

Educational Data Mining using Fuzzy Sets to Facilitate Usability and User Experience - An Approach to Integrate Artificial Intelligence and Human-Computer Interaction

by

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Abstract

Artificial Intelligence (AI) and Human-Computer Interaction (HCI) have the common goal of enhancing effectiveness of a system and making it easier for people to use. AI accomplishes that by demonstrating intelligent behavior on a machine, whereas HCI involves the design approach required to obtain usability and user experience. This study integrates AI and HCI techniques in a real-world application complementing the aims of each field. A web based system was developed for a school board in Eastern Canada by following the user-centered approach of HCI. In the course of designing a good interface, it was found that fuzzy inference of AI was going on in users' minds when they formed conceptual models to understand the application. The interface was evaluated by applying heuristic evaluation, cognitive walkthroughs and user feedback. It was shown that usability and user experience can be improved by employing fuzzy set techniques. Therefore, fuzzy set modeling can serve as a user centered method for HCI design. Furthermore, data gathering techniques of HCI helped to define the cognitive processes that could be replicated with the aid of fuzzy sets.

Keywords

Educational Data Mining, Fuzzy Sets, Computational Intelligence, Human-Computer Interaction

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Chapter 1

1 Introduction

Artificial Intelligence (AI) started its journey with the goal to demonstrate intelligent behavior on computational systems. Conventional AI techniques were based on symbolic computing, search and methods to narrow the search. These are known as hard computing that require a precisely stated analytical model. However, real world problems are often imprecise and uncertain, where ideal models are not available. Hence, the researchers came up with the idea to generate approximate solution of a process in order to handle imprecision, uncertainty, and partial truth. This approach is known as approximate reasoning. L. Zadeh (1965) [22] introduced Fuzzy Set theory that provides a simple way to attain a definite conclusion based on vague, ambiguous or imprecise information. Since its inception, fuzzy sets have been widely applied in various fields [1] [2] [3] [4] [14] [15] that include educational data mining among others.

Educational Data Mining (EDM) for knowledge discovery in the education sector has been an emerging research area due to the rapid growth of educational data and their unique settings. Fuzzy sets have been applied in EDM [14] [15] [16] [17] [18] with the aim of improving students' academic performance. Such systems, like any other, need their user interfaces to be carefully designed.

Human-Computer Interaction (HCI) involves the design approach that has the goal to obtain usability as well as to ensure good user experience. HCI is a multi-disciplinary field in which researchers often learn from different disciplines, such as psychology, biology, physics and others, in order to attain the goal. Applying Artificial Intelligence (AI) techniques in the area of HCI has been discussed in the literature. H. Lieberman (2009) [5] argues that AI and HCI can complement

each other. User-centered approach and testing methods of HCI can benefit AI to obtain intelligent interfaces, while AI applications can serve HCI's goals of providing usability and good user experience.

This chapter presents an overview of the thesis starting with a framework in Section 1.1 about the problem to be undertaken at the school board within which the fusion of HCI and AI are to be explored. Section 1.2 explains the purpose of the study and novelty. An outline of the thesis is stated in Section 1.3.

1.1 Framework

This study is concerned with the development of a web-based system for a school board. The users of the system are higher management of the school board that include the Director of Education, Superintendents and Principals of Schools. The purpose of the system is to provide an overall picture of the schools under the board in order to help the managers in making decisions for the upcoming year in terms of budget, student achievements, and disciplinary issues.

Upper management at the school board followed a number of procedures at the end of every school year in order to make a plan for the next year. The procedures are briefly stated as follows:

- The Principals of the schools filled up a paper-based form known as Annual Growth Plan that provided information about their schools along with their feedback and sent the forms to the Superintendents (manager of the Principals).
- Human Resources (HR) department listed the staffs that would be evaluated in the new school year. This list was sent to the Principals and the Superintendents. Verbal/email

communications were done for confirmation of receipt of the lists and scheduling the appraisals.

- The Principals entered data about their schools into a stand-alone web-based system that was not integrated with other available databases. The Superintendents had access to the system to view the data that were entered by the Principals and make decisions about the upcoming year accordingly.

However, the Superintendents often did not receive the paper-based Annual Growth Plan form from every Principal in a timely manner. Staff appraisals could not be executed on time due to communication gaps between HR department and schools. Furthermore the Principals did not update the web-based system by entering data about their schools. For some reason they were reluctant to do so.

School board upper management thought that the web interface should be improved to make it easier for principals to enter information about their schools. Upon further analysis, however, it was found that the users were unwilling to enter data using the web based system because they were already entering the same data into other individual systems. Therefore, this was not simply a matter of improving the look and feel of the user interface as managers had concluded.

1.2 Purpose of the Study and Novelty

The aim of this master's thesis is to develop a web-based system for decision making to explore how AI techniques can be used to improve usability and user experience. HCI techniques helped to determine the area where AI techniques could be applied and AI techniques were found to be helpful in improving interface design. In the course of designing a good interface, it was found that fuzzy inference of AI was going on in users' minds when they formed conceptual models to

understand the application. Therefore, the focus of this work was on applying fuzzy sets in the interface.

The novelties of this study across different disciplines are stated as follows:

- ***Human-Computer Interaction (HCI)***: Previous research integrating HCI and fuzzy techniques concerns developing intelligent systems for facial expression recognition, recognition of emotions, for example [7] [8]. The novelty of this thesis is that fuzzy set techniques have been used for improving the usability and user experience while using a web-based system.
- ***Educational Data Mining (EDM)***: Related works show that fuzzy sets have so far been used in educational data mining with focus on students [14] [15] [16] [17] [18]. The novelty here lies in applying fuzzy set theory on schools' performance rather than students' performance.
- ***Artificial Intelligence (AI)***: Literature shows that there had been a divide between HCI and AI [6]. This study shows that there are existing heuristics in HCI that can be used to evaluate interfaces with intelligent systems.

1.3 Outline of the thesis

The structure of the remainder of this thesis is organized in five chapters. Chapter 2 discusses the literature in the area of human-computer interaction (HCI), educational data mining (EDM) and approximate reasoning based on fuzzy sets. Chapter 3 provides an overview of the existing situation and defines the application requirements. Chapter 4 gives a detail explanation of the steps taken toward the solution. The description comprise the basic stages of interface design from data

gathering to implementation along with every detail about choosing the colors considering their impact on user interface, data automation techniques and data mining method using fuzzy sets. Chapter 5 describes the evaluation procedure highlighting the outcomes of different evaluation methods. Finally, chapter 6 concludes with a brief summary of the study and suggests research recommendations for future work.

Chapter 2

2 Review of the Literature

A school board application provided the framework for research into use of user-centered approach to implement fuzzy educational data mining. A fuzzy set approach requires that we describe how users see their data and what kinds of decisions they wish to make. User-centered approach of HCI was useful to determine the area where fuzzy data mining could be implemented.

This chapter reviews the literature of the topics about *human-computer interaction*, *educational data mining*, and *approximate reasoning based on fuzzy sets*. The chapter comprises the goals and objectives of researchers on these topics as well as the techniques that have been previously applied by the researchers in these areas.

2.1 Human-Computer Interaction (HCI)

Human-Computer Interaction is a widely used discipline that has been popular in different application areas. At the present era, where the technology has reached to such extent that almost everything is computerized, it has been essential to consider the interaction between the human and the computer technologies. There was a time when human beings had to adapt themselves to

the way that the technology operated in order to complete a task using computing systems. This approach made it tedious to learn how to use computing systems and required much training. Therefore researchers have thought to turn the scenario around so that it is the computing system that can be adapted to the processes human beings use in completing a task.

2.1.1 Interaction Design Process

Interaction Design (ID) involves the design approach that has the goal to obtain the usability of the system as well as to ensure a good user experience. The process of Interaction Design involves the following four activities:

- Establishing Requirements
- Designing Alternatives
- Prototyping
- Evaluating

Y. Rogers et al. (2011) [25] have proposed a lifecycle model of interaction design. This lifecycle model was followed to develop the school board application. Figure 2.1 illustrates the lifecycle model of interaction design that they have proposed.

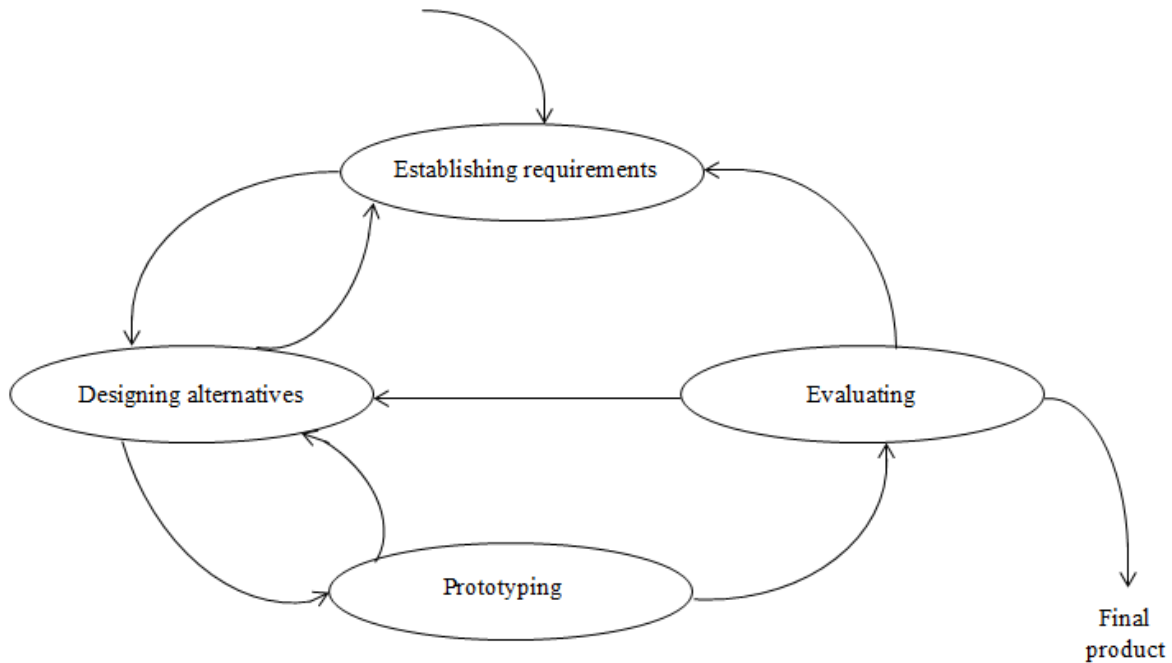


Figure 2.1: Lifecycle Model of Interaction Design [adapted from Y. Rogers et al., 2011 [25]]

Although this lifecycle model is not applicable to all interactive designs, it was useful for the school board application because it applied to the development of web based software. The implementation of the lifecycle model will be elaborated in Chapter 4.

An effective design begins with identifying the user and then establishing the requirements in terms of usability from the user's perspective. A recent study [26] has pointed out the usability requirements to be the most important type of non-functional requirements for web applications. An approach to develop usability requirements was proposed with the aim to improve the quality of web applications in terms of usability. Additionally, [27] have developed a framework of multiple models in order to establish requirements from a large perspective. The models include defining the system in focus, identifying the stakeholders of the system, recognizing their needs,

formulating objectives of the overall system and determining the required processes and requirements. The framework has been piloted with promising results.

Establishing requirements for the school board application involved gathering data in order to determine the requirements, analyzing and presenting the data using use cases so that the requirements were specific and clear enough to continue the design process. Alternative designs and prototypes were created. The users could not be involved for a systematic usability testing due to various reasons (described in Chapter 5). Heuristic evaluation and cognitive walkthroughs were implemented and the resulting prototypes were shown to the users from time to time to collect their feedback. M. Brayshaw (2014) [28] has shown using three case studies that heuristic evaluation is effective in such cases where users are not accessible.

2.1.2 Triangulation

Triangulation is a method that uses more than one approach to investigate a phenomenon. The objective of triangulation is to enhance confidence in the findings to be able to make valid claims. It provides an opportunity to uncover deeper meaning in the data. There are different types of triangulation, such as data triangulation, investigator triangulation, theory triangulation, methodological triangulation, and environmental triangulation. The method along with all its types is thoroughly discussed by L. Guion (2011) [29]. While collecting data for requirements of the school board application, methodological triangulation was performed. Methodological triangulation involves applying more than one data gathering technique in order to maximize the credibility and validity of the data. A recent study [30] on the students' use of recorded lectures indicated the effectiveness of methodological triangulation. The study shows that high quality surveys and interviews with a combination of log data can provide a complete picture of the issues.

Another study [31] that investigated the effect of sign placement has also proved to capture a better scenario with the combination of different methods of data collection compared to using only one method. Development of the school board application used a combination of interview, observation and documentation research method to collect the data for requirements. The evaluation techniques also involved more than one method including heuristic evaluation and cognitive walkthrough.

2.2 Educational Data Mining (EDM)

Data mining (DM) involves the techniques to extract useful information from vast amounts of data. With the rapid growth of computing and technology, dealing with huge amounts of data has become essential in every field. Data mining is the intelligence required to explore the data and extract information and patterns in the data that were not previously known.

Data Mining has been successfully applied in different fields such as business [24], biomedical informatics [9], genetics [10], education [11] and more. The rapid growth of educational data has established Educational Data Mining (EDM) itself to be recognized as an individual research area. Moreover, it has been found that the traditional DM techniques cannot always be applied to educational data in the same way as they were applied to previous application areas. Problems occur due to the uniqueness of the objectives of educational software, which include students modeling, predicting course outcomes, and human judgment. Therefore, data mining techniques had to be adapted in order to apply to the educational domain.

2.2.1 Educational Knowledge Discovery Process

The process of educational knowledge discovery includes an iterative cycle of collecting the raw data from the educational environment, forming hypothesis and testing them. Testing involves

modifying the raw data with preprocessing methods, realizing some patterns in the data by applying data mining and interpreting the results as useful information [12]. The following diagram illustrates the process that was followed in this research.

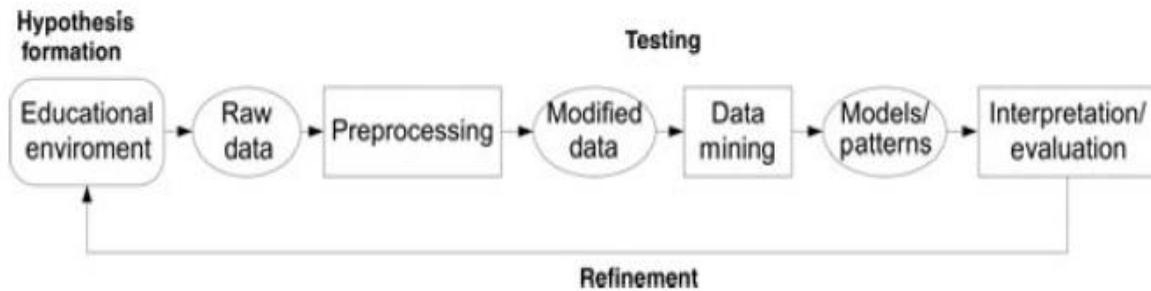


Figure 2.2: Educational Knowledge Discovery Process [taken from C. Romero and S. Ventura, 2012 [12]]

2.2.2 EDM Methods

O. Scheuer and B. McLaren (2012) [13] proposed some taxonomies of EDM methods such as supervised model induction, unsupervised model induction, parameter estimation, relationship mining, distillation of data for human judgment, and discovery with models.

This thesis adopted the method known as distillation of data for human judgment that includes summarization, visualization and/or interactive interfaces. Summarization of school board data was accomplished in order to highlight useful information that could be used for decision making.

2.3 Approximate Reasoning based on Fuzzy Sets

Humans have the ability to use approximate information to make decisions while dealing with uncertain, imprecise, incomplete and inconsistent concepts. A revolution occurred in artificial intelligence during 1960s, after which it was possible to automate approximate reasoning to solve

real life problems. Neural networks, fuzzy sets, rough sets, Bayesian networks, and various hybridizations of these are among the techniques used to implement approximate reasoning. A fuzzy set approach has been selected over the other alternatives for this research because the idea of fuzzy inference seemed to model conceptualizations provided by upper management at the school board.

2.3.1 Fuzzy Sets

Classification of a new object into known classes of objects can be done using properties of the object itself. For example, readers can be classified based on their personality traits for selection of books they might like to read; genes can be classified by their function and the proteins they encode for determining traits of an organism; text (or hypertext) documents can be classified under predefined categories. The existing methods of classification are often insufficient and this is where the ability to deal with uncertainty comes in.

In traditional mathematics, a class is a set and classification rules are such that every object is classified into exactly one class. But many natural problems cannot be defined with simply 0 and 1. For example, by looking at the assessment results of a student, we can conclude, this student performed *good* in 'Reading' test; he did *very good* in 'Writing'; however, he was *not that good* in 'Math'. Now what does '*good*' mean? How does that differ from '*very good*'? What does '*not that good*' stand for? The available deterministic and statistical classification methods [19] [20] [21] are not very reliable for providing answers to such questions. Fuzzy set theory was introduced by Prof. L. A. Zadeh to define the vagueness that we wish to express.

Fuzzy set theory [22] is based on the idea that the statement 'x is a member of set A' does not always have to be either true or false. The proposition may be partially true. This means that instead

of saying that x is in set A , the theory permits description of the extent to which x is in set A . Therefore, the student's result example can be defined as

Reading Result	0.7 in set 'Good'
Writing Result	1.0 in set 'Good'
Math Result	0.4 in set 'Good'

Hence, all the three results are members of set 'Good', but with a degree of membership. There is no uncertainty that the Writing result is good.

2.3.2 Fuzzy Membership Functions

Membership Functions (MFs) are used to determine the degree of membership of an object in the set. A membership function for a fuzzy set A is any function from A to the real unit interval $[0,1]$.

This project involved Trapezoidal functions as membership functions. A Trapezoidal function can be defined by a lower limit a , an upper limit d , a lower support limit b , and an upper support limit c , where $a < b < c < d$.

$$\mu_A(x) = \begin{cases} 0, & (x < a) \text{ or } (x > d) \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ 1, & b \leq x \leq c \\ \frac{d-x}{d-c}, & c \leq x \leq d \end{cases} \dots\dots\dots \text{Eq. 2.1}$$

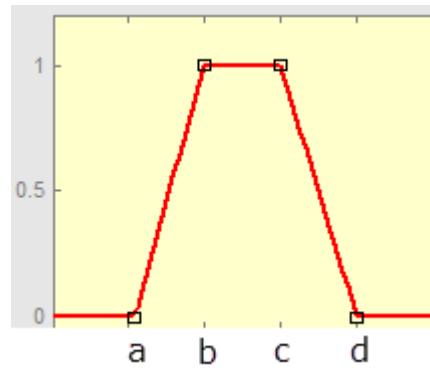


Figure 2.3: Trapezoidal Function [adapted from eMathTeacher[15]]

Two special cases of a trapezoidal function include R-functions and L-functions.

R-functions assume parameters $a = b = -\infty$ and are defined as

$$\mu_A(x) = \begin{cases} 0, & x > d \\ \frac{d-x}{d-c}, & c \leq x \leq d \\ 1, & x < c \end{cases} \quad \dots\dots\dots\text{Eq. 2.2}$$

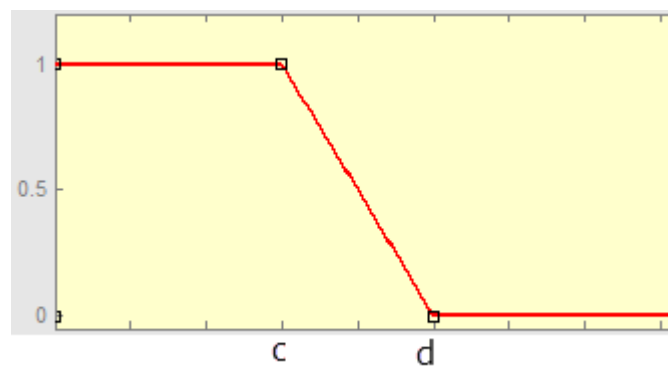


Figure 2.4: R-Function [adapted from eMathTeacher[15]]

L-functions consider parameters $c = d = +\infty$ and can be defined as

$$\mu_A(x) = \begin{cases} 0, & x < a \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ 1, & x > b \end{cases} \quad \dots\dots\dots\text{Eq. 2.3}$$

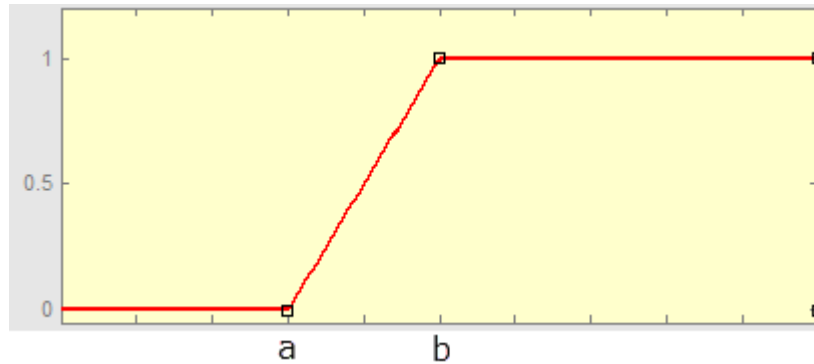


Figure 2.5: L-Function [adapted from eMathTeacher[15]]

2.3.3 Standard Fuzzy Operations

The standard fuzzy operations that were used in this research are defined as follows:

- **UNION:** Let μ_A and μ_B be membership functions that define the fuzzy sets A and B, respectively, on the universe X. The union of fuzzy sets A and B is a fuzzy set defined by the membership function:

$$\mu_{A \cup B} = \max\{\mu_A(x), \mu_B(x)\} \quad \text{for all } x \in X \quad \dots\dots\text{Eq. 2.4}$$

- **INTERSECTION:** Let μ_A and μ_B be membership functions that define the fuzzy sets A and B, respectively, on the universe X. The intersection of fuzzy sets A and B is a fuzzy set defined by the membership function:

$$\mu_{A \cap B} = \min\{\mu_A(x), \mu_B(x)\} \quad \text{for all } x \in X \quad \dots\dots\text{Eq. 2.5}$$

2.3.4 Steps of Fuzzy Inference System

There are different types of methods available for fuzzy inference systems. In this project, the most commonly used method known as Mamdani's method was adopted. The steps of Mamdani's fuzzy inference systems are:

- **Fuzzification:** This method takes crisp values as input and obtains their membership values by applying a fuzzy membership function.
- **Inference:** A knowledge base is created to store IF-THEN rules provided by experts. Fuzzy values obtained from fuzzification are input to derive conclusions from the rules.
- **Aggregation:** The outputs of each rule are combined into a fuzzy output by using a fuzzy aggregation operator.
- **Defuzzification:** The fuzzy output is then transformed into a crisp value. One of the most popular defuzzification methods is 'centroid' that takes the centre of the area of the fuzzy output.

This research project used a fuzzy inference system in order to determine overall performance of a school regarding provincial assessment results (referred to as EQAO) for each grade. The process has been described in detail in Chapter 4 (Section 4.6).

2.3.5 Fuzzy Set Techniques in EDM

A recent study [14] proposed a novel approach to predict students' academic performance using a combination of Cuckoo Search and Hierarchical Adaptive Neuro-Fuzzy Inference System. Another study [15] used a fuzzy inference based model to predict the likelihood of student dropouts from a program of study at the end of their first semester. S. Chen and T. Li (2013) [16] presented

a method for students' answer scripts evaluation based on fuzzy sets. I. Saleh and S. Kim (2009) [17] used fuzzy reasoning to infer scores of students using traditional triangular membership functions (MFs). Later, I. Hameed and C. Sorensen (2010) [18] improved the reliability of the previous researchers' system by using Gaussian MFs.

