APPLICATION OF FUZZY LOGIC IN MEASURING STUDENTS' PERFORMANCE AT KAIBOI TECHNICAL TRAINING INSTITUTE

BY

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DECLARATION

DECLARATION BY THE CANDIDATE:

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DEDICATION

For my family Ann, Dan , Ray, Joy and my parents Joseph and Truphena and siblings Jane and Aaron thanks for the support.

ABSTRACT

Assessment of academic performance in whatever form, remains the only practical and veritable means of gauging students' learning outcomes. Assessment as it is used today using numerical and statistical scores have many shortcomings like: uneven scores awarded by different examiners, test area covering a sample of the syllabus, tests having measurement error, examinations being criterion referenced and not norm referenced and done within a time limit. The aim of the study was to investigate how comments are given by lecturers at Kaiboi Technical Training Institute with a view of developing a system that uses linguistic and numerical variables to measure students' performance. The objectives of the study were to: identify the current academic performance comments given by lecturers to classifying students' academic performance so as to model the data to develop a membership function, use fuzzy logic to model the membership function generated to get student's numeric grade, model fuzzy sets using a suitable membership function to determine a student's grade in linguistic variables, develop a system that uses fuzzy logic to measure student's performance. The study was informed by fuzzy logic theoretical framework which is a multivalued logic that allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low, good/bad. The study used case study research design. A document review was used to get comments and numerical scores from students' records, the data was modelled to a Trapezoidal membership function which was used to get degree of membership and crisp values. Prototyping methodology was used to model and develop the system. Previous students' records were used as training data. The system developed calculates degree of membership that incorporates marks and comments in students' final grade and gives comments based on the student's performance. The output from the system showed variation in the students marks when comments are incorporated. The study has incorporated comments in measuring students' performance and is therefore an addition to the current knowledge on students' performance measurement.

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I am truly grateful to my family for the support given to me in the course of the study.

DEFINITION OF TERMS

Criterion referenced examinations: Degree of competence attained by a particular student which is independent of reference to the performance of others.

Defuzzification: Getting a crisp value from a combination of fuzzy sets.

Formative evaluation: examinations that monitor the progress of the students like continuous examination s, assignments.

Fuzzification: Expressing linguistic variables in form of a membership function

Fuzzy logic: is a multi valued logic that allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low.

Fuzzy membership function: Representation of linguistic variables in a way that limits are identified for calculation of degree of membership.

Gaussian distribution: A probability distribution that assumes a normal curve.

Norm referenced examinations: They are examinations used is to compare individuals like in a class.

Summative evaluation: Evaluation is conducted at the end of each instructional segment like end of course examinations.

LIST OF ABBREVIATIONS

CAT: Continuous assessment tets'

KNEC: Kenya National Examinations Council

KTTI: Kaiboi Technical Training Institute

MOHEST: Ministry of Higher Education Science and Technology

TIVET: Technical Industrial Vocational and Entrepreneurship Training

CHAPTER ONE

INTRODUCTION

1.0 Introduction

Assessment is a popular way of accessing teaching and learning in many academic institutions. It is the only practical and veritable means of gauging students learning outcomes. In education, examinations have become a necessary component of the education system and given after certain intervals (Ajidagba, 1991).

However the use of examinations and tests have always been abused or overused. Examinations have become a bogey to students' and have hindered more purposeful learning. They are the aspect of the educational system most feared by students and most criticised by the public: yet in the absence of any better alternative, tests and testing cannot be abolished. The shortcomings of test and testing have, however, continued to stimulate efforts in the direction of developing new and better tests and improving testing situations and procedures (Afolayan, n.d.).

Assessment as it is used today using numerical and statistical scores have many shortcomings like: uneven scores awarded by different examiners and test area normally covers a sample of the whole syllabus. College examinations offered by national examinations councils like Kenya National Examinations Council (KNEC) do have shortcomings in that they are mainly criterion referenced and not norm referenced examinations. They are also done in as few as seven days for a course that takes three years to complete.

In order to make assessment more effective, classroom assessment then should be included in the student’s marks so as to make the marks more reliable.

Khairul (2002) did a study on data driven fuzzy rule based approach for student academic performance evaluation. Shimizu and Yamashita,(1995) presented a study of applying fuzzy reasoning for educational evaluation of calligraphy. Al-Hamadi, (2003) developed a design of neurofuzzy technique of neurofuzzy model in a college of engineering. Johanyak (2009) developed three fuzzy inference based student evaluation methods and introduced sets of criteria for fuzzy methods aiming the evaluation of students academic performance. Dombi, (1986) did a study on membership function as an evaluation technique.

1.1 Background of the Study

Kaiboi Technical Training Institute is one of the Technical and vocational institutes in Kenya (TIVET). The Institute offers courses in mechanical, electrical, automotive and agricultural engineering. Other courses are information technology, computer studies and business courses. Admission to the Institute is based on the guidelines provided by the Ministry of Higher Education Science and Technology (MOHEST). The courses offered are of three types’ artisan, craft and diploma courses. (www.kaiboitech.ac.ke). Currently the population of Kaiboi Technical Training Institute is about 70 members of teaching staff and 861 students.

Studies are done in three terms a year, the diploma courses take three years while the craft and artisan courses take two years. Each year consist of three terms each of three months. Each term the student’s sit for two CATs and an end of term exam. At the end of year the students' sit for an end of year examination, at the end of the course, they sit for an end of course examination that is administered all over the country by the Kenya National Examinations Council.

Basing on the performance in the exam the students are then awarded marks and a grade. The students must pass all the exams to be given a pass certificate which can be a *Distinction* for an average of more than 75, a *Credit pass* for a mean more than 65 and a *Pass* for a mean more than 40. The students who fail a single subject are given a chance to redo the examination in the next sitting. Students who fail to score more than 40 in two subjects redo the course. Since evaluation is done across the country sometimes the examination is not fair to the students and they may end up failing not because of inaptitude but because of the situation of the examinations.

1.1.1 Kaiboi Technical Examination System

Various examinations are done at KTTI they are: continuous assessment tests, end term examinations, end of stage examinations and end of course examinations. Continuous assessment tests are done within the term. End of term examinations are done at the end of every term. The individual course lecturers set and administer end term examinations. The end of stage examinations are done at the end of the year and they determine whether a student should proceed to the next year of study.

The end of course examinations are done at the end of the course. The examinations are normally administered by the Kenya National Examinations Council (KNEC) and the results determine whether a student has passed or failed the examinations. (KTTI. Academic Policy, 2011).

In Kaiboi Technical the results are normally represented in numerical terms with a predetermined grade. The teacher gives comments which are influenced by the students' efforts, situations under which the exam was undertaken, student attitude towards learning and the students' cooperation in the learning environment, and students' performance in comparison with others. The reports given by KTTI consist of a numerical mark which is between 0 and 100, a grade which are: distinction, credit, pass and fail and comments given by teachers are also included.

The current method of classifying and grading student academic performance using arithmetical techniques only does not necessarily offer the best way to evaluate human acquisition of knowledge and skills. It is expected that reasoning based on fuzzy logic provides an alternative way of handling various kinds of imprecise data, which often reflects the way people think and make judgements. An example is in the case of tutors' comments in the performance of a student which are always given by the course lecturers alongside the numerical grades. Currently the comments are not factored in the calculation of the final grade of the student.

1.1.2 Fuzzy Logic

Basically, Fuzzy Logic (FL) is a multi valued logic that allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low, etc. Notions like rather tall or very fast can be formulated mathematically and processed by computers, in order to apply a more human-like way of thinking in the programming of computers (Zadeh, 1984). Tutor's comments are always expressed in linguistic variables like excellent, good, very good, average, improve. The comments can be evaluated using fuzzy logic to give a precise students grade that considers the students numerical score and the teachers comments.

1.1.3 Fuzzy Logic and Students Academic Performance

According to Kosko (1992) Fuzzy logic systems are unique because they are able to simultaneously handle numerical data and linguistic data. This feature is used to build up a formal, quantitative framework that captures the vagueness of human knowledge as it is expressed via natural languages like comments given by lecturers such as good, average, fair, very good, excellent. Using fuzzy logic a system can be created that incorporates both numerical scores and comments. By the use of a membership function both numerical scores and comments can be mapped to get a numerical value.

1.2 Statement of the Problem

According to Miller and Miller, (2004), the holistic assignment of grades such as A, B, C in evaluating students grades communicate little about the overall quality and tells little about the students strengths. They propose the use of simple comments as a way improving assessment especially on students answer sheets. According to Law (1995),

some problems with standardized examinations include awarding of uncertain scores. Different examiners may award marks which may vary especially in practical subjects. The primary method of assessment which usually involves awarding of numerical marks by the evaluator basing on a marking scheme may fluctuate depending on the evaluator's experience.

Fairtest, (2010) has reasons on how accurate is a test and provides the following three reasons: Firstly, the items on the test are only a sample of the whole subject area. There are often thousands of questions that could be asked, but tests may have just a few dozen questions. A test score is therefore an estimate of how well the student would do if she could be asked all the possible questions.

Secondly all tests have “measurement error”. No test is perfectly reliable. A score that appears as an absolute number say Tom 64 really is an estimate. For example Tom’s “true score” is probably between 56 and 70, but it could even be further off. Third, there are many other possible causes of measurement error. A student can be having a bad day. Test taking conditions often are not the same from place to place (they are not adequately “standadized”). Different versions of the same test are in fact not quite exactly the same. In written examinations the questions also have problems as a study done by Fairest, (2010) organization shows. Having one or more correct answers can cause a student’s reported percentile score to jump more than ten points.

Examinations usually have to be completed in a time limit. Some students do not finish, even if they know the material. This can be particularly unfair to students whose first language is not English or who have learning disabilities. Assessment of the students when in college is also another problem, whether it is formative evaluation (CAT’s) or summative evaluation like end term and end year exams. Students performance is given comments and sometimes it is possible to have a student scoring *50%* and given the comment *V.Good* while the same student scores *70%* in another course and given the comment *Good*. This shows that there is no consistency in award of comments like grading system that is fixed. Comments are also awarded by norm referencing (comparing with peers) than using criterion referencing (comparing them with students all over the country) Cox and Graham (1966).

The comments of the lecturers should be captured, and fuzzy logic offers a way of capturing natural language comments and by deffuzysification it offers the flexibility of measuring the true student's performance in addition to using numerical grades.

1.3 Aim of the Study

The aim of the study was to establish how comments are given with a view of developing a system that uses linguistic and numerical variables to measure students' performance.

1.4 Objectives

The objectives of the study are:

1. To identify the current comments given by lecturers for classifying student's academic performance
2. To model the data on comments obtained so as to develop a membership function.
3. To use fuzzy logic to model the membership function generated to get a student's numerical grade.
4. To model fuzzy sets using a suitable membership function to determine a student's grade in linguistic variables.
5. To develop a system that uses fuzzy logic to measure student's performance.

1.5 Research questions

1. What comments are given by tutors during student academic evaluation?
2. How can these comments be mapped/modelled into fuzzy logic membership functions?
3. How can student numerical grades be determined using fuzzy logic?
4. How can a students' numeric grade be modelled or converted to a linguistic variable?
5. How does the incorporation of comments affect the grade of a student?
6. Can a fuzzy logic system be developed to address current problems?

1.6 Assumptions of the study

1. Comments given by tutors' reflect the students' ability to take instructions, class participation and performance in comparison to other students in class and not necessarily the grade alone.
2. Comments given by tutors' in various subjects vary for the same numerical score.

1.7 Significance of the study

The study intends to use fuzzy logic to come up with a true measure of students' performance. Fuzzy logic was used to give a grade based on the lecturer's comments and the score was used to adjust the score given by numerical scores. This alleviates the problems associated with only numerical scores. Comments also eliminate errors caused by "measurement error". A student with a score like 50% may actually be having a mark from 40% to 60%. Comments are more general like good comment could be any mark above 70%.

Study is very useful for college lecturers since classroom experience, acquisition of knowledge and skills, student’s attitudes towards learning can be factored in student’s grades. The experience on the teaching and learning process is also be factored in the student’s final grade.

The use of the new method ensures that true student’s performance will be measured and the results will ensure fair and representative performance of students is adequate. The study when implemented will encourage students to excel more because it offers a flexible and fair way of grading students that encompasses all the teaching and learning experience over the period rather than only the examination time.

The study will also be useful to national examination councils where they can incorporate comments in calculation of a students’ grade. Fuzzy logic could also be applied in appraisals of seminar presentations, staff performance and project assessment, where a numeric score is difficult to ascertain and linguistic variables preferred. Lastly, the study is an addition to literature on improving student evaluation.

1.8 Scope of Study

The study is focused on the development of fuzzy systems. It aims to builds a method which uses fuzzy rule models and their associated inference mechanisms for student performance evaluation. The proposed method is applied to student’s numerical scores, from assessment components (assignments, tests, final exams) to produce a score for individual students. The study takes in the lecturers’ comments as they are and use the comments to develop a solution using fuzzy logic. For application of the proposed method, a real student academic performance dataset was obtained from the KTTI. In particular, data for first and second academic year diploma students was used. Visual Basic. 6.0 software was used to develop the system.

1.9 Limitations of the study

The major limitation of the study is the availability of literature concerning fuzzy logic application in comments that can inform the research in many ways.

1.10 Chapter Summary

The chapter has dealt with the introduction to assessment and its importance in educational performance measurement. Various authors that have written about assessment and fuzzy logic are also introduced. The chapter looks also at the background of the study by highlighting the current examinations practices at KTTI. Fuzzy logic is also introduced and its use in measuring students academic performance as well as problems experienced by the examination systems are discussed and these introduces the aim, objectives as well as the research questions of the and the assumptions of the study. The significance of the study are highlighted as well as the scope of the study and its limitations.

The next chapter discusses related literatures pertaining to the theoretical framework and the conceptual framework. Application of fuzzy logic in students' performance is discussed as well as student evaluation methods. Existing approaches to student academic performance evaluation and membership functions are reviewed.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

In this chapter the theoretical framework, the conceptual framework and various approaches to student academic performance are going to be discussed. Later studies on membership function is going to be discussed based on the findings of other researchers.

2.1 Theoretical Framework

According to Greswell (2003) a theory provides a lens that shapes what is looked at and questions asked in the course of the study. Greswell (2003) further notes that a theory is a set of interrelated constructs (variables), definitions and propositions that present a systematic view of phenomena by specifying relations among variables with the purpose of explaining phenomena. A theory develops as explanation to advance knowledge in particular field. Knowledge on ***Fuzzy Logic*** modelling and application greatly informed the study in terms of presenting the variables (comments) and the representation of the numerical marks in a *fuzzy membership function*. This ultimately led to the modelled solution for KTTI examinations.

2.1.1 Fuzzy Logic

Fuzzy logic was first used by Professsor Lofti A. Zadeh at the University of Califonia in Berkeley. According to Zadeh, 1964, Fuzzy Logic (FL) is a multi valued logic that allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low, etc. Notions like rather tall or very fast can be formulated mathematically and processed by computers, in order to apply a more human-like way of thinking in the programming of computers. In situations where words like very high, very low and near maximum are used in real life situations representation in computer logic under normal circumstances would be difficult without the use of ***fuzzy logic*** modelling.

In a broad sense, ***fuzzy logic*** refers to ***fuzzy sets***, which are sets with blurred boundaries, and in a narrow sense, ***fuzzy logic*** is a logical system that aims to formalize approximate reasoning (Bih,2006).

Bih, (2006) also notes that some of the important concepts of linguistic variables are words which are in natural languages. A relation in between two linguistic variables may then be expressed in terms of ***fuzzy if then rules***.

According to Reddy (2009) ***fuzzy logic*** is a methodology, to solve problems which are too complex to be understood quantitatively, based on ***fuzzy set theory***. He further notes that the central assertion underlying in fuzzy logic approach is that entities in the real world simply do not fit into neat categories like a project is not small, medium or large. It could in fact be something in between; perhaps mostly a large project but also something like a medium project. This can be represented as a degree of belonging to a particular linguistic category.

2.1.2 Fuzzy Sets and Crisp Sets

Hellman,(2001) defines the two important components of ***fuzzy logic***, ***fuzzy sets*** and ***crisp set.*** The ***fuzzy sets*** and ***crisp set*** are defined as supposing that ***X*** is a set of all real numbers between ***0*** and ***1***. From the set ***X*** a subset ***A*** can be defined such that

0≤A≤ 0.3. The function assigns a number ***1*** or ***0*** for each element in ***X*** depending on whether the element is in the subset ***A*** or not the elements assigned ***1*** are assumed to be in the subset ***A*** and ***0*** not in the subset. In linguistic terms it can be said that supposing the comment "Good" is given for any student with numerical score of more that **50** out of the maximum **100**. So if the score is **70** the student is given the comment "Good", diagrammatically shown as:

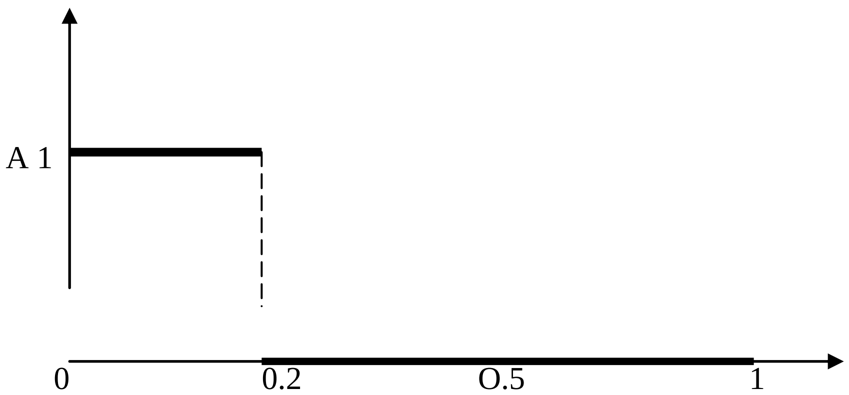


Figure 1: Characteristic Function of a Crisp Set (Hellman,2001)

In the case the upper range is set at **0.2** but supposing the boundary for **g** to **0.20** to an arbitrary point, in other words the strict separation between the members of the subset **A** and the non members so that there are members that belong to neither **A** or in between. For example if it is pressure and there is pressure values that is either high or low there could be pressure that is low and not so low. Another example is if the same comment "Good" has got no lower limit, if the comment can take any value between an upper limit and a lower limit. The natural way is to construct another set **B** which represents the not so low and not so high, not so good and not so bad. A fuzzy set would then allow the representation of such notion as shown in **Figure 2** below.

