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.
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.

![Educational Knowledge Discovery Process Diagram](image)

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

2.2.2 EDM Methods


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

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading</td>
<td>0.7 in set ‘Good’</td>
</tr>
<tr>
<td>Writing</td>
<td>1.0 in set ‘Good’</td>
</tr>
<tr>
<td>Math</td>
<td>0.4 in set ‘Good’</td>
</tr>
</tbody>
</table>

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.

\[
\mu_A(x) = \begin{cases} 
0, & (x < a) \text{ or } (x > d) \\
\frac{x-a}{b-a}, & a \leq x \leq b \\
1, & b \leq x \leq c \\
\frac{d-x}{d-c}, & c \leq x \leq d 
\end{cases} \quad \text{Eq. 2.1}
\]
Two special cases of a trapezoidal function include R-functions and L-functions.

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

$$\mu_A(x) = \begin{cases} 
0, & x > d \\
\frac{d-x}{d-c}, & c \leq x \leq d \\
1, & x < c 
\end{cases}$$

$$\ldots\ldots\text{Eq. 2.2}$$

L-functions consider parameters $c = d = +\infty$ and can be defined as
The standard fuzzy operations that were used in this research are defined as follows:

- **UNION**: Let $\mu_A$ and $\mu_B$ 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:

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

- **INTERSECTION**: Let $\mu_A$ and $\mu_B$ 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:

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

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

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.
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.

![Add Staff Form in Existing System](image)

**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.

![EQAO Grade 3 Reading Results Trends in Existing System](image)

Figure 4.3: EQAO Grade 3 Reading Results 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

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

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Backend Database</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trillium</td>
<td>An enterprise solution system for student information management</td>
<td>Oracle</td>
</tr>
<tr>
<td>IPPS</td>
<td>A web-based solution for staff information management</td>
<td>MS SQL Server</td>
</tr>
<tr>
<td>Student Enrolment System</td>
<td>An in-house web-based solution</td>
<td>Oracle</td>
</tr>
<tr>
<td>Data Warehouse</td>
<td>Data warehouse</td>
<td>MS SQL Server</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Module</th>
<th>Available in Another Information System?</th>
<th>Name of Information System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff List and Appraisal Dates</td>
<td>Yes</td>
<td>IPPS</td>
</tr>
<tr>
<td>Student Involvement List</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Home Schooling List</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Violent Incident List</td>
<td>Yes</td>
<td>Trillium</td>
</tr>
<tr>
<td>School Council List</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Community Partners List</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>Planned Use of Funds</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Provincial Assessment Results</td>
<td>Yes</td>
<td>Data Warehouse</td>
</tr>
<tr>
<td>Trends</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Suspensions Trends</td>
<td>Yes</td>
<td>Trillium</td>
</tr>
<tr>
<td>Student Attendance Trends</td>
<td>Yes</td>
<td>Trillium</td>
</tr>
<tr>
<td>Staff Attendance Trends</td>
<td>Yes</td>
<td>IPPS</td>
</tr>
<tr>
<td>Grades in a School</td>
<td>Yes</td>
<td>Trillium</td>
</tr>
<tr>
<td>Number of Staff</td>
<td>Yes</td>
<td>IPPS</td>
</tr>
<tr>
<td>Population</td>
<td>Yes</td>
<td>Student Enrolment System</td>
</tr>
<tr>
<td>Number of Identified Exceptional Students</td>
<td>Yes</td>
<td>Trillium</td>
</tr>
<tr>
<td>EQAO Results</td>
<td>Yes</td>
<td>Data Warehouse</td>
</tr>
<tr>
<td>OLSAT Results</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Number of Suspensions</td>
<td>Yes</td>
<td>Trillium</td>
</tr>
<tr>
<td>Pass Rates</td>
<td>Yes</td>
<td>Data Warehouse</td>
</tr>
<tr>
<td>Pathways</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Credit Accumulation</td>
<td>No</td>
<td>N/A</td>
</tr>
</tbody>
</table>