In this chapter, background research in main areas of this thesis have been covered, specifically, human-computer interaction, educational data mining, and fuzzy reasoning. In the remainder of this thesis, HCI techniques and fuzzy reasoning will be investigated in the educational domain.

Chapter 3

3 Problems with Existing System

Annual school improvement planning had been a challenge for the school board. Users were laboriously trying to do school planning using an existing system. In spite of the effort they were investing, they were drawing inconsistent conclusions from the data.

This chapter describes the starting point from which an application of fuzzy reasoning was developed and implemented. A shared and integrated information system was required to facilitate communication among the Superintendents, Principals and Human Resources at the school board. HCI techniques were applied to obtain usability of data and processes and to encourage users to interact with the system. Unstructured interviews with upper management revealed that they wanted all data organized in as many ways as possible. They did not know if or how such presentation might help them make decisions, but they were reluctant to miss out any data. Their reluctance to let go any of the data suggested the researcher that a data mining approach may help

them better make sense of their data. Thus, a careful development of a user interface resulted in a precise description of user needs by which it was discovered where data mining would be useful.

Section 3.1 covers the previous year end process that was carried out by the School Board in order to obtain decisions about the upcoming school year. This outdated process included sending/receiving manual forms, communicating based on verbal and informal methods to obtain information, as well as maintaining a web-based system that was inadequate for drawing consistent conclusions. These problems were impeding the use of data mining methods and preventing users from conceiving of solutions that would aid in their decision making processes. The requirements of the new system have been enumerated in Section 3.2.

3.1 Year End Process

The School Board had established a number of procedures that were carried out at the end of every school year as a preparation for starting the new school year. The procedures are described in the following subsections.

3.1.1 Annual Growth Plan

The Principals of the schools had to complete a paper-based form (Figure A.1, A.2, A.3 and A.4 in Appendix A) and send that to the relevant Superintendents at the School Board. The format of the form was slightly different for the Elementary and Secondary schools due to their different assessment types. The first page of the form contained various information about the schools such as (a) number of staff, (b) population over last 5 years, (c) number of identified students with behavioral, learning disability and ASD, (d) provincial assessment results over last 5 years, (e) special education results over last 5 years with comparison among school, board and province, and

(f) number of suspensions that occurred in last 5 years. These information provided the Superintendents (managers of a group of Principals) an overview about the schools. The next page included feedback from the Principals about the areas for growth, growth strategies, target dates for completion, confirmation of completed objectives and suggested learning plan for next year. After receiving the forms from all the schools, the Superintendents (Manager of a group of Principals) had to analyze the data in the forms, review the feedback from the Principals and make important decisions based on their analysis and review.

3.1.2 Staff Appraisal

Human Resources department of the school board had to generate reports based on an automated Staff Information Management System in order to identify the staff that would be evaluated in a new school year. One copy of these reports was sent to the Superintendents and another copy was sent to the Principals of the schools. Communications through telephones or emails were required in order to confirm receipt of the reports and schedule the evaluations.

3.1.3 Existing Web-based System

Previous subsections (3.1.1 and 3.1.2) have described manual processes. In this subsection, the existing web-based system will be discussed.

A web-based system was intended to be introduced to the school board, but it could not be established due to its huge data entry requirement and unreliability. This system was taken as a framework for the new system. Since the technology that was used for this system was obsolete, a completely new system was required with current technology. The existing system contained the following modules.

- Staff
 - Staff List and Appraisal Dates
- Student
 - Student Involvement List
 - Home Schooling List
 - Violent Incident List
- Community
 - School Council List
 - Community Partners List
 - Planned Use of Funds
- Trends
 - Provincial Assessment Results
 - Student Suspensions
 - Student Attendance
 - Staff Attendance

The Principals of schools had to add/update each and every data item to populate the staff, student, and community lists. The trends section was designed to generate graphs that showed the trends over the last 5 years with various breakups and provided options to add comments about every year. Nevertheless, lots of data entry was required in order to view each graph.

3.2 Application Requirements

The year-end process that the School Board had tried to establish involved various cumbersome procedures that were clearly in need of refinement. Lots of communication gaps existed in the

annual growth plan and staff appraisals processes and the existing web based system was never used to update the schools' information properly. For example, if a school did send the Annual Growth Plan on time, they did not have time to make arrangement for their staff appraisals. As a result, the Superintendents could not collect information about all the schools to make decisions in a timely manner. The decision making process required a centrally controlled system by which communication among the Superintendents, Principals and Human Resources department could be facilitated.

3.2.1 Combine Year End Procedures into a Single System

A new system had to be generated that could combine all the steps included in the year-end process. The Annual Growth Plan form had to be combined along with all the lists that were available in the existing web-based system. The staff list had to be populated with the appraisal information so that separate reports were not required to be sent/received for appraisals. The existing system was quite old and hence some fields had become irrelevant over time.

3.2.2 Prepopulate Data

The term 'prepopulate' is used in this thesis to mean presenting data automatically in web pages without requiring users to enter them. In this sense we say that the data has been automated.

All the information systems that were available in the school board had to be analyzed to see which fields in the lists and in the Annual Growth Plan form existed so that they could be automated. This was intended to minimize data entry and provide data consistency among all the information systems in the school board.

3.2.3 Representation Technique for Trends Data

Upper managers were interested to know the trends regarding school performance. Research of the literature was required to obtain effective representation of trends data that could provide a clear picture about schools and thus help in making right decisions for the upcoming year. This was where fuzzy sets came into play. Trends data were to be collected from diverse information systems in such a way that they could be input to a fuzzy inference system. Fuzzy set data mining could then be applied to those data.

Graphs in the existing system needed to be generated automatically and with data that resided in a variety of existing information systems. Since the graphs that were available in the existing system were rarely updated, the effectiveness of the representation techniques in those graphs was not verified. Furthermore, the way information was displayed did not meet current needs.

In the process of solving the school board's problems as outlined above, this thesis topic emerged. It was obvious from the onset that HCI techniques would be required. Recent literature revealed that there is an overlap in the goals of HCI and AI [6]. Therefore AI methods were investigated. Since school board deals with large amount of data and data mining is related to AI, educational data mining was explored.

Chapter 4

4 Integration of AI and HCI

This chapter illustrates the steps undertaken to develop the school board application with focus on Human-Computer Interaction (HCI) and Educational Data Mining (EDM) using fuzzy sets.

Section 4.1 covers the data gathering process. Use cases to define the interactions of different users are illustrated in Section 4.2. Section 4.3 contains brief explanation about database design. Section 4.4 captures the decisions about impact of colors on the user interface. Data automation techniques are described in Section 4.5. Section 4.6 covers preprocessing techniques that were used to obtain input to fuzzy inference system as well as fuzzy rule generation and the results of fuzzy inference on preprocessed data.

4.1 Data Gathering

In order to determine the requirements for the new system, a method known as triangulation (discussed in Section 2.1.2) was used that combines different approaches. The stakeholders were identified and interviewed in order to understand the requirements from the users' perspective. The existing web-based system was studied thoroughly. The information systems that were available in the school board were analyzed to decide which data could be prepopulated into the new system. The outcome of employing such rigorous techniques for requirements gathering was a more accurate, consistent and concise description of the data as seen by users.

4.1.1 Identifying the Stakeholders

The following list shows the stakeholders involved in the system

- Director of Education
- Superintendents of Schools
- Principals of Schools
- Human Resources Department Personnel

4.1.2 Interviews

The stakeholders were interviewed in different sessions at different stages of the project. The School Board Management requested that the Principals of schools not be involved at the initial stage. The Director of Education and the Superintendents of Schools were engaged in the initial requirement collection process. Human Resources personnel were involved while working on the staff appraisal and attendance trends. Eventually the Principals were involved during the implementation and they provided feedback about the usability and user experience while interacting with the system.

The interviews were unstructured [25] and included open questions in order to discover as much information as possible. To name a few of such open questions were:

- What do you do at the end of the year to plan for the upcoming year?
- What do you understand from the EQAO reading result breakups in the graph in the existing system?
- What kind of decision will you take by looking at these EQAO graphs?

It was understood from the interviews that the stakeholders wanted to see every data item with as many breakups as possible. For example, the provincial assessment (referred to as EQAO) results contained Level 1 (Lowest Mark) to Level 4 (Highest Mark) indicators. The stakeholders wanted to know the percentage of students obtaining each level and have it be shown in a graph. However, they were unable to completely specify how knowing all these breakups could assist them with decision making. Their response was that they would like to see what technology could give them before they would be able to tell how they could benefit from it.

4.1.3 Study of the Existing Web Application

The existing web application was studied in order to identify the data as well as the existing representation techniques. The system contained two types of information, which were list information and trends information. The following subsections provide brief summaries about the two types along with screenshots to illustrate the initial presentation layout from which an interface was designed to acquire new knowledge and present it in a new way.

4.1.3.1 List Information

Users were required to enter information in lists and were provided options to update/delete the information, if required. Figure 4.1 shows the Staff List and Appraisal Dates as in the existing system. The figure has been blurred due to the sensitivity of data.

[Redacted] - Staff List and Appraisal Dates

[Main Menu](#) [Print](#) [Add](#)

Displaying records 1 to 20 of 44 staff entries found. [Next Page](#)▶

Click on the person's name to edit the record				Summative Report Dates for New Teachers		Summative Report Dates		Supervisor
Full Name	Staff Group	FTE	Seniority Date	Scheduled Eval. Year	Date of First Summative Report	Date of Second Summative Report	Date of First Summative Report	
[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]
[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]
[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]
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[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]	[Redacted]

[General Staff Comments](#)

Figure 4.1: Staff List and Appraisal Dates in Existing System

In order to populate this list, a form had to be filled up. Figure 4.2 shows the form to add a staff into the staff list. Clicking on a staff name in the list provided the same form prepopulated with the existing data with an option to update/delete the information.

- Annual School Report

Main Menu

Return to List

Enter your staff information in the fields below and click "Submit" to submit your changes

Submit Staff Details Entry		
<input type="text"/> First Name	<input type="text"/> Last Name	
<input type="text"/> Staff Group	<input type="text"/> FTE (Full Time = 1, Half Time = 0.5 etc...)	
<input type="text"/> / <input type="text"/> / <input type="text"/> Seniority Date <small>(DD/MMM/YYYY)</small>	<input type="text"/> Scheduled Eval. Year	<input type="text"/> Supervisor
Summative Reports		
Summative Report for New Teachers	Summative Report	
<input type="text"/> / <input type="text"/> / <input type="text"/> Date of First Summative Report	<input type="text"/> / <input type="text"/> / <input type="text"/> Date of First Summative Report	
<input type="text"/> / <input type="text"/> / <input type="text"/> Date of Second Summative Report	<input type="text"/> / <input type="text"/> / <input type="text"/> Date of Second Summative Report	
Click "Delete" to remove this person from your staff list Delete		

Figure 4.2: Add Staff Form in Existing System

All other lists in the existing system included the same concept for adding/updating data and the presentation style of the list was also similar to Figure 4.1.

4.1.3.2 Trends Information

The trends section required the user to enter data about different breakups in order to generate graphs that show the trends. The breakups varied among the type of information such that

provincial assessment results contained breakups with different level indicators, whereas suspension trends contained breakups with duration of suspension.

Figure 4.3 and 4.4 shows EQAO Grade 3 Reading Result Trends for a school and the form to generate those graphs respectively.

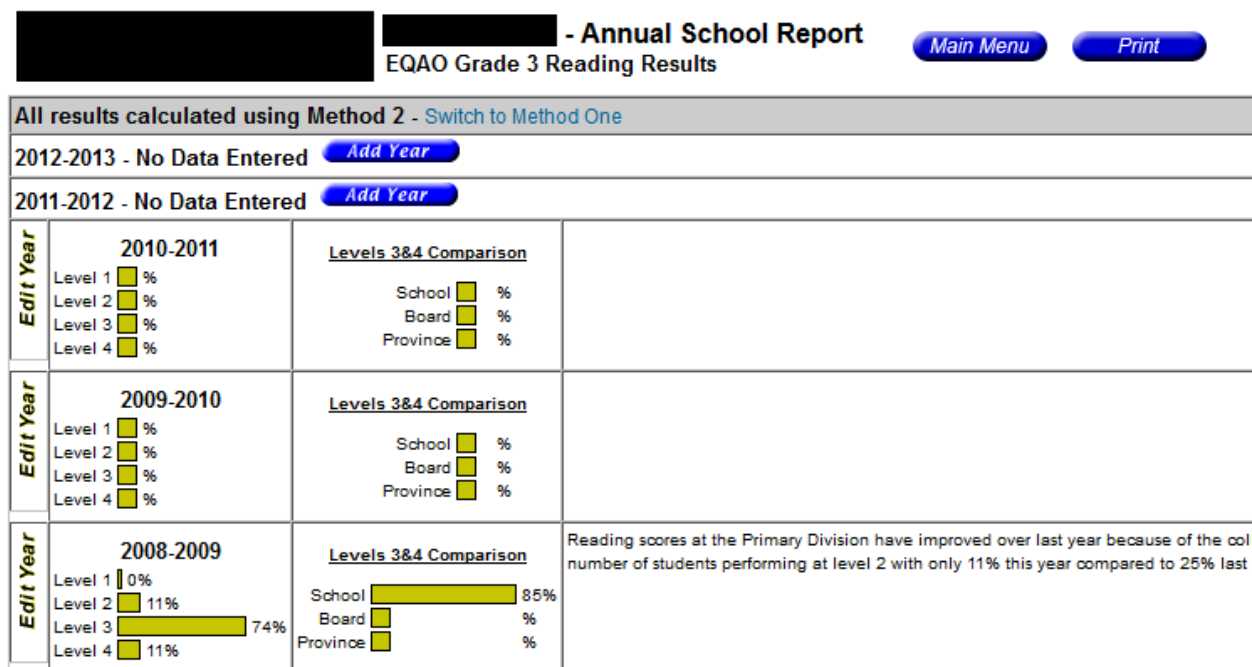


Figure 4.3: EQAO Grade 3 Reading Results Trends in Existing System

- Annual School Report [Main Menu](#) [View 5-Year Trend](#)

2008-2009 EQAO Grade 3 Results

Enter the percentage of students achieving at each level in the fields below.
 You must enter numbers for Method 2, but Method 1 numbers are optional.

Submit You must click "Submit" to save your changes			
2008-2009 Reading Results			
Method 2	Method 1	Comments	Levels 3 & 4 comparison (Method 2)
Level 1: <input type="text" value="0"/> %	<input type="text"/> %	<div style="border: 1px solid gray; padding: 2px;"> Comments for 2008-2009 Reading Results. This field is for providing additional information about the performance of students at each level. </div>	School: <input type="text" value="85"/> %
Level 2: <input type="text" value="11"/> %	<input type="text"/> %		Board: %
Level 3: <input type="text" value="74"/> %	<input type="text"/> %		Prov: %
Level 4: <input type="text" value="11"/> %	<input type="text"/> %		
2008-2009 Writing Results			
Method 2	Method 1	Comments	Levels 3 & 4 comparison (Method 2)
Level 1: <input type="text" value="0"/> %	<input type="text"/> %	<div style="border: 1px solid gray; padding: 2px;"> Comments for 2008-2009 Writing Results. This field is for providing additional information about the performance of students at each level. </div>	School: <input type="text" value="79"/> %
Level 2: <input type="text" value="21"/> %	<input type="text"/> %		Board: %
Level 3: <input type="text" value="74"/> %	<input type="text"/> %		Prov: %
Level 4: <input type="text" value="5"/> %	<input type="text"/> %		
2008-2009 Math Results			
Method 2	Method 1	Comments	Levels 3 & 4 comparison (Method 2)
Level 1: <input type="text" value="0"/> %	<input type="text"/> %	<div style="border: 1px solid gray; padding: 2px;"> Comments for 2008-2009 Math Results. This field is for providing additional information about the performance of students at each level. </div>	School: <input type="text" value="89"/> %
Level 2: <input type="text" value="5"/> %	<input type="text"/> %		Board: %
Level 3: <input type="text" value="63"/> %	<input type="text"/> %		Prov: %
Level 4: <input type="text" value="26"/> %	<input type="text"/> %		

Figure 4.4: Form to Add EQAO Result Trends in Existing System

4.1.4 Analyze Different Information Systems in School Board

In order to collect data from available information systems, three steps were followed:

- Identify the different information systems that existed in the school board

- Find out whether a module could be pulled from another system and if yes, list out which system contained information about that module
- Finally, look for every field of the module in the information system. In case a field did not exist in an information system, check if that field could be replaced with some other data that was available in the other system. Also check for any extra field that could be useful.

It was found that the information systems had different database systems at the backend to store the information. Table 4.1 shows the list of information systems available in the School Board.

Name	Description	Backend Database
Trillium	An enterprise solution system for student information management	Oracle
IPPS	A web-based solution for staff information management	MS SQL Server
Student Enrolment System	An in-house web-based solution	Oracle
Data Warehouse	Data warehouse	MS SQL Server

Table 4.1: List of Information Systems Available in School Board

Table 4.2 shows a list of whether a module existed in another system and if it did, which system contained the information.

Module	Available in Another Information System?	Name of Information System
Staff List and Appraisal Dates	Yes	IPPS
Student Involvement List	No	N/A
Home Schooling List	No	N/A
Violent Incident List	Yes	Trillium
School Council List	No	N/A

Community Partners List	No	N/A
Planned Use of Funds	No	N/A
Provincial Assessment Results Trends	Yes	Data Warehouse
Student Suspensions Trends	Yes	Trillium
Student Attendance Trends	Yes	Trillium
Staff Attendance Trends	Yes	IPPS
Grades in a School	Yes	Trillium
Number of Staff	Yes	IPPS
Population	Yes	Student Enrolment System
Number of Identified Exceptional Students	Yes	Trillium
EQAO Results	Yes	Data Warehouse
OLSAT Results	No	N/A
Number of Suspensions	Yes	Trillium
Pass Rates	Yes	Data Warehouse
Pathways	No	N/A
Credit Accumulation	No	N/A

Table 4.2: List of Modules Available in Other Information Systems

The rest of this chapter describes the new Annual School Improvement Planning System.

4.2 Use Cases

Use case diagrams were developed in order to document the interactions between the system and the users. The documentation was useful for both conceptual design and requirement gathering.

Figure 4.5, 4.6, 4.7, 4.8, 4.9 and 4.10 illustrate the use case diagrams for the new system.

