
 20   POIS
 21   IF Outdoor/Physical IS Average          1            THEN Criminology IS Medium
 22   IF Outdoor/Physical IS High             0            THEN Criminology IS High
 23   IF Outdoor/Physical IS Low              0            THEN Criminology IS Low
 24   IF Outdoor/Physical IS Very High        0            THEN Criminology IS Very High
 25   IF Outdoor/Physical IS Very Low         0            THEN Criminology IS Very Low
 26
```

Figure 5.4.2 A: Inference Engine

The inference engine will then choose the rules whose fuzzified value is greater than 0 and the higher value per Linguistic Variable of the consequent.

```
Inference Engine 2.txt ☒
  1   Fuzzified Value         Consequent
  2   1                       THEN Criminology IS High
  3   0.42                    THEN Criminology IS Very High
  4   1                       THEN Criminology IS Medium
```

Figure 5.4.2 B: Inference Engine 2

The fuzzified values will now be sent to defuzzification method to look for the exact value of the consequent.

5.4.3. Defuzzification

At the end of the rule firings the system will give a value of linguistic value of a course. What the defuzzification does is that the linguistic value formulated in the rule inference will be converted into a numerical value output or grade of membership to determine how high or how low a course is scored base on the data input and rules.

The technique used for the defuzzification is called the Center of Gravity. The center of gravity can be equated by this formula:

$$y_q^{crisp} = \frac{\sum_{i=1}^{R} b_i^q \int_{y_q} \mu_{\hat{B}_q^i}\left(y_q\right) dy_q}{\sum_{i=1}^{R} \int_{y_q} \mu_{\hat{B}_q^i}\left(y_q\right) dy_q}$$

Figure 5.4.3 A: Center of Gravity
Formula
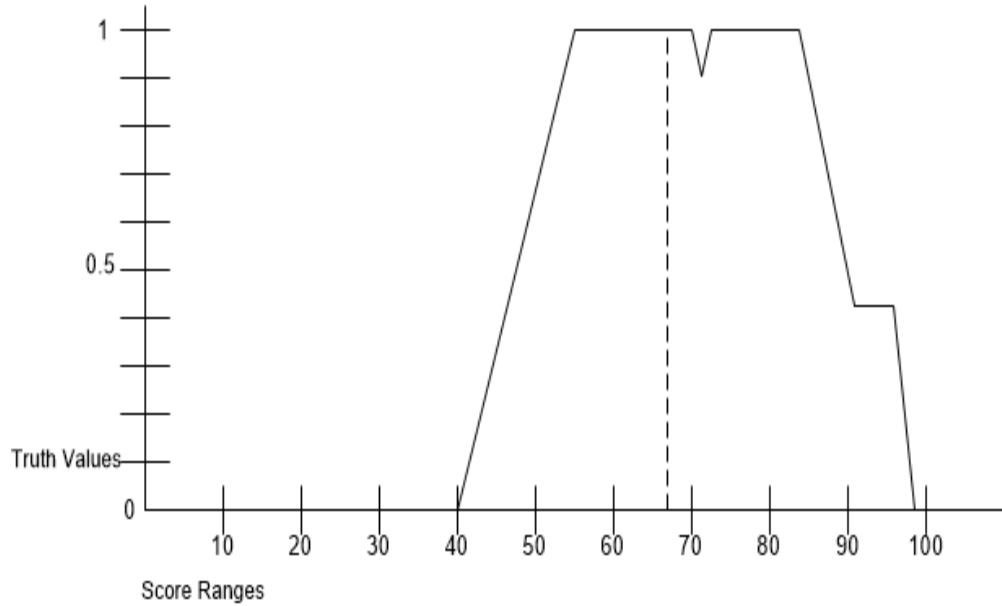
.

Or graphically presented like:

Figure 5.4.3 B: Center of Gravity
Graph

The graph was the entire truth values base from the rule inference. The defuzzification gets the area of it and then gets the center in order to come up with a crisp output.

The system will loop through fuzzy inference and defuzzification to get all the the grade of courses. The highest grade/s formulated from the defuzzification will be the suggested course of the system.

It is possible to get multiple course suggestion in the given rules and fuzzy sets. In this example 4 courses will be suggested to the user.

Figure 5.4.3 C: Course Output

5.5. Tuning

Tuning was done since making the system. The proponents took several interviews to the experts to update the rules of the system. Due to the system needs to have a course to the rules in each Test in order to have more accurate system. The proponents then added rules to the courses that were not found in the other courses. After doing these the system tends to have more trusted courses base on the experts assessment.

5.6. Evaluation

Evaluation was done by comparing actual test scores of particular students. The test was assessed by one of the interviewed guidance counselor. The guidance counselor only provided three students test scores that includes POIS, PACT, and NCAE. The assessment is as follows: Engineering, Field Engineering , and Agriculture. The System's result was

1st student	2nd student	3rd student
Agricultural Engineering Chemical Engineering	Agricultural Engineering Chemical Engineering	Agriculture

Computer Engineering	Computer Engineering	
Electrical Engineering	Electrical Engineering	
Industrial Engineering	Industrial Engineering	
Mechanical Engineering	Mechanical Engineering	

In engineering the systems has chosen many fields of the engineering unlike the expert's assessment.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusion

The proponents therefore conclude that with the use of Fuzzy Logic and having it as an expert system, the system can generate a suggested course to the student based on the test scores as inputs, and with the use of knowledge acquisition given by the expert as rules to the Fuzzy Expert System.

The main findings that the proponents have are that it is possible to convert the expert's decision making on how to assess the course of a student into code. By doing so, the proponents have engaged the area of expert systems and fuzzy logic; expert systems because basically expert systems are systems that are based on what the expert says or shows, it fits perfectly in the proponents context. Fuzzy logic because there are portion in the test score that is not exact which is the Aptitude test in the NCAE in the proponents' case.

The work that the proponents have done is useful in a way that it helps the experts in assessing courses to students. It can be used either the expert is there or not in assessing the courses, it gives convenience.

6.2. Recommendations

The Recommendation of the Proponents is to widen the scope of the context. In the proponents system the fuzzy logic was not utilize enough. There are so many possibilities that the fuzzy logic could take for example the tuition of a course or class behavior of a student.

Another recommendation of the proponents is to know how to test the reliability or accuracy of a fuzzy expert system. In the previous research or related literature there is no accuracy or reliability that was proposed by using a fuzzy logic system. It only shows that the expert and programmer should be able to have an agreement before finalizing the system.

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