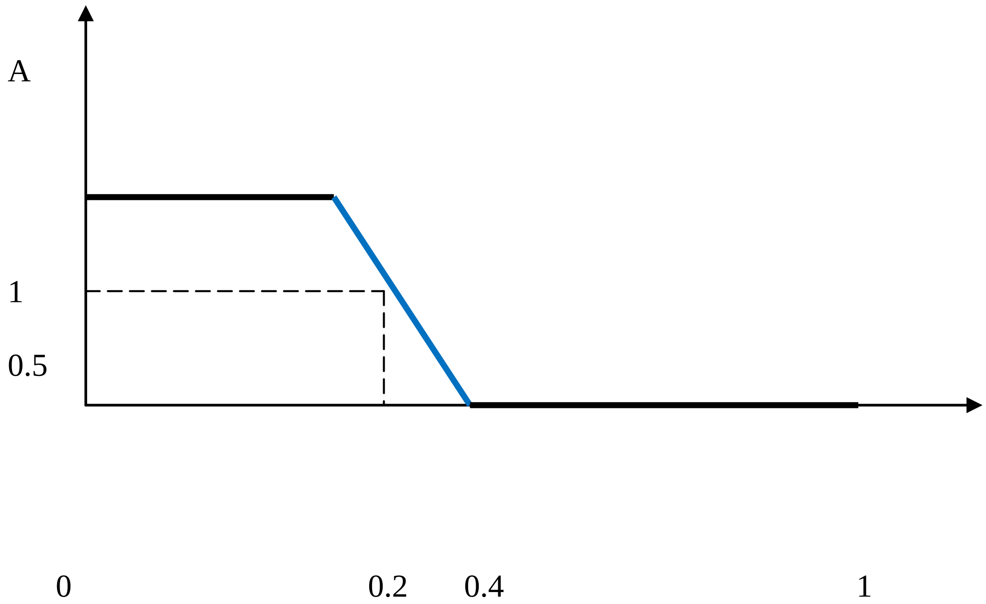


Figure 2: Characteristic Function of a Fuzzy Set (Hellman, 2001)

Reddy (2009), notes that fuzzy sets can be effectively used to represent linguistic values such as low, young, and complex. He further notes that fuzzy set can be defined mathematically by assigning to each possible individual in the universe of discourse a value representing its grade of membership in the fuzzy set to a greater or lesser degree as indicated by a larger or smaller membership grade. The fuzzy set is represented as where $\boldsymbol{x}$ is an element in $\boldsymbol{X}$ and $\boldsymbol{\mu A(x)}$ is a membership function of set $\boldsymbol{A}$ which defines the membership of fuzzy set $\boldsymbol{A}$ in the universe of discourse $\boldsymbol{X}$**.**

2.1.3 Operations on Fuzzy Sets

Hellman, (1965), notes that the basic operations on *fuzzy sets* are *fuzzy union* and fuzzy *negation*. Similar to the operations on *crisp sets fuzzy sets*, it is possible to intersect, unify and negate fuzzy sets. It can be shown that these operators coincide with the crisp unification and intersection if we only consider the membership degrees **0** and **1**. For example, if **A** is a fuzzy interval between **5** and **8** and **B** be a fuzzy number about **4** as shown in the **Figure 3** below.

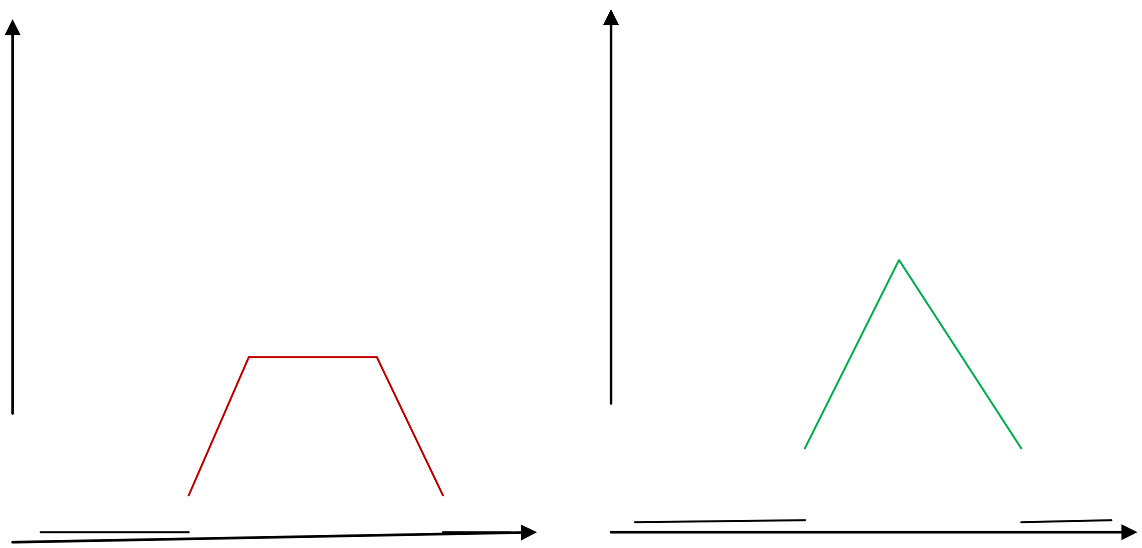


Figure 3: Example fuzzy sets (Hellman, 2001)

In this case, the fuzzy set between 5 and 8 AND about 4 is

μ_A μ_B

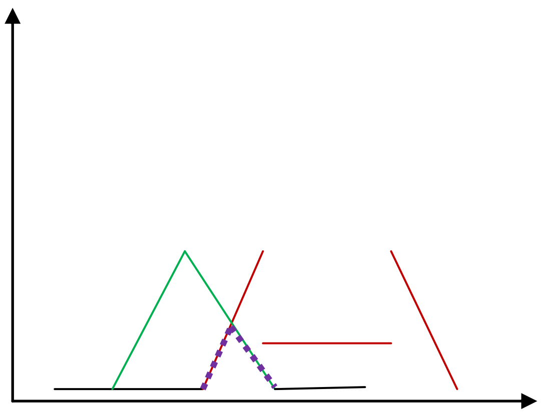


Figure 4: Exampe: Fuzzy AND (Hellman, 2001)

set between 5 and 8 OR about 4 is shown in the next figure

the NEGATION of the fuzzy set A is shown below.

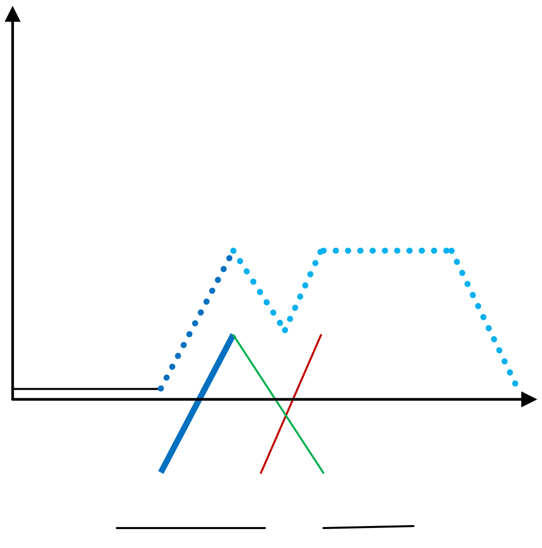


Figure 5: Example: Fuzzy OR (Hellman, 2001)

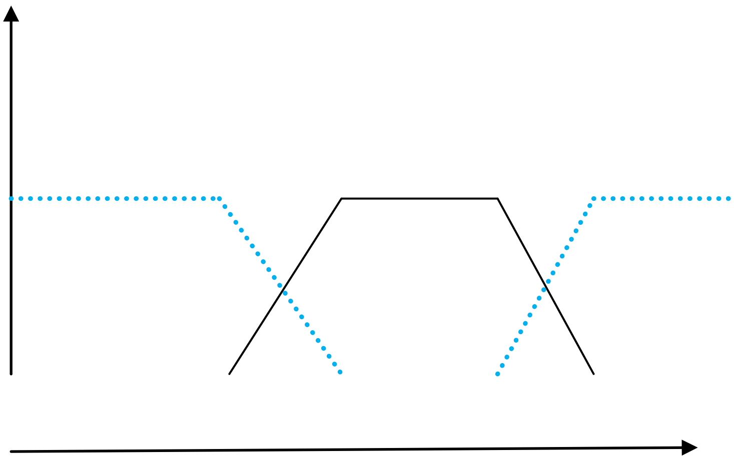


Figure 6: Example: Fuzzy Negation (Hellman, 2001)

Fuzzy classifiers into categories are one application of fuzzy theory. Expert knowledge is used and can be expressed in a natural language way using linguistic variables, which are described by fuzzy sets.

Now the expert knowledge for these variables can be formulated as a rules like

IF feature **A** low **AND** feature **B** medium **AND** feature **C** medium **AND** feature **D** medium **THEN** Class = class 4.

Table 1: Example of a fuzzy rule base: (Hellman, 2001)

	Feature a	Feature b	Feature c	Feature d	class
1	low	medium	medium	Medium	Class 1
2	medium	high	medium	low	Class 2
	….	….	…		

Rules read as (e.g. **RULE No.2: IF** A is medium **AND B** is high. **AND C** is medium **AND** D is low. **THEN** class 2. Linguistic rules describing the control system consist of two parts; an antecedent block (between the **IF** and **THEN**) and a consequent block (following THEN). For student results the set of comments may be represented in fuzzy sets for example **IF** comments are good, good, fair, V. good THEN good. Depending on the system, there may be many situations and it may not be necessary to evaluate every possible input combination, since some may rarely or never occur. By using fuzzy evaluations process, fewer fuzzy rules can be evaluated improving the fuzzy logic system.

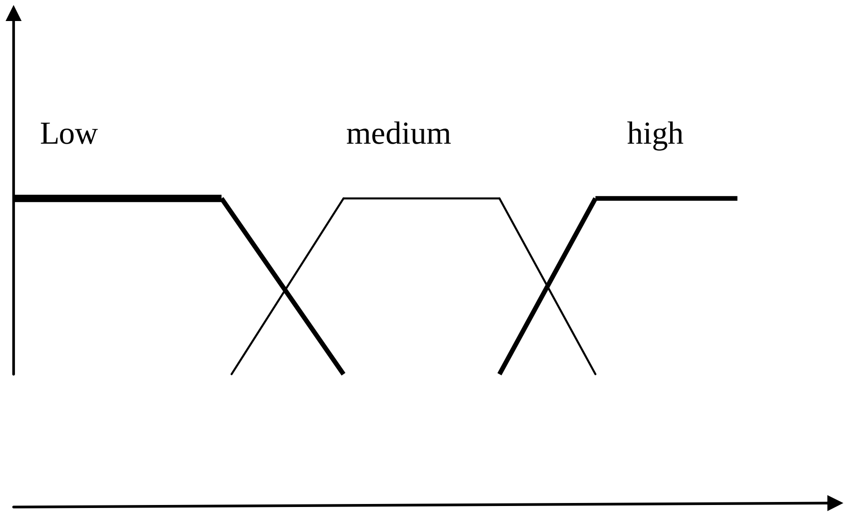


Figure 7: Example: Linguistic Variables (Hellman, 2001)

The inputs are combined logically using the ***AND*** operator to produce output response values for all expected inputs. The active conclusions are then combined into a logical sum for each membership function. A firing strength for each output membership function is computed. All that remains is to combine these logical sums in a ***defuzzification*** process to produce the crisp output.

The fuzzy outputs for all rules are finally aggregated to one fuzzy set. To obtain a crisp decision from this fuzzy output, we have to ***defuzzify*** the fuzzy set, or the set of singletons. The challenge is to get one representative value as the final output form individual sets. There are several heuristic methods (***defuzzification*** methods), that can be used to map out the output from various fuzzy sets of inputs one of them is e.g. to take the centre of gravity of the fuzzy set as shown in figure 9, which is widely used for fuzzy sets. For the discrete case with singletons usually the maximum-method is used where the point with the maximum singleton is chosen.

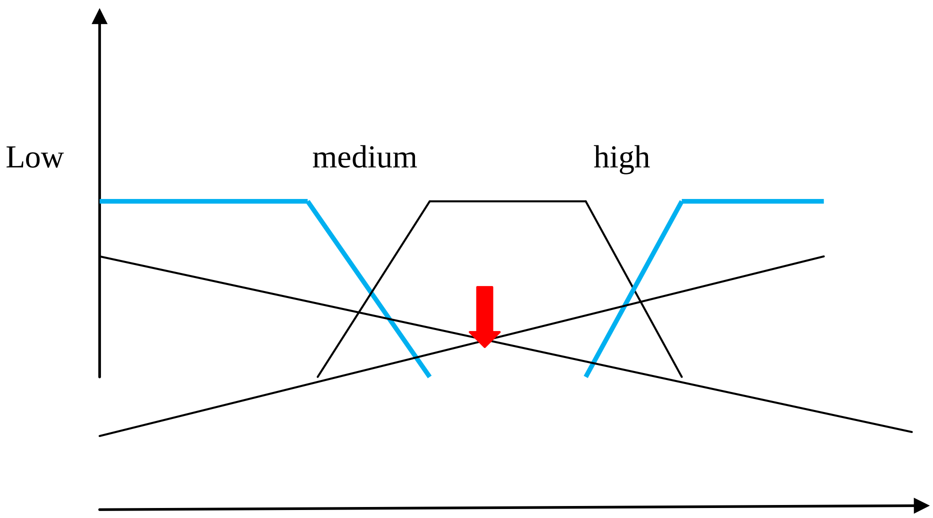


Figure 8: Defuzzification using the centre of gravity approach (Hellman, 2001)

2.1.4 Application of Fuzzy Logic in Students Evaluation

If Linguistic variables like comments of the lecturers are to be captured, fuzzy logic offers a way of capturing natural language comments and by *defuzzification* it offers the flexibility of measuring the true student's performance. An example is if a student with a numerical mark of **50** is given a comment of good in one subject and mark **72** with comment excellent in another.

The true student's grade can be calculated by finding the degree of membership of the comment to various grades. When a membership function is developed it is possible to find the true students mark. Using the membership function in figure 10 developed by Biswas (1995) it is possible to *defuzzyfy* the marks into one numerical score.

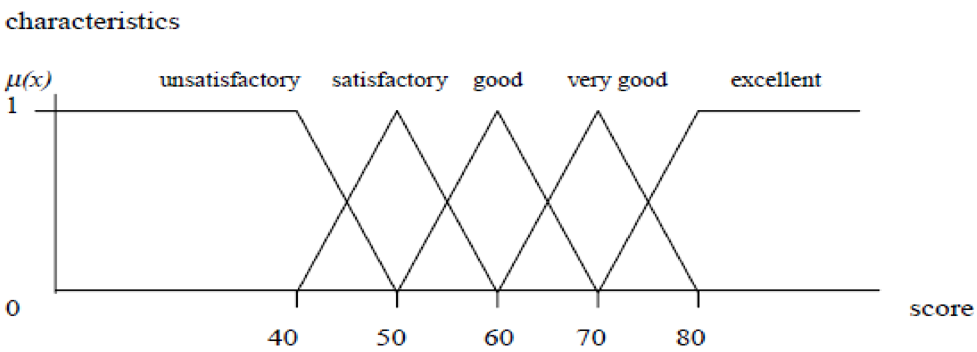


Figure 9 : Membership function of student academic performance (Biswas 1995)

From the membership function the mark 55 could have taken the comment good or satisfactory using the fuzzy and rule.

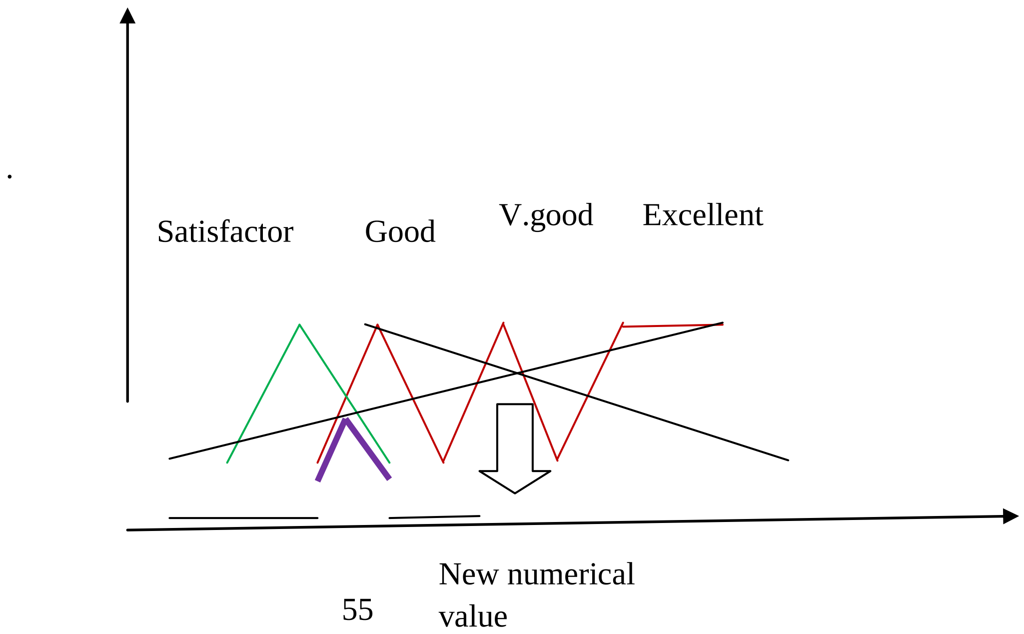


Figure 10: Defuzzification of Numerical Marks

The best approaches can be used to *defuzzify* numerical marks as is discussed in the literature review.

2.2 Conceptual Framework

Fuzzy approach was used to model the method of student performance evaluation. The new method strengthens the present system by providing additional information to be used for decision making by the user of the system (KTTI). **Figure 11** shows the modelled method of student academic performance evaluation. Evaluation components of a student include a numerical score. On the diagram shown on **Figure11**The teachers comments are added to get the final students grade.

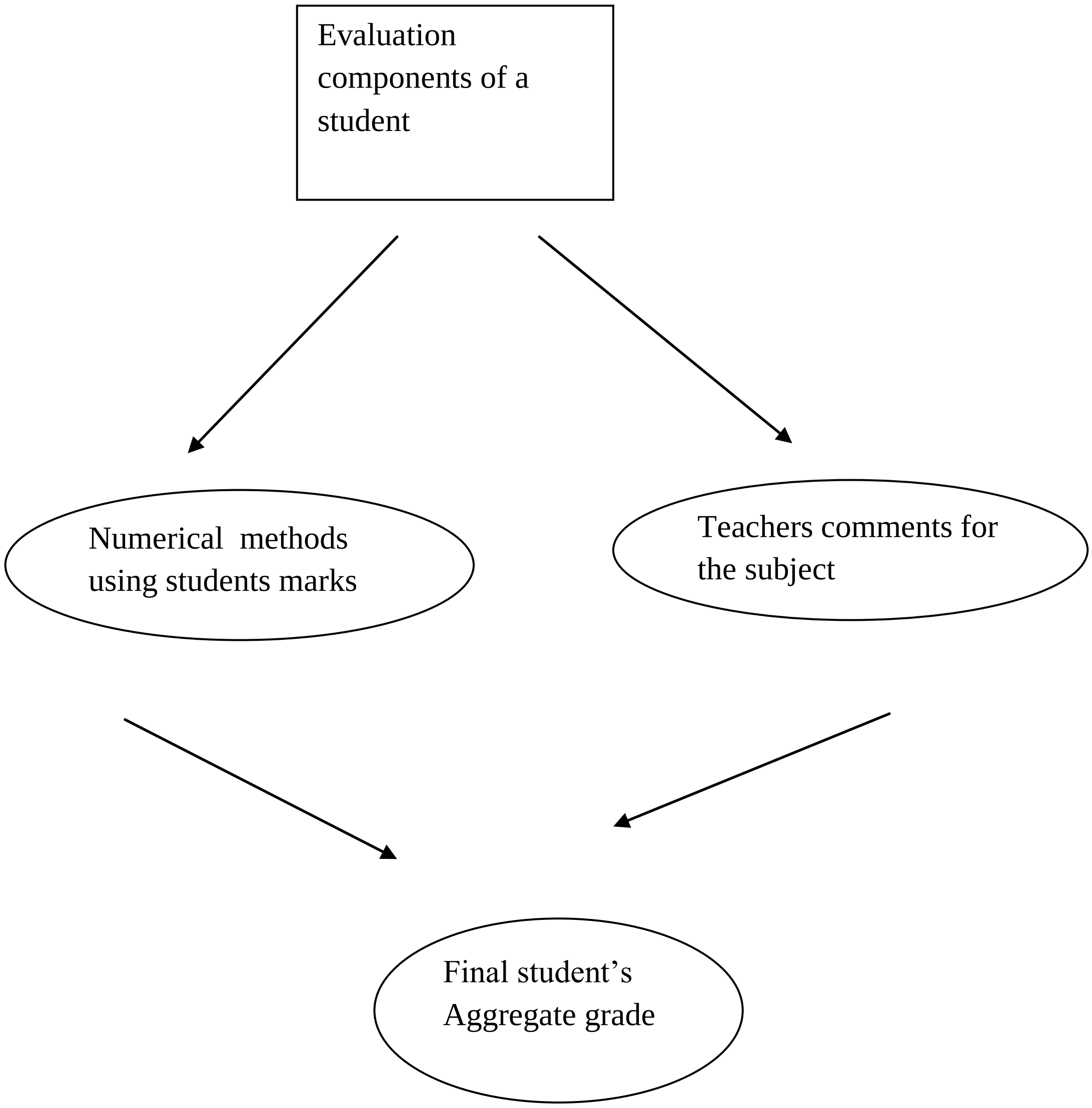


Figure 11: Fuzzy logic model of student academic performance evaluation

2.3 Overview of student evaluation methods

There are various evaluation methods currently being used in institutions of learning. Examinations are very important component of the learning process. Examinations may either be formative or summative. Formative evaluation serves to probe what individual students are learning and how well they are meeting the goals of a course (whether related to disciplinary content or to using transferable intellectual and practical skills). Typical assessment questions at this stage according to Miller (2005) would be: is the student learning as expected? Has the student's work improved over the semester? How well has the student achieved the learning outcomes set for the course?, what are the student's strengths and weaknesses? Finally, how well is the instructor communicating with and engaging the student? Summative evaluation answers the following questions: has the student's work improved and/or met standards during the program or since admission to college, how well has the student achieved the disciplinary outcomes of the major program and how well the student has achieved the general learning outcomes of the institution across the course. The sources of evidence at this stage would be: embedded work in individual courses, for example quizzes and exams, papers, projects, presentations, portfolios that assemble samples of the student's work in a number of courses, projects, student self-reflection on the learning process, relevant externally developed exams (e.g., for licensure) Miller (2005).