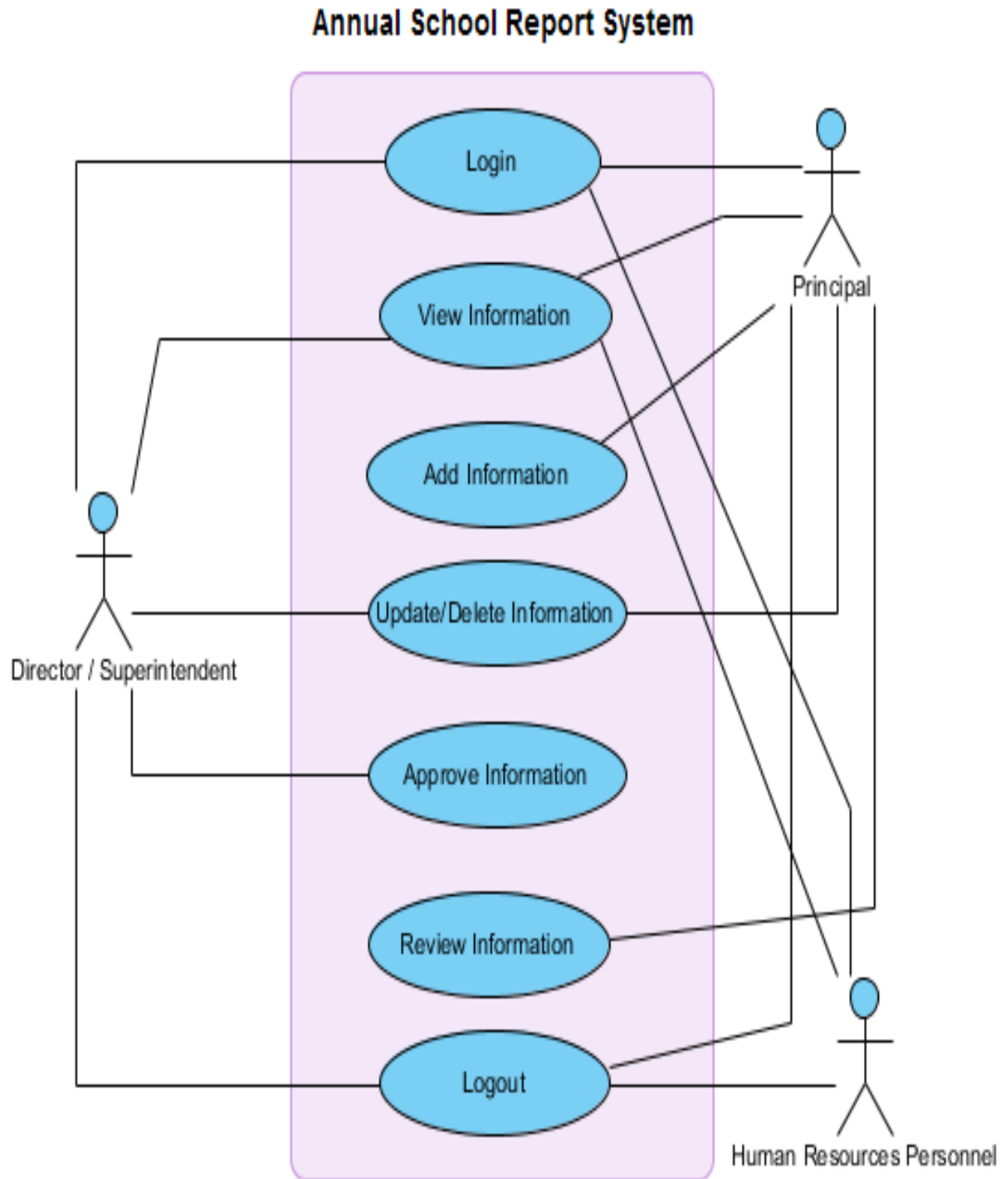


Figure 4.5: Use Case Diagram for Annual School Report System

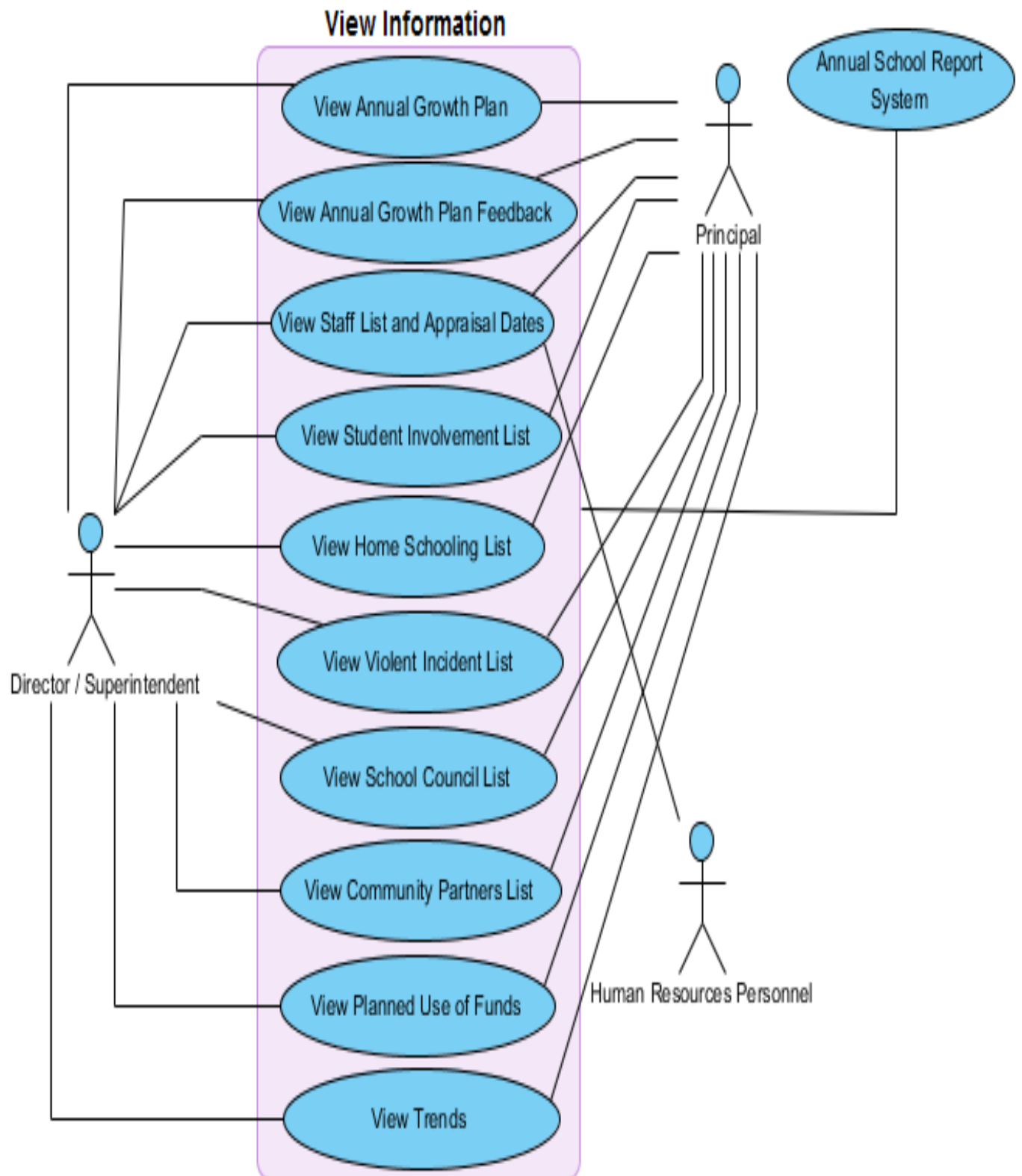


Figure 4.6: Use Case Diagram for View Information

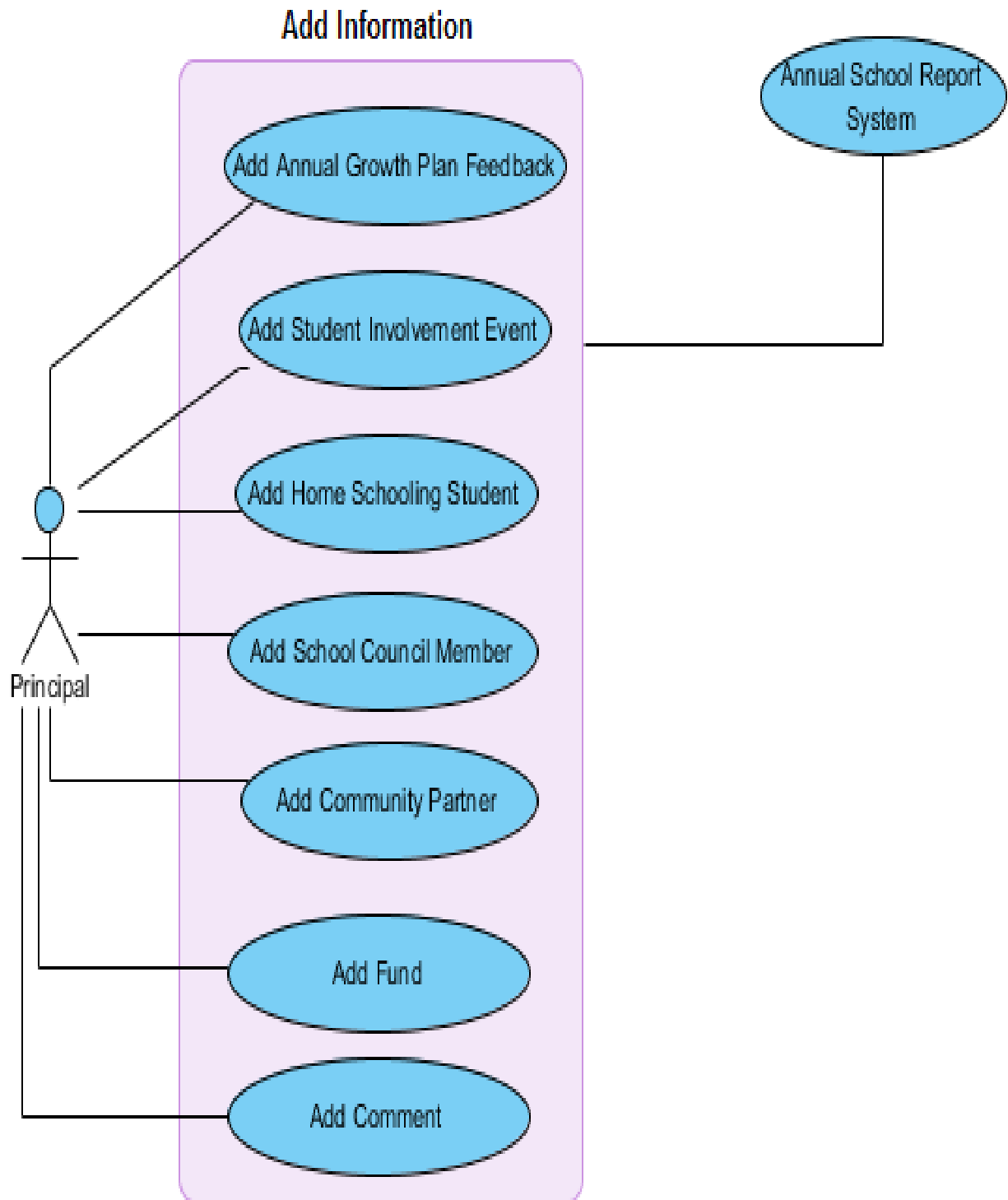


Figure 4.7: Use Case Diagram for Add Information

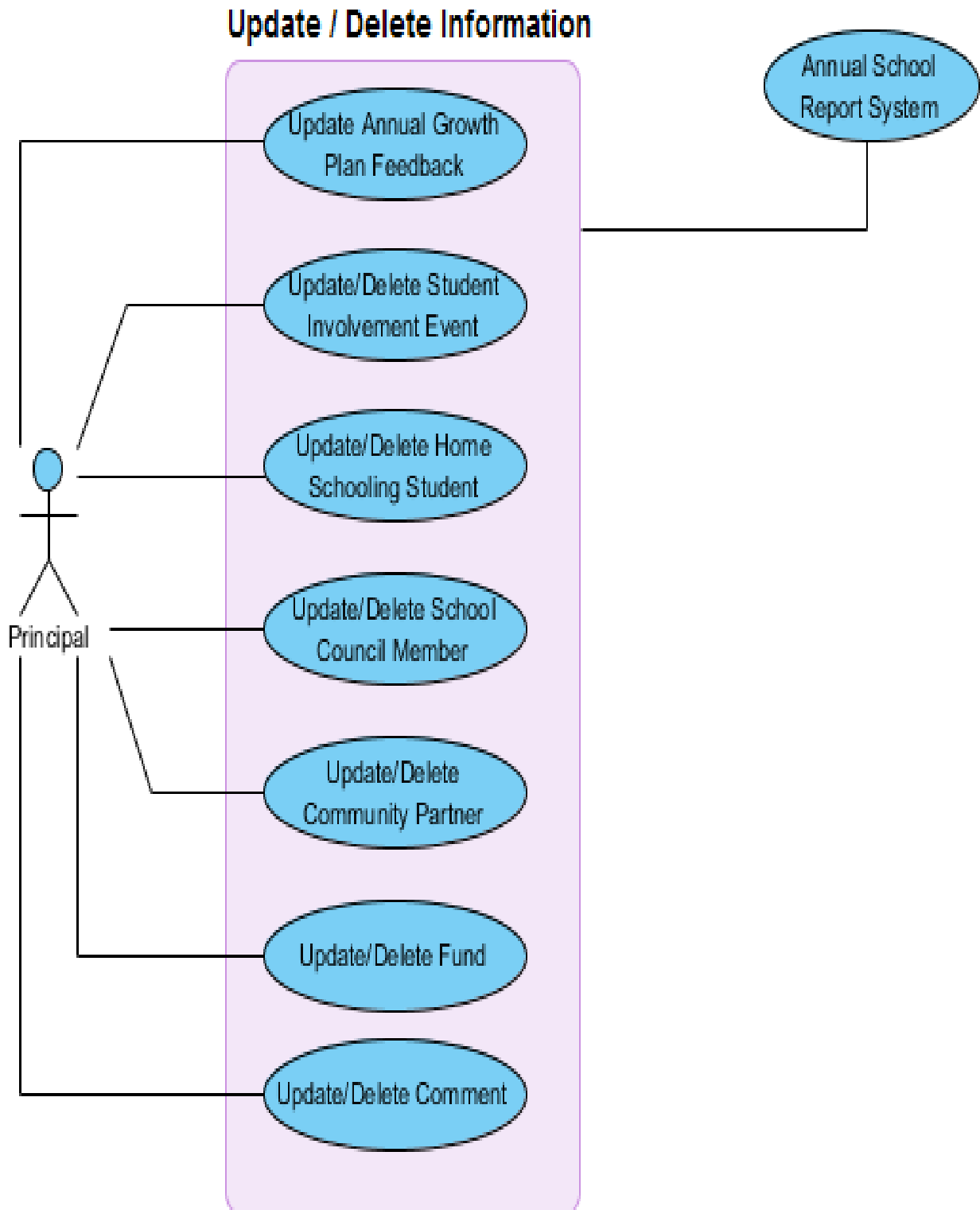


Figure 4.8: Use Case Diagram for Update/Delete Information

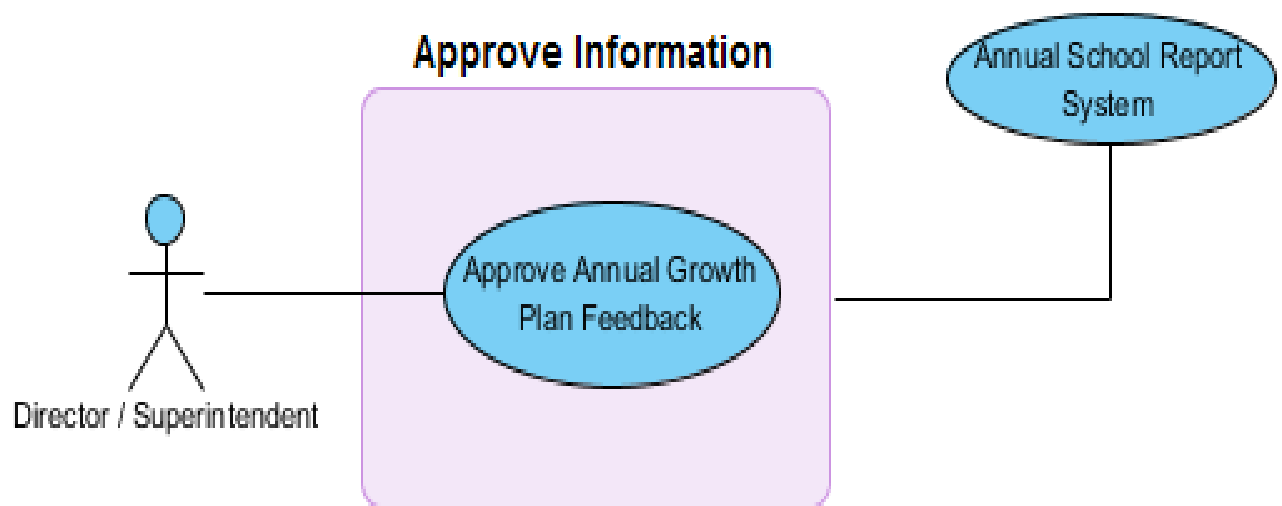


Figure 4.9: Use Case Diagram for Approve Information

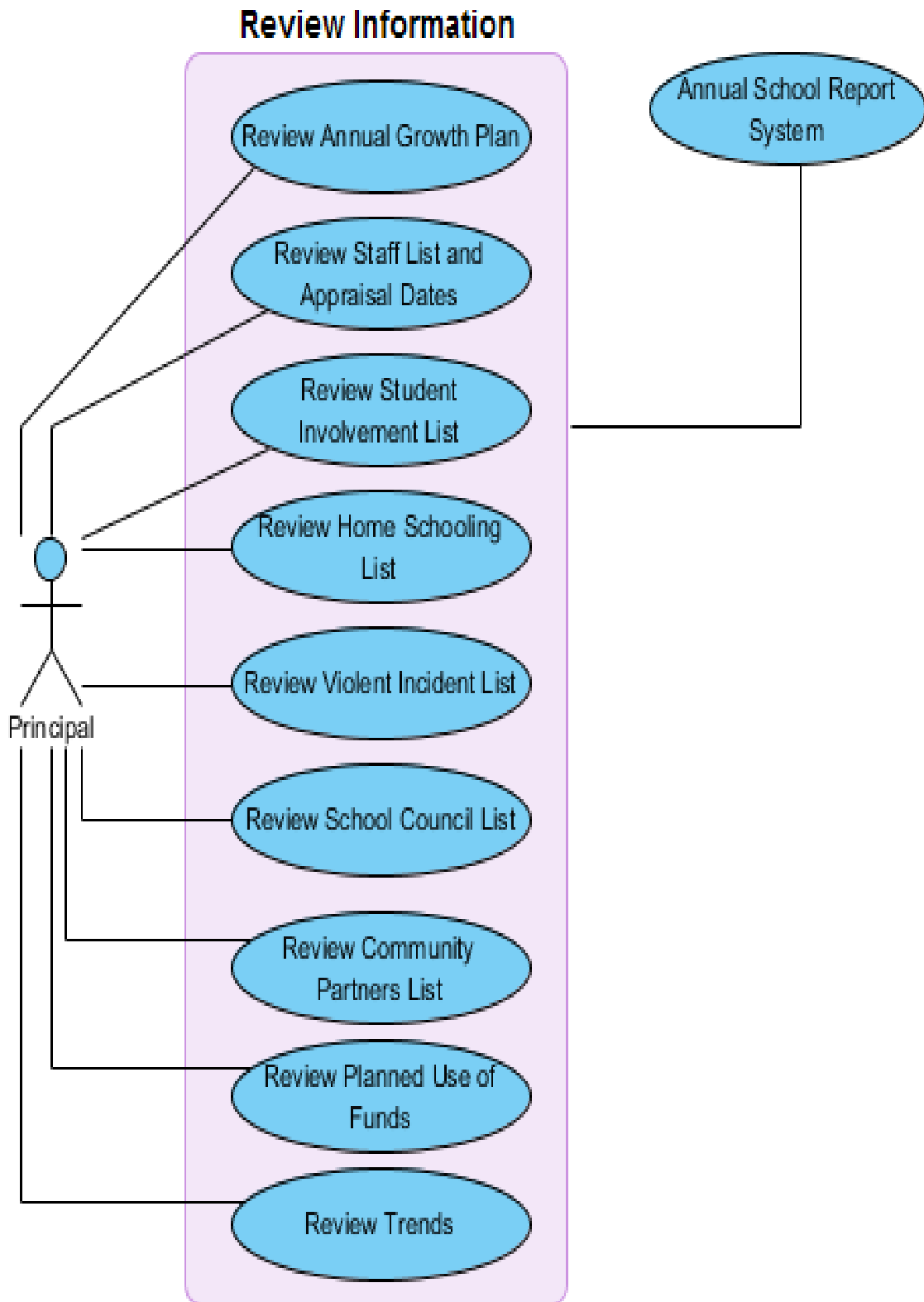


Figure 4.10: Use Case Diagram for Review Information

4.3 Database Design

The data that were not available in any information system were required to be added/updated/deleted into the new system. For that reason a database (named as ASREPORT) was designed to store those data. Design of the database for storing and pulling information is beyond the scope of this research. Hence details about the database design have not been discussed further.

4.4 Determining the Impact of Colors on User Interface

Fusion of visual data and knowledge for decision making was a key feature in the design of the new web interface of the school board application. Previous research [38] has shown that blue is frequently regarded as users' favourite color irrespective of age and culture. The information that is provided by the system is of a delicate nature, e.g. high suspension rates, poor performance on provincial tests, poor staff attendance, violent incidents in schools. Hence, different shades of blue were used in the interface to provide the users with soothing feelings, because blue is a relaxing color [39].

Three colours (blue, orange and gray) were investigated by N. Bonnardel (2011) [34] to determine their effect on users' behaviour and cognitive processes. Information presented in nonlinear forms (i.e. in indented lists) was better memorized in orange than were purely linear forms presenting the same information. The website developed here was primarily recognition oriented rather than recall. On that basis, use of the color orange was not seen to be an advantage to help the users to navigate the system. The menu items and buttons were presented in a linear fashion clearly

indicating the next possible action thus minimizing memorization for the user. The color orange was therefore never used.

4.5 Data Automation Techniques

In the context of this thesis, data automation means the drawing of data from multiple information systems by formulating SQL queries to populate a web page. The data that were to be automated were scattered in different database systems in different environments. Hence, the data had to be sorted out and retrieved using complicated queries. The following subsections explain the techniques that have been used to automate the data.

4.5.1 Staff List and Appraisal Dates

Staff information resided in the Staff Information Management System maintained by Human Resources Department. The data were retrieved using the following algorithm:

```

Establish connection to IPPS
For each location
  Get employee ids with open position
  For each employee
    Get name and employee group code
    Get summation of actual fte
    Get seniority service eligibility date where
      Case when employee group indicates 'teacher'
        seniority service code for teachers
      Case when employee group indicates 'EA' or 'DECE'
        seniority service code for EAs or DECEs
      Case when employee group indicates 'staff official'
        seniority service code as blank
    Get latest appraisal date
    Get latest next appraisal date
    Calculate evaluation year from next appraisal date
  If job code indicates 'principal'
    Get name of the Principal
  Get alternate location code
  For each alternate location
    Get name of the Superintendent
For each resultset
  Store each field
Close connection

```

Persuasive techniques [33] had been applied in the interface in order to motivate the staff appraisal process. In the staff list, staff members that had to be evaluated in a current year were highlighted in green. As a result, at a glance of the staff list, the Principals were able to identify the staff members that were to be evaluated that year. The color green was chosen for highlighting since green was found to be the most clearly discernible color by the users [34]. The meaning of the highlighted rows was explained in the instruction section at the top of the page. The procedure that had been used to achieve this was as follows:

```
Extract current year from system date
Store current year as a variable
For each staff
    If evaluation year matches with current year
        Highlight the row
    Else
        Do nothing
```

Figure 4.11 shows the outcome for the Staff List and Appraisal Dates. The figure has been blurred due to the sensitivity of data.

Public School
Staff List and Appraisal Dates

Instructions

Staff information has been imported from TRILLIUM and is not editable. Please contact Thomas Roccoforte if you have any concerns/questions about any data.
 Staff highlighted in green should be scheduled to be evaluated this year.
 General comments can be added/edited by clicking on the button below the general comments section.
 If you are the Principal of the school, please click on the 'Review' button at the bottom of the page every time you review the list so that the system shows the latest date you have reviewed the information.

Principal: [REDACTED]

Superintendent: [REDACTED]

Name	Employee ID	Staff Group	FTE	Starting Date	Last Appraisal Date	Next Appraisal Date	Scheduled Evaluation Year
Bonnie, Erin	110719	CLASSROOM	1.00000	12-Sep-2018			
Chaharal, Katherine	110401	CLASSROOM	1.00000	12-Sep-2018	16-Aug-2018		
DiGirolamo, George	114304	EDUCATIONAL	1.00000	16-Jun-1989	28-Jun-2017		
Eng, Bernard	114114	TEACHING	1.00000	16-Sep-1980	14-Dec-2016	14-Sep-2018	2018, 2019
Greene, Judy	117790	TEACHING	1.00000	12-Sep-2018			
Hudson, Hilary	112547	TEACHER	1.00000	N/A	28-Jun-2012	14-Sep-2016	2016, 2017
Hunt, Sherry	114079	EDUCATIONAL	1.00000	17-Feb-1980	21-Apr-2016		
Ising, Shelley	114522	TEACHING	1.00000	14-Sep-1980	14-Sep-2016	14-Sep-2018	2018, 2019
Kingsley, Amanda	110718	TEACHING	1.00000	23-Sep-2013	18-May-2018	14-Sep-2018	2018, 2019
Larson, Clara	113441	TEACHING	1.00000	14-Nov-2002	28-May-2013	14-Sep-2017	2017, 2018
Lewis, Shelley	117380	TEACHING	1.00000	05-Jun-2013	13-Jun-2018	14-Sep-2018	2018, 2019
Lewis, Terrell	110500	TEACHING	1.00000	26-Jun-2004	27-Nov-2016	14-Sep-2018	2018, 2019
MacDonald, Lynn	112007	TEACHER	1.00000	N/A	17-Jun-2000	14-Sep-2013	2013, 2014
MacLean, Jennifer	114179	EDUCATIONAL	1.00000	18-Sep-2007	21-Jun-2018		
McCollister, Terri	114026	EDUCATIONAL	1.00000	15-Dec-1987	21-Jun-2018		
McLennan, Cathy	114414	EDUCATIONAL	1.00000	14-Sep-1980	24-Jun-2011		
McGregor, Lisa	110014	TEACHING	1.00000	15-Sep-2000	30-May-2018	14-Sep-2018	2018, 2019
McNeil, George	110722	CLASSROOM	1.00000	14-Sep-2011			
Mohrman, Tara	114426	TEACHING	1.00000	14-Sep-1980	17-May-2011	14-Sep-2011	2011, 2014
Morris, Jason	115034	TEACHING	1.00000	20-Nov-2000	14-Sep-2016	14-Sep-2018	2018, 2019

Figure 4.11: Staff List and Appraisal Dates

4.5.2 Violent Incident List

Violent incident information was pulled from the Student Information Management System. The following algorithm was used to retrieve the data:

```

Establish connection to TRILLIUM
For each location
  Calculate school year from system date
  For each school year
    Get infraction
    If infraction indicates 'violent incident'
      Get incident id
      Get incident date
      Get incident description
      Get person id
      For each person
        Calculate age from birth date
        Get gender
      For each incident
        Get suspension flag
  
```



```
        Get expulsion flag
        Get police contact flag
        Get violent flag
        Get suspension number of days
For each resultset
    Store each field
Close connection
```

Interestingly, some discrepancies were found in the data that were retrieved. There were some incidents, where the infraction information indicated that a violent incident had occurred. However, the violent incident flag was not checked in the system. Conversely, some incidents were found without any description entered. It was necessary to draw attention of the Principals to these records. As a solution, the mistakes were highlighted in yellow with instructions to the Principals on how to correct those information. The reason behind using the highlighting color yellow was that the users feel cautious when they see yellow [34] [37]. The procedure that was used to achieve this was as follows:

```
For each incident
    If incident description field is blank
        Highlight the field
    Else
        Do nothing
    If violent incident flag is 'No'
        Highlight the field
    Else
        Do nothing
```

Figure 4.12 shows the Violent Incident List. The figure has been blurred due to the sensitivity of data.