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:

```plaintext
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.
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.
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.

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.

![EQAO Results Trends](image)

**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.

![EQAO Results Trends](image)

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

Figure 4.17: EQAO Grade 3 Writing 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:

<table>
<thead>
<tr>
<th>Year</th>
<th>Reading</th>
<th>Writing</th>
<th>Math</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009-2010</td>
<td>36</td>
<td>45</td>
<td>49</td>
</tr>
<tr>
<td>2010-2011</td>
<td>49</td>
<td>59</td>
<td>61</td>
</tr>
<tr>
<td>2011-2012</td>
<td>42</td>
<td>55</td>
<td>66</td>
</tr>
<tr>
<td>2012-2013</td>
<td>58</td>
<td>64</td>
<td>71</td>
</tr>
<tr>
<td>2013-2014</td>
<td>42</td>
<td>39</td>
<td>48</td>
</tr>
</tbody>
</table>

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).

![FIS Editor: EQAO_Performance](image)

**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:

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

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

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

\(\mu_{\text{few}}(x)\) and \(\mu_{\text{most}}(x)\) 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.
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:

\[
\mu_{\text{poor}}(\text{performance}) = \begin{cases} 
0, & \text{performance} > 1.9 \\
\frac{1.9 - \text{performance}}{1.9 - 1.0}, & 1.0 \leq \text{performance} \leq 1.9 \\
1, & \text{performance} < 1.0 
\end{cases} \quad \text{(Eq. 4.3)}
\]
\[
\mu_{\text{average}}(\text{performance}) = \begin{cases} 
0, & (\text{performance} < 1.1) \\
\frac{\text{performance}-1.1}{1.9-1.1}, & 1.1 \leq \text{performance} \leq 1.9 \\
1, & 1.9 \leq \text{performance} \leq 2.1 \\
\frac{2.9-\text{performance}}{2.9-2.1}, & 2.1 \leq \text{performance} \leq 2.9 
\end{cases} 
\] (Eq. 4.4)

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

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

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

<table>
<thead>
<tr>
<th>Rules</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reading</td>
<td>Writing</td>
</tr>
<tr>
<td>Rule 1</td>
<td>Few</td>
<td>Few</td>
</tr>
<tr>
<td>Rule 2</td>
<td>Few</td>
<td>Few</td>
</tr>
<tr>
<td>Rule 3</td>
<td>Few</td>
<td>Most</td>
</tr>
<tr>
<td>Rule 4</td>
<td>Few</td>
<td>Most</td>
</tr>
<tr>
<td>Rule 5</td>
<td>Most</td>
<td>Few</td>
</tr>
<tr>
<td>Rule 6</td>
<td>Most</td>
<td>Few</td>
</tr>
<tr>
<td>Rule 7</td>
<td>Most</td>
<td>Most</td>
</tr>
<tr>
<td>Rule 8</td>
<td>Most</td>
<td>Most</td>
</tr>
</tbody>
</table>

Table 4.3: Fuzzy Relations
• **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.
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.

```matlab
% 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('EQAO_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.

<table>
<thead>
<tr>
<th></th>
<th>Few</th>
<th>Most</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reading</strong></td>
<td>$1 \ (\because 36 \leq 40)$</td>
<td>$0 \ (\because 36 \leq 40)$</td>
</tr>
<tr>
<td></td>
<td>(as per Eq. 4.1)</td>
<td>(as per Eq. 4.2)</td>
</tr>
<tr>
<td><strong>Writing</strong></td>
<td>$\frac{60-45}{60-40} = 0.75 \approx 0.8 \ (\because 40 \leq 45 \leq 60)$</td>
<td>$\frac{45-40}{60-40} = 0.25 \approx 0.2 \ (\because 40 \leq 45 \leq 60)$</td>
</tr>
<tr>
<td></td>
<td>(as per Eq. B.1 in Appendix B)</td>
<td>(as per Eq. B.2 in Appendix B)</td>
</tr>
</tbody>
</table>
\[
\begin{array}{c|c|c}
\text{Math} & \frac{60-49}{60-40} = 0.55 \approx 0.6 \ (\because 40 \leq 49 \leq 60) & \frac{49-40}{60-40} = 0.45 \approx 0.4 \ (\because 40 \leq 49 \leq 60) \\
& \text{(as per Eq. B.3 in Appendix B)} & \text{(as per Eq. B.4 in Appendix B)}
\end{array}
\]