The results should be presented in a way that it can be interpreted by students, parents, teachers and policy makers. Examinations can either be norm referenced or criterion referenced. Afolayan (n.d.) notes that the two examinations are meant to serve different purposes. He notes that the main purpose of norm referenced examinations is to compare individuals and the main purpose of criterion referenced examinations is to make decisions based on the performance of the student with respect to some criterion. In criterion referenced examinations one is not interested in the constraints put in the course of learning. Both types of examinations are important in determining learning outcome of the student.

Afolayan (n.d.) further notes that criterion-referenced tests permit direct interpretation of progress, it facilitates individual instruction, eliminate pressure on the teacher to "teach the test" and enables teachers to check on students progress at regular intervals. Though the criterion referenced examinations have some advantage Afolayan notes that they do not tell much about achievement, they are difficult to obtain and they are necessary for measuring some small fraction of educational achievement like interest and abilities.

Khairul (2002) notes that there are several reasons why student's performance needs to be assessed. They are: to indicate students level of understanding, for making academic decisions for planning further action, to provide information about teacher's ability to instruct. He further notes that academic performance can be done in two formats formative and summative. Formative evaluation monitors the progress of the students' while summative evaluation is conducted at the end of each instructional segment. Assessment components may include the following: Series of tests and quizzes, formal written examinations, individual assignment and coursework, group work, observation, thesis publications and oral presentation. In most instances all the examination components are not tested in summative evaluation like KNEC examinations. Some components of examinations like oral presentations, group work, observations and assignments can best be done by teachers in the course of teaching. The outcome of these methods of examinations can best be captured as comments given by the lecturers.

2.4 Existing Fuzzy Approach for Student Academic Performance Evaluation

Khairul (2002) studied existing approach for student academic performance. He notes that Student academic performance evaluation usually involves linguistic terms such as good, bad, satisfactory, excellent, etc., which involve a substantial amount of fuzziness. The characteristic functions of students' achievement could be defined, for example as shown in **Figure 12.**

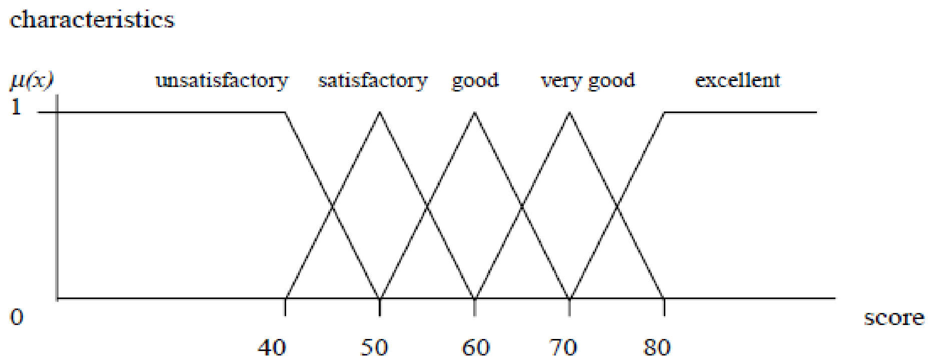


Figure 12 : Membership function of student academic performance (Khairul 2002)

Khairul, (2002) notes that there are different kinds of academic performance evaluation, different types of evaluation components (questions, topics, subjects, courses, etc.) may be presented using different membership functions. For each of the evaluation components they could be defined according to the characteristics of the components, which may be different in nature of presentation. He used an example, 'achievement in different subjects and notes that achievement in different subjects could be different. He gives an example of performance in Mathematics' and he states that it could be different from 'achievement in English language. He notes that different kinds of linguistic variables or comments may be used and the characteristics of the linguistic terms used may vary according to some relevant standard. He gives an example that the linguistic term ‘excellent’ might be a score of above 90. For example, the linguistic term 'excellent' might be a score above 90 instead of 80 as shown in **Figure 12**. He proposed a membership function $\boldsymbol{\mu(x)}$ which could be used for each evaluation component. With different membership functions generated it will make it easier for the adoption of the use of fuzzy sets to represent student academic performance. He notes that the use of fuzzy logic and the method he is proposed ‘A Data-Driven Fuzzy Rule-Based Approach for Student’ is rather new and previous methods of research using fuzzy logic did not use a standard procedure in developing of membership function.

AI-Hammadi and Milne, (2003) agrees that fuzzy set theory is an efficient and effective method to represent the uncertainty and fuzzy terms in the assessment environments. They note that fuzzy classification scoring systems helps in making assessment in less time and with very good level of accuracy that can only be compared with the best teacher’s grades.

Khairul (2002) gives a description of several previous studies using fuzzy approaches for such applications. He categorized the studies into four different approaches, namely

a) Fuzzy similarity based

b) Fuzzy expected value based

c) Using fuzzy membership function values alongside statistical theory, and

d) Simple fuzzy rule-based. Other approaches include

e) Neuro fuzzy approach

f) Fuzzy inference based approach

2.4.1 Fuzzy Similarity Based Approach

Biswas, (1995) as reported by Khairul (2002) proposes an application of fuzzy sets to student academic evaluation. The reason advocated by Biswas is that educational grading systems involves some fuzziness and fuzzy theory can be used to provide a model of subjective judgements. He stares that the method could be used for assessing students' answers using several criteria such as it's accuracy, coverage and clear expression on the answers. The procedure Biswas used worked as follows:

(a) Create Standard Fuzzy Sets (SFS) for linguistic variables

(b) Award fuzzy marks to Question ***i, Qi*** using the fuzzy grade sheet (which contain rows for question number and columns for awarding marks in term of fuzzy values).

(c) Calculate the degree of similarities between ***Qi*** and ***SFS.***

(d) Find the maximum values and award the final grade.

(e) Calculate the total score based on several questions and the total mark.

Khairul (2002) notes that although the method shows some usefulness in awarding marks from different question the main drawback is that the method needs an evaluator to award fuzzy marks instead of awarding a single score. The other drawback was that it consumed a lot of time to perform the matching operations.

2.4.2 A Neuro – Fuzzy Approach for Student Performance Modelling

AI-Hammadi and Milne, (2003) developed a design of Neuro-Fuzzy technique for modelling student performance in a college of engineering. Zoran (2006) developed neuro-fuzzy reasoner for student modelling. The main function of the Neuro-Fuzzy model as developed by Al-Hammadi (2003) was to support the student admittance procedure by evaluating and predicting student performance before acceptance to the college as well as assessing the suitability of the entry exams. A number of factors were considered such as secondary school tests results, college entry results and the kind of school graduated from, personality and communication skills. The results from secondary school examinations in selected subjects was taken and fuzzy set theory was used to predict the performance of the students when they join the college so as to differentiate between suitable and unsuitable students' before they join the college.

The method developed by Zoran (2006) was to classify students basing on qualitative observations and their characteristics. The method involves defining fuzzy sets for inputs, defining fuzzy sets for inputs, defining fuzzy rules and creating and training the neural network. The inputs to the system are time and score and the output are comments such as good, bad , very good or excellent.

Al Hamadi (2003) notes that Neuro Fuzzy Systems have many advantages: their ability and adaptive capability and they are able to handle numerical data and linguistic knowledge simultaneously, when the definition of the problem is vague and uncertain.

Al Hamadi notes that the combination of Neural systems and fuzzy logic of the two methods. In neuro fuzzy approach for student performance modelling, a certain prior knowledge is available in the form of fuzzy rules. He notes that the Neuro-Fuzzy (NF) system can be initialized with these rules. In neuro fuzzy approach for student performance modelling the remaining rules can be found by learning.

Al Hamadi (2003) created two files one containing the secondary school marks and the other containing college entry test. The output was the student performance in the college. The number of fuzzy sets per input was chosen to be weak, below average, above average, excellent. A test was then done to choose the membership function. The Gaussian membership function was chosen because it had the least mean square error. The study was only intended to provide a way of predicting student's performance before they join the college and not to measure performance. The study by Al-Hamadi (2003) was very useful in measuring the mean square error for the membership functions and greatly inform the study on the kind of membership function to use.

2.4.3. Fuzzy Expected Value Based Approach

Khairul (2002) notes that the fuzzy expected Value based method has been used to build a structural model of the educational grading system using fuzzy approach by Law (1995). The main reason of using the method is that score/marks fluctuate a little. Fairtest (2010) agrees with the assumption that marks may fluctuate and sites a situation where a student with a score of 80 may actually mean that the marks could be between 70 and say 90 meaning that the score given to students for the performance is not always precise. Johanyak (2009) also notes that in cases of the evaluating students' answer scripts containing narrative responses quite often there is vagueness in the opinion of the evaluator that hardly can be fitted in the frames of the traditional evaluation techniques where a response is rated by a single crisp value. Law (1995) gives three reasons to support the fuzzy expected value based approach:

(a) Marks may fluctuate a little for a student meaning that a student's marks are not always precise.
(b) Vague data is normally used in examinations
(c) To draw meaning from information collected their was need to employ a new method.

The expected value based approach according to Khairul, (2002) has a procedure which involves: calculation of expected value for linguistic variables, calculating new score and finally calculating the aggregate score. The drawback of this method is that it involves complex computational processes and cannot integrate different fuzzy environments.

2.4.4. Using Fuzzy Memberships Function Values alongside Statistical Theory

Khairul (2002) notes that the first research carried out into the use of fuzzy membership function values alongside statistical theory for performance assessment was reported in Fourali (1994). The main aim of using the method is to use prior learning with evidence. The main reason behind the method proposed by Fourali is that academic competence is itself fuzzy concept and that decision on evidence e.g academic certificate may have different interpretations by different people, therefore it can said to be fuzzy as different assessors may have different standards. This method works by calculating the final score, ***X,*** using the expected value defined as follows:

$$X = \frac{\sum f(x_i).x_i}{\sum f(x_i)} \quad \text{...(1)}$$

Where ***xi*** is a rating value from 0 to 10 which refers to competency (where 0 indicates extremely unsatisfactory and 10 indicates extremely satisfactory). The same interpretation may be used for the numerical scores that have ratings of values from 0 to 100 as it is with the examination system at KTTI. The values ***f(xi)*** are ordinate values (frequency of rating ***xi*** in fuzzy values) with respect to the rating ***xi***. The method consists of two steps:

(a) Award a rating value ***xi*** for each category of evidence.

(b) Calculate the expected value, ***X***, based on ordinate values ***f(xi)*** and the use of balance

The drawback to the method was that it relied on ratings between 0 and 10 but not marks based on numerical scores. The method used by Fourali,(1994) could be used to get a crisp value if the degree of membership is known as well as having the numerical scores between 0 and 100. The same formula could be used to get the final score from many tests.

2.4.5. Fuzzy Inference-based Student Evaluation Methods

Johanyak, (2009) developed three fuzzy inference based student evaluation methods. He notes that in cases where a total score is not possible can result in quite significant difference between the marks given by various evaluators. This is so especially in students answer scripts containing narrative responses and quite often Johanyak (2009) notes that opinion of various examiners may vary. The problem partly can be traced back to the uncertainty in the opinion or the evaluator that cannot be expressed properly in the traditional one-value-based scoring. Fuzzy set theory based evaluation methods can reduce the mentioned differences. He notes that several methods have been published in order to deal with the problem that includes using fuzzy inference and using fuzzy arithmetic. The advantage of the inference based evaluation methods approach is that the rules are easily readable and understandable. Their drawback however is that it requires lots of work in preparation by human expert graders. The other drawback is that the system is task specific. The rule base system can only operate with low number of fuzzy sets.

2.4.6. Simple Fuzzy Rule-Based Approach

Shimizu and Yamashita, (1995) presented a study of applying fuzzy reasoning for educational evaluation of calligraphy as reported by Khairul, (2002). They propose that the reason behind the use of fuzzy approach is that evaluation of calligraphy and art is affected by the teachers' sensitivity. Different teachers may have different levels of sensitivity resulting in different marks. The authors employed a fuzzy rule-based approach where the rule set is provided by an expert (teacher). The process of building the evaluation system has two parts:

(a) Construction of evaluation tree based on technical variable, x and sensitivity variable y.

(b) Generate reasoning tree based on fuzzy partition (high, medium and low) of input variables *x* and *y*, and fuzzy partition (excellent, very good, good, fair, poor) of output variable *z*.

2.5. Criteria for Comparison of Fuzzy Evaluation Methods

Johanyak (2009) gives sets of criteria for fuzzy methods aiming at evaluation of the students' academic performance. He considers these requirements as properties that help the reader to compare the overviewed methods. The seven points noted are as follows:

1. The method should not increase the time needed for the assessment compared to the traditional evaluation techniques.
2. The method should help the graders to express the vagueness in their opinion.
3. The method should be transparent and easy to understand for both parties involved in the assessment process, i.e. the students and the graders.
4. The method should ensure a fair grading, i.e. it should be beneficial for all students.
5. The method should allow the teacher to express the final result in form of a total score or percentage as well as in form of grades using a mapping between them.
6. The method should be easy implementable in software development terms.
7. The method should be compatible with the traditional scoring system, i.e. when the grader provides crisp scores for each response the total score and the final grade should be identical with the one calculated by the traditional way.

2.6 Membership Functions

Khairul, (2002) notes that membership functions can be defined using many methods that include: heuristic methods, piecewise linear functions such as triangular & trapezoidal membership functions, simple linearly decreasing and increasing function, functions based on probalistic curves and the distribution of values presented as histogram, Neural network-based methods and clustering methods.

Reddy (2009), notes that a fuzzy set is characterized by a membership function, which associates with each point in the fuzzy set a real number in the interval **[0, 1]**, called degree or grade of membership. The membership function may be triangular, trapezoidal or Gaussian etc. A triangular membership function is described by a triplet **(a, m, b)**, where ‘m’ is the modal value, ‘a’ and ‘b’ are the right and left boundary respectively. Dombi (1986) did a study on membership functions as an evaluation method and the main objectives were to find membership functions: that are easy to calculate and fit to the problem. The membership functions should also have few parameters for better clarity. The parameters used in the study should be meaningful to the users of the system. The membership functions should also be linearised for the sake of developing applications and the membership functions should also be closely connected.

2.6.1 Different membership functions

Dombi (1986) classified the articles on membership functions and came up with five methods:

1. Heuristically based membership functions

2. Membership functions based on reliability concerns with respect to the particular problem.
3. Membership function based on more theoretical concern.
4. Membership functions and control
5. Membership function as a model for human concepts

Mandal (2008) did a study on functions for ***fuzzification*** of membership functions. He presents the following types of membership functions that include **a *gaussian, triangular, s-shaped or bell function.***

Mandal defines A **Gaussian** membership function by

G(u:m,σ)=exp[-{(u-m)/√2σ}2]

Where the parameters ***m*** and ***σ*** control the centre and width of the membership function. Diagrammatically the *gausian* function can be plotted as:

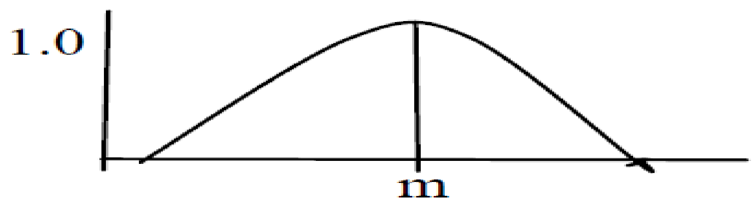


Figure 13: Gaussian function source Mandal (2008)

The other function is a **Triangular** membership function with straight lines. The function is formally defined as:

Λ(u:α,β,γ) = 0 u<α

= (u-α)/ (β-α) α<=u<=β

=(α - u)/(β-α) β<=u<=γ

=0 u>γ

Daneshvar (2011) notes that the ***Gaussian distribution*** is usually quite good approximation for a class model shape in a suitably selected feature space. He further notes that it is a mathematically sound function and extends easily to multiple dimensions.