School											
Violent Incident List (2013-2014)											
<p>Instructions</p> <p>Student information has been imported from Trillium and is not editable. Sections highlighted in yellow indicate missing data in Trillium. General comments can be added/edited by clicking on the button below the general comments section. If you are the Principal of the school, please click on the 'Review' button at the bottom of the page every time you review the list so that the system shows the latest date you have reviewed the information.</p>											
No	Incident Date	Infraction	Incident Description	Age	Gender	Suspension	Expulsion	Police Contacted	Violent Incident	Length	Incident ID
1	20-Nov-2013	PhysAssault	While under suspension, the student entered the building and approached a student who was seated on the floor in the hallway and assaulted him. Without warning, the student attempted to kick the student in the face and put his foot on the locker behind him. His feet started to shove punches at the student's face while he was still seated. Another student intervened and pulled her off of the student. The student then left the building and was outside behind lifts. Cameron's dragging about the incident to several other students. When the Vice-Principal approached he took off running down Spall's street towards Starytown. The student's who was assaulted left eye was red and swollen and was taken for medical treatment and to check on possible concussion.	15	Male	Yes	No	Yes	Yes	20	000112174
2	01-Apr-2014	PhysAssault		17	Male	No	Yes	No	No		000112638
3	01-Apr-2014	UseofWeapons	Tristen Martin is expelled for using a weapon to threaten bodily harm to another person. Tristen admitted to the above and he acknowledged his mistake. He wants help and counseling and he understands that upon successful completion of the Whole-Child-Wellness program and (Spartan) he may return to a secondary program.	16	Male	No	Yes	No	No		000112639
4	25-Feb-2014	PhysAssault	On Feb 25th during lunch at approximately 11:30 in front of the library James assaulted another student. James punched the student in the face several times bruising his right cheek and eye and cutting his nose. An ambulance was called for the other student as he was complaining of a headache and numbness in his arm. He was taken to the hospital and examined by a doctor.	17	Male	Yes	No	Yes	Yes	20	000112647
5	03-Mar-2014	UseofWeapons	On Feb 25 during period one in the auto shop, Tristen was wearing a knife under his desk at the time he was talking to the student that he was going to stab the other students. Police were contacted as a result of this incident. Tristen was arrested and charged and a violent incident form was completed.	16	Male	Yes	No	Yes	Yes	20	000112651

Figure 4.12: Violent Incident List

This section has described the data automation techniques that contributed towards good user experience and usability.

4.6 Data Summarization using Fuzzy Set Techniques

The term 'summarization' is used in the Educational Data Mining (EDM) community to mean providing a compact description of some part of the data [35]. A recent paper [36] uses the term 'summarization' for educational data mining itself including all of its techniques as outlined in Section 2.2.2. This thesis uses 'data summarization' to refer to the combination of multiple criteria information. This was achieved by using fuzzy aggregation of inferences (as described in Section 2.3.4) in a fuzzy knowledge base.

Data summarization based on Fuzzy sets required crisp values that could be used as inputs to the fuzzy inference system. Computation of crisp input was done in the school board data in a preprocessing step. Fuzzy set data mining was then applied to those crisp values. A fuzzy inference

system was created to determine overall performance of a school regarding provincial assessment result (referred to as EQAO). Figure 4.13 shows the process flow.

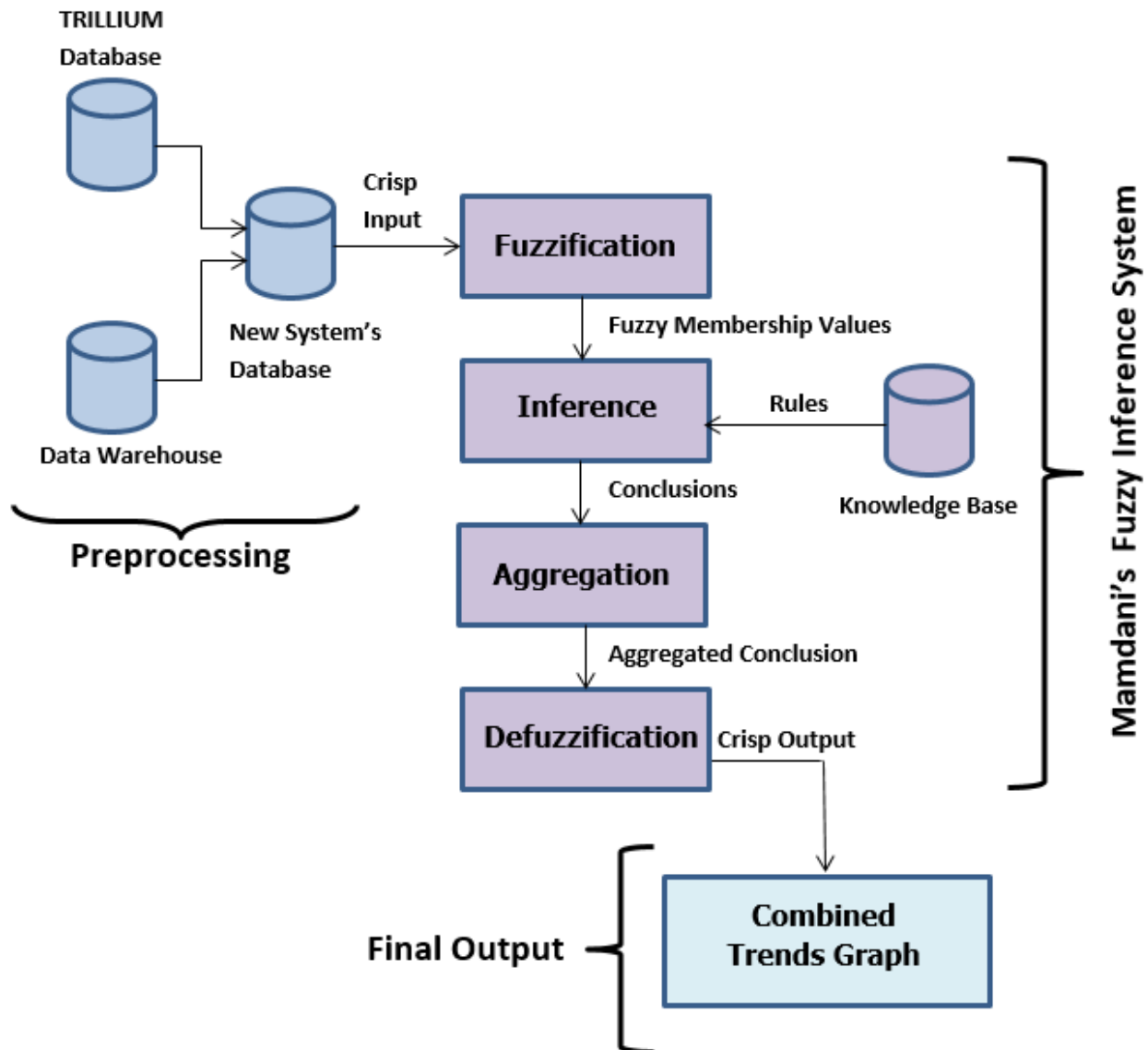


Figure 4.13: Data Summarization Process

The process has been elaborated in the following subsections.

4.6.1 Preprocessing

EQAO involved three tests for each grade in elementary schools, which were reading, writing and math. The school board database contained data about each test result for individual students. The data was preprocessed in order to obtain the crisp values that could be used as input to the fuzzy inference system. Provincial assessment (referred to as EQAO) results existed in the data warehouse (as shown in Figure 4.13). The results were stored individually by students on assessment date basis. The date range within a school year did not reside in data warehouse. That information was stored in Trillium database. Therefore a connection had to be established to Trillium to collect the start date and end date of each school year. After that a connection to data warehouse was established. The data were not stored as per level; rather they were stored as per marks of each student. The levels were determined from the marks such that marks between 1 and 1.9 lied in level 1, marks between 2 and 2.9 lied in level 2 and so on for level 3 and level 4. The number of students for each level was counted. The percentages were then calculated by dividing number of students at each level by total number of students at all levels and multiplied by 100. Finally a connection to the new system's database (known as ASREPORT) was established to create a temp table and store those data. The following algorithm was used to collect the data and store them in the temp table:

```

Establish connection to TRILLIUM
Calculate school years from system date
For each school year
    Collect start date and end date
Store each field
Close connection to TRILLIUM
Establish connection to Data Warehouse
For each school
    For each assessment date between start date and end date of school year
    For each course title
    For each grade
    For each mark between 1 and 1.9
        Count rows
    For each mark between 2 and 2.9
        Count rows

```

```

For each mark between 3 and 3.9
    Count rows
For each mark between 4 and 4.9
    Count rows
For each resultset
    Calculate percentage
Store each field
Close connection to Data Warehouse
Establish connection to ASREPORT
Create temp table
Populate each field
Close connection

```

The information was presented in a graph in the following manner.

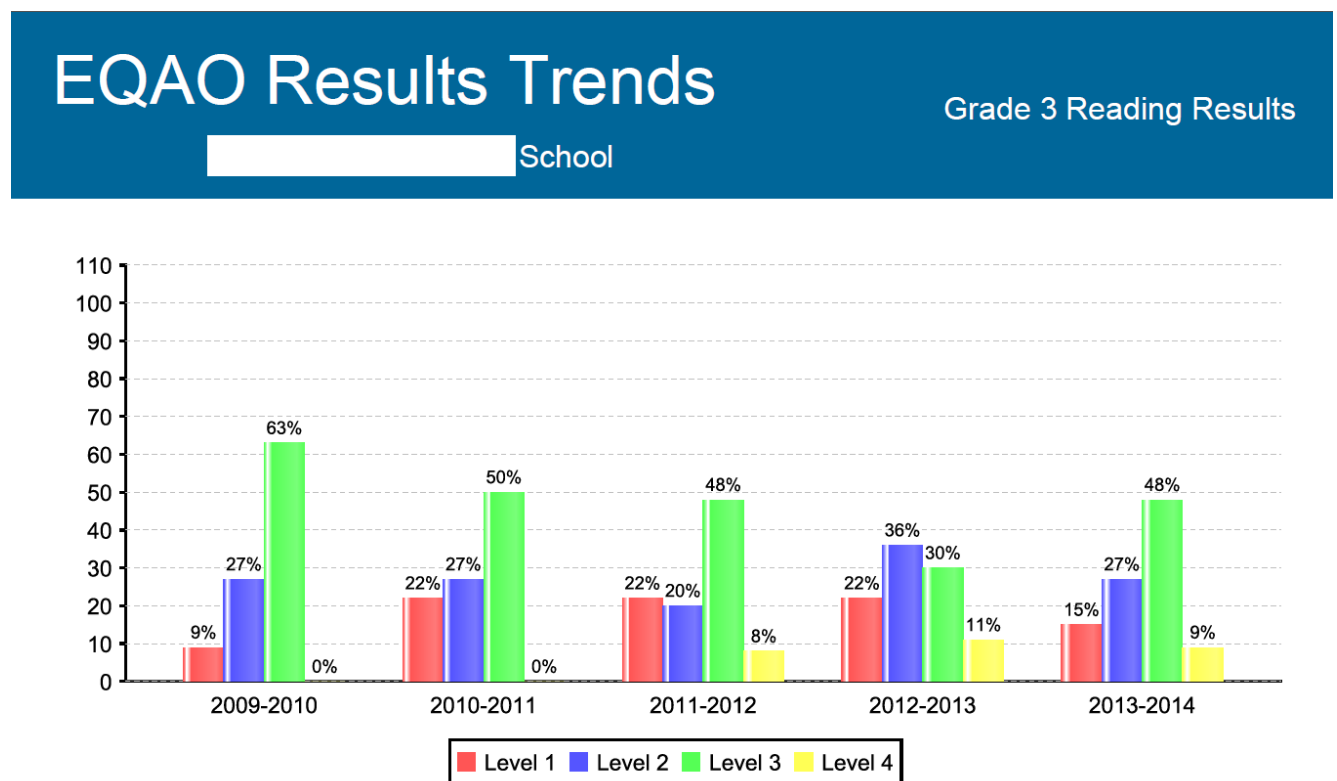


Figure 4.14: EQAO Grade 3 Reading Result Trends Graph by Year

This graph (Figure 4.14) contained breakups with all the four levels as per the old system format.

In order to fit the data as input to a fuzzy inference system, the graph was simplified such that

Level 1 and Level 2 were combined as Low Level and Level 3 and Level 4 were combined as High Level. The summarized EQAO Grade 3 Reading Results graph is shown in Figure 4.15.

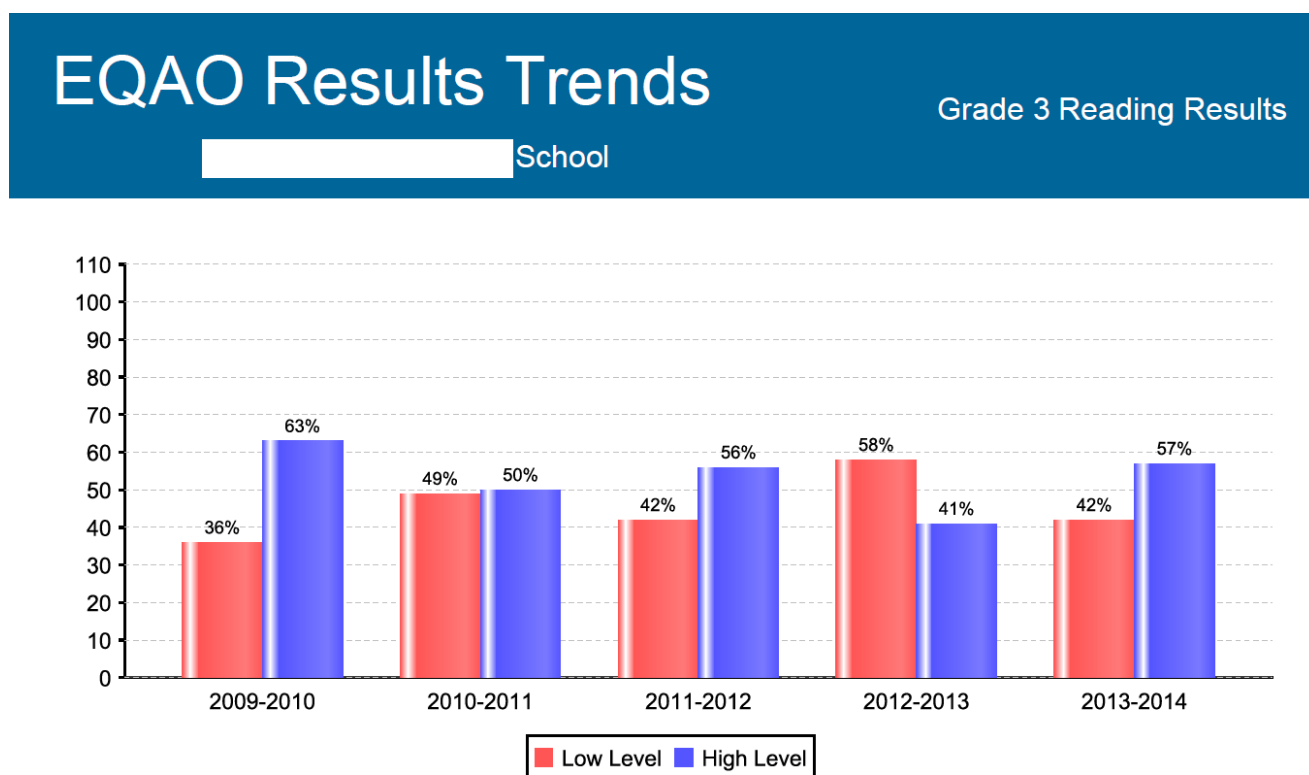


Figure 4.15: EQAO Grade 3 Reading Result Trends Graph by Year Summary

To simplify further, it was found that knowing only the low level percentage was enough to determine whether the number of students were higher at low level or high level since the total of two bars were approximately 100 (few less than 100 at times due to round off). As a result, the data were reduced to only low level percentages as follows (Figure 4.16, 4.17, 4.18):

EQAO Results Trends

Grade 3 Reading Results

_____ School

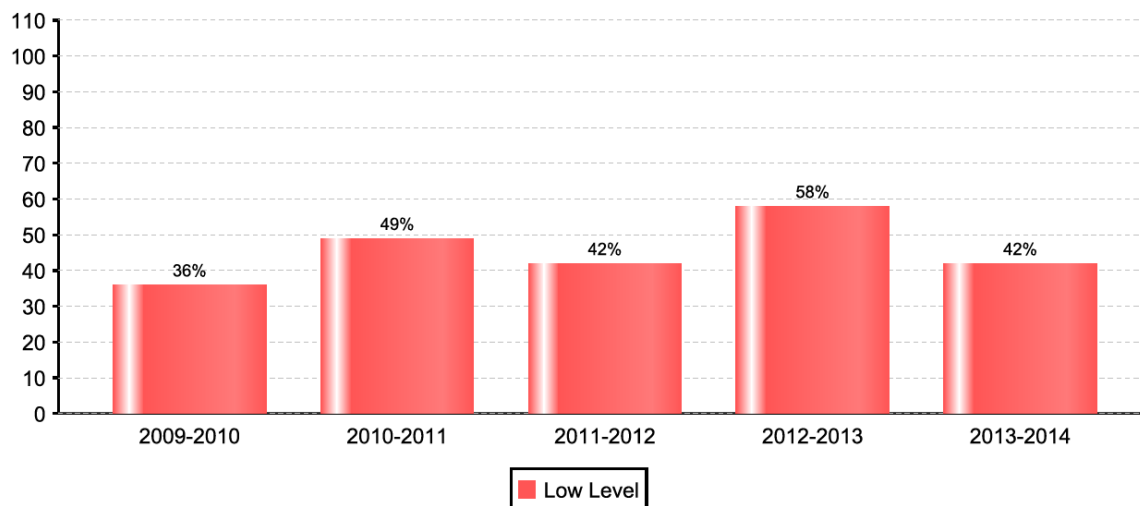


Figure 4.16: EQAO Grade 3 Reading Result Low Level Trends Graph

EQAO Results Trends

Grade 3 Writing Results

_____ School

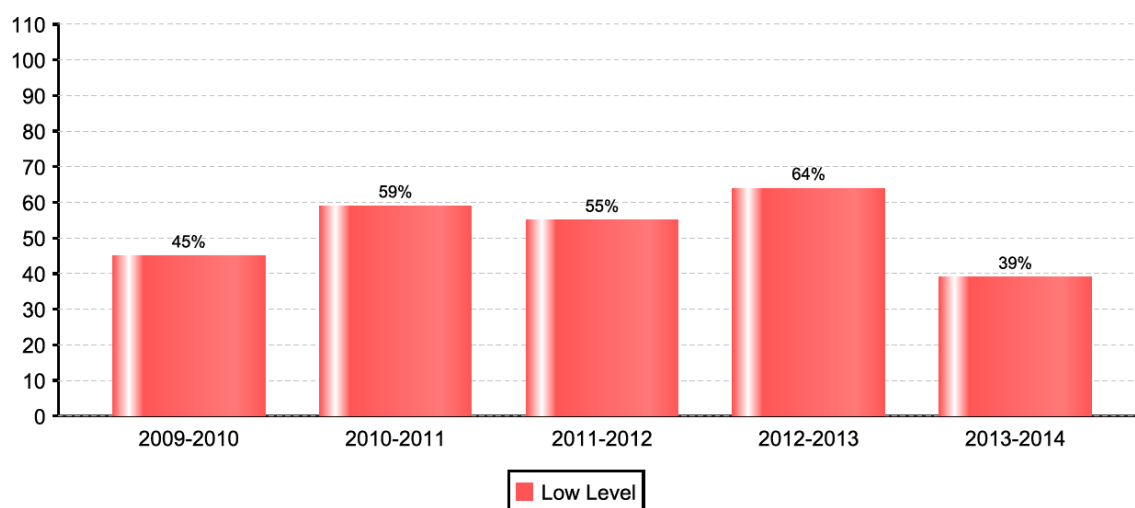


Figure 4.17: EQAO Grade 3 Writing Result Low Level Trends Graph

EQAO Results Trends

Grade 3 Math Results

School

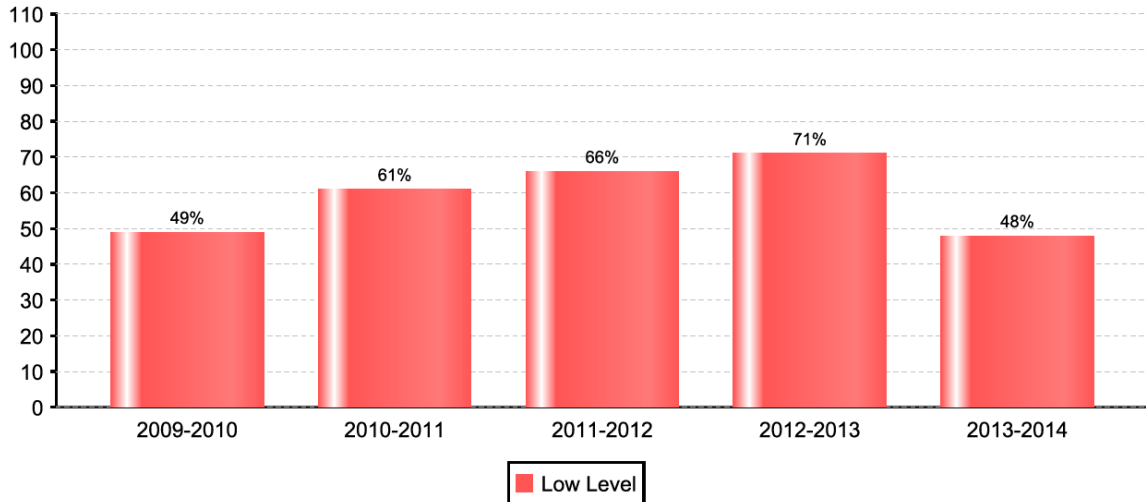


Figure 4.18: EQAO Grade 3 Math Result Low Level Trends Graph

The numeric data for the above graphs (Figure 4.16, 4.17, 4.18) were exported into a text file so that they could be sent to the fuzzy inference system as inputs. The format of the text file was as follows:

```
Year Reading Writing Math
2009-2010 36 45 49
2010-2011 49 59 61
2011-2012 42 55 66
2012-2013 58 64 71
2013-2014 42 39 48
```

4.6.2 Fuzzy Inference System

A Mamdani fuzzy inference system (FIS) (discussed in Section 2.2.6) was generated using MatLab with 3 input variables that were reading, writing and math, and 1 output variable performance (Figure 4.19).

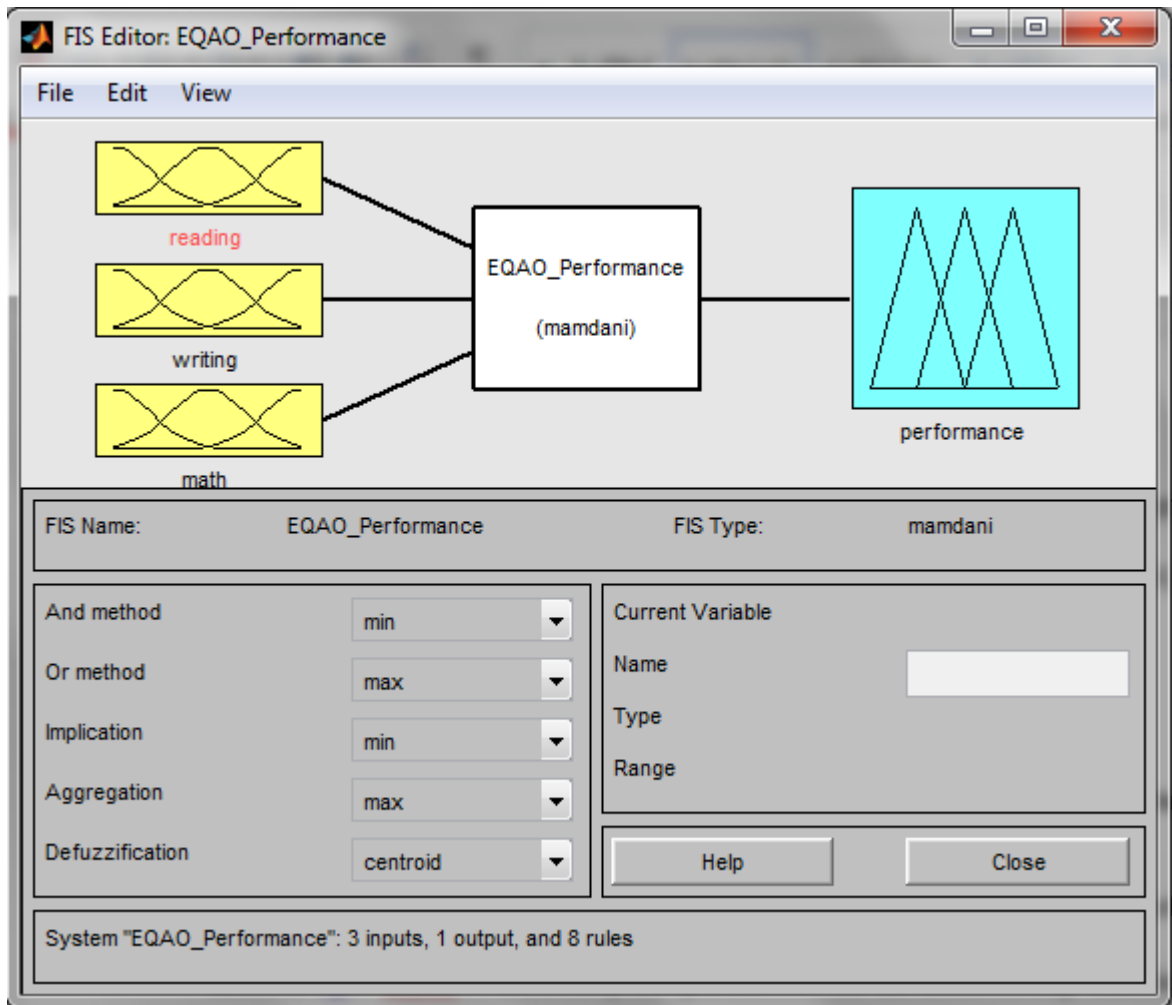


Figure 4.19: Fuzzy Inference System Structure

Trapezoidal membership functions were used due to their good performance reported in literature [32]. The parameters for the membership functions were defined based on experience dealing with the school board. For each of *reading*, *writing* and *math* variable, two membership functions were *few* and *most*. The *few* membership function is an R-function and the *most* membership function is

an L-function (discussed in section 2.3.2). The membership functions for input variables were defined as follows:

$$\mu_{few}(reading) = \begin{cases} 0, & reading > 60 \\ \frac{60-reading}{60-40}, & 40 \leq reading \leq 60 \text{ (Eq. 4.1)} \\ 1, & reading < 40 \end{cases}$$

$$\mu_{most}(reading) = \begin{cases} 0, & reading < 40 \\ \frac{reading-40}{60-40}, & 40 \leq reading \leq 60 \text{ (Eq. 4.2)} \\ 1, & reading > 60 \end{cases}$$

The membership functions for writing and math were similarly defined and those definitions can be found in Appendix B.

$\mu_{few}(x)$ and $\mu_{most}(x)$ were entered in MatLab using the edit option at the top left corner of the input screen. Figure 4.20 shows the membership functions (MF) for reading. The writing and math MFs are similar and included in Appendix B.

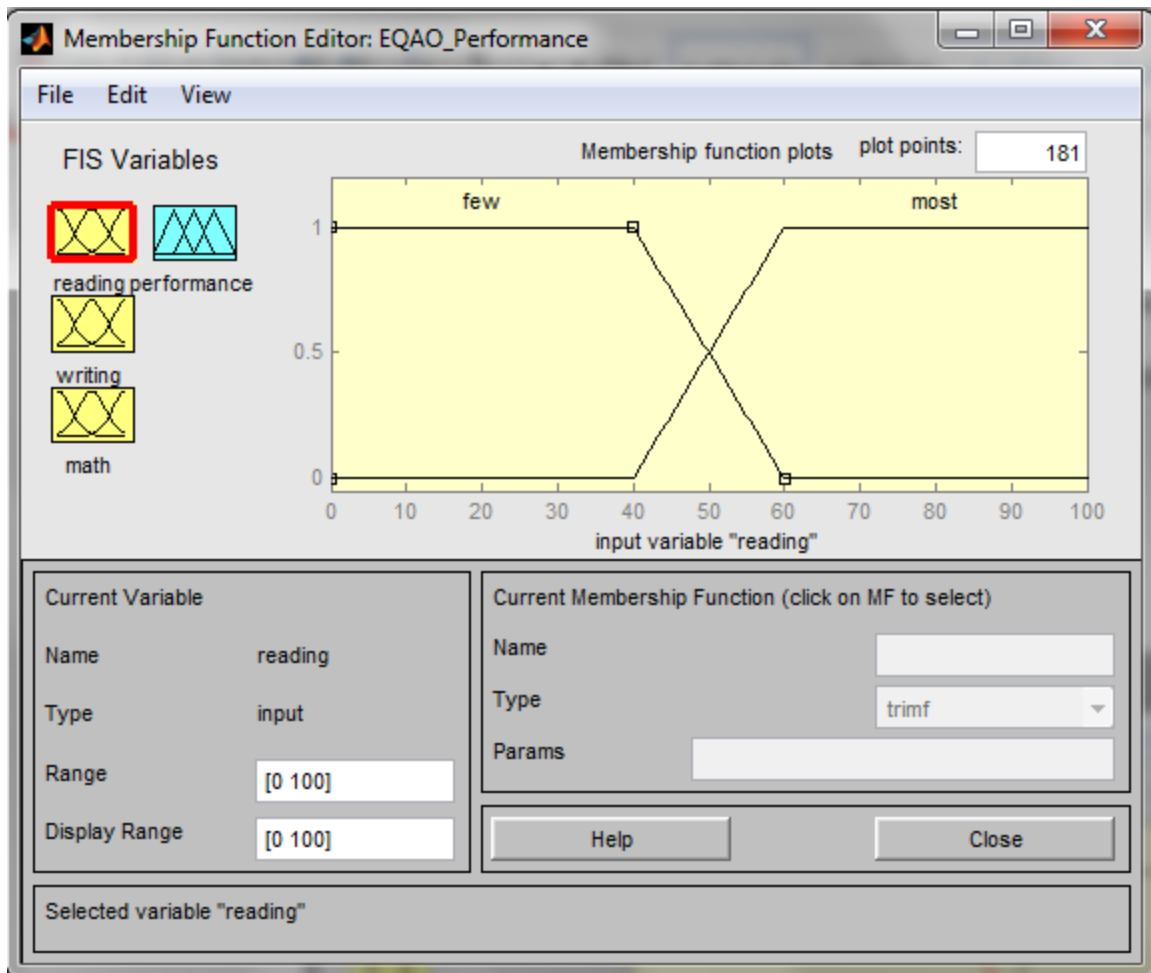


Figure 4.20: Fuzzy Membership Function – reading (Input)

The membership functions for output variable performance were *poor* (trapezoidal R-function), *average* (trapezoidal), *good* (trapezoidal), and *excellent* (trapezoidal L-function). They were defined as follows:

$$\mu_{poor}(performance) = \begin{cases} 0, & performance > 1.9 \\ \frac{1.9-performance}{1.9-1.0}, & 1.0 \leq performance \leq 1.9 \dots \text{(Eq. 4.3)} \\ 1, & performance < 1.0 \end{cases}$$

$$\mu_{average}(performance) = \begin{cases} 0, & (performance < 1.1) \\ & \text{or } (performance > 2.9) \\ \frac{performance-1.1}{1.9-1.1}, & 1.1 \leq performance \leq 1.9 \\ 1, & 1.9 \leq performance \leq 2.1 \\ \frac{2.9-performance}{2.9-2.1}, & 2.1 \leq performance \leq 2.9 \end{cases} \dots(\text{Eq.4.4})$$

$$\mu_{good}(performance) = \begin{cases} 0, & (performance < 2.1) \\ & \text{or } (performance > 3.9) \\ \frac{performance-2.1}{2.9-2.1}, & 2.1 \leq performance \leq 2.9 \\ 1, & 2.9 \leq performance \leq 3.1 \\ \frac{3.9-performance}{3.9-3.1}, & 3.1 \leq performance \leq 3.9 \end{cases} \dots (\text{Eq. 4.5})$$

$$\mu_{excellent}(performance) = \begin{cases} 0, & performance < 3.1 \\ \frac{performance-3.1}{3.9-3.1}, & 3.1 \leq performance \leq 3.9 \\ 1, & performance > 3.9 \end{cases} \dots(\text{Eq. 4.6})$$

Figure 4.21 shows the membership functions for performance that was entered in MatLab.

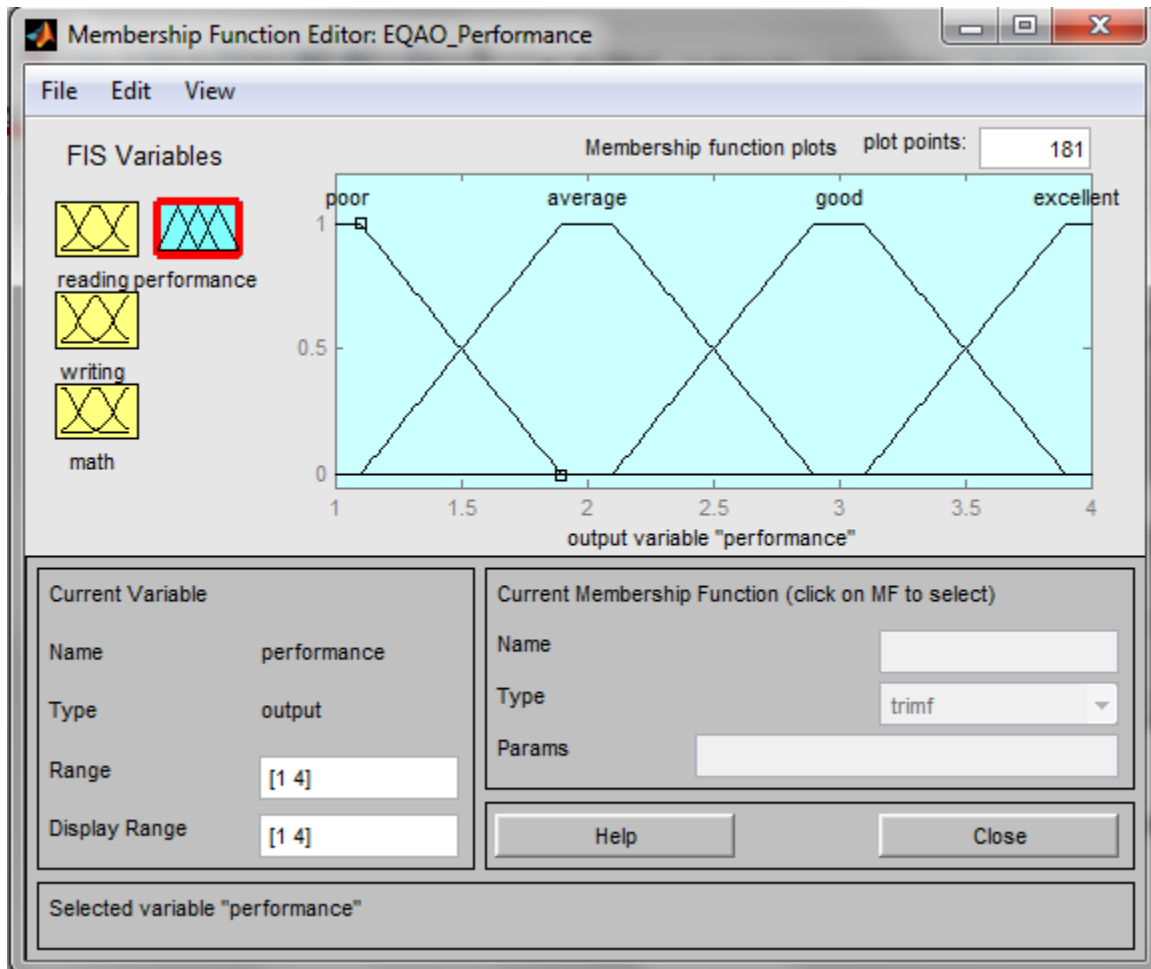


Figure 4.21: Fuzzy Membership Function – performance (Output)

Once the fuzzy membership functions were defined, the rules were conveniently entered using another input screen that gave all possible combinations of membership functions from which the rules were selected. The rules that were generated implied that if number of students getting low level in each of reading, writing and math are ‘few’, then the result is ‘excellent’. Similarly, if number of students getting low level in each of reading, writing and math are ‘most’, then the result is ‘poor’. If any two of reading, writing and math are ‘few’, then the result is ‘good’ and if any two of reading, writing and math are ‘most’, then the result is ‘average’. Table 4.3 shows the relations.

Rules	Input			Output
	Reading	Writing	Math	Performance
Rule 1	Few	Few	Few	Excellent
Rule 2	Few	Few	Most	Good
Rule 3	Few	Most	Few	Good
Rule 4	Few	Most	Most	Average
Rule 5	Most	Few	Few	Good
Rule 6	Most	Few	Most	Average
Rule 7	Most	Most	Few	Average
Rule 8	Most	Most	Most	Poor

Table 4.3: Fuzzy Relations

Therefore, the following 8 rules were entered into the system:

- **Rule 1:** If (reading is few) and (writing is few) and (math is few) then (performance is excellent)
- **Rule 2:** If (reading is few) and (writing is few) and (math is most) then (performance is good)
- **Rule 3:** If (reading is few) and (writing is most) and (math is few) then (performance is good)

- **Rule 4:** If (reading is few) and (writing is most) and (math is most) then (performance is average)
- **Rule 5:** If (reading is most) and (writing is few) and (math is few) then (performance is good)
- **Rule 6:** If (reading is most) and (writing is few) and (math is most) then (performance is average)
- **Rule 7:** If (reading is most) and (writing is most) and (math is few) then (performance is average)
- **Rule 8:** If (reading is most) and (writing is most) and (math is most) then (performance is poor)

Figure 4.22 show the generated rules in MatLab.

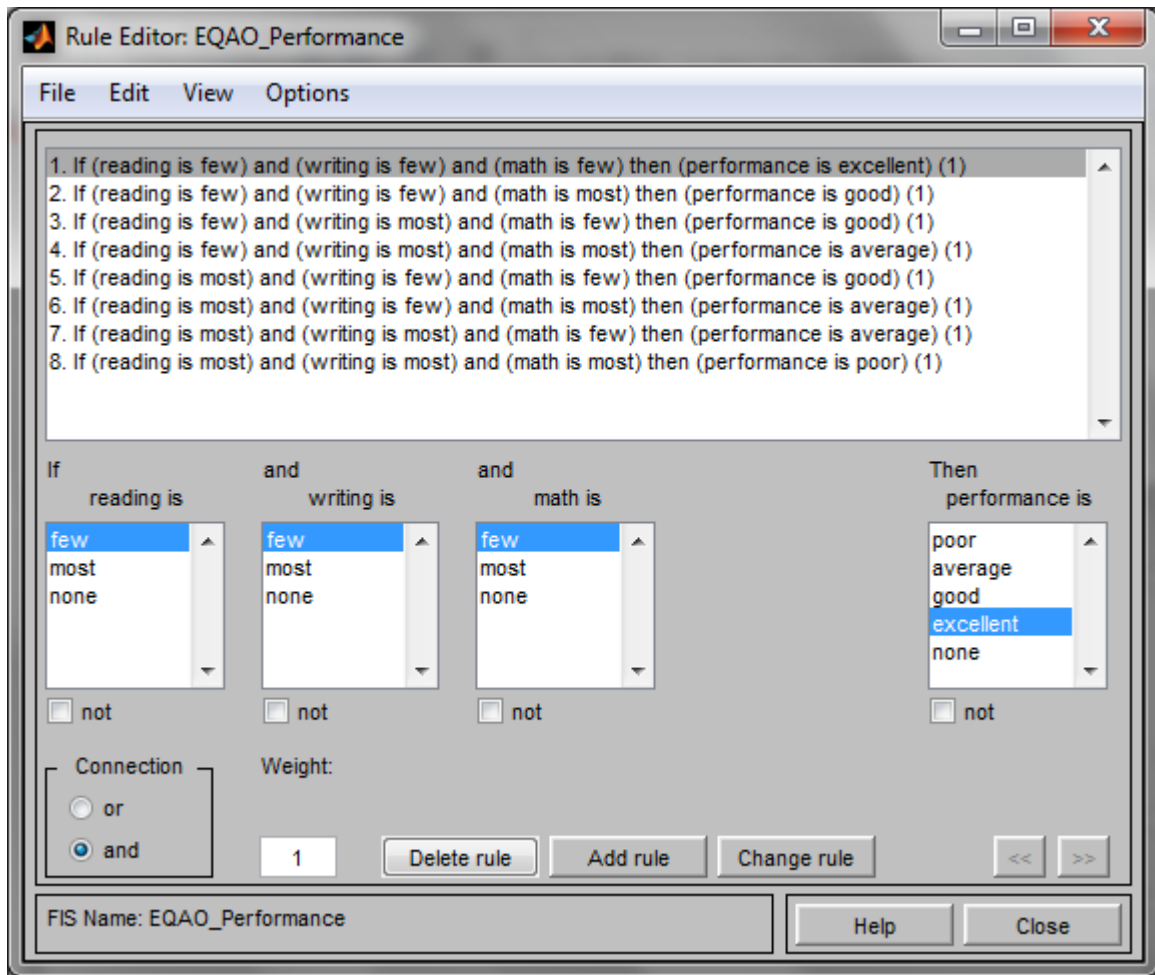


Figure 4.22: Rules for Fuzzy Inference

4.6.3 MatLab Code Explanation with Results

MatLab codes were written to read data from the input file, make inferences using the fuzzy inference system and generate a combined trend graph. In this section, the MatLab codes are explained along with the steps required to generate the results in the FIS.

```
% Import data from text file
filename = 'School A Data.txt';
delimiterIn = ' ';
headerlinesIn = 1;
A = importdata(filename,delimiterIn,headerlinesIn);
```



```

% Assign values to the variable year
year = A.textdata(2: end,1)

% Assign reading, writing and math data to the variables
reading = A.data(:,1)
writing = A.data(:,2)
math = A.data(:,3)

```

In the above code, the data were read from the text file and the variables were assigned.

```

% Read the structure of the fuzzy inference system
performance_fis=readfis('EQAQO_Performance.fis');

% Perform fuzzy computations to determine overall performance
performance=evalfis([reading writing math],performance_fis)

```

The fuzzy inference system (described in Section 4.6.2) was read by calling readfis function and crisp inputs of reading, writing and math with five years data were given to the evalfis function. The evalfis function performs fuzzification, inference, aggregation and defuzzification. Each of the steps that were performed internally by evalfis is described below.

- **Fuzzification:** Fuzzification was performed on the crisp values for each year to derive membership values. For example, for year 2009-2010, if reading = 36, writing = 45, and math = 49, the following membership values were derived as shown in Table 4.4.

	Few	Most
Reading	1 ($\because 36 \leq 40$) (as per Eq. 4.1)	0 ($\because 36 \leq 40$) (as per Eq. 4.2)
Writing	$\frac{60-45}{60-40} = 0.75 \approx 0.8$ ($\because 40 \leq 45 \leq 60$) (as per Eq. B.1 in Appendix B)	$\frac{45-40}{60-40} = 0.25 \approx 0.2$ ($\because 40 \leq 45 \leq 60$) (as per Eq. B.2 in Appendix B)

Math	$\frac{60-49}{60-40} = 0.55 \approx 0.6 (\because 40 \leq 49 \leq 60)$ (as per Eq. B.3 in Appendix B)	$\frac{49-40}{60-40} = 0.45 \approx 0.4 (\because 40 \leq 49 \leq 60)$ (as per Eq. B.4 in Appendix B)
-------------	----------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------

Table 4.4: Membership Value Calculation for Input Variables

- **Inference:** The membership values derived from fuzzification were input to generated rules (Figure 4.22) and a conclusion was derived from each rule by using ‘*min*’ function (INTERSECTION as in Section 2.3.3).

Consider the inputs of year 2009-2010, where reading = 36, writing = 45, and math = 49

Rule 1: few(reading) = 1, few(writing) = 0.8, few(math) = 0.6

$$\Rightarrow \text{excellent}(\text{performance}) = \min(1, 0.8, 0.6) = 0.6$$

Rule 2: few(reading) = 1, few(writing) = 0.8, most(math) = 0.4

$$\Rightarrow \text{good}(\text{performance}) = \min(1, 0.8, 0.4) = 0.4$$

Rule 3: few(reading) = 1, most(writing) = 0.2, few(math) = 0.6

$$\Rightarrow \text{good}(\text{performance}) = \min(1, 0.2, 0.6) = 0.2$$

Rule 4: few(reading) = 1, most(writing) = 0.2, most(math) = 0.4

$$\Rightarrow \text{average}(\text{performance}) = \min(1, 0.2, 0.4) = 0.2$$

Rule 5: most(reading) = 0, few(writing) = 0.8, few(math) = 0.6

$$\Rightarrow \text{good}(\text{performance}) = \min(0, 0.8, 0.6) = 0$$

Rule 6: most(reading) = 0, few(writing) = 0.8, most(math) = 0.4

$$\Rightarrow \text{average}(\text{performance}) = \min(0, 0.8, 0.4) = 0$$

Rule 7: most(reading) = 0, most(writing) = 0.2, few(math) = 0.6

$$\Rightarrow \text{average}(\text{performance}) = \min(0, 0.2, 0.6) = 0$$

Rule 8: most(reading) = 0, most(writing) = 0.2, most(math) = 0.4

$$\Rightarrow \text{poor}(\text{performance}) = \min(0, 0.2, 0.4) = 0$$

- **Aggregation:** The outputs were combined using the fuzzy aggregation operator ‘max’ (UNION as in Section 2.3.3). For the above example,

$$\text{excellent}(\text{performance}) = \max(\text{rule 1}) = \max(0.6) = 0.6$$

$$\text{good}(\text{performance}) = \max(\text{rule 2, rule 3, rule 5}) = \max(0.4, 0.2, 0) = 0.4$$

$$\text{average}(\text{performance}) = \max(\text{rule 4, rule 6, rule 7}) = \max(0.2, 0, 0) = 0.2$$

$$\text{poor}(\text{performance}) = \max(\text{rule 8}) = \max(0) = 0$$

- **Defuzzification:** Centroid defuzzification method was then applied to the data. This means that the center of gravity of the aggregated area was calculated to obtain a crisp output. For the above example, the crisp output for performance for 2009-2010 school year was 2.84.

Figure 4.23 shows the fuzzy operations using rule viewer in MatLab for year 2009-2010.