A typical plot of the triangular membership function is given as:

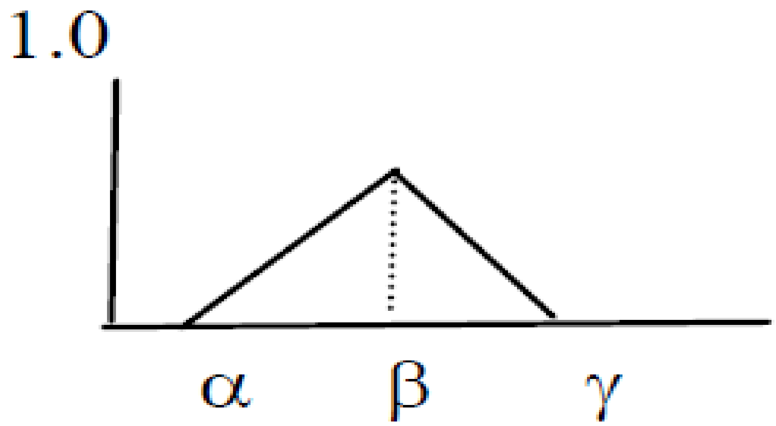


Figure 14: Triangular membership function source Mandal (2008)

Trapezoidal Function is represented as:

f(x, a, b, c, d) = 0 when x < a and x > d

(x - a) / (b - a) when a <= x <= b

1 when b <= x <= c

(d - x) / (d - c) when c <= x <= d

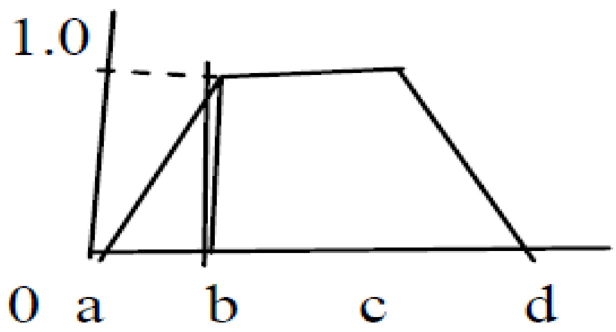


Figure 15: Trapezoidal membership function source Mandal (2008)

S-shaped membership function is represented as:

$\mathbf{S(u:\alpha,\beta,\gamma)} \quad \mathbf{=0 \; u<\alpha}$

$\mathbf{=2[(u-\alpha)/(\gamma-\alpha)]2 \; \alpha<u<=\beta}$

$\mathbf{=1-2[(u-\gamma)/(\gamma-\alpha)]2 \; \beta<u<=\gamma}$

$\mathbf{=1 \; u>\gamma}$

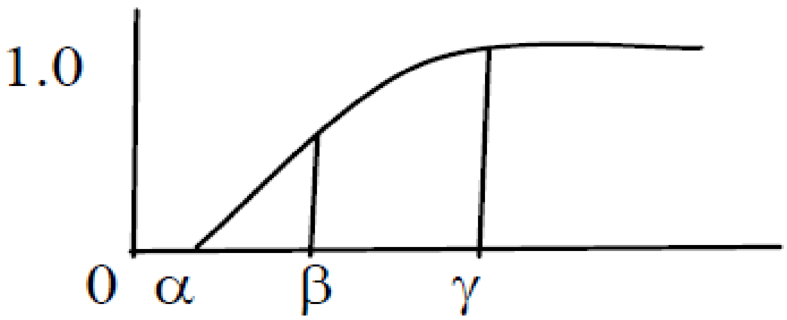


Figure 16: Typical form of the S-function source Mandal (2008)

The **Bell** function depends on three parameters

a, b, and **c** as given by

f(x;a,b,c)=1/(1+((x-c)/a)2b

where the parameter **b** is usually positive. The parameter **c** locates the centre of the curve.

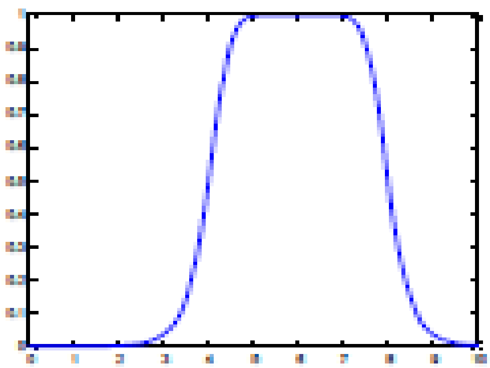


Figure 17: Bell shaped membership function source Mandal (2008)

Some of the functions under the ones used based on reliability concerns with respect to a particular problem include a function which is piecewise linear which uses the formula below.

$$\mu(x) = \begin{cases} 0 & \text{if } x \le a, \\ w_1 \frac{x-a}{b-a} & \text{if } a \le x \le b, \\ 1 & \text{if } b \le x \le c, \\ w_2 \frac{d-x}{d-c} & \text{if } c \le x \le d, \\ 0 & \text{if } d \le x. \end{cases}$$

……………….(2)

This was the most suitable for use by the study because of the variables on comments are many and can be used interchangeably.

Dombi (1986) also notes that it is not easy to find common features among the various approaches to developing membership functions although he found out that in every article:

1. Has all membership functions being continuous
2. All membership functions map an interval **[a, b]** to **[0, 1]**,
3. Membership functions can either be monotonically increasing or monotonically decreasing. Or could be divided into the two.
4. The monotonous membership functions are either convex or concave functions. monotonically increasing functions have the property **u (a) = 0**, **u (b) = 1**, while monotonically decreasing functions have the property **u (a)** = **1, u (b) = 0.**
5. Very important is the linear form or linearization of the membership function.

2.7 Deffuzyfication Techniques

Once a membership function has been generated, for a set of scores or fuzzy values, a crisp value has to be found. There are various methods of finding a crisp value from a set of fuzzy values. According to Sladoje (2007), Gunabi (2003), Sameena (2011), Jean (2004), Ross(1995) the most common ***defuzzification*** methods are:

- The centre of gravity method (COG)
- Weighted average ***defuzzification*** Technique
- The maxima methods:
- Mean of Maxima
- smallest of maxima and
- last of maxima

The centre of gravity method

This method is also known as centre of gravity or centre of area defuzzification.. according to Ross(1995) This is the most commonly used technique and is very accurate. The ***centroid defuzzification*** technique can be expressed as

$$x^* = \frac{\int \mu_i(x)\, x\, dx}{\int \mu_i(x)\, dx} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

(3)

where x^* is the defuzzified output, $\mu_i(x)$ is the aggregated membership function and x is the output variable. This method determines the centre of the area of the combined membership functions Ross further notes that the only disadvantage of this method is that it is computationally difficult for complex membership functions.

Weighted Average Defuzzification Technique

In this method the output is obtained by the weighted average of the each output of the set of rules stored in the knowledge base of the system. The weighted average ***defuzzification*** technique can be expressed as

$$x^* = \frac{\sum_{i=1}^{n} m^i w_i}{\sum_{i=1}^{n} m^i} \qquad \text{………………………………………………………….(4)}$$

where $\boldsymbol{x^*}$ is the defuzzified output, $\boldsymbol{m^i}$ is the membership of the output of each rule, and $\boldsymbol{w_i}$ is the weight associated with each rule. Ross (1995) notes that this method is computationally faster and easier and gives fairly accurate result.

Jean (2004) notes that in cases where more than one rule possesses the same crisp consequent, then the application of weighted average method can be done by considering the **AND** operator and also the **OR** operator for situations in which there are more than one membership function.

The maxima methods

Gunadi (2003) notes that .Maxima methods consider values with maximum membership the methods include , ***first of maxima (FOM), last of maxima LOM), mean of maxima (MOM)*, and *centre of maxima (median)*.** Sameena (2011), notes that the largest of maximum takes the largest amongst all membership functions. The ***Smallest of Maximum*** selects the smallest output with the maximum membership function as the crisp value. The Mean of Maximum is calculated by taking into consideration the active rules with the highest degree of fulfilment.

2.8. Chapter Summary

Various methods and ways involving fuzzy logic have been advocated be various researchers. The underlying principle is that educational assessment is itself fuzzy. Different researchers have looked at various components of students' evaluation. The fuzzy similarity based approach by Biswass (1995) deals with measuring the accuracy and coverage of students answer scripts. The value based approach by Johanyak (2009) deals with evaluating students answer scripts. Using fuzzy membership function alongside statistical theory by Fourali (1994), deals with academic certificates and its interpretation. Simple fuzzy rule based approach by Shimizu and Yamashita (1995) deals with evaluation of calligraphy and art. All the methods have components of fuzziness in its application and they deal with particular components of students evaluation.

However all the methods covered do not deal with components of formative evaluation. The learning process is not considered in all the methods. The use of formative evaluation then by incorporating comments is a new method that should be considered to give more weight to traditional numerical scores.

The chapter has discusses various literatures pertaining to the theoretical framework and the conceptual framework. Application of fuzzy logic in students' performance is discussed as well as student evaluation methods. Existing approaches to student academic performance evaluation and membership functions are reviewed. The ***fuzzification*** and ***defuzzification*** methods are also discussed.

The next chapter deals with research design methodology and the variables, population and sampling techniques, sample size and discussed. Data modelling methods and system development methodology are discussed. Finally ethical considerations that were considered in the research are discussed.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter contains the research methodology that was used in the study.

Different methodologies were used in the study. These involve methodologies for developing membership functions and for software development. Prototyping system development methodology was used to come up with the system that incorporates tutor's comments in the final student's grade.

3.1 Research Design

A case study was used in the study, Neale (2006) notes that a case study is a story about something special or interesting. Stories can be about individuals, organizations process, programs, neighbourhoods, institutions and even events. In the study the comments given by lecturers were taken as a special part of the research and so the case study was the best research design for the study.

Yin (1984), defines the case study research method as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used.

Neale (2006) further notes that case studies are appropriate when there is a unique or interesting story to be told, or to provide context to the data (source as outcomes) offering a more complex picture of what happened in the program and why. The case study as noted by Neale (2006) has advantages in that it provides a detailed information and data can be presented in multiple methods. The drawback is that it could be lengthy.

Baxter (2008) notes that a case study design should be considered when: the focus of the study is to answer “how” and “why” questions, you cannot manipulate the behaviour of those involved in the study, you want to cover contextual conditions because you believe they are relevant to the phenomenon under study and the boundaries are not clear between the phenomenon and context. The case study then was the most suitable because it was used to answer the question on how comments are given by the lecturers of KTTI. The study also involved the study of the documents of which the researcher had no control over the contents of the documents and finally the comments given the lecturers were not the same for the same numerical mark.

Dooley (2002) notes that the case study research, like all other forms of research, must be concerned with issues such as methodological rigor, validity, and reliability. This is accomplished through the six elements: determination and defining the research questions, selecting the cases and determine data-gathering and analysis techniques, preparing to collect data, collecting data in the field, evaluating and analyze the data and finally preparing the report.

3.1.1 Variables

The research question that were answered by the use of the case study methodology is what comments are given by tutors during student evaluation and how can these comments be mapped/modelled into fuzzy logic membership functions.

The variables that were collected in the study are the students report details like the marks and the teacher's comments. The details were collected in a document review guide shown in **Appendix 1.**

3.1.2 Sampling Technique

Multi stage sampling was used. In this sampling method, first students' documents were put to clusters according to the course. The numbers of students in the departments were selected using random sampling.

3.1.3. Sample size

The sample size and distribution was as follows:

Table 2: Sample size

Department	No of records	Artisan	Craft/certificate	Diploma	Total	Percentage
Automotive Engineering	104	3	5	5	**13**	**10**
Agricultural Engineering	63	---	3	5	**8**	**12**
General Agriculture	124	----	10	4	**14**	**11**
Electrical Engineering	146	----	4	10	**14**	**10**
Carpentry and Joinery	8	1	2	--	**4**	**50**
Mechanical Engineering	103	--	5	7	**13**	**13**
Information	127	---	3	10	**13**	**10**

Technology						
Business	145	---	6	8	**14**	**10**
Secretarial	41	---	4	---	**4**	**10**
Total					**97**	**11**

3.1.4 Data Collection Method and Documents

The data was collected from students' files. Simple random sampling was used to pick out the students records from the files. A check list was used to count the number of documents per department. The data collected was presented in a document review schedule. Documents for review were available. Data collection was done without much challenge given that only documents were reviewed. The data was then clustered according to the comments to aid in data modelling.

3.2. Data Modelling

Data collected were presented in a Gaussian distribution table as AI-Hammadi and Milne (2003) showed that the Gaussian function produced the least mean square error.

Table 2: Data Modelling

Linguistic variable	Parameters of Gaussian distribution		Parameters of Membership Function		
	Mean (μ)	Standard deviation (σ)	Lower boundary	Centre	Upper Boundary
V1					
V2					
V3					
V4					

The formula presented by Mandal (2008) was used to get a crisp value for the numerical scores. The method involved identification of the value $\boldsymbol{\mu_{(x)}}$. This is because the method is able to address membership functions that overlap in shape.

$$\mu(x) = \begin{cases} 0 & \text{if } x \leq a, \\ w_1 \frac{x-a}{b-a} & \text{if } a \leq x \leq b, \\ 1 & \text{if } b \leq x \leq c, \\ w_2 \frac{d-x}{d-c} & \text{if } c \leq x \leq d, \\ 0 & \text{if } d \leq x. \end{cases}$$

……………….(2)

3.3 Defuzzification Techniques

Of the defuzzification techniques presented earlier in the literature review which are; the centre of gravity method (COG), weighted average *defuzzification* technique and the maxima methods. The weighted average method was used because according to Ross (1995) this method is computationally faster and easier and gives fairly accurate result.

The method works by calculating the final score (crisp value) as follows

$$\boldsymbol{score} = \sum \mathbf{U}\boldsymbol{r}.\boldsymbol{x} \,/\, \sum \mathbf{U}\boldsymbol{r}$$
…………………………………………………………....(5)

Where $\boldsymbol{u_r}$ is the degree of membership and **x** is the centre value parameters of ***Gaussian fuzzy membership function.***

3.4 System Development Methodology

According to Somerville (2007) there are several process paradigms that may be used in the development of the systems. They include waterfall models, evolution development and component based software engineering methods. The waterfall model delivers a system by following the process of requirements analysis, system software design, implementation and unit testing, integration and system testing and operation and maintenance. The phases begin each after the other and the time constraints may be experienced since documentation is available at every phase. The other disadvantage is that it may be difficult to respond to changing customer requirements.

Sommervile (2007) also notes that evolutionary development based on an idea of developing an initial implementation exposing the user to user comments and refining it through many versions until an adequate system has been developed. Component based software engineering involves people working on a project and finding a code to modify and incorporate it into the project.

The paradigm that was suitable for the project is a paradigm that is geared towards producing an accelerated delivery of a project and the user also engages in the system. The requirement of the system are already known since a new system is not being developed but a modification of the system is made so as to incorporate students comments in developing the system because it has the following advantages: it has improved system usability, a closer match for the system to the user needs, improved design quality, improved maintainability and a reduction in the development effort.

Prototyping methodology was used in developing the system. According to Pressman (2005) Prototyping is one of the evolutionary process models that is used when the system requirements of the system are well defined but the details of the product or system extensions have yet to be defined. Prototyping is iterative in nature and enables software developers to develop increasingly more complete versions of the software.

Presman (2005) also notes that prototyping paradigm assists the software engineer and the customer to better understand the end result of the software when the requirements of the system are fuzzy.

The diagram below shows the Prototyping process.

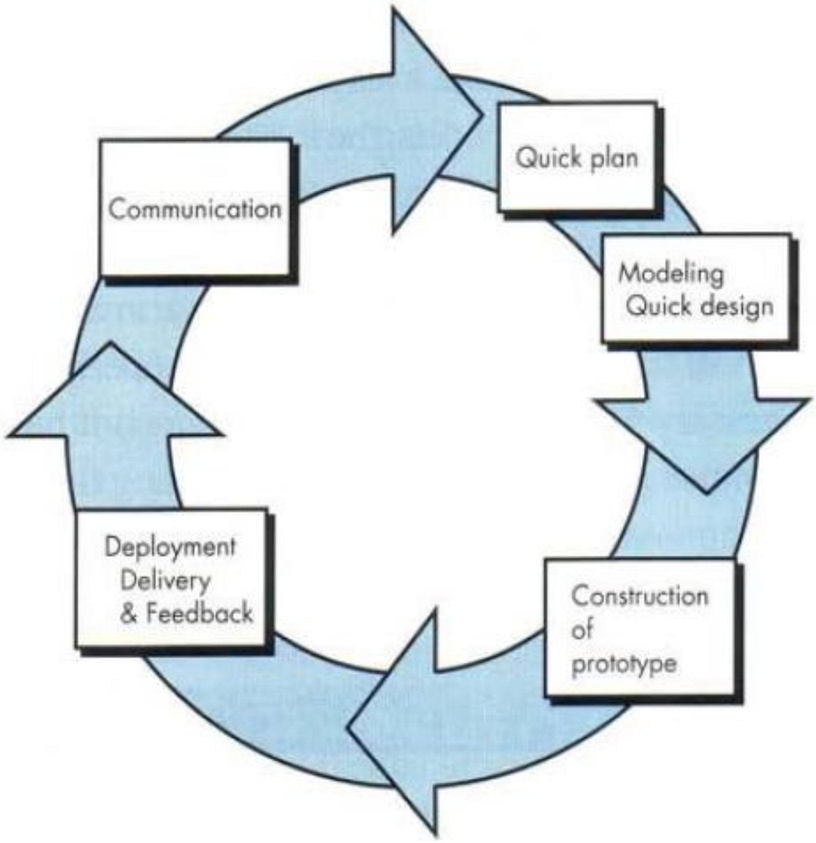


Figure 18: Prototyping Methodology (Source: Pressman, 2005)

Prototyping begins with communication the engineer communicates the overall objectives of the software identity whether requirements and outline areas or whether other definitions that enable the software development to succeed need to be defined. A prototype is then modelled in the form of a quick design. Pressman (2005) also notes that those aspects of the software that are visible to the customer. Feedback from the user will then be used to develop another prototype that is an improvement of the previous until the final software that satisfies the user is reached.

3.5 System modelling and development tools

Various software development tools were used to develop the system. The following visual basic 6.0 components are used; Microsoft ADO data control 6.0, Microsoft data bound grid control 5.0, Microsoft data bound list controls 6.0, Microsoft datagrid control 6.0 and Microsoft hierarchical flexigrid control 6.0. The degree of membership is calculated by the use of Database Grid and Microsoft ActiveX Data Objects ADO data control. The ADO data control is designed to create a connection to a database using (ADO). At design time, a connection string is created. **RecordSource** property is set to the database manager.

To retrieve reports data environment property is used to get commands and connections to the database. SQL statement builder is used to retrieve records according to the desired criteria. The package and deployment wizard is used to package the software.

3.6 Ethical considerations

The researcher asked for permission to conduct the research from the Ministry of higher Education Science and Technology and the principal of Kaiboi Technical Training Institute. Students' marks were not attributed to any students but to an entity student1. The training data were generated from past records but were not attributed to any student.

Confidentiality was also maintained in line with KTTI and Moi University rules and regulations.

3.7 Chapter Summary

The chapter has dealt with research design, variables in the study, sampling techniques and sample size. The chapter has also dealt with data modelling and system development methodology. Ethical considerations are also discussed in the chapter. The next chapter deals with how data is analyzed to get a membership function. Fuzzy if –the-rules is then be determined for the various comments. The degree of membership of the numeric grades to the linguistic variables in the membership function is also be determined.

CHAPTER FOUR

DATA MODELLING

4.0. Introduction

The chapter deals with the development of the membership function, determining grades using the membership function and converting students' grades to a linguistic variable.

4.1 Membership Function

The comments given by the lecturers and the number of instances that they were given by the lecturers to the students are given in **Table 4.**

Table 3: Linguistic variables frequency of use

Linguistic Variable	Instances
AIM HIGHER	36
AVERAGE	27
CAN DO BETTER	4
EXCELLENT	13
FAIL	13
FAIR	53
GOOD	187
IMPROVE	67
KEEP IT UP	40
V. GOOD	98
WEAK	9
WORK HARDER	40

To get a membership function the comments given by the lecturers and the marks were recorded from academic report cards of 97students. The data was then analyzed to give the following parameters of a ***Gaussian distribution***: the mean and standard deviation. The parameters of ***Gaussian fuzzy numbers*** are then calculated by having lower boundary minus two standard deviations while centre is the mean and the upper boundary is the mean plus two standard deviations as it covers 95% of the sample population. Research done by Al-Hamadi and Milne (2003) shows that the Gaussian distributions parameters produced the least mean square error. The parameters of the Gaussian distribution are shown in the **Table 5.**

Table 4: Parameters of Gaussian distribution

Linguistic Variable	**Parameters of a Gaussian Distribution**		**Parameters of Membership Function**		
	Mean	**Standard Deviation**	**Lower boundary**	**Centre**	**Upper Boundary**
AIM HIGHER	52.25	10.02	32.21	52.25	72.29
AVERAGE	55.67	3.27	49.13	55.67	62.21
CAN DO BETTER	58	0	58	58	58
EXCELLENT	83	4.24	74.52	83	100
FAIL	22	10.15	1.7	22	42.3
FAIR	55.75	6.86	42.03	55.75	69.47
GOOD	68.21	7.85	52.51	68.21	83.91
IMPROVE	41.73	5.91	29.91	41.73	53.55
KEEP IT UP	67.33	8.33	50.67	67.33	83.99
V. GOOD	79.86	5.95	67.96	79.86	91.76
WEAK	44	0	44	44	44
WORK HARDER	39.56	16.34	6.88	39.56	72.24

The ***fuzzy membership function*** generated had many linguistic variables having the same numerical scores. It was noted that there are numerical scores sharing different linguistic variables. To determine the points ***a, b, c*** and ***d*** so as to make the fuzzy membership function linear the points ***a, b, c*** and ***d*** are determined such that ***a*** is the lower limit of the linguistic variable ***b*** is the lower limit of the linguistic variable that is more than the mean of the current linguistic variable.

If the current linguistic variable is given by V_1, and the mean by μ_n, lower Limit by L_1 then the upper linguistic variable is determined such that $b > \mu_n \leq c$ the lower variable is determined as $a > \mu_{n-1} \leq \mu_n$. The upper and the lower linguistic variables then are determined using the formula above as shown in **Table 6.**

Table 5: Upper and Lower Variables of the Linguistic Variables

Linguistic Variable				
	Mean	**Standard Deviation**	**Lower Variable**	**Upper Variable**
FAIL	22	10.15	0	Improve
WORK HARDER	39.56	16.34	6.88	Aim Higher
IMPROVE	41.73	5.91	29.91	Aim Higher
WEAK	44	0	44	44
AIM HIGHER	52.25	10.02	Fail	Good
AVERAGE	55.67	3.27	Improve	Fair
FAIR	55.75	6.86	Improve	V.Good
CAN DO BETTER	58	0	58	58
KEEP IT UP	67.33	8.33	Average	V. Good
GOOD	68.21	7.85	Average	V. good
V. GOOD	79.86	5.95	Aim Higher	Excellent
EXCELLENT	83	4.24	Good	100

Table 6: Linguistic variables and limits a, b, c and d

Linguistic Variable	**a**	**b**	**c**	**d**
FAIL	0	0	29.91	42.3
WORK HARDER	6.88	6.88	32.21	72.24
IMPROVE	29.91	29.91	32.21	53.55
WEAK	44	44	44	44
AIM HIGHER	32.21	42.3	52.51	72.29
AVERAGE	49.13	53.55	55.75	62.21
FAIR	42.03	53.55	67.33	69.47
CAN DO BETTER	58	58	58	58
KEEP IT UP	50.67	62.21	67.96	83.99
GOOD	52.51	62.21	67.96	83.91
V. GOOD	67.96	72.29	74.52	91.76
EXCELLENT	74.52	83.91	83.91	100

4. 2 . Determination of Degree of Membership

The formula below was used to calculate the degree of membership according to the rules of ***Trapezoidal membership function.***

$$\mu(x) = \begin{cases} 0 & \text{if } x \le a, \\ w_1 \frac{x-a}{b-a} & \text{if } a \le x \le b, \\ 1 & \text{if } b \le x \le c, \\ w_2 \frac{d-x}{d-c} & \text{if } c \le x \le d, \\ 0 & \text{if } d \le x. \end{cases}$$

…………………………(3).

4.2.1 Fuzzy if-Then Rules

If linguistic variable is ***fail*** then

$\mu(x)$ =

0 if $x \leq 0$, = 1 if $x \leq 29.91$, . = $(42.3\text{-}x)/42.3\text{-}29.1$ if. $29.91 \leq x \leq 42.3$, = 0 if $x \geq 42.3$

If linguistic variable is ***improve*** then

$\mu(x)$ =

0 if $x \leq 29.91$, = 1 if $29.91 \leq x \leq 32.21$, = $(53.55 \text{-}x)/53.55\text{-}29.91$ if. $29.91 \leq x \leq 53.55$, = 0 if $x \geq 53.55$

If linguistic variable is ***fair*** then

$\mu(x)$ =

0 if $x \leq 42.3$, = $(x\text{-}42.3)/(53.55\text{-}42.03)$, if $42.3 \leq x \leq 53.55$ =1 if $53.55 \leq x \leq 67.33$, = $(69.47\text{-}x)/(69.47\text{-} 67.33)$ if $67.33 \leq x \leq 69.47$. = 0 if $x \geq 69.47$.

If linguistic variable is ***work harder***

$\mu(x)$ =

0 if $x \leq 6.88$, = $(x\text{-}6.88)/(6.88\text{-}6.88)$, if $6.88 \leq x \leq 32.21$ =1 if $6.88 \leq x \leq 32.21$, = $(72.24\text{-}x)/(72.24\text{-} 32.21)$ if $32.21 \leq x \leq 72.24$. = 0 if $x \geq 72.24$.

If linguistic variable is ***weak***

$\mu(x)$ =

0 if $x \leq 44$, =1 if $x = 44$, =0 if $x \geq 44$.

If linguistic variable is ***aim higher***

$\mu(x)$ =

0 if $x \leq 32.21$, = $(x\text{-}32.21)/(42.3\text{-}32.21)$, if $42.3 \leq x \leq 53.51$, =1 if $42.3 \leq x \leq 53.51$ = $(72.29\text{-}x)/(72.29\text{-} 53.51)$ if $53.51 \leq x \leq 72.29$. = 0 if $x \geq 72.29$.

If linguistic variable is ***average***

$\mu(x) =$

0 if $x \leq 49.13$, $= (x-49.13)/(53.55-49.13)$ if $49.13 \leq x \leq 53.55$. $=1$ if $53.55 \leq x \leq 55.75$ $= (55.75-x)/(72.29- 53.51)$ if $53.51 \leq x \leq 72.29$. $= 0$ if $x \geq 72.29$.

If linguistic variable is ***fair***

$\mu(x) =$

0 if $x \leq 42.03$, $= (x- 42.03)/(53.55-42.03)$ if $42.03 \leq x \leq 53.55$. $=1$ if $53.55 \leq x \leq 67.33$, $= (69.47-x)/(69.47- 67.33)$, if $67.33 \leq x \leq 69.47$. $= 0$ if $x \geq 69.47$.

If linguistic variable is ***keep it up***

$\mu(x) =$

0 if $x \leq 50.67$, $= (x- 50.67)/(62.21-50.67)$ if $50.67 \leq x \leq 62.21$. $=1$ if $62.21 \leq x \leq 67.96$, $= (83.99-x)/(83.99- 67.96)$, if $67.96 \leq x \leq 83.91$. $= 0$ if $x \geq 83.99$.

If linguistic variable is ***Good***

$\mu(x) =$

0 if $x \leq 52.51$, $= (x- 52.51)/(62.21-52.51)$ if $52.51 \leq x \leq 62.21$. $= 1$ if $62.21 \leq x \leq 67.96$, $= (83.91- x)/(83.91- 67.96)$, if $67.96 \leq x \leq 83.91$. $= 0$ if $x \geq 83.91$.

If linguistic variable is ***V. Good***

$\mu(x) =$

0 if $x \leq 67.96$, $= (x- 67.96)/(72.29-67.96)$ if $67.96\leq x \leq 72.29$. $= 1$ if $72.29 \leq x \leq 74.52$, $= (91.76- x)/(91.76- 74.52)$, if $74.52 \leq x \leq 91.76$. $= 0$ if $x \geq 91.76$.

If linguistic variable is ***Excellent***

$\mu(x) =$

0 if $x \leq 74.52$, $= (x- 74.52)/(83.91-74.52)$ if $74.52\leq x \leq 83.91$. $= 1$ if $83.91 \leq x \leq 83.91$, $= (100- x)/(100- 83.91)$, if $83.91\leq x \leq 91.76$. $= 0$ if $x \geq 100$

4.3 Calculating of numerical mark

To get the numerical mark (defuzzification), the weighted average defuzzification technique was used. In this method the output is obtained by the weighted average of the each output of the set of rules stored in the knowledge base of the system. The weighted formula is given as:

$score = \sum \mathrm{U}x.x \,/\sum\mathrm{U}x$……………………………………………….(5)

Where $\sum \mathrm{U}x.x$the sum of the membership degree is multiplied by the numerical score and $/\sum\mathrm{U}x$ is the sum of membership degree for all the linguistic variables.

For example given the following sample results shown in **Table 8 and 9**.

Table 7: Student training data 1

Subject	**Numerical Score**	**Comment**
Information systems	62	Fair
Introduction to computers	68	Fair
Computer applications	78	V. Good
Entrepreneurship	93	V. good
Communication skills	88	V. good
PPM	55	Fair

μ(x) for the first linguistic variable ***fair*** is

= 1 since b ≤ X≤ c

μ(x) for the second linguistic variable ***fair*** is

(69.47-68)/69.47-67.33)= 0.687

μ(x) for the third linguistic variable ***V. good***

91.76 – 78/(91.76-74.52)= 0.7981

μ(x) for the fourth subject linguistic variable ***V. good***

=0 since x>91.76

μ(x) for the fifth subject linguistic variable ***V. good***

=(91.76-88)/(91.76-74.52) = 0.218

μ(x) for the sixth subject linguistic variable ***fair***

= 1 since b ≤ X≤ c

To determine the numerical grade

= 62 +0.687*68+0.7981*78+0+0.218*88+55/3.1081

= 245.154/3.7031

= 66.20

The average when using only numerical scores would have been 74 fuzzy logic now makes the score 66.20

For another student with the following marks:

Table 8: Student training data 2

Subject	**Numerical score**	**Comment**
Maths	13	Fail
TT	35	Work harder
IOM	35	Work harder
TD	42	Improve
Science	40	Improve

The degree of membership is calculated as:

μ(x) for the first subject variable ***fail*** will be

= 1

$\mu(x)$ for the second and third subject's variable ***work harder*** is

(72.24-35)/(72.24-32.21) = 0.98

$\mu(x)$ for the fourth subject linguistic variable ***improve*** is

(53.55-42)/(53.55-32.21) = 0.514

$\mu(x)$ for the fourth subject linguistic variable ***improve*** is

(53.55-40)/(53.55-32.21) = 0.635

The numerical score

= 13+35*0.98+35*0.98+42*0.514+40*0.635/(1+0.98+0.98+0.514+0.635)

= 128.588/(4.109)

= 31

= 31. The numerical average would have been 33 but the use of fuzzy logic makes the numerical score ***31.***

4.4 Modelling fuzzy sets to linguistic variable

The current grades given to students are given as shown in **Table 10.**

Table 9: Grading System

GRADE	MARKS	
1	80-100	Distinction
2	75-79	Distinction
3	70-74	Credit
4	60-69	Credit
5	50-59	Pass
6	40-49	Pass
7	35-39	Refer
8	30-34	Refer
9	0-29	Fail

In order to model the linguistic variables to produce a membership function, the dominant linguistic variables used by the lecturers as per *Table 5* was modelled using the *Gaussian distribution* so as to obtain a *Trapezoidalr membership* function that does not overlap in shape. The variables of the *Gaussian distribution* are shown in *Table 12* below.

Table 10: Dominant linguistic variables

COMMENT	**MEAN**	**a**	**SD**	**b**
V.GOOD	79.9	70.9	6.0	88.8
GOOD	68.2	59.3	7.9	77.1
IMPROVE	41.7	32.8	5.9	50.7
FAIR	55.8	46.8	6.9	64.7
AVERAGE	55.7	46.7	3.3	64.6
WORK HARDER	39.6	30.6	16.3	48.5

In order to determine the membership function for the data, the means of the linguistic variables plus or minus one standard deviation is calculated as shown in **Table 11** above.

4.5 Chapter Summary

The chapter has dealt with how the data is analyzed by using a ***Gaussian distribution*** to get limits that creates a ***Trapezoidal membership function***. Fuzzy if then rules are then determined for the various comments. The degree of membership of the numeric grades to the linguistic variables in the membership function is calculated. Overall numerical mark is also determined for the individual student. A membership function that determines the overall comment of the student is modelled.

CHAPTER FIVE

SOFTWARE DEVELOPMENT

5.0 Introduction

The chapter deals with software development using prototyping methodology. The methodology involves four stages that include communication, formulation of a quick plan and modelling the decision, construction of the prototype and finally development and feedback.

5.1 General Objectives of the System

The system so developed should be able to do the functions that the current system does and also add the comments based on the fuzzy if-then else rules developed in chapter four. So the general objectives of the system were:

- To develop a system that calculates the degree of membership for the numerical scores to the comments given.
- To develop a system that incorporates marks and comments in the final student's grade.
- To develop a system that gives comments to students basing on the performance of the students.
- To develop a system that produces a report card for the students.

5.2 Modelling and Quick Design

The section deals with the design tools used in designing the system.

5.2.1 Database Design

The study used an extended entity relationship diagram to show how the entities relate.

5.2.1.1 Extended Entity Relationship Diagram

The extended entity relationship diagram shows the relationship between entities and attributes.

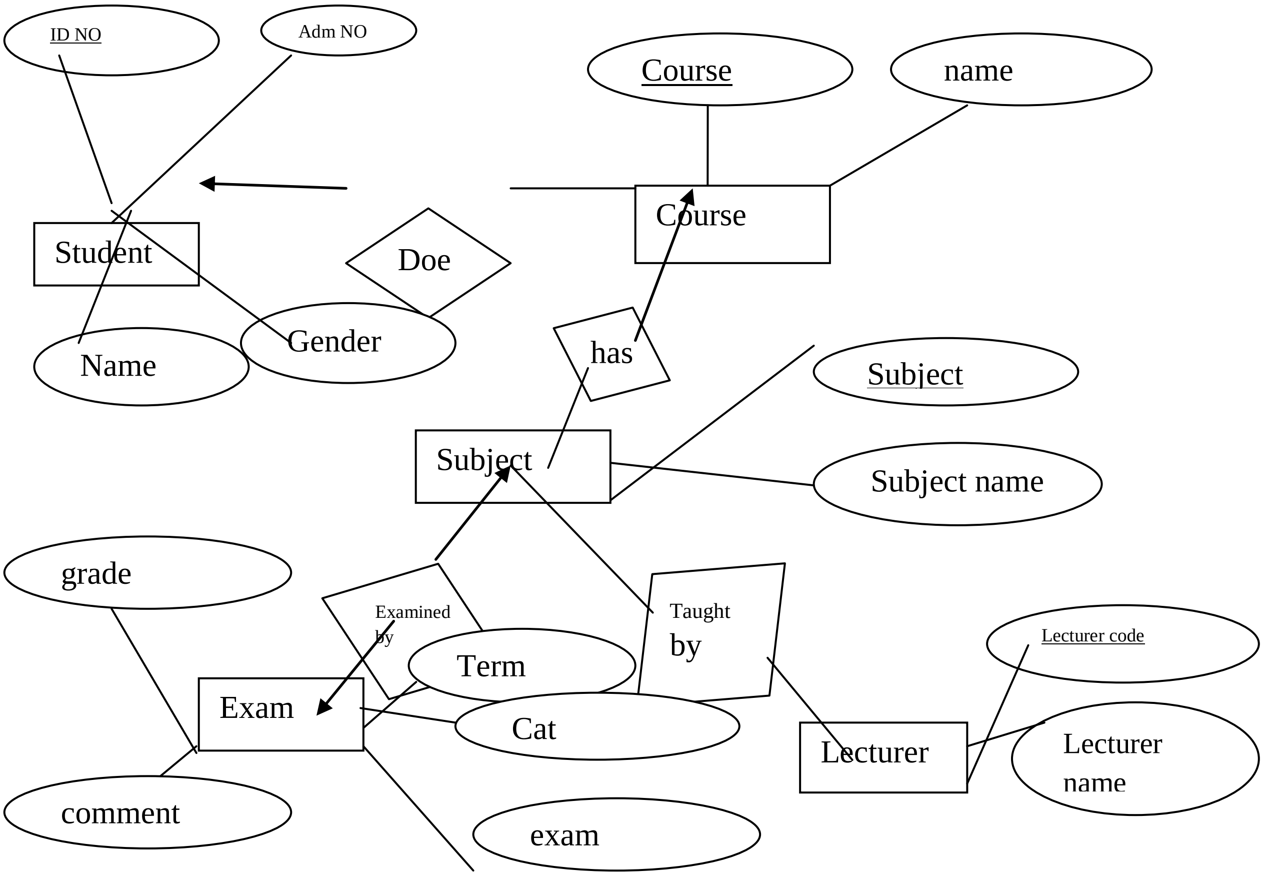


Figure 19: EER Diagram

5.2.2 Input Design

The input to the system consists of students' particulars like name, Adm No, performance in CATs and Exams, attendance in percentage and the comments given. The details can be entered in a form shown in **Figure 20** below.

Course				**Subject**		
Student name	**Adm No**	**Cats**	**Exam**	**Total**	**% Att**	**Comments**

Figure 20: Input Design

5.2.3 Output Design

Output from the system consists of a report from like the one shown below in ***Figure 21.***

KAIBOI TECHNICAL TRAINING INSTITUTE

REPORT CARD

NAME: ________________________________ ADM. NO ______________________________

COURSE: CLASS:

SUBJECT NAME	MARKS			GRAD E	% ATT	COMMEN T	INITIAL S
	CA T	EXAM	TOA L				

OVERALL COMMENT ______________________________

OVERALL GRADE ________________________________

5.3 System Modules

The system developed has the following modules

- Login (user authentication)
- Student registration

- Institute parameters entry
- Degree of membership calculation
- Student final mark calculation
- Grade determination
- Report generation.

Login (user authentication)

The system can be used by many users to enter data. The users of the system at KTTI total to about 80 members of staff. Each user will be required to enter a user name and password which is compared with the database; if the user is authentic he /she is given access to the system.

Student Registration.

Details of the student namely: name, admission number, course, date of birth, gender, address, telephone number, county, parent, and date of admission are entered in the students' entry module.

Institute Parameters Entry.

Institutes parameters like the term, courses, and subjects in each course, lecturers particulars are entered in input forms.

Degree of Membership Calculation

The degree of membership is calculated by the use of Database Grid and Microsoft ActiveX Data Objects ADO data control.. The ADO data control is designed to create a connection to a database using (ADO). At design time, a connection string is created. **RecordSource** property is set to the database manager.

According to Holzner (1998), the data control enables movement around in a database from record to record and to display and manipulate data from the records in bound controls. This control displays a set of arrow buttons that can be manipulated to move through a database, and the records from that database are displayed in bound controls.

Data access can be done in the data control with writing of a few lines of code. Data-bound controls automatically display data from one or more fields for the current record, and the data control performs all operations on the current record. If the data control is made to move to a different record, all bound controls automatically pass any changes to the data control to be saved in the database. The data control then moves to the requested record and passes back data from the current record to the bound controls where it's displayed. When an application begins, Visual Basic uses data control properties to open a selected database.

In the project the connection sample code shown below is used.

```
Private Sub Form_Load()
Dim rs As Recordset
Set db = OpenDatabase("C:\Documents and Settings\User\My
Documents\sql3")
Set rs = db.OpenRecordset("exam")
rs.Edit
End Sub
```

Is used to connect to the database SQL3 which is the database holding the project database.