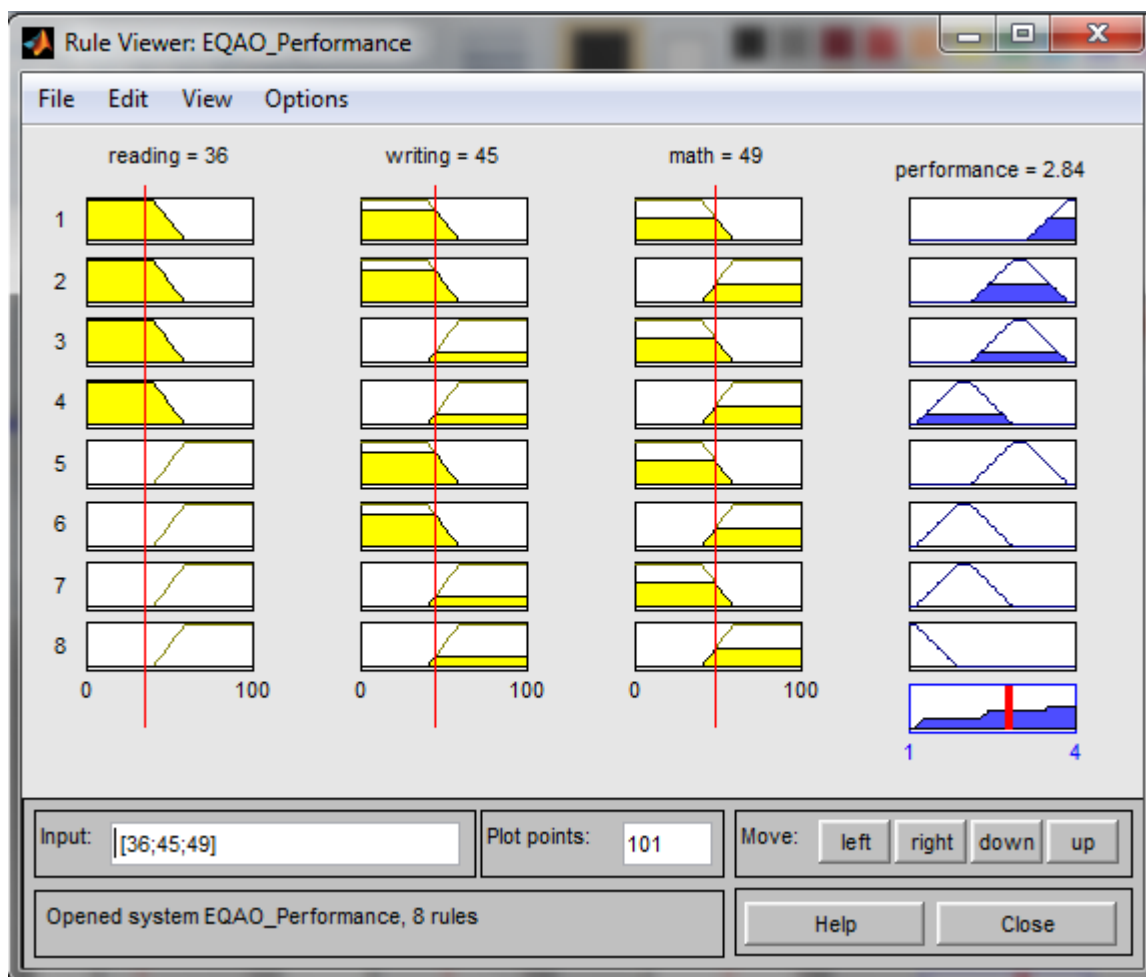


Figure 4.23: Fuzzy Operations for Year 2009-2010

Similar operations were performed for each year's data and an overall performance combining reading, writing and math was derived for each year. Table 4.5 shows the results for School 'A'.

School Year	Performance
2009 – 2010	2.8396
2010 – 2011	1.9529

2011 – 2012	2.2667
2012 – 2013	1.4780
2013 – 2014	3.0402

Table 4.5: Overall Performance of School ‘A’ on a Scale of 1 to 4

```
% Generate a bar chart for overall performance
bar(performance, 'BarWidth', 0.7, 'facecolor', 'i');
caption = sprintf('EQAO Grade 3 overall Performance');
title(caption, 'FontSize', 16);
xlabel('School Year', 'FontSize', 14);
ylabel('Performance', 'FontSize', 14);
set(gca, 'XTickLabel', year);
set(gcf, 'name', 'EQAO Grade 3', 'numbertitle', 'off');
```

A new trend graph (Figure 4.24) was then generated showing the overall performance combining reading, writing and math results.

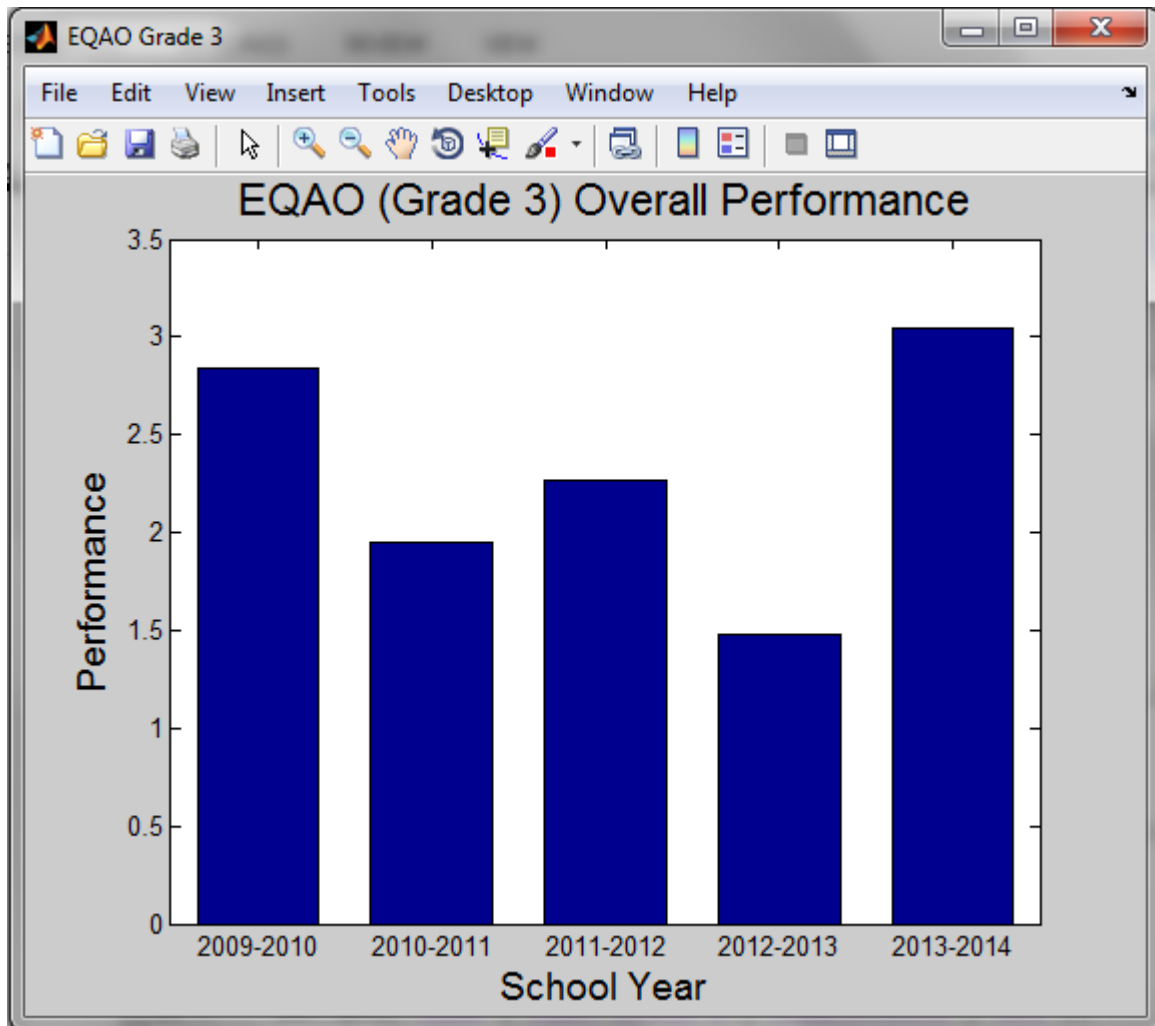


Figure 4.24: Combined Trends Graph

This subsection has shown how a fuzzy inference system was created and used for data summarization. The term ‘summarization’ is used in the EDM to mean a compact description of data. Such a description helped the managers to evaluate the overall performance of the schools. When managers can see the performance of schools, they are able to make plans for the upcoming year such as where to allocate resources and what remedial action can be taken.

A new annual school improvement planning system was required because the school board was unable to plan using the existing methods. In this chapter, implementation of a web application for

annual school improvement planning has been described. Sections 4.1 to 4.5 illustrate the use of conventional HCI techniques to design the interface and section 4.6 presents a proposed HCI technique based on fuzzy sets. The integration of Artificial Intelligence (AI) and Human-Computer Interaction (HCI) has been used to enhance the effectiveness of the web application as well as to provide good user experience.

Chapter 5

5 Evaluation of Usability and User Experience

The school board application was required to be verified in terms of usability and user experience. This evaluation process involved the testing of the prototype in terms of various criteria such as whether it meets the requirements, and how the user feels while using it.

Initially, the problem was presented such that there was a web-based system by which the managers wanted to view data to make decisions. However the users at the school end were reluctant to enter data into the system. As a result, the managers wanted a way that the users would get interested in entering the data. While analyzing further why the users were unwilling to enter data, it was found that they were already entering the same data into other individual systems. This means that the information the managers wanted the schools to enter already existed. Another finding was that the Principals were sensitive about the data that they were asked to enter into the system. Those data represented the performance of their schools in terms of suspension rates, violent incidents, staff attendance, student attendance and provincial test results. Hence, they were not comfortable

entering the data whenever the performance was not the best, such as high suspension rates or poor provincial test result.

The researcher thought that integrating the data from those multiple systems would be a better approach because it would solve their immediate problem as well as provide solutions for problems that might be encountered later. The users were delighted with this prospect once they realized that such would be possible. The user interface was improved therefore by data automation. This is to emphasize that data automation has had a huge impact on the development of a good user interface that could not have been gained by simply asking users what a satisfying interface would be.

This chapter illustrates the evaluation techniques that were implemented on the school board application in order to assure that it met the usability criteria as well as provided good user experience. The evaluation process started with following a framework known as DECIDE [25] that is described in Section 5.1. Section 5.2 includes the highlights about the heuristic evaluation findings. Section 5.3 explains the cognitive walkthrough process to predict potential problems that could be faced by users. Section 5.4 discusses the positive impact of data automation as well as summarization using fuzzy techniques to facilitate good user experience.

5.1 The DECIDE Framework

The DECIDE framework [25] provides a checklist for planning a thorough evaluation study. The following were the steps that were carried out in the evaluation study of the School Board application as defined in the DECIDE framework.

5.1.1 **D**etermine the Goals

The goal of the evaluation study of the school board application was to determine the extent to which the user interface facilitated the users' ability to complete the routine tasks and make decisions based on the information provided. To ensure satisfaction in the eyes of the end users, quality attributes of the user interface were needed to be evaluated. The quality attributes that must be exhibited included the usability, functionality, efficiency, security, availability, and maintainability of the system.

5.1.2 **E**xplore the Questions

The following were the questions that were to be answered by the evaluation study in order to make the goals operational.

1. Was the school board application interface able to deliver the promised services dependably and accurately?
2. Did the interface have good appearance and navigational design?

The first question concerns the usability of the interface and the second question is about the user experience.

5.1.3 **C**hoose the Evaluation Methods

The evaluation methods used were the *heuristic evaluation*, and *cognitive walkthroughs*. Heuristic evaluation and cognitive walkthroughs do not involve the users. Heuristic evaluation [Nielsen, 2010] is a usability inspection method in which HCI experts use a checklist to evaluate the user interface. In cognitive walkthroughs, the HCI expert examines each step of the processes

by simulating the actions by test driving the user interface. Cognitive walkthroughs are domain specific, whereas heuristic evaluation tends to be more general.

5.1.4 **I**dentify the Practical Issues

A practical issue that was faced in evaluation phase was that upper management at the school board were very busy and were not available for systematic usability testing. Such usability testing would involve users in lab or field environments, but it was not possible to assemble. Principals of different schools, Superintendents (each in charge of a group of schools) and the Director of Education in one place at one time. In fact, getting a 5 minute appointment with any of them was a challenge. As a result, heuristic evaluation and cognitive walkthroughs were chosen to evaluate the user interface, since these techniques do not require user involvement.

5.1.5 **D**ecide How to Deal with the Ethical Issues

Privacy of data was an ethical issue while working on this project. An ethical approval form was completed and was accepted by the school board so that the researcher could use the data for this study. Due to confidentiality of data, it was not possible to involve lower level school board employees for usability testing. On the basis of the approval of the school board, an application was made to the Laurentian Ethics Review Board that was approved.

5.1.6 **E**valuate, Analyze, Interpret, and Present the Data

The school board application was evaluated against a number of heuristics that had been proposed by past researchers. The findings were analyzed using a qualitative approach. Though users were not explicitly involved in evaluation of the system that would be used by the School Board, interaction with them proved valuable for gaining an understanding of their acceptance of the system. In this section, the implementation of heuristic evaluation and cognitive walkthroughs are discussed. The design was modified iteratively according to the recommendation derived from the evaluation studies and user feedback.

5.2 Heuristic Evaluation

The heuristics that were used in this evaluation study include Neilson's (2010) [40] heuristics, Budd's (2005) [41] heuristics, Horton's (2005) [42] design guideline, and Koyani's (2004) [43] design guideline. The system was checked to see whether the criteria of the heuristics and guidelines were met. Recommendations were made at the evaluation phase where the criteria were not met and the interface was updated according to the suggestion revealed by the evaluation. The checklist for each heuristic, a brief description of what was found and indication of where improvements could be made are included in the Appendix C. Highlights of evaluation of the web design will be described next.

Many of the criteria were already satisfied by the new system prior to using the heuristic evaluation. To name a few, straightforward interface with meaningful names for buttons and menu items, confirmation messages after every operation, minimization of user memory load, and minimalistic design. The error messages specified the problem type as well as the next action for resolution and thus helping the users to recognize, diagnose and recover from errors. Uniformity of the interface with other school board applications reduced the need for external documentation. The application

relies greatly on well-known conventions for layout and organisation of the items displayed on its interface (e.g. page headers are at the top of each page, page headers in one color and section headers in another color). Even users that are new to using the application will not have trouble orienting themselves because consistency has been maintained with overall design patterns that are familiar to most web users. While evaluating against Koyani's [43] design guideline, it was found that the interface did not contain excessive use of colors.

The evaluation pointed out some improvements that could be made. For example, lack of error prevention capability was found in the interface and the recommendation was that adding some short instructions in every page could prevent errors. The interface was then updated accordingly. There were some cases where the evaluation recommendation did not match with the users' preferences. For example, the Annual Growth Plan form contained too many information that violated Horton's (2005) [42] design guideline. However, the users were accustomed to a particular format and they wanted to see the same format on the web. Hence, the form was not updated in accordance with the heuristic.

5.3 Cognitive Walkthroughs

Cognitive walkthrough was used to ensure a thorough review for predicting potential problems faced by users without involving the users specifically. Every step of the processes were simulated by the researcher and the following three questions were answered.

Q. 1. Will users know what to do?

Q. 2. Will users see how to do it?

Q.3. Will users understand from feedback whether the action was correct or not?

It was a lengthy and laborious process as illustrated in Appendix D, because the review was done on a micro level for each and every process no matter how small. The main results were that short instructions could be given to the user at particular steps where needed, but finding the particular places where such guidance should be provided required answering the above questions for every possible place.

5.4 Data Automation and Summarization

The existing system required the users to enter data in order to generate trend graphs. This included huge data entry with percentage calculation for each breakup criteria of the graphs. After successful data automation, user feedback indicated that they were highly satisfied to be able to view the same graph just by a click of mouse without any data entry from their side. After the data were automated, provincial assessment test (EQAO) result trends were presented in three different graphs that were generated automatically.

Even though the users were highly satisfied with the resulting trend graphs, they still had to do mental processing to make decisions based on those graphs. Fuzzy set techniques were then applied to summarize the three graphs by generating a single combined result trend graph. The result trend graph was derived by following the rules of fuzzy logic. Therefore, the accuracy with which the data summarization models the users' mental processing has been verified by mathematical definitions.

Multiple criteria decision making was difficult for the user and required a large amount of information to be presented at one time. When the multiple criteria were automatically combined, thereby simplifying the cognitive processes for decision making, the interface became simpler and the cognitive load imposed on the user was reduced. This approach satisfied a number of heuristics

that researchers see as contributing to improved usability and good user experience. The heuristics include Neilson's (2010) [40] *minimalist design*, Budd's (2007) [41] heuristic about *minimizing unnecessary complexity and cognitive load* and Horton's (2005) [42] design guideline of *breaking materials into meaningful chunks to give the website structure*.

This chapter has described application of heuristics used in HCI to verify user satisfaction. A simulation technique known as cognitive walkthroughs were illustrated for ensuring usability and good user experience. The implementation of these well-known evaluation techniques show that educational data mining using fuzzy sets can facilitate usability and user experience of an application.

Chapter 6

6 Conclusions and Future Work

This study explored how HCI and AI techniques can be combined in a real-world application complementing the aims of each field. The goal of this thesis was to develop an application by following a user-centered approach of HCI to obtain usability and good user experience. An objective toward this goal was the establishment of a knowledge base upon which fuzzy educational data mining was applied to improve the quality of information for managers in making better decisions.

This chapter summarizes the study, explains the contributions and provides research recommendations for future. Section 6.1 includes a brief summary of the study. Contributions are described in Section 6.2. Finally, section 6.3 presents some approaches that can be explored in future.

6.1 Summary of the Study

The school board application was developed using the user-centered approach of HCI with the goal of obtaining usability and good user experience. Data gathering techniques of user-centered approach included interviewing the managers at the school board in order to identify the user needs. Initially, the managers thought that improving the look of the interface would be sufficient to encourage the principals to enter data to facilitate their (managers') decision making.

Further analysis of user requirements revealed the fact that duplicate effort resulting in huge data entry was an important reason why the users were reluctant to use the existing system. As a solution to that, data automation from existing information systems was implemented on the user interface to reduce data entry. This approach not only reduced the data entry, but also ensured consistency of data in the school board.

After successful automation of data, the users were involved again to collect their response about the improved application. They were observed while using the system. The users highly appreciated the application with prepopulated data. However, it was found that much of mental processing were still required to make decisions based on those automated data, specifically on multiple criteria information. This is where the observation technique of HCI aided to find out where AI techniques could be implemented. Data summarization using fuzzy educational data mining were then applied to combine multiple criteria information that abbreviated the presentation without loss of information. Moreover, this mechanism reduced the memory load on the managers. Thus implementation of AI technique facilitated the HCI goal of enhancing usability and user experience.

6.2 Contributions

The main contributions of the thesis are as follows:

- Exploration of fuzzy set techniques for improving usability and user experience.
- Expansion of the area of EDM beyond student learning to include knowledge discovery in school board data to help managers make informed decisions.
- The observation that user involvement can help to determine what cognitive processes can be replicated with the aid of a computer.
- Design of an interface based on integration of knowledge expressed in a variety of forms (i.e. automated data, discovered knowledge, color data, and graphical information).
- Illustration that data automation across a diversity of databases, information management systems and environments has a huge impact on encouraging user engagement with the system.
- Demonstration that existing heuristics in HCI can be used to evaluate intelligent systems.
- Experimentation with real data and practical environment.

6.3 Recommendations for Future Research

Further research on integration of Artificial Intelligence (AI) and Human-Computer Interaction (HCI) are expected in the following directions:

- A systematic usability testing involving users in terms of a lab study can be conducted to evaluate and analyze the user feedback about the interface.
- The data mining feature developed in this study covers a small part of the school board data. This feature can be extended to cover more data.

- Fuzzy set techniques can be applied on an application area different from educational environment to see whether they can contribute in usability and user experience.
- This study implements ‘Distillation of Data for Human Judgment’ method of Educational Data Mining (EDM). Other EDM methods, such as text mining, process mining and relationship mining, can be explored to see whether they complement HCI.
- Other available AI techniques, such as neural networks, rough sets, Bayesian nets, and swarm intelligence, can be investigated in terms of integration of AI and HCI.

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Appendix A: Manual Forms at the School Board



PPA-06

Elementary Principal Annual Growth Plan

SCHOOL: GRADES: DATE:

SCHOOL DATA

# of Vice Principals	<input style="width: 50px;" type="text"/>	# of Educational Assistants	<input style="width: 50px;" type="text"/>	Framework School	<input style="width: 50px;" type="text"/>
# of Secretaries	<input style="width: 50px;" type="text"/>	# of ISP Classrooms	<input style="width: 50px;" type="text"/>	Networking School	<input style="width: 50px;" type="text"/>
# of Teaching Staff	<input style="width: 50px;" type="text"/>	# of Early Childhood Educators	<input style="width: 50px;" type="text"/>	Operating Budget	\$ <input style="width: 100px;" type="text"/>

School Population as of October 31

2007-08	2008-09	2009-10	2010-11	2011-12
<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>

Exceptional Students as of October 31

# of Identified Students	# of Identified Behaviour	# of Identified Learning Disability	# of Identified ASD
<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>

EQAO Results - Grade 3

	2008-09	2009-10	2010-11	2011-12
Reading	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>
Writing	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>
Math	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>

EQAO Results - Grade 6

	2008-09	2009-10	2010-11	2011-12
Reading	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>
Writing	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>
Math	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>

Current Year Special Education – Grade 3

	School		Board		Province	
	Exempt	Level 3&4	Exempt	Level 3&4	Exempt	Level 3&4
EQAO - Reading	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>
EQAO - Writing	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>
EQAO - Math	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>

Current Year Special Education – Grade 6

	School		Board		Province	
	Exempt	Level 3&4	Exempt	Level 3&4	Exempt	Level 3&4
EQAO - Reading	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>
EQAO - Writing	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>
EQAO - Math	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>

Peter Moffat (2007 Demo Sorter Ranking of RDSB schools): /35

Most Recent OLSAT Results (Average SAI)

Grade 4	<input style="width: 70px;" type="text"/>
Grade 7	<input style="width: 70px;" type="text"/>

Date of Test:

of Suspensions

2008-09	2009-10	2010-11	2011-12
<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>	<input style="width: 50px;" type="text"/>

Other:

69 Young Street, Sudbury, Ontario P3E 3G5 | Tel: 705.674.3171 | Fax: 705.674.5471 | rainbowschools.ca

Figure A.1: Annual Growth Plan Form for Elementary Schools – First Page



PPA-06

Elementary Principal Annual Growth Plan

Areas for Growth	Growth Strategies / Supports (ways of acquiring skills). Follow-up if required.	Target Dates for Completion	Confirmation of Completed Objectives (dates, data, etc.)	Suggested Learning Plan for Next Year

The Supervisory Officer and Principal agree on the Annual Growth Plan.

Supervisory Officer Signature

Date

Principal Signature

Date



PPA-04

Secondary Principal Annual Growth Plan

SCHOOL: _____ GRADES: _____ DATE: _____

SCHOOL DATA

of Vice Principals _____ # of Educational Assistants _____ Framework School _____
 # of Secretaries _____ # of ISP Classrooms _____ Operating Budget \$ _____
 # of Teaching Staff _____ # of Program Leaders _____

School Population as of October 31

2007-08	2008-09	2009-10	2010-11	2011-12
_____	_____	_____	_____	_____

Exceptional Students as of October 31

# of Identified Students	# of Identified Behaviour	# of Identified Learning Disability	# of Identified ASD
_____	_____	_____	_____

Grade 9 Math Results

	2008-09	2009-10	2010-11	2011-12
Applied	_____	_____	_____	_____
Academic	_____	_____	_____	_____

Grade 10 OSSLT Results

	2008-09	2009-10	2010-11	2011-12
Overall Results	_____	_____	_____	_____
Males	_____	_____	_____	_____
Females	_____	_____	_____	_____

Pass Rates – Applied / Academic

	Math	English	Science
Grade 9 - Applied	_____	_____	_____
Grade 9 - Academic	_____	_____	_____
Grade 10 - Applied	_____	_____	_____
Grade 10 - Academic	_____	_____	_____

Pathways # of Students Enrolled

	Co-op	OYAP	SHSM	eLearning	Dual Credit
2009-10	_____	_____	_____	_____	_____
2010-11	_____	_____	_____	_____	_____
2011-12	_____	_____	_____	_____	_____

All Pass Rates

	University	College	Workforce
Grade 11	_____	_____	_____
Grade 12	_____	_____	_____

Credit Accumulation

	2009-10	2010-11	2011-12
Year 1	_____	_____	_____
Year 2	_____	_____	_____

of Suspensions

2008-09	2009-10	2010-11	2011-12
_____	_____	_____	_____

Other: _____

69 Young Street, Sudbury, Ontario P3E 3G5 | Tel: 705.674.3171 | Fax: 705.674.5471 | rainbowschools.ca

Figure A.3: Annual Growth Plan Form for Secondary Schools – First Page



PPA-04

Secondary Principal Annual Growth Plan

Areas for Growth	Growth Strategies / Supports (ways of acquiring skills). Follow-up if required.	Target Dates for Completion	Confirmation of Completed Objectives (dates, data, etc.)	Suggested Learning Plan for Next Year

The Supervisory Officer and Principal agree on the Annual Growth Plan.