Fuzzy if then rules were then implemented in visual basic as follows:

If linguistic variable is V. Good

$\mu(x) = 0$ if $x \leq 67.96$, $= (x- 67.96)/(72.29-67.96)$ if $67.96 \leq x \leq 72.29$. $= 1$ if $72.29 \leq x \leq 74.52$, $= (91.76- x)/(91.76- 74.52)$, if $74.52 \leq x \leq 91.76$. $= 0$ if $x \geq 91.76$.

the implementation in visual basic code is done as:

```
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"0 where [comment]= 'v.good'And [totalnumerical]<=
67.96")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"([totalnumerical]-67.96)/(72.29-67.96) where [comment]=
'v.good'And [totalnumerical]>= 69.96 and
[totalnumerical]<= 72.29")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"1 where [comment]= 'v.good'And [totalnumerical]>= 72.29
and [totalnumerical]<= 74.52")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"(91.76-[totalnumerical])/(91.96-74.52) where [comment]=
'v.good'And [totalnumerical]>= 74.52 and
[totalnumerical]<= 91.76")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"0 where [comment]= 'v.good'And [totalnumerical]>=
91.76")
```

Where exam is the database table name and membership degree is a field in the exam table. The representation of the other comments' is presented on **Appendix 2.**

Student final mark calculation

The student's final mark was calculated form the subject entries. The sum of all the total marks multiplied by the membership function is calculated and divided by the total membership function using the code below.

```
Dim i As Integer
Dim x As Integer
Dim z As Integer
Dim totmembership As Double
Dim TOTALMEMBERSHIP As Double
Dim TOTALMARK As Double
Dim comment As String
Dim overalcomment As String
TOT = 0
totmembership = 0
TOTALMARK = 0
For i = 0 To ENTRY.ApproxCount - 1
ENTRY.Row = i
ENTRY.Col = 7
TOT = Val(TOT) + Val(ENTRY.Text)
Next i
For c = 0 To ENTRY.ApproxCount - 1
ENTRY.Row = c
ENTRY.Col = 6
TOTALMEMBERSHIP = Val(TOTALMEMBERSHIP) + Val(ENTRY.Text)
Next c
Text1.Text = TOT
```

```
Text2.Text = TOTALMEMBERSHIP
If Val(TOTALMEMBERSHIP) > 0 Then
Text3.Text = Val(TOT) / Val(TOTALMEMBERSHIP)
Else
Text3.Text = 0
End If
End sub
```

Grade Determination

Grade of the student is determined as per **Table 11**. And the resulting grade is displayed.

Report Generation.

Various reports are generated from the system and the most important is the report card shown in **Figure 19**.

5.4 System Output

The objectives of the system were to develop a system that calculates the degree of membership for the numerical scores to the comment given. The system designed provided membership degree as calculated in the training data of **Table 9** and **Table 10**.

The second objective of the system was to develop a system that incorporates marks and comments in the final student grade. The output in the **Figure 22** below shows an intergraded average of **66.02** that incorporates comments and numerical score, the numerical average of **74** is for only the numerical marks. The third objective is to develop a system that gives comments basing on the performance of the students, the output in **Figure 22** shows a comment of good. The system then can be said to have achieved the objectives set out.

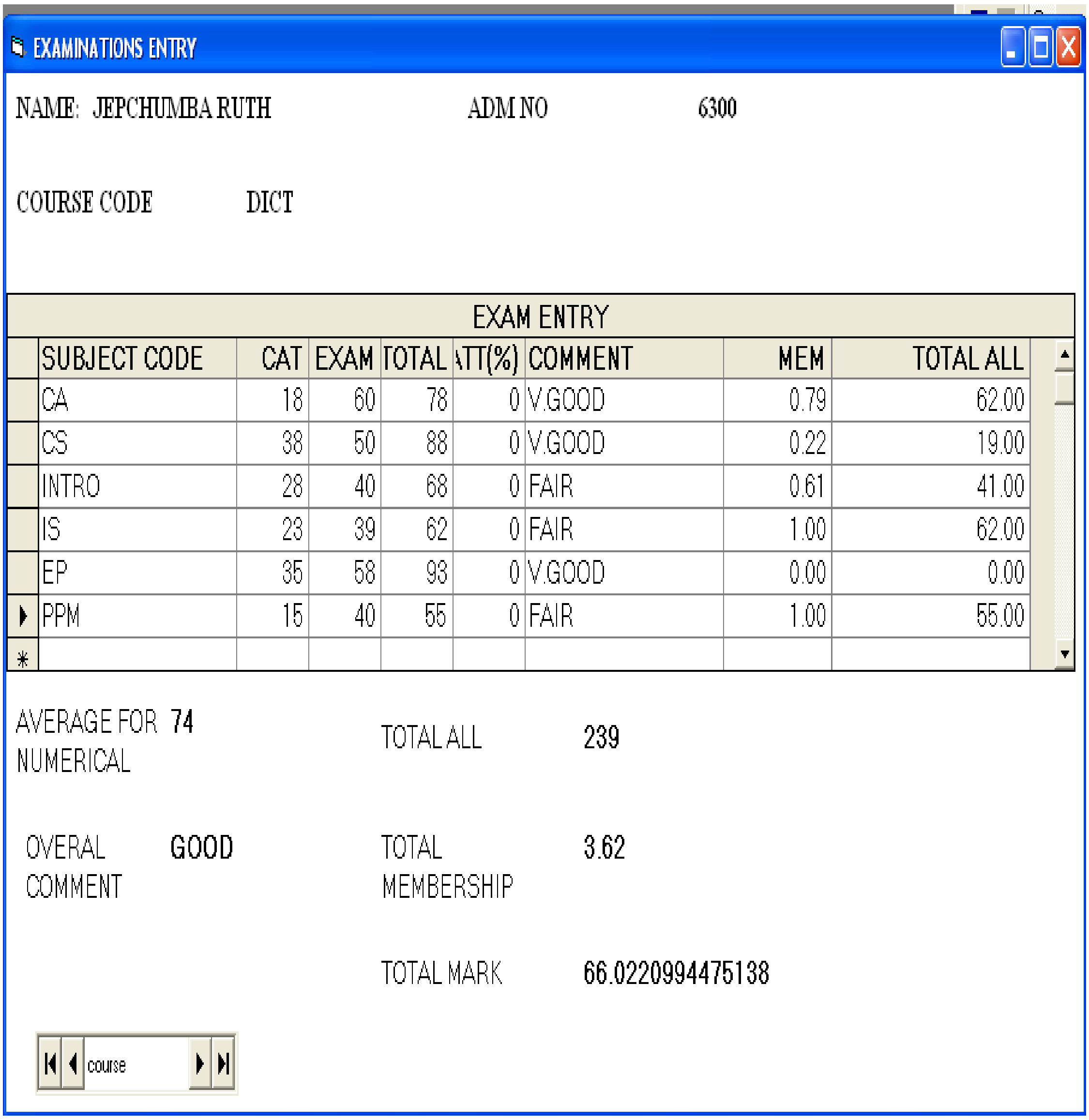
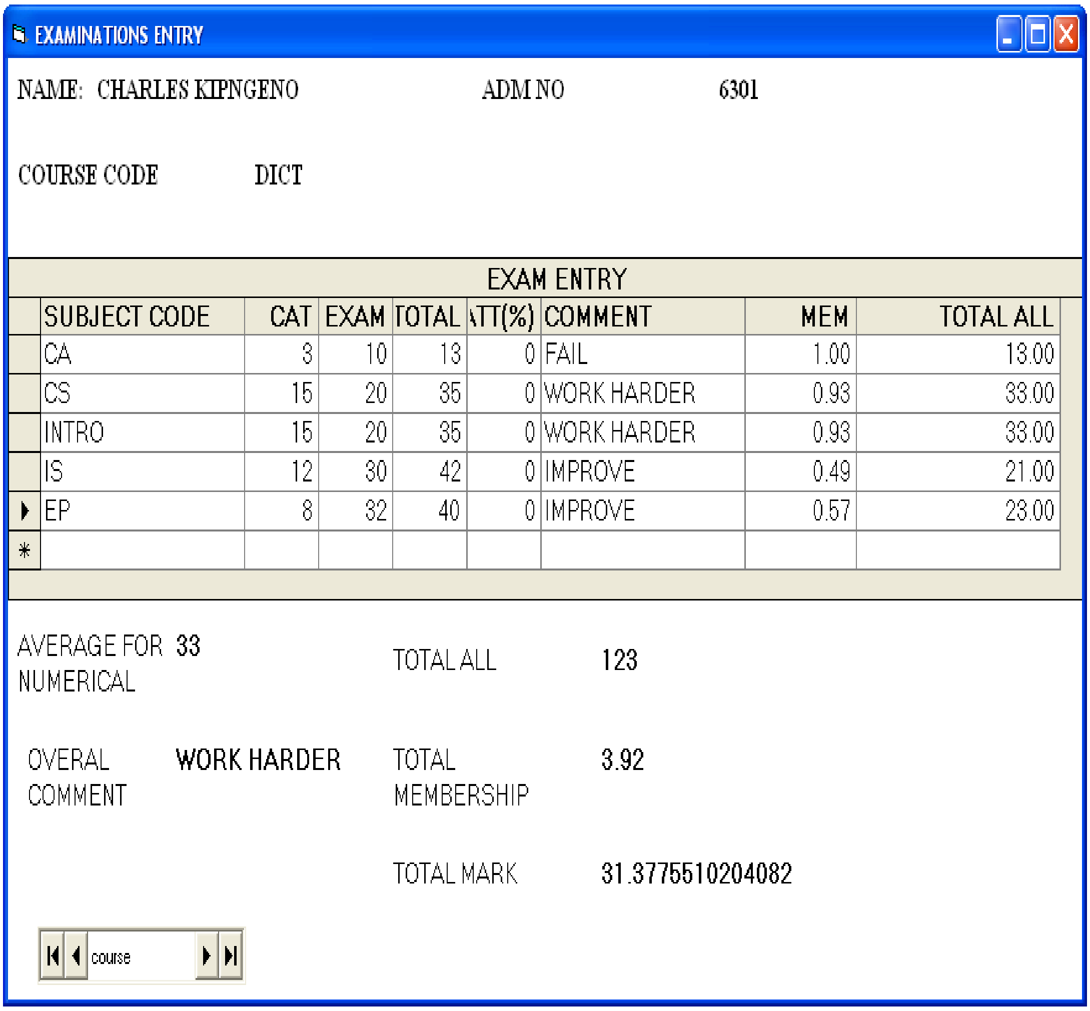


Figure 20: Systems Output 1



EXAMINATIONS ENTRY

NAME: CHARLES KIPNGENO ADM NO 6301

COURSE CODE DICT

EXAM ENTRY

SUBJECT CODE	CAT	EXAM	TOTAL	ATT(%)	COMMENT	MEM	TOTAL ALL
CA	3	10	13	0	FAIL	1.00	13.00
CS	15	20	35	0	WORK HARDER	0.93	33.00
INTRO	15	20	35	0	WORK HARDER	0.93	33.00
IS	12	30	42	0	IMPROVE	0.49	21.00
EP	8	32	40	0	IMPROVE	0.57	23.00

AVERAGE FOR NUMERICAL 33

TOTAL ALL 123

OVERAL COMMENT WORK HARDER

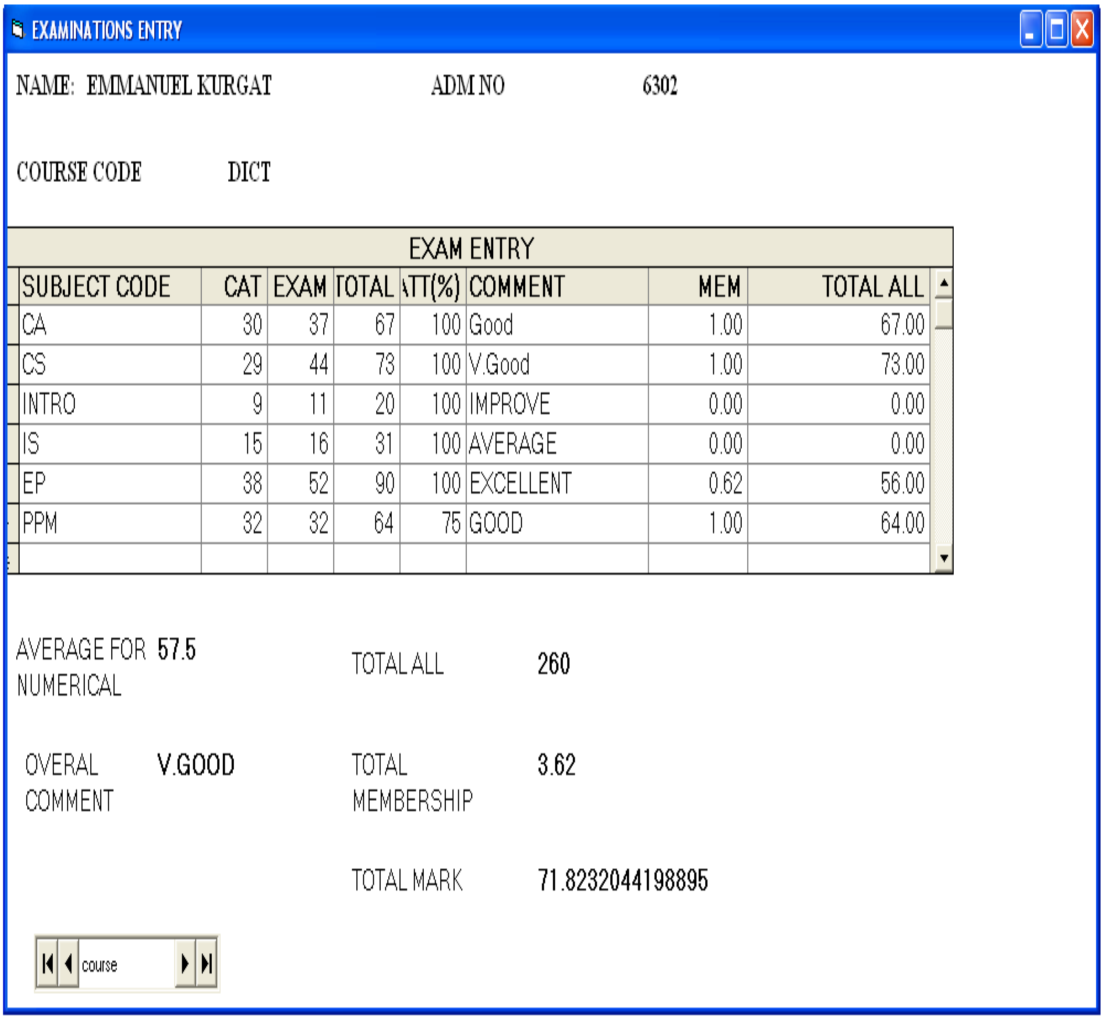
TOTAL MEMBERSHIP 3.92

TOTAL MARK 31.3775510204082

course

Figure 21: System output 2

Student's performance also may change positively if the preferred linguistic variables (Good, V.Good and Excellent) have a higher degree of membership as compared to the less preferred linguistic variables like (improve, weak, work harder, fail). As shown in the **Figure 24** below.



EXAMINATIONS ENTRY

NAME: EMMANUEL KURGAT ADM NO 6302

COURSE CODE DICT

EXAM ENTRY

SUBJECT CODE	CAT	EXAM	TOTAL	ATT(%)	COMMENT	MEM	TOTAL ALL
CA	30	37	67	100	Good	1.00	67.00
CS	29	44	73	100	V.Good	1.00	73.00
INTRO	9	11	20	100	IMPROVE	0.00	0.00
IS	15	16	31	100	AVERAGE	0.00	0.00
EP	38	52	90	100	EXCELLENT	0.62	56.00
PPM	32	32	64	75	GOOD	1.00	64.00

AVERAGE FOR NUMERICAL 57.5

TOTAL ALL 260

OVERAL COMMENT V.GOOD

TOTAL MEMBERSHIP 3.62

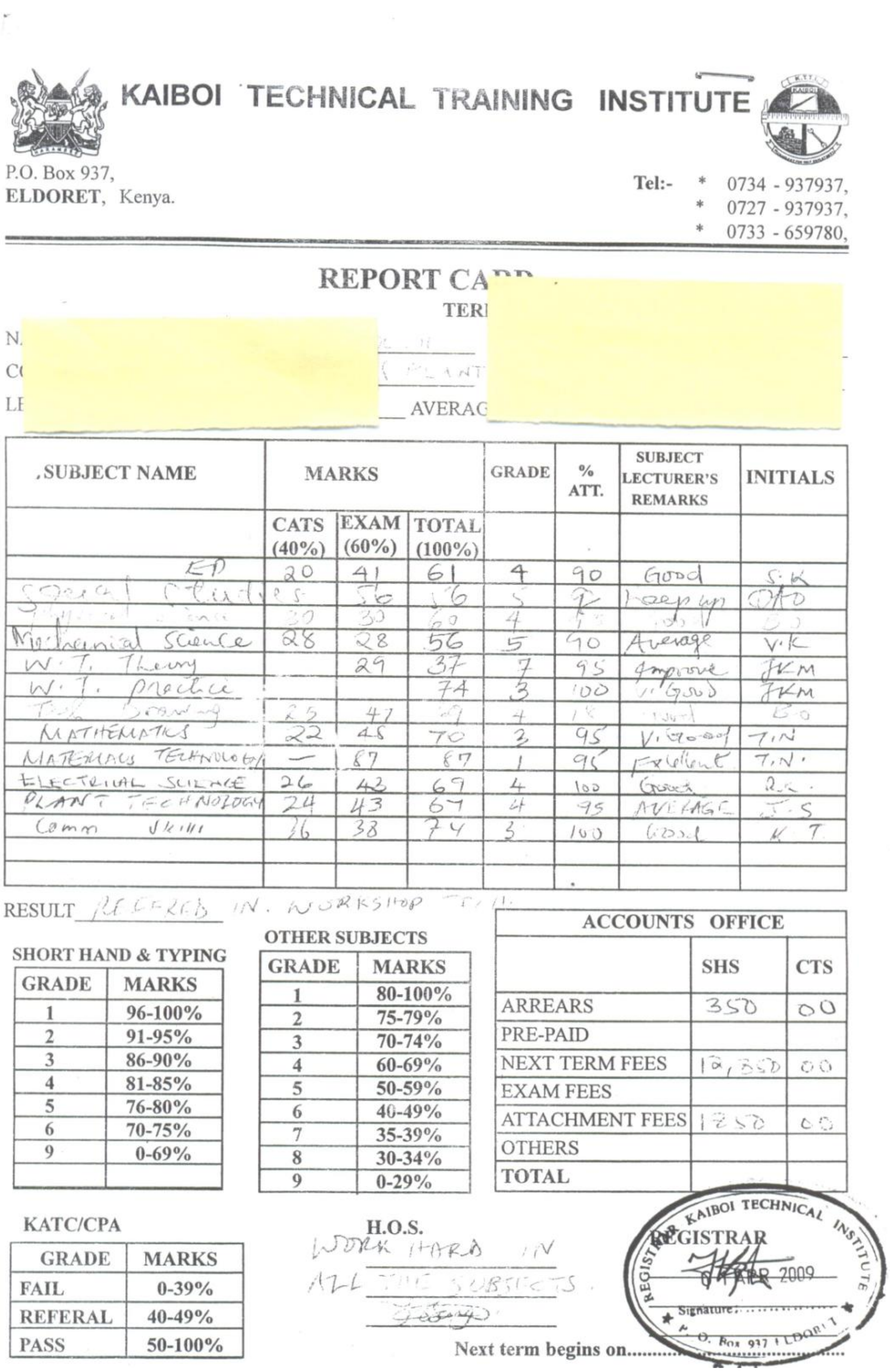
TOTAL MARK 71.8232044198895

course

Figure 22: Systems output 3

The numerical scores average is **57.5** yet the new mark that has the numerical variables input becomes **71** which is way above the **57.5** for the numerical average alone. This is important in determining students' performance especially in boundary points or where students tie in numerical scores.