Supervisory Officer Signature

Date

Principal Signature

Date

69 Young Street, Sudbury, Ontario P3E 3G5 | Tel: 705.674.3171 | Fax: 705.674.5471 | rainbowschools.ca

Figure A.4: Annual Growth Plan Form for Secondary Schools – Second Page

Appendix B: Membership Functions

$$\mu_{few}(writing) = \begin{cases} 0, & writing > 60 \\ \frac{60-writing}{60-40}, & 40 \leq writing \leq 60 \\ 1, & writing < 40 \end{cases} \dots\dots\dots (\text{Eq. B.1})$$

$$\mu_{most}(writing) = \begin{cases} 0, & writing < 40 \\ \frac{writing-40}{60-40}, & 40 \leq writing \leq 60 \\ 1, & writing > 60 \end{cases} \dots\dots\dots (\text{Eq. B.2})$$

$$\mu_{few}(math) = \begin{cases} 0, & math > 60 \\ \frac{60-math}{60-40}, & 40 \leq math \leq 60 \\ 1, & math < 40 \end{cases} \dots\dots\dots (\text{Eq. B.3})$$

$$\mu_{most}(math) = \begin{cases} 0, & math < 40 \\ \frac{math-40}{60-40}, & 40 \leq math \leq 60 \\ 1, & math > 60 \end{cases} \dots\dots\dots (\text{Eq. B.4})$$

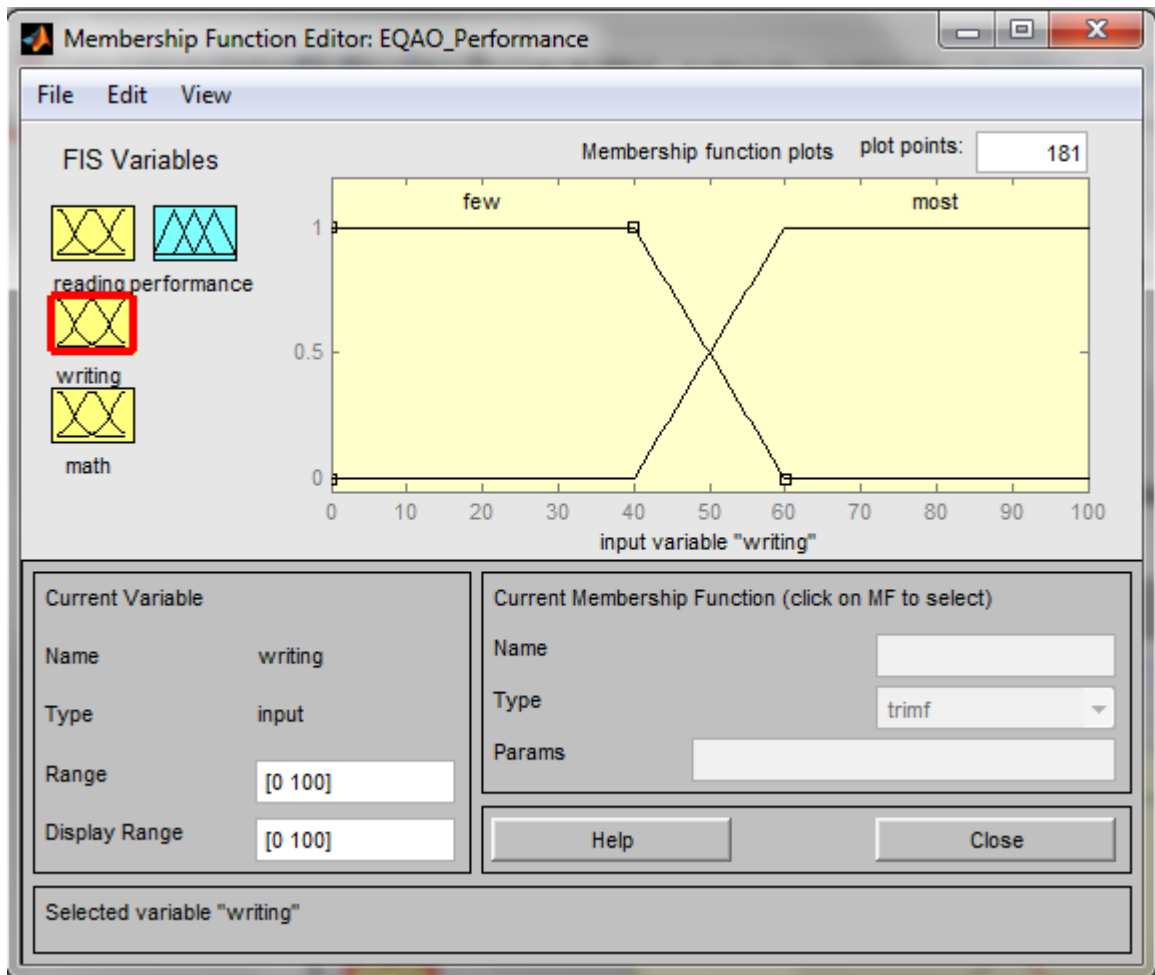


Figure B.1: Fuzzy Membership Function – writing (Input)

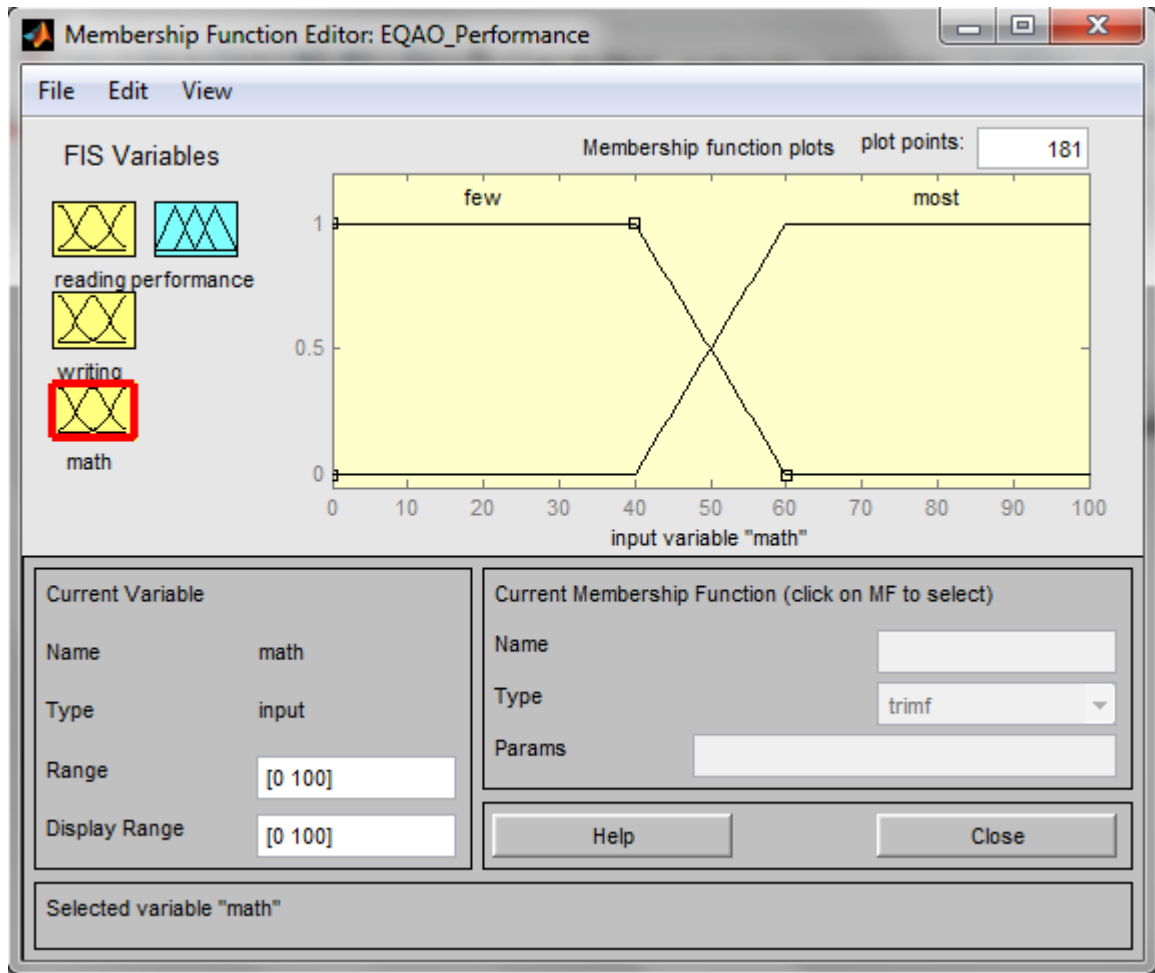


Figure B.2: Fuzzy Membership Function – math (Input)

Appendix C: Heuristic Evaluation

The following are the findings of different heuristics that were used to evaluate the user interface.

Neilson's (2010) heuristics

- ***Visibility of system status***

Each operation notifies with confirmation messages that the operation has been performed successfully.

- ***Match between system and the real world***

The system speaks to the user in his/her own language, with words (staff list, appraisal dates, violent incident list), rather than technical terms. Error messages are stated as the following example shows: 'The feedback for this year does not exist in the system. You may add the feedback from Annual Growth Plan'. If user clicks on Annual Growth Plan the next link is ->Feedback of the Principal, and the next is->Add Feedback. As can be seen, phrases and concepts familiar to the user are being used in the error message, and the levels of linking make information appear in a natural and logical order.

- ***User control and freedom***

The system provides error messages specifying the next step to recover from the error. Thus, the application provides enough freedom to the users to control any unwanted states that they might face while using the system.

- ***Consistency and standards***

The system is consistent through the different processes within the application. Furthermore it has been designed to be consistent with the standards that are maintained in the other applications that are used in the school board. This provides the users a familiar environment throughout their interaction with the system.

- ***Error prevention***

Some efforts can be taken for error prevention such as providing short instructions in the forms for smoother error-free transactions.

- ***Recognition rather than recall***

The interface seems user-friendly because information is provided to the users to navigate throughout the system. The menu items, buttons and the error messages indicate the possible action options and thus minimize the memory load on the user.

- ***Flexibility and efficiency of use***

Flexibility means that the system caters to both novice and experienced users. The application provides a straightforward interface with affordances (e.g. meaningful names for buttons and menu items) that should make even the most novice of users feel comfortable and the experienced users feel at ease.

- ***Aesthetic and minimalist design***

The aesthetics implemented in the creation of the application go a long way to making this system look simple. There is no extra information that can distract the users. The idea of ‘doing more with less’ (or minimalistic design) is embraced to ensure that the users do not get overwhelmed by too many information.

- ***Help user recognize, diagnose, and recover from errors***

The error messages are elaborated with the specification of the problem type as well as the next action for resolution. This helps the users to recognize, diagnose and recover from errors on their own.

- ***Help and documentation***

It does not seem that much documentation is required for such an application due to uniformity with the other applications used in the school board. However, as mentioned earlier in the ‘Error Prevention’ heuristic, short instructions in every page can be helpful for the users.

Budd’s (2007) Heuristics:

- ***Clarity***

The interface contains clear and meaningful labels, icons and language for the intended users.

- ***Minimize unnecessary complexity and cognitive load***

The system is quite simple without any unnecessary functionality or process steps.

- ***Provide users with context***

The interface provides the users with a sense of context by providing clear title in each page and the feedback messages after every operation. However, some more short instructions into the forms would be helpful.

- ***Promote a pleasurable and positive user experience***

The design of the interface is fairly simple and consistent with the other applications used in the school board. This promotes a positive user experience while using the system.

Horton’s (2005) Design Guideline:

- ***Good graphical design is important. Reading long sentences, paragraphs, and documents is difficult on screen, so break material into discrete, meaningful chunks to give the website structure.***

This heuristic highlights that the Annual Growth Plan form contains too many information.

Koyani et al. (2004) Design Guideline:

- ***Avoid excessive use of color. Color is useful for indicating different kinds of information, i.e. cueing.***

The interface does not contain excessive use of colors. The colors are used only for distinguishing the different kinds of information, e.g. separating the menu, headers and footer; the error messages are red; the confirmation messages are blue.

Appendix D: Cognitive Walkthroughs

The following includes a cognitive walkthrough of the various tasks using the school board application.

Task 1: Log into the system

Typical users: Director, Superintendents, Principals, and HR Personnel

Step 1. Enter username and password and click Login button

Q: Will users know what to do?

Answer: Yes, it is intuitive to enter the username and password into the textboxes. However, a short instruction mentioning to enter the username and password in order to log into the system would be better.

Q: Will users see how to do it?

Answer: Yes, the username and password textboxes are available and it is obvious to the user to know to type in the username and password and then click 'Login' button.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, their actions take them to the School List page providing that the username and password are correct. In case of incorrect username and/or password, the system shows error messages mentioning to try again.

Task 2: Select a school from the School List

Typical users: Director, Superintendents, Principals, HR Personnel

Step 1. Click on the School Code to get into a school's information

Q: Will users know what to do?

Answer: May or may not. Although it is intuitive to know that the hyperlinked School Code or Name will take the user to that school's information, a short instruction mentioning to click the school code in order to get into the school's information would be better.

Q: Will users see how to do it?

Answer: Yes, once the instruction is provided, the hyperlinked school code makes it clear to click the desired school code/name and get into that school's information.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the hyperlink takes the user to a Welcome page for that school.

Task 3: Set yearly settings

Typical users: Principals

Step 1. Click on ‘Yearly Setup’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Yearly Setup’ menu option is clear enough for the user to understand that this is the place to go for yearly settings.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to the Yearly Setup page.

Step 2. Select a school year

Q: Will users know what to do?

Answer: May or may not. A short instruction would make it clearer.

Q: Will users see how to do it?

Answer: Yes, the dropdown list specifies to select a year.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the dropdown list shows the year that the user has chosen.

Step 3. Import the data by clicking the Import button beside each type

Q: Will users know what to do?

Answer: May or may not. A short instruction would make it clearer.

Q: Will users see how to do it?

Answer: Yes, the labels are clear enough.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system provides a feedback confirming the action.

Task 4: View Annual Growth Plan

Typical users: Director, Superintendents, Principals

Step 1. Click on ‘Annual Growth Plan’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Annual Growth Plan’ menu option is clear enough for the user to understand that this is the place to go for viewing the annual growth plan.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘View Annual Growth Plan’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘View Annual Growth Plan’ submenu option is clear enough for the user to understand that this is the place to go for viewing the annual growth plan.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Annual Growth Plan’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to the Annual Growth Plan page.

Task 5: Update Annual Growth Plan

Typical users: Director, Superintendents, Principals

Step 1. Click on ‘Annual Growth Plan’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Annual Growth Plan’ menu option is clear enough for the user to understand that this is the place to go for updating the annual growth plan.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘View Annual Growth Plan’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘View Annual Growth Plan’ submenu option is clear enough for the user to understand that this is the place to go for updating the annual growth plan.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Annual Growth Plan’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to the Annual Growth Plan page.

Step 5. Edit the textboxes and press ‘Update’

Q: Will users know what to do?

Answer: Yes, the labels are clear.

Q: Will users see how to do it?

Answer: Yes, the textboxes and the button are visible.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system provides a feedback.

Task 6: Add Annual Growth Plan Feedback

Typical users: Principals

Step 1. Click on ‘Annual Growth Plan’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Annual Growth Plan’ menu option is clear enough for the user to understand that this is the place to go for adding feedback about the annual growth plan.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘Feedback of the Principal’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘Feedback of the Principal’ submenu option is clear enough for the user to understand that this is the place to go for adding feedback about the annual growth plan.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Annual Growth Plan’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on ‘Add Feedback’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘Add Feedback’ submenu option is clear enough for the user to understand that this is the place to go for adding feedback about the annual growth plan.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Feedback of the Principal’ submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to a blank Annual Growth Plan Feedback page.

Step 4. Select a School Year

Q: Will users know what to do?

Answer: May or may not. A short instruction would make it clearer.

Q: Will users see how to do it?

Answer: Yes, the dropdown list specifies to select a year.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the dropdown list shows the year that the user has chosen.

Step 5. Enter the feedbacks and click Add button

Q: Will users know what to do?

Answer: Yes, the labels are clear and the blank textboxes are intuitive.

Q: Will users see how to do it?

Answer: Yes, the textboxes and the Add button are available.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system provides a feedback.

Task 7: View Annual Growth Plan Feedback

Typical users: Director, Superintendents, Principals

Step 1. Click on ‘Annual Growth Plan’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Annual Growth Plan’ menu option is clear enough for the user to understand that this is the place to go for viewing feedback about the annual growth plan.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘Feedback of the Principal’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘Feedback of the Principal’ submenu option is clear enough for the user to understand that this is the place to go for viewing feedback about the annual growth plan.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Annual Growth Plan’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on ‘View/Update Feedback’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘View/Update Feedback’ submenu option is clear enough for the user to understand that this is the place to go for viewing feedback about the annual growth plan.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Feedback of the Principal’ submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to the Annual Growth Plan Feedback page.

Step 4. Select a School Year and press Enter

Q: Will users know what to do?

Answer: Yes. The page has nothing else but a drop-down menu asking to select a year. However, a short instruction would be better.

Q: Will users see how to do it?

Answer: Yes, the dropdown list specifies to select a year and the Enter button is visible too.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system provides a feedback either by showing the feedback of that year or mentioning that the feedback for that year has not been entered yet.

Task 8: Update/Confirm/Approve Annual Growth Plan Feedback

Typical users: Director, Superintendents, Principals

Step 1. Click on ‘Annual Growth Plan’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Annual Growth Plan’ menu option is clear enough for the user to understand that this is the place to go for updating feedback about the annual growth plan.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘Feedback of the Principal’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘Feedback of the Principal’ submenu option is clear enough for the user to understand that this is the place to go for updating feedback about the annual growth plan.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Annual Growth Plan’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on ‘View/Update Feedback’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘View/Update Feedback’ submenu option is clear enough for the user to understand that this is the place to go for updating feedback about the annual growth plan.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Feedback of the Principal’ submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to the Annual Growth Plan Feedback page.

Step 4. Select a School Year and press Enter

Q: Will users know what to do?

Answer: Yes. The page has nothing else but a drop-down menu asking to select a year. However, a short instruction would be better.

Q: Will users see how to do it?

Answer: Yes, the dropdown list specifies to select a year and the Enter button is visible too.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system provides a feedback either by showing the feedback of that year or mentioning that the feedback for that year has not been entered yet.

Step 5. Edit the textboxes and press ‘Update’ or ‘Confirm’ or ‘Approve’ as required

Q: Will users know what to do?

Answer: Yes, the labels are clear.

Q: Will users see how to do it?

Answer: Yes, the textboxes and the buttons are available.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system provides a feedback.

Task 9: View Staff List and Appraisal Dates

Typical users: Director, Superintendents, Principals, HR Personnel

Step 1. Click on ‘Staff’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Staff’ menu option is clear enough for the user to understand that this is the place to go for viewing staff list.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘Staff List and Appraisal Dates’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘Staff List and Appraisal Dates’ submenu option is clear enough for the user to understand that this is the place to go for viewing staff list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Staff’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on ‘View Staff List and Appraisal Dates’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘View Staff List and Appraisal Dates’ submenu option is clear enough for the user to understand that this is the place to go for viewing staff list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Staff List and Appraisal Dates’ submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to the Staff List and Appraisal Dates page.

Task 10: View Student Involvement List

Typical users: Director, Superintendents, Principals

Step 1. Click on ‘Students’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Students’ menu option is clear enough for the user to understand that this is the place to go for viewing student involvement list.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘Student Involvement List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘Student Involvement List’ submenu option is clear enough for the user to understand that this is the place to go for viewing student involvement list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Students’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on ‘View Student Involvement List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘View Student Involvement List’ submenu option is clear enough for the user to understand that this is the place to go for viewing student involvement list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Student Involvement List’ submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to the Student Involvement List page.

Task 11: Add to Student Involvement List

Typical users: Principals

Step 1. Click on ‘Students’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Students’ menu option is clear enough for the user to understand that this is the place to go for adding event into the student involvement list.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘Student Involvement List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘Student Involvement List’ submenu option is clear enough for the user to understand that this is the place to go for adding event into the student involvement list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Students’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on ‘Add to Student Involvement List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘Add to Student Involvement List’ submenu option is clear enough for the user to understand that this is the place to go for adding event into the student involvement list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Student Involvement List’ submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to a blank student involvement page.

Step 4. Enter the event information and click Add button

Q: Will users know what to do?

Answer: Yes, the labels are clear and the blank textboxes are intuitive.

Q: Will users see how to do it?

Answer: Yes, the textboxes and the Add button are visible.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system provides a feedback.

Task 12: Update or Delete from Student Involvement List

Typical users: Principals

Step 1. Click on 'Students' menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The 'Students' menu option is clear enough for the user to understand that this is the place to go for updating or deleting from student involvement list.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on 'Student Involvement List' submenu

Q: Will users know what to do?

Answer: Yes, the 'Student Involvement List' submenu option is clear enough for the user to understand that this is the place to go for updating or deleting from student involvement list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the 'Students' menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on 'View Student Involvement List' submenu

Q: Will users know what to do?

Answer: Yes, the 'View Student Involvement List' submenu option is clear enough for the user to understand that this is the place to go for updating or deleting from student involvement list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the 'View Student Involvement List' submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to the Student Involvement List page.

Step 4. Click on the name of an event

Q: Will users know what to do?

Answer: May or may not. Although the hyperlinked event field gives an indication that clicking on it would give the details of the event, a short instruction at the top mentioning this would make it more clear to the user.

Q: Will users see how to do it?

Answer: Yes, the hyperlinked event field is visible.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the hyperlink takes the user to the student involvement page prepopulated with that specific event information.

Step 5. Edit the textboxes and press ‘Update’ or simply press ‘Delete’

Q: Will users know what to do?

Answer: Yes, the labels and buttons are clear.

Q: Will users see how to do it?

Answer: Yes, the textboxes and the button are available.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system provides a feedback.

Task 13: View Home Schooling List

Typical users: Director, Superintendents, Principals

Step 1. Click on ‘Students’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Students’ menu option is clear enough for the user to understand that this is the place to go for viewing home schooling list.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘Home Schooling List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘Home Schooling List’ submenu option is clear enough for the user to understand that this is the place to go for viewing student involvement list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Students’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on ‘View Home Schooling List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘View Home Schooling List’ submenu option is clear enough for the user to understand that this is the place to go for viewing home schooling list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Home Schooling List’ submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to the Home Schooling List page.

Task 14: Add to Home Schooling List

Typical users: Principals

Step 1. Click on 'Students' menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The 'Students' menu option is clear enough for the user to understand that this is the place to go for adding student into the home schooling list.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on 'Home Schooling List' submenu

Q: Will users know what to do?