Given a students report in the previous format as shown below in **Figure 26.**



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AVERAG

SUBJECT NAME	MARKS			GRADE	% ATT.	SUBJECT LECTURER'S REMARKS	INITIALS
	CATS (40%)	EXAM (60%)	TOTAL (100%)				
EP	20	41	61	4	90	Good	S.K
Special Studies		56	56	5	[illegible]	Keep up	[illegible]
[illegible] Science	30	30	60	4	[illegible]	Good	BO
Mechanical Science	28	28	56	5	90	Average	V.K
W.T. Theory		29	37	7	95	Improve	JKM
W.T. practice			74	3	100	V. Good	JKM
Tech Drawing	25	47	[illegible]	4	[illegible]	Good	BO
MATHEMATICS	22	48	70	3	95	V. Good	T.N
MATERIALS TECHNOLOGY	—	87	87	1	95	Excellent	T.N.
ELECTRICAL SCIENCE	26	43	69	4	100	Good	R.K.
PLANT TECHNOLOGY	24	43	67	4	95	AVERAGE	J.S
Comm Skills	36	38	74	3	100	Good	K T

RESULT REFERED IN. WORKSHOP T/T.

SHORT HAND & TYPING

GRADE	MARKS
1	96-100%
2	91-95%
3	86-90%
4	81-85%
5	76-80%
6	70-75%
9	0-69%

OTHER SUBJECTS

GRADE	MARKS
1	80-100%
2	75-79%
3	70-74%
4	60-69%
5	50-59%
6	40-49%
7	35-39%
8	30-34%
9	0-29%

ACCOUNTS OFFICE

	SHS	CTS
ARREARS	350	00
PRE-PAID		
NEXT TERM FEES	12,350	00
EXAM FEES		
ATTACHMENT FEES	1250	00
OTHERS		
TOTAL		

KATC/CPA

GRADE	MARKS
FAIL	0-39%
REFERAL	40-49%
PASS	50-100%

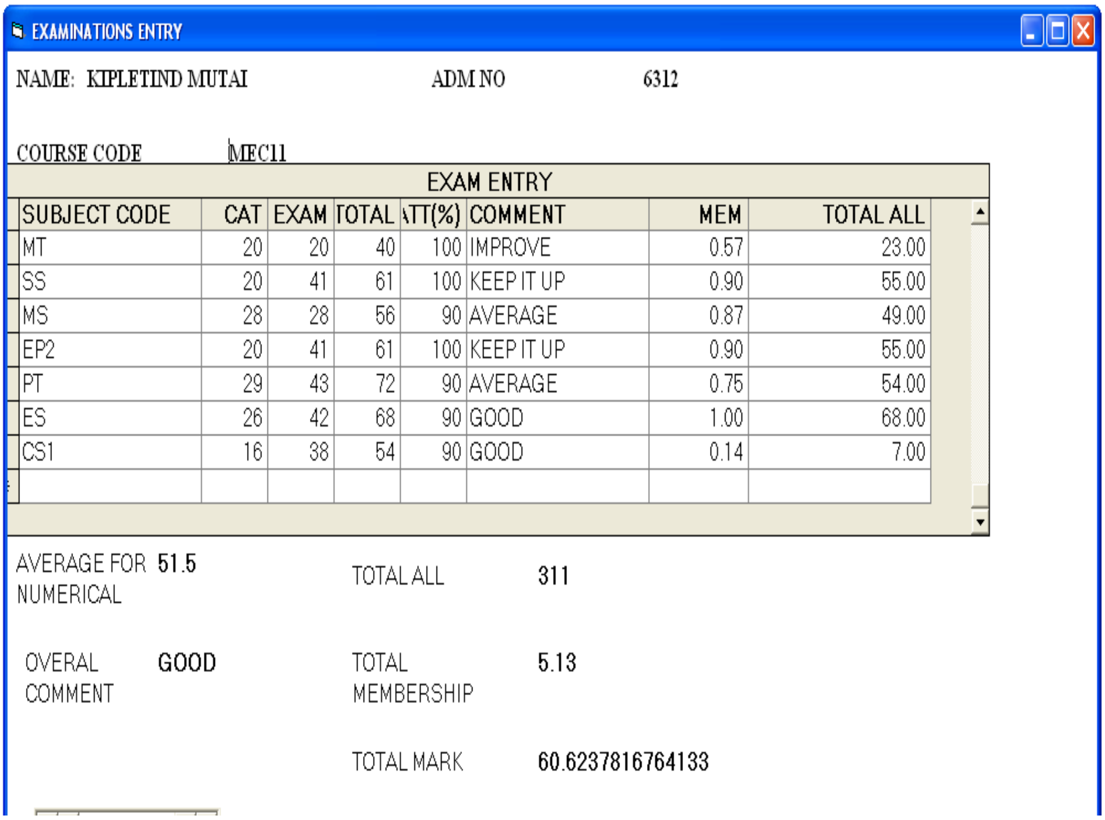
H.O.S.
WORK HARD IN ALL THE SUBJECTS.

REGISTRAR
KAIBOI TECHNICAL INSTITUTE
2009
Signature:
P.O. Box 937 ELDORET

Next term begins on..........

Figure 23: Previous Reports

The numerical score for the student is shown in the **Figure 27** below.



EXAMINATIONS ENTRY

NAME: KIPLETIND MUTAI ADM NO 6312

COURSE CODE MEC11

EXAM ENTRY

SUBJECT CODE	CAT	EXAM	TOTAL	ATT(%)	COMMENT	MEM	TOTAL ALL
MT	20	20	40	100	IMPROVE	0.57	23.00
SS	20	41	61	100	KEEP IT UP	0.90	55.00
MS	28	28	56	90	AVERAGE	0.87	49.00
EP2	20	41	61	100	KEEP IT UP	0.90	55.00
PT	29	43	72	90	AVERAGE	0.75	54.00
ES	26	42	68	90	GOOD	1.00	68.00
CS1	16	38	54	90	GOOD	0.14	7.00

AVERAGE FOR NUMERICAL 51.5

TOTAL ALL 311

OVERAL COMMENT GOOD

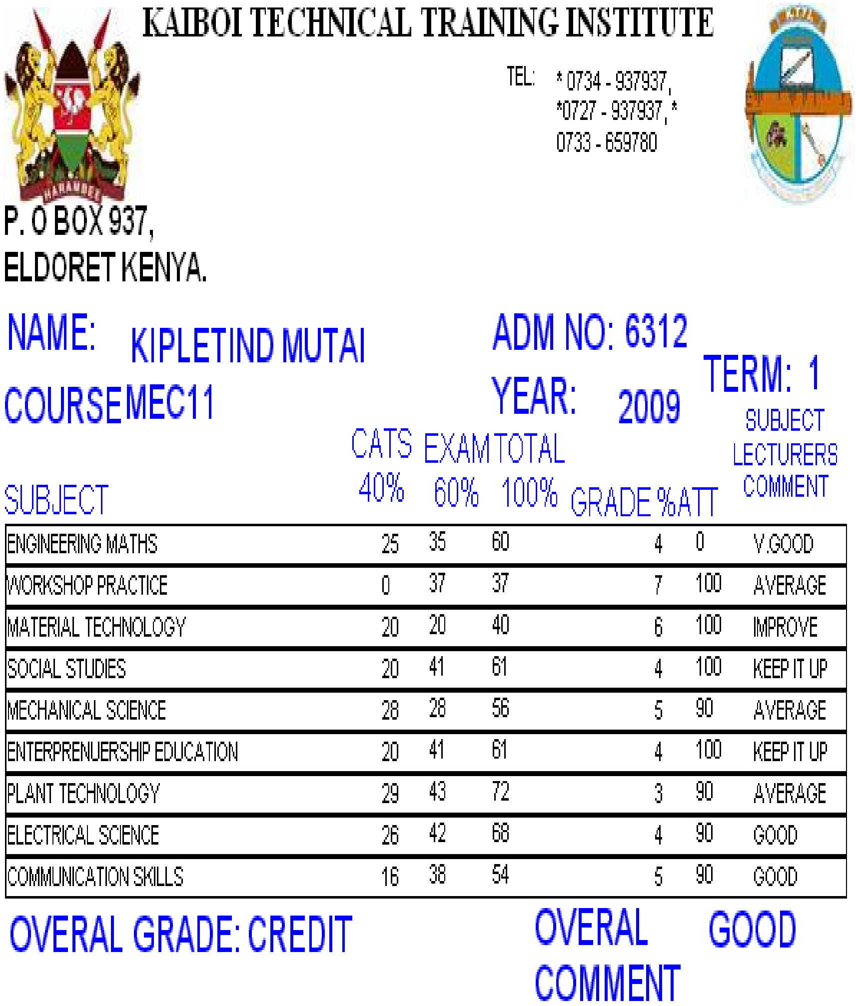
TOTAL MEMBERSHIP 5.13

TOTAL MARK 60.6237816764133

Figure 24: System Output 4

The output from the system when using the numerical score alone is **51.5** When comments are incorporated the score now becomes **60.62** with a comment of "GOOD".

The new output from the system looks like the one below.



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P. O BOX 937,
ELDORET KENYA.

NAME: KIPLETIND MUTAI ADM NO: 6312

COURSE MEC11 YEAR: 2009 TERM: 1

SUBJECT	CATS 40%	EXAM 60%	TOTAL 100%	GRADE	%ATT	SUBJECT LECTURERS COMMENT
ENGINEERING MATHS	25	35	60	4	0	V.GOOD
WORKSHOP PRACTICE	0	37	37	7	100	AVERAGE
MATERIAL TECHNOLOGY	20	20	40	6	100	IMPROVE
SOCIAL STUDIES	20	41	61	4	100	KEEP IT UP
MECHANICAL SCIENCE	28	28	56	5	90	AVERAGE
ENTERPRENUERSHIP EDUCATION	20	41	61	4	100	KEEP IT UP
PLANT TECHNOLOGY	29	43	72	3	90	AVERAGE
ELECTRICAL SCIENCE	26	42	68	4	90	GOOD
COMMUNICATION SKILLS	16	38	54	5	90	GOOD

OVERAL GRADE: CREDIT OVERAL COMMENT GOOD

Figure 25: Data Report 2

5.5 Chapter Summary

The chapter dealt with system design including EER diagram, input and output design, system modules of login, student registration, parameters entry, degree of membership calculation and student final mark calculation. The grade is determined and reports generated. The system output is also shown with system output of selected runs and reports.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.0 Conclusion

Fuzzy logic has been used to represent intermediate values that are defined between conventional linguistic statements like true/false or bad/good. Fuzzy logic has also been used in educational institutions to represent student performance in various ways. The use of comments and numerical scores is a new way of representing students' performance.

The study has shown that fuzzy logic can be used to represent student performance in terms of numerical scores and the comments given by the lecturer. The study has shown that the use of comments greatly reduce the dependency on numerical scores alone thus eliminating the drawbacks of numerical scores alone. The use of comments ensures that uncertain scores and measurement error are eliminated to some degree, the use of comments in examinations also ensures that the traditional statistical scores which are criterion referenced are added value by making them norm referenced.

The ***first objective*** of the study was to identify the current comments given by lecturers for classifying students' academic performance a sample of 97 students records were used and the comments given by the lecturers documented in **Table 5** and **Table 6.** The ***second objective*** was to model the data acquired so as to develop a membership function. The study has shown that a membership function can be developed from random comments given by examiners. The *Gaussian distribution* used in developing the membership function by adding two standard deviations to the mean of the comment means that **95%** of the comments are incorporated , this is a fair representation when developing the membership function. Al-Hammadi and Milne (2003) carried out a test to choose the membership function with the best mean square error, the *Gaussian distribution* as used in the study gave the best mean square error.

The ***third objective*** of the study was to use fuzzy logic to model the membership function generated to get a students final numerical grade. The study has shown that fuzzy ***if-then*** rules can be generated from the membership functions which were used to combine the comments and the statistical scores so as to give a numerical score that combines the two. The formula presented by Dombi (1986) was used to get a crisp value for the numerical score. The degree of membership was calculated using a formula also used by Nabadan (2002). The final score was calculated by using the formula used by Fourali (1994).

The ***fourth objective*** was to model fuzzy sets using a suitable membership function to determine a student's grade in linguistic variables. A membership function was also modelled and generated using the *Gaussian distribution* using the dominant linguistic variables giving a true representation of comments that are given by the instructors.

To ***fifth objective*** was to develop a system that uses fuzzy logic to measure student's performance. Visual basic 6.0 was used to generate scores for students' minimizing computational work of the lecturers.

The fuzzy method modelled in chapter four agrees with the criteria developed by Johanyak (2009) as criteria for comparing of fuzzy evaluation methods that are: the method should not increase the time needed for assessment. Comments have always been given with examination marks so the time for assessment remains the same. The second criteria is the method developed should help the grader express vagueness in opinion, this is the major strength with the method developed because vagueness in form of linguistic variables (comments) is dealt with. The third criteria is it should ensure fair grading and the final grade should be expressed in final total score or percentage. The system developed gives the final average mark as well as the final grade. The other criteria is that it should be implementable in software development terms which has been done and the trial runs presented in **figure 16** and **17.** The software can calculate the degree of membership, combine the marks and comments to a numerical score, give comments basing on students performance and produce a report card.

The research into the use of comments to represent a numerical score shows that traditional ways of representing scores of students that are fuzzy in nature can be represented in comments and not necessarily in numerical scores. The comments can then be used to represent scores of students in numerical terms.

The study is very significant in that it can be used to measure performance is situations that numerical scores are not quite defined like seminar presentations, interviews, students' participation in an activity, soft skills like networking, readiness to learn and ability to take instructions can be represented in comments by the examiner and the results can be presented in a numerical score.

6.1 Recommendations

The following are recommendation of the study.

6.1.1 System implementation

i. The system developed can incorporate marks and comments in the student's final grade, however great care must be taken to ensure that the comments given are not ambitious or pessimistic. A student with a score of say **40** should not be given a comment of good as this is an unrealistic comment. Likewise a student with a favourable score of say **80** should not be given a comment of say fair. In both ways when the system is implemented the membership function degree will be 0 and hence in both ways the comments will not contribute to the students score.

ii. The system could also be improved by making it interactive so that users can be able to get particular results from any location with an internet connection.

6.1.2 Recommendations for further research

i. The development of membership function using the Gaussian distribution may have provided a solution for the problem because it covers 95 percent of all the comments given by the lecturers, but for future research the membership function should be developed that develops a linear membership function, so that all the comments are incorporated.

ii. Pre training of the comments before development of the membership function should also be considered so as to develop a membership function of a limited number of comments so that a linear membership function with only one upper level limit intersecting the lower limit of the next variable (linguistic). Comments that do not affect the numerical scores could be reduced if pre training of the variables is done by identifying sets of linguistic variables that can be used by the instructors.

iii. The contribution of comments and numerical scores in causes where the degree of membership is **0**, should also be a point of concern. An example is a student with a numerical score of **50** and a comment of V.good. The implications to the teacher may be that the student has shown great effort and should be rewarded with an adjustment upwards for the numerical scores. The numerical score will give a membership degree of **0** thus will not be part of final numerical result. A proper membership function that deals with such cases should be developed so as to put into consideration numerical scores with degree of membership of **0**.

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Appendix 1

Table 11: Document Review Guide

Student	**Subjects**	**Marks**	**Comment**	**Grade**
1	Subject 1			
	Subject 2			
	Subject 3			
	Subject n			
2	Subject 1			
	Subject 2			
	Subject 3			
	Subject n			

Appendix 2

Representation of Fuzzy If-then Rules in Visual Basic 6.0 Code

If comment is fair

```
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"0 where [comment]=  'fair'And [totalnumerical]<= 42.3")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"([totalnumerical]-42.3)/11.52 where [comment]=
'fair'And [totalnumerical]>= 42.3 and [totalnumerical]<=
53.55")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"1 where [comment]=  'fair'And [totalnumerical]>= 53.55
and [totalnumerical]<= 67.33")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"(69.47-[totalnumerical])/2.41  where [comment]=
'fair'And [totalnumerical]>= 67.33 and [totalnumerical]<=
69.47")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"0 where [comment]=  'fair'And [totalnumerical]>= 69.47")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
```

If comment is fail

```
"1 where [comment]=  'fail'And [totalnumerical]<= 29.91")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"(42.3-[totalnumerical])/12.4 where [comment]=  'fail'And
[totalnumerical]>= 29.91 and [totalnumerical]<= 42.3")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"0 where [comment]=  'fail'And [totalnumerical]>= 42.3")
```

If comment improve

```
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"0 where [comment]=  'improve'And [totalnumerical]<=
29.91")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"1 where [comment]=  'improve'And [totalnumerical]>=
29.91 and [totalnumerical]<= 32.21")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"(53.55-[totalnumerical])/23.65  where [comment]=
'improve'And [totalnumerical]>= 29.91 and
[totalnumerical]<= 53.55")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"0 where [comment]=  'improve'And [totalnumerical]>=
53.55")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
```

If comment work harder

```
"0 where [comment]=  'work harder'And [totalnumerical]<=
6.88"
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"1 where [comment]=  'work harder'And [totalnumerical]>=
6.88 and [totalnumerical]<= 32.21")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"(72.24-[totalnumerical])/40.03  where [comment]=  'work
harder'And [totalnumerical]>= 32.21 and
[totalnumerical]<= 72.24")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
```

```
"0 where [comment]=  'work harder'And [totalnumerical]>=
72.24")
```

If comment is weak

```
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"0 where [comment]=  'weak'And [totalnumerical]<44")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"1 where [comment]=  'weak'And [totalnumerical]= 44")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"0 where [comment]=  'weak'And [totalnumerical]> 44")
```

If comment is aim higher

```
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"0 where [comment]=  'aim higher'And [totalnumerical]<=
32.21")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"([totalnumerical]-32.21)/10.09 where [comment]=  'aim
higher'And [totalnumerical]>= 42.3 and [totalnumerical]<=
53.51")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"1 where [comment]=  'aim higher'And [totalnumerical]>=
42.3 and [totalnumerical]<= 53.51")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"(72.29-[totalnumerical])/18.75  where [comment]=  'aim
higher'And [totalnumerical]>= 53.51 and
[totalnumerical]<= 72.29")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
```

```
"0 where [comment]=  'aim higher'And [totalnumerical]>=
72.29")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
```

If Comment is average

```
"0 where [comment]=  'average'And [totalnumerical]<=
49.13")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"([totalnumerical]-49.13)/4.42 where [comment]=
'average'And [totalnumerical]>= 49.13 and
[totalnumerical]<= 53.55")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"1 where [comment]=  'average'And [totalnumerical]>=
53.55 and [totalnumerical]<= 55.75")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"(55.75-[totalnumerical])/18.75  where [comment]=
'average'And [totalnumerical]>= 53.51 and
[totalnumerical]<= 72.29")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"0 where [comment]=  'average'And [totalnumerical]>=
72.29")
```

If comment is keep it up

```
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"0 where [comment]=  'keep it up'And [totalnumerical]<=
50.67")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
```

```
"([totalnumerical]-50.67)/11.54 where [comment]=  'keep
it up'And [totalnumerical]>= 50.67 and [totalnumerical]<=
62.21")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"1 where [comment]=  'keep it up'And [totalnumerical]>=
62.21 and [totalnumerical]<= 67.96")
```

If comment is average

```
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"(83.99-[totalnumerical])/15.95  where [comment]=
'average'And [totalnumerical]>= 67.96 and
[totalnumerical]<= 83.91")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"0 where [comment]=  'average'And [totalnumerical]>=
83.99")
```

If comment is good

```
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"0 where [comment]=  'good'And [totalnumerical]<= 52.51")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"([totalnumerical]-52.67)/(72.29-52.51) where [comment]=
'good'And [totalnumerical]>= 52.51 and [totalnumerical]<=
72.29")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"1 where [comment]=  'good'And [totalnumerical]>= 72.29
and [totalnumerical]<= 74.52")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
```

```
"(83.91-[totalnumerical])/(83.91-74.52)  where [comment]=
'good'And [totalnumerical]>= 74.52 and [totalnumerical]<=
83.91")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"0 where [comment]=  'good'And [totalnumerical]>= 83.91")
```

If comment is v.good

```
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"0 where [comment]=  'v.good'And [totalnumerical]<=
67.96")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"([totalnumerical]-67.96)/(72.29-67.96) where [comment]=
'v.good'And [totalnumerical]>= 69.96 and
[totalnumerical]<= 72.29")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"1 where [comment]=  'v.good'And [totalnumerical]>= 72.29
and [totalnumerical]<= 74.52")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"(91.76-[totalnumerical])/(91.96-74.52)  where [comment]=
'v.good'And [totalnumerical]>= 74.52 and
[totalnumerical]<= 91.76")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"0 where [comment]=  'v.good'And [totalnumerical]>=
91.76")
```

If comment is excellent

```
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
```

```
"0 where [comment]=  'excellent'And [totalnumerical]<=
74.52")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"([totalnumerical]-74.52)/(83.91-74.52) where [comment]=
'excellent'And [totalnumerical]>= 74.52 and
[totalnumerical]<= 83.91")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"1 where [comment]=  'excellent'And [totalnumerical]=
84")
db.Execute ("UPDATE [exam] SET [membershipdegree] = " & _
"(100-[totalnumerical])/(100-83.91)  where [comment]=
'excellent'And [totalnumerical]>= 74.52 and
[totalnumerical]<= 100")
```

Appendix 3: System User Manual

1.0 Introduction

Kaiboi Technical Training Institute management system is software that is used to store, update calculate students performance and retrieve reports. The system is quite friendly and easy to use.