Answer: Yes, the 'Home Schooling List' submenu option is clear enough for the user to understand that this is the place to go for adding student into the home schooling list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the 'Students' menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on 'Add to Home Schooling List' submenu

Q: Will users know what to do?

Answer: Yes, The 'Add to Home Schooling List' submenu option is clear enough for the user to understand that this is the place to go for adding student into the home schooling list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the 'Home Schooling List' submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to a blank home schooling page.

Step 4. Enter a Student ID

Q: Will users know what to do?

Answer: May or may not. A short instruction would make it clearer.

Q: Will users see how to do it?

Answer: Yes, the textbox and the Enter button are visible.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system provides a feedback either by bringing up a blank home schooling form prepopulated with the student basic information or an error message in case of an incorrect ID.

Step 5. Enter the student information and click Add button

Q: Will users know what to do?

Answer: Yes, the labels are clear and the blank textboxes are intuitive.

Q: Will users see how to do it?

Answer: Yes, the textboxes and the Add button are visible.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system provides a feedback.

Task 15: Update or Delete from Home Schooling List

Typical users: Principals

Step 1. Click on ‘Students’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Students’ menu option is clear enough for the user to understand that this is the place to go for updating or deleting from home schooling list.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘Home Schooling List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘Home Schooling List’ submenu option is clear enough for the user to understand that this is the place to go for updating or deleting from home schooling list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Students’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on ‘View Home Schooling List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘View Home Schooling List’ submenu option is clear enough for the user to understand that this is the place to go for updating or deleting from home schooling list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘View Home Schooling List’ submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to the Home Schooling List page.

Step 4. Click on a student ID

Q: Will users know what to do?

Answer: May or may not. Although the hyperlinked student ID field gives an indication that clicking on it would give the details of the student, a short instruction at the top mentioning this would make it more clear to the user.

Q: Will users see how to do it?

Answer: Yes, the hyperlinked student ID field is visible.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the hyperlink takes the user to the home schooling page prepopulated with that specific student information.

Step 5. Edit the textboxes and press ‘Update’ or simply press ‘Delete’

Q: Will users know what to do?

Answer: Yes, the labels and buttons are clear.

Q: Will users see how to do it?

Answer: Yes, the textboxes and the button are available.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system provides a feedback.

Task 16: View Violent Incident List

Typical users: Director, Superintendents, Principals

Step 1. Click on ‘Students’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Students’ menu option is clear enough for the user to understand that this is the place to go for viewing violent incident list.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘Violent Incident List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘Violent Incident List’ submenu option is clear enough for the user to understand that this is the place to go for viewing violent incident list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Students’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on ‘View Violent Incident List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘View Violent Incident List’ submenu option is clear enough for the user to understand that this is the place to go for viewing violent incident list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Violent Incident List’ submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to the Violent Incident List page.

Task 17: View School Council List

Typical users: Director, Superintendents, Principals

Step 1. Click on ‘Community’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Community’ menu option is clear enough for the user to understand that this is the place to go for viewing school council list.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘School Council List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘School Council List’ submenu option is clear enough for the user to understand that this is the place to go for viewing school council list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Community’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on ‘View School Council List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘View School Council List’ submenu option is clear enough for the user to understand that this is the place to go for viewing school council list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘School Council List’ submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to the School Council List page.

Task 18: Add to School Council List

Typical users: Principals

Step 1. Click on ‘Community’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Community’ menu option is clear enough for the user to understand that this is the place to go for adding member into the school council list.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘School Council List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘School Council List’ submenu option is clear enough for the user to understand that this is the place to go for adding member into the school council list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Community’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on ‘Add to School Council List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘Add to School Council List’ submenu option is clear enough for the user to understand that this is the place to go for adding member into the school council list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘School Council List’ submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to a blank school council page.

Step 4. Enter the member information and click Add button

Q: Will users know what to do?

Answer: Yes, the labels are clear and the blank textboxes are intuitive.

Q: Will users see how to do it?

Answer: Yes, the textboxes and the Add button are visible.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system provides a feedback.

Task 19: Update or Delete from School Council List

Typical users: Principals

Step 1. Click on ‘Community’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Community’ menu option is clear enough for the user to understand that this is the place to go for updating or deleting from school council list.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘School Council List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘School Council List’ submenu option is clear enough for the user to understand that this is the place to go for updating or deleting from school council list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Community’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on ‘View School Council List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘View School Council List’ submenu option is clear enough for the user to understand that this is the place to go for updating or deleting from school council list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘School Council List’ submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to the Violent Incident List page.

Step 4. Click on a name

Q: Will users know what to do?

Answer: May or may not. Although the hyperlinked name field gives an indication that clicking on it would give the details of the member, a short instruction at the top mentioning this would make it more clear to the user.

Q: Will users see how to do it?

Answer: Yes, the hyperlinked name field is visible.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the hyperlink takes the user to the school council page prepopulated with that specific member information.

Step 5. Edit the textboxes and press ‘Update’ or simply press ‘Delete’

Q: Will users know what to do?

Answer: Yes, the labels and buttons are clear.

Q: Will users see how to do it?

Answer: Yes, the textboxes and the button are available.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system provides a feedback.

Task 20: View Community Partners List

Typical users: Director, Superintendents, Principals

Step 1. Click on ‘Community’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Community’ menu option is clear enough for the user to understand that this is the place to go for viewing community partners list.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘Community Partners List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘Community Partners List’ submenu option is clear enough for the user to understand that this is the place to go for viewing community partners list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Community’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on ‘View Community Partners List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘View Community Partners List’ submenu option is clear enough for the user to understand that this is the place to go for viewing community partners list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Community Partners List’ submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to the Community Partners List page.

Task 21: Add to Community Partners List

Typical users: Principals

Step 1. Click on ‘Community’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Community’ menu option is clear enough for the user to understand that this is the place to go for adding member into the community partners list.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘Community Partners List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘Community Partners List’ submenu option is clear enough for the user to understand that this is the place to go for adding member into the community partners list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Community’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on ‘Add to Community Partners List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘Add to Community Partners List’ submenu option is clear enough for the user to understand that this is the place to go for adding member into the community partners list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Community Partners List’ submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to a blank community partner page.

Step 4. Enter the member information and click Add button

Q: Will users know what to do?

Answer: Yes, the labels are clear and the blank textboxes are intuitive.

Q: Will users see how to do it?

Answer: Yes, the textboxes and the Add button are visible.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system provides a feedback.

Task 22: Update or Delete from Community Partners List

Typical users: Principals

Step 1. Click on ‘Community’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Community’ menu option is clear enough for the user to understand that this is the place to go for updating or deleting from community partners list.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘Community Partners List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘Community Partners List’ submenu option is clear enough for the user to understand that this is the place to go for updating or deleting from community partners list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Community’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on ‘View Community Partners List’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘View Community Partners List’ submenu option is clear enough for the user to understand that this is the place to go for updating or deleting from community partners list.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Community Partners List’ submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to the Community Partners List page.

Step 4. Click on a name

Q: Will users know what to do?

Answer: May or may not. Although the hyperlinked name field gives an indication that clicking on it would give the details of the community, a short instruction at the top mentioning this would make it more clear to the user.

Q: Will users see how to do it?

Answer: Yes, the hyperlinked name field is visible.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the hyperlink takes the user to the community partner page prepopulated with that specific community information.

Step 5. Edit the textboxes and press ‘Update’ or simply press ‘Delete’

Q: Will users know what to do?

Answer: Yes, the labels and buttons are clear.

Q: Will users see how to do it?

Answer: Yes, the textboxes and the button are available.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system provides a feedback.

Task 23: View Planned Use of Funds

Typical users: Director, Superintendents, Principals

Step 1. Click on ‘Community’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Community’ menu option is clear enough for the user to understand that this is the place to go for viewing planned use of funds.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘Planned Use of Funds’ submenu

Q: Will users know what to do?

Answer: Yes, The ‘Planned Use of Funds’ submenu option is clear enough for the user to understand that this is the place to go for viewing planned use of funds.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Community’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on ‘View Planned Use of Funds’ submenu

Q: Will users know what to do?

Answer: Yes, The ‘View Planned Use of Funds’ submenu option is clear enough for the user to understand that this is the place to go for viewing planned use of funds.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Planned Use of Funds’ submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to the Planned Use of Funds page.

Task 24: Add to Planned Use of Funds

Typical users: Principals

Step 1. Click on ‘Community’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Community’ menu option is clear enough for the user to understand that this is the place to go for adding activity into the planned use of funds.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘Planned Use of Funds’ submenu

Q: Will users know what to do?

Answer: Yes, The ‘Planned Use of Funds’ submenu option is clear enough for the user to understand that this is the place to go for adding activity into the planned use of funds.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Community’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on ‘Add to Planned Use of Funds’ submenu

Q: Will users know what to do?

Answer: Yes, the ‘Add to Planned Use of Funds’ submenu option is clear enough for the user to understand that this is the place to go for adding activity into the planned use of funds.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Planned Use of Funds’ submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to a blank planned use of funds page.

Step 4. Enter the activity information and click Add button

Q: Will users know what to do?

Answer: Yes, the labels are clear and the blank textboxes are intuitive.

Q: Will users see how to do it?

Answer: Yes, the textboxes and the Add button are visible.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system provides a feedback.

Task 25: Update or Delete from Planned Use of Funds

Typical users: Principals

Step 1. Click on ‘Community’ menu on the menu bar

Q: Will users know what to do?

Answer: Yes, the welcome page indicates the user to choose an option from the menu bar. The ‘Community’ menu option is clear enough for the user to understand that this is the place to go for updating or deleting from planned use of funds.

Q: Will users see how to do it?

Answer: Yes, the menu is available in the menu bar.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 2. Click on ‘Planned Use of Funds’ submenu

Q: Will users know what to do?

Answer: Yes, The ‘Planned Use of Funds’ submenu option is clear enough for the user to understand that this is the place to go for updating or deleting from planned use of funds.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Community’ menu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu opens up with the submenu.

Step 3. Click on ‘View Planned Use of Funds’ submenu

Q: Will users know what to do?

Answer: Yes, The ‘View Planned Use of Funds’ submenu option is clear enough for the user to understand that this is the place to go for updating or deleting from planned use of funds.

Q: Will users see how to do it?

Answer: Yes, the submenu is available right after clicking on the ‘Planned Use of Funds’ submenu.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to the Planned Use of Funds page.

Step 4. Click on an activity

Q: Will users know what to do?

Answer: May or may not. Although the hyperlinked activity field gives an indication that clicking on it would give the details of the activity, a short instruction at the top mentioning this would make it more clear to the user.

Q: Will users see how to do it?

Answer: Yes, the hyperlinked activity field is visible.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the hyperlink takes the user to the planned use of fund page prepopulated with that specific activity information.

Step 5. Edit the textboxes and press ‘Update’ or simply press ‘Delete’

Q: Will users know what to do?

Answer: Yes, the labels and buttons are clear.

Q: Will users see how to do it?

Answer: Yes, the textboxes and the button are available.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system provides a feedback.

Task 26: Add General Comments into the Lists

Typical users: Principals

Step 1. Go to a list page and click on ‘Add Comment’

Q: Will users know what to do?

Answer: Yes, the label and the button are intuitive enough for the user to understand this.

Q: Will users see how to do it?

Answer: Yes, the label and the button are visible.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, clicking on the button takes the user to a blank comment page.

Step 2. Enter the comment and click ‘Add’

Q: Will users know what to do?

Answer: Yes. The textbox and the button are enough intuitive.

Q: Will users see how to do it?

Answer: Yes, the textbox and the Add button are visible.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system takes the user to the list page with the added comment in it and provides a confirmation message.

Task 27: Update/Delete General Comments into the Lists

Typical users: Principals

Step 1. Go to a list page and click on ‘Edit Comment’

Q: Will users know what to do?

Answer: Yes, the label and the button are intuitive enough for the user to understand this.

Q: Will users see how to do it?

Answer: Yes, the label and the button are visible.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, clicking on the button takes the user to a comment page prepopulated with that specific comment.

Step 2. Edit the comment and click ‘Update’ or simply click ‘Delete’

Q: Will users know what to do?

Answer: Yes. The textbox and the buttons are enough intuitive.

Q: Will users see how to do it?

Answer: Yes, the textbox and the buttons are visible.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the system takes the user to the list page with the updated comment in it and provides a confirmation message.

Task 28: Review the Lists

Typical users: Principals

Step 1. Go to a list page and click on ‘Review’

Q: Will users know what to do?

Answer: Yes, the button is intuitive enough for the user to understand this.

Q: Will users see how to do it?

Answer: Yes, the button is visible.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, clicking on the button shows the username and the date in Reviewed By and Review Date fields respectively.

Task 29: Log Out from the System

Typical users: Director, Superintendents, Principals

Step 1. Click ‘Logout’ in the menu bar

Q: Will users know what to do?

Answer: Yes, the menu is clear enough for the user to know this.

Q: Will users see how to do it?

Answer: Yes, the menu is visible.

Q: Will users understand from feedback whether the action was correct or not?

Answer: Yes, the menu takes the user to the login page.

Appendix E: Gradual Design of Interface

The user interface was established by iterative steps of prototyping and evaluating the interface. Figure E.1 shows the initial prototype of School Council List. The interface was then evaluated and modified according to the recommendations of the evaluation.

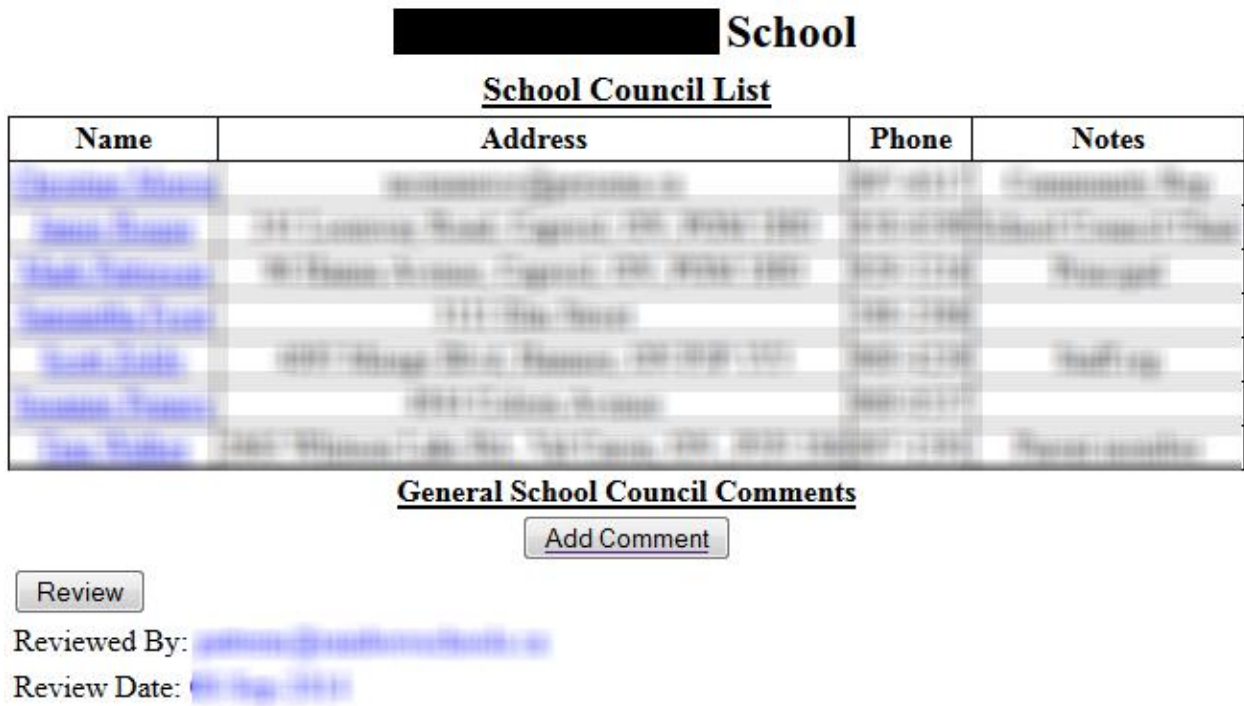



Figure E.1: School Council List Interface at Initial Stage

Recommendations of the first evaluation were as follows:

1. An instruction section at the top mentioning the basic functionalities should be added to assist the users.
2. Name, Address and Notes data fields should be left aligned.

As per evaluation recommendation, instruction section was added at the top and alignments were modified. The page looked as shown in Figure E.2.

School
School Council List

 **Instructions**

You may update a record by clicking on the Name of the member.
 General comments can be added/edited by clicking on the button at the end of the form.
 If you are the Principal of the school, please click on 'Review' button every time you review the list so that the system shows the latest date when you have reviewed the information.

Name	Address	Phone	Notes
School Council	111-111-111	111-111	Comments: No
School Council	111-111-111	111-111	Comments: No
School Council	111-111-111	111-111	Comments: No
School Council	111-111-111	111-111	Comments: No
School Council	111-111-111	111-111	Comments: No
School Council	111-111-111	111-111	Comments: No
School Council	111-111-111	111-111	Comments: No
School Council	111-111-111	111-111	Comments: No

General School Council Comments

Reviewed By: [admin@schoolcouncil.com](#)
 Review Date: [11/11/11](#)

Figure E.2: School Council List Interface after First Evaluation

Another evaluation was carried out and some more recommendations were gathered. The following were the recommendations of the second evaluation:

1. There should be a gap before the 'General School Council Comments' section starts.
2. There should be a gap between 'General School Council Comments' section header and 'Add Comment' button.
3. Since only the Principals are supposed to click the 'Review' button, this button should not be shown to any other type of users.

Figure E.3 illustrates the interface after modification as per evaluation recommendations.

[Redacted] School
School Council List

 **Instructions**

You may update a record by clicking on the Name of the member.

General comments can be added/edited by clicking on the button at the end of the form.

If you are the Principal of the school, please click on 'Review' button every time you review the list so that the system shows the latest date when you have reviewed the information.

Name	Address	Phone	Notes
Christine Thomas	10000000000000000000	907-2517	Comments: None
John Thomas	11111111111111111111	907-2518	Comments: Council Chair
John Thomas	22222222222222222222	907-2519	Principal
John Thomas	33333333333333333333	907-2520	
John Thomas	44444444444444444444	907-2521	Staff rep
John Thomas	55555555555555555555	907-2522	
John Thomas	66666666666666666666	907-2523	Parent/Community

General School Council Comments

Reviewed By: [\[Redacted\]](#)

Review Date: [\[Redacted\]](#)

Figure E.3: School Council List Interface after Second Evaluation

The interface was evaluated again and the following recommendations were found:

1. The table information looks clumsy. Add some spaces before and after each item.
2. Highlight the column headers with a background color.
3. Remove 'bold' style from column titles.

The look of the table was then updated. The interface looked as shown in Figure E.4.

School
School Council List

 **Instructions**

You may update a record by clicking on the Name of the member.
 General comments can be added/edited by clicking on the button at the end of the form.
 If you are the Principal of the school, please click on 'Review' button every time you review the list so that the system shows the latest date when you have reviewed the information.

Name	Address	Phone	Notes
Christine Adams	40000000000000000000	000-0000	Comments: No
John Adams	44 Columbia Road, Ipswich, IP5 2PH, UK	01473 2000	School Council Chair
John Adams	44 Columbia Road, Ipswich, IP5 2PH, UK	01473 2000	Principal
Margaret Cook	111 The Street	01473 2000	
Jack Cook	10000000000000000000	000-0000	Staff rep
Christine Adams	40000000000000000000	000-0000	
John Adams	44000000000000000000	000-0000	Parent/teacher

General School Council Comments

Reviewed By: [admin@schoolcouncil.co.uk](#)
 Review Date: 01/10/2011

Figure E.4: School Council List Interface after Third Evaluation

Finally, one more evaluation was performed and the recommendations included the following:

1. Highlight the section headers with background colors.
2. Remove 'bold' style from section headers.
3. Remove 'underline' style from section headers.
4. Change the font style and size to make the interface aesthetically pleasing.

Figure E.5 illustrates the interface that met the evaluation criteria and was well accepted by the users. User acceptance of the data acquisition interface was important for encouraging them to use it so that data could be available for managerial decision making.

School

School Council List

 **Instructions**

You may update a record by clicking on the Name of the member.
 General comments can be added/edited by clicking on the button below the general comments section.
 If you are the Principal of the school, please click on the 'Review' button at the bottom of the page every time you review the list so that the system shows the latest date you have reviewed the information.

Name	Address	Phone	Notes
Christine Brown	4000 Main Street, Toronto, ON M5S 1A5	416-123-4567	Community Rep
John Brown	247 Victoria Road, Toronto, ON M5S 1A5	416-123-4567	School Council Chair
John Brown	247 Victoria Road, Toronto, ON M5S 1A5	416-123-4567	Principal
Margaret Cook	247 Victoria Road	416-123-4567	
John Cook	4000 Main Street, Toronto, ON M5S 1A5	416-123-4567	Staff rep
Margaret Brown	4000 Main Street	416-123-4567	
John Brown	4000 Main Street, Toronto, ON M5S 1A5	416-123-4567	Parent member

General School Council Comments

Reviewed By: [james@edtechschool.ca](#)
 Review Date: 10-Sep-2011

Figure E.5: School Council List Interface at Final Stage

Appendix F: MatLab Program

```
% Import data from text file
filename = 'School A Data.txt';
delimiterIn = ' ';
headerlinesIn = 1;
A = importdata(filename,delimiterIn,headerlinesIn);

% Assign values to the variable year
year = A.textdata(2: end,1)

% Assign reading, writing and math data to the variables
reading = A.data(:,1)
writing = A.data(:,2)
math = A.data(:,3)

% Read the structure of the fuzzy inference system
performance_fis=readfis('EQAO_Performance.fis');

% Perform fuzzy computations to determine overall performance
performance=evalfis([reading writing math],performance_fis)

% Generate a bar chart for overall performance
bar(performance, 'BarWidth', 0.7, 'facecolor', 'i');
caption = sprintf('EQAO Grade 3 overall Performance');
title(caption, 'FontSize', 16);
xlabel('School Year', 'FontSize', 14);
ylabel('Performance', 'FontSize', 14);
set(gca, 'XTickLabel', year);
set(gcf, 'name', 'EQAO Grade 3', 'numbertitle', 'off');
```

Appendix G: Ethics Approval



APPROVAL FOR CONDUCTING RESEARCH INVOLVING HUMAN SUBJECTS
Research Ethics Board – Laurentian University

This letter confirms that the research project identified below has successfully passed the ethics review by the Laurentian University Research Ethics Board (REB). Your ethics approval date, other milestone dates, and any special conditions for your project are indicated below.

TYPE OF APPROVAL / New X / Modifications to project / Time extension	
Name of Principal Investigator and school/department	Sheikh Shushmita Jahan (Math and Computer Science) Julia Johnson (Supervisor, Math and Computer Science)
Title of Project	Approximate Reasoning in Educational Data for Improvement Planning for Schools
REB file number	2014-03-09
Date of original approval of project	March 27, 2014
Date of approval of project modifications or extension (if applicable)	
Final/Interim report due on	March 27, 2015
Conditions placed on project	Final report due on March 27, 2015

During the course of your research, no deviations from, or changes to, the protocol, recruitment or consent forms may be initiated without prior written approval from the REB. If you wish to modify your research project, please refer to the Research Ethics website to complete the appropriate [REB form](#).

All projects must submit a report to REB at least once per year. If involvement with human participants continues for longer than one year (e.g. you have not completed the objectives of the study and have not yet terminated contact with the participants, except for feedback of final results to participants), you must request an extension using the appropriate [REB form](#).

In all cases, please ensure that your research complies with [Tri-Council Policy Statement \(TCPS\)](#). Also please quote your REB file number on all future correspondence with the REB office.

Congratulations and best of luck in conducting your research.

Susan James, Chair
Laurentian University Research Ethics Board