2.0 Installation

2.0.1 Steps for installing the system

Step 1: The system **installation CD** contains a folder called Fuzzy Project. Insert it into

the CD drive open it and **select setup** and wait for the system to be installed.

Step 2: The installation CD also contains a database called **SQL3**. Copy the

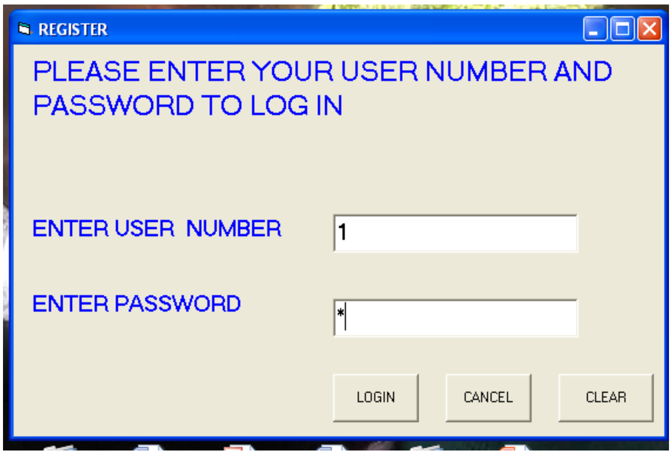
Database to the path **C:\Documents and Settings\User\My Documents\sql3**

Step 3: Click on **Start** and move to KAIBOI **TECHNICAL TRAINING**

INSTITUTE STUDENTS MANAGEMNT SYSTEM, click on it.

3.0 Log In

To log into the system a user number and password is required. The default password is the user's number. i.e. if the user number is 1 the password is 1.



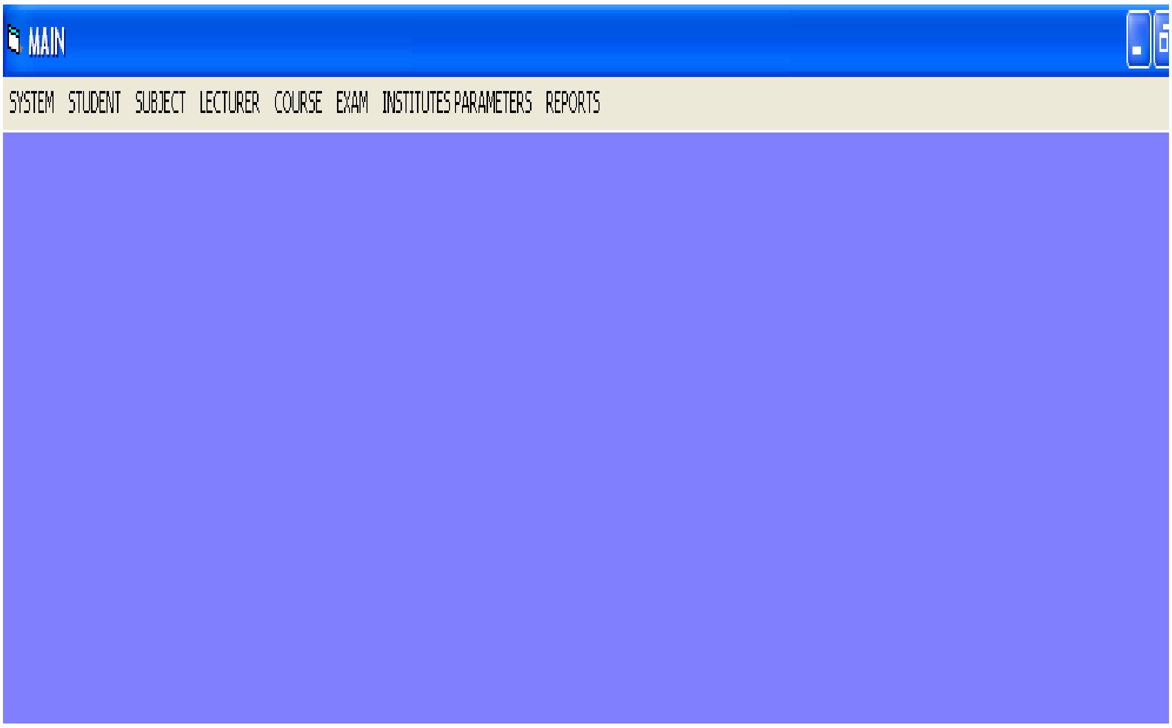
Screenshot 1: Login Form

NOTE: The password and number can be changed during program execution

4.0 Main Menu

The main form consist of the following menu items,

- **System**
- **Student**
- **Subject**
- **Lecturer**
- **Course**
- **Exam**
- **Institute parameters**
- **Reports**

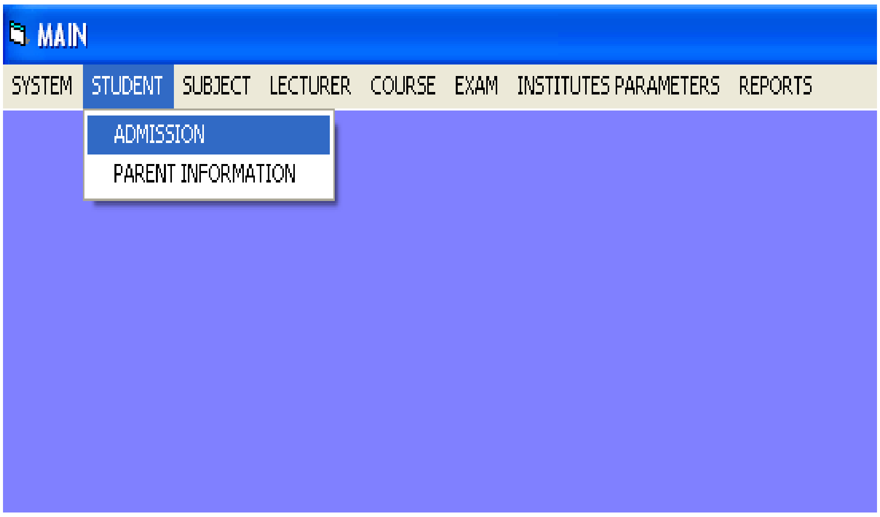


Screenshot 2: Main Form

5.0 Student Details

Student admission details and parent information can be entered by clicking on the

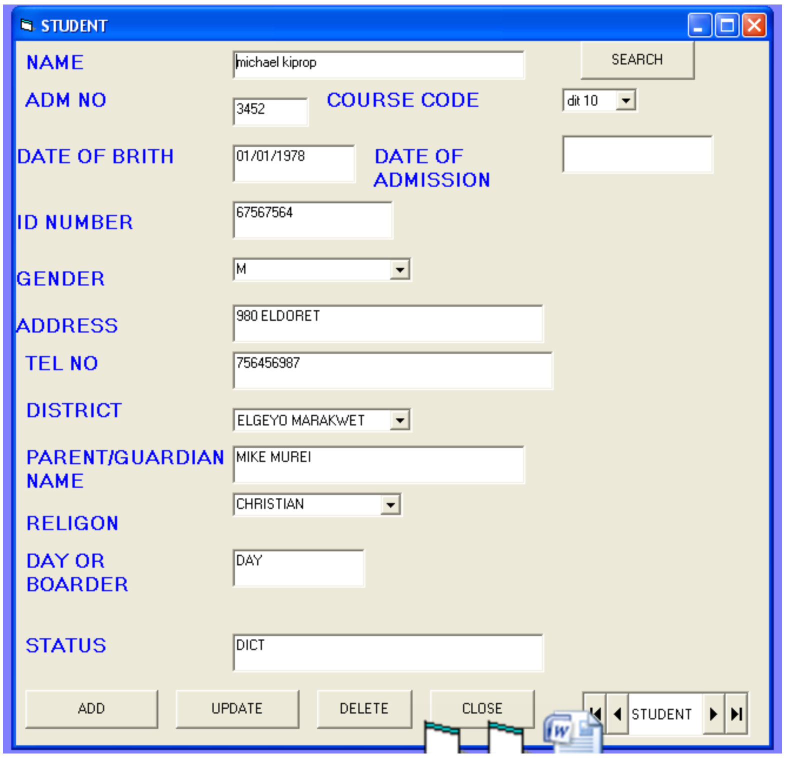
STUDENT



Screenshot 3: Student Menu

5.0.1 Student Admission

Click on the **STUDENT** menu and choose **admission** click on it. You get a form like the one below



Screenshot 4 Student Entry

Note: Records entered must have a unique admission number otherwise the records will not be added.

6.0 Use of Tabs

On every form there are tabs that can be used to:

ADD: Used when you want to add a record

UPDATE: Used when you want to make changes in the details in the database

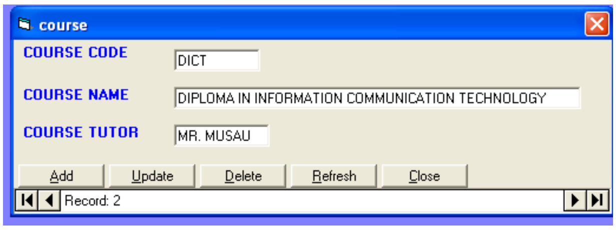
DELETE: Used to delete records from the database

CLOSE: Used to close the form.

Parent information can be entered by using the same menu **STUDENT** and the sub menu **parent information.**

7.0 Course

Courses must be entered before entering the subject details in the course. Details are entered by clicking on the course then opening the form course.



Screenshot 5: Course Form

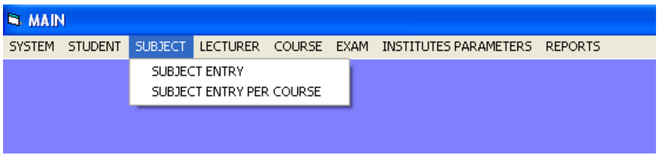
Note: The course code is a unique field and no two courses should have the same code.

8.0 Subjects

Steps to edit subjects

Step 1: Click on the subject menu.

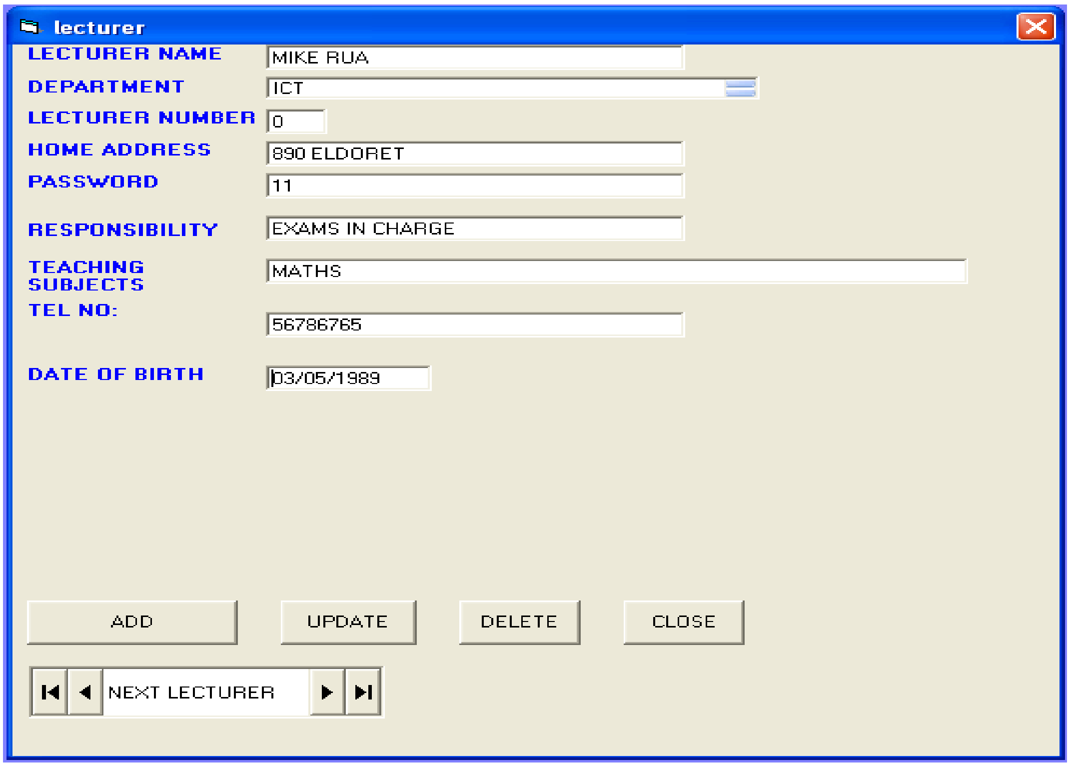
Step 2: There are two ways of entering subjects can be entered using the form subject entry or subject entry per course which is suitable for entering many subject per course as shown in **screenshot 6.**



Screenshot 6: Subject Menu

9.0 Lecturer details

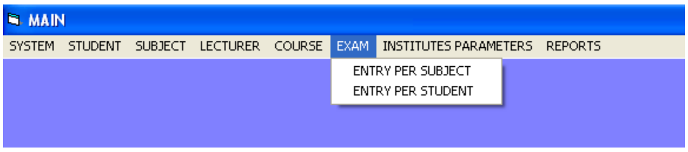
Lecturers' details are entered using the lecturer form as shown



Screenshot 7: Lecturer Form

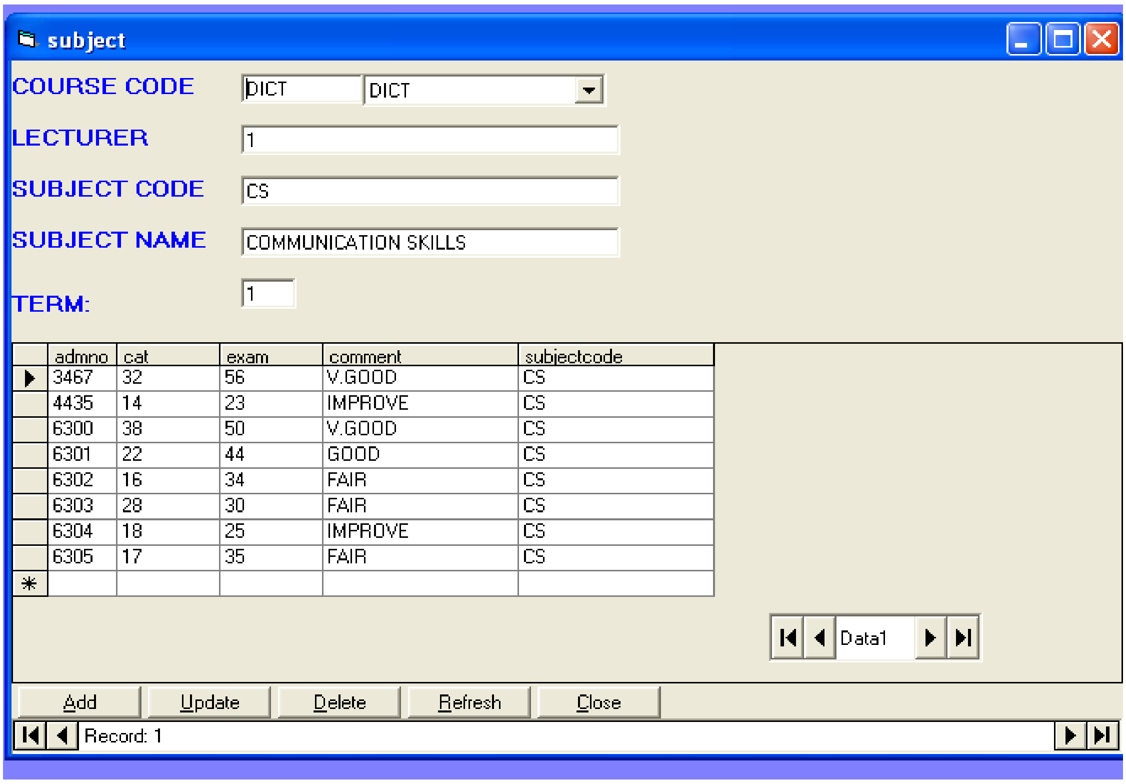
10.0 Examinations Entry

Step 1: Click on **EXAM** on the main menu as shown below



Screenshot 8: Exam Menu

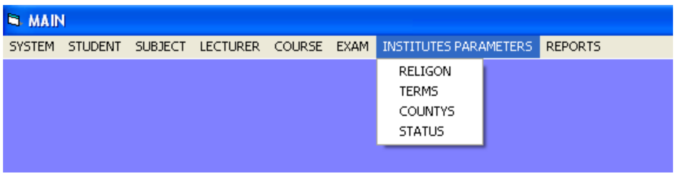
Step 2: Examinations can be entered by subject or per student. For a course tutor it is simpler to enter per subject because the list of all the students can be entered as shown in **screenshot 9.**



Screenshot 9: Subject Entry Per Course

11.0 Institute Parameters

Institute parameters like Religion, Terms, county and students' status can be entered through the menu item INSTITUTE PARAMETERS as shown in **screenshot10.**



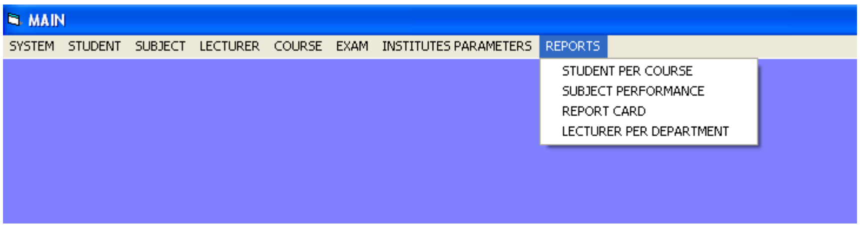
Screenshot 10: Institute parameters

12.0 Reports

Several reports can be generated from the system they are: list of students per course, Subject performance, Report card and list of lecturers per department. To get the desired report click on the **REPORTS** menu and then the desired reports.

The reports are

- List of Students per course
- Subject performance
- Report card
- Lecturers list



Screenshot 11: Reports Menu