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 ‘\text{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

\[\Rightarrow \text{excellent(performace)} = \min(1,0.8,0.6) = 0.6\]

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

\[\Rightarrow \text{good(performace)} = \min(1,0.8,0.4) = 0.4\]

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

\[\Rightarrow \text{good(performace)} = \min(1,0.2,0.6) = 0.2\]

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

\[\Rightarrow \text{average(performace)} = \min(1,0.2,0.4) = 0.2\]

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

\[\Rightarrow \text{good(performace)} = \min(0,0.8,0.6) = 0\]

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

\[\Rightarrow \text{average(performace)} = \min(0,0.8,0.4) = 0\]

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

\[\Rightarrow \text{average(performace)} = \min(0,0.2,0.6) = 0\]
Rule 8: most(reading) = 0, most(writing) = 0.2, most(math) = 0.4

=> poor(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,

  excellent (performance) = max (rule 1) = max (0.6) = 0.6

  good (performance) = max (rule 2, rule 3, rule 5) = max (0.4, 0.2, 0) = 0.4

  average (performance) = max (rule 4, rule 6, rule 7) = max(0.2, 0, 0) = 0.2

  poor (performance) = max(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.
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’.

<table>
<thead>
<tr>
<th>School Year</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009 – 2010</td>
<td>2.8396</td>
</tr>
<tr>
<td>2010 – 2011</td>
<td>1.9529</td>
</tr>
<tr>
<td>School Year</td>
<td>Performance</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>2011 – 2012</td>
<td>2.2667</td>
</tr>
<tr>
<td>2012 – 2013</td>
<td>1.4780</td>
</tr>
<tr>
<td>2013 – 2014</td>
<td>3.0402</td>
</tr>
</tbody>
</table>

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.
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 Determine 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 Explore 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 Choose 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 Identify 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 Decide 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 Evaluate, 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) \cite{Neilson2010} \textit{minimalist design}, Budd’s (2007) \cite{Budd2007} heuristic about \textit{minimizing unnecessary complexity and cognitive load} and Horton’s (2005) \cite{Horton2005} design guideline of \textit{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.

\textbf{Chapter 6}

6 \hspace{1cm} 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.

References


Appendix A: Manual Forms at the School Board

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

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

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

---

Supervisory Officer Signature  Date  

Principal Signature  Date

---

Figure A.2: Annual Growth Plan Form for Elementary Schools – Second Page
**Rainbow District School Board**

### Secondary Principal Annual Growth Plan

**SCHOOL:**

**GRADES:**

**DATE:**

### SCHOOL DATA

<table>
<thead>
<tr>
<th># of Vice Principals</th>
<th># of Educational Assistants</th>
<th>Framework School</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th># of Secretaries</th>
<th># of ISP Classrooms</th>
<th>Operating Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th># of Teaching Staff</th>
<th># of Program Leaders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### School Population as of October 31

<table>
<thead>
<tr>
<th>2007-08</th>
<th>2008-09</th>
<th>2009-10</th>
<th>2010-11</th>
<th>2011-12</th>
</tr>
</thead>
</table>

### Exceptional Students as of October 31

<table>
<thead>
<tr>
<th># of Identified Students</th>
<th># of Identified Behaviour</th>
<th># of Identified Learning Disability</th>
<th># of Identified ASD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

### Grade 9 Math Results

<table>
<thead>
<tr>
<th>2008-09</th>
<th>2009-10</th>
<th>2010-11</th>
<th>2011-12</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Applied</th>
<th>Academic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

### Grade 10 OSSLT Results

<table>
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<tr>
<th>2008-09</th>
<th>2009-10</th>
<th>2010-11</th>
<th>2011-12</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Overall Results</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Pass Rates – Applied / Academic

<table>
<thead>
<tr>
<th>Math</th>
<th>English</th>
<th>Science</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Grade 9 - Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grade 9 - Academic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grade 10 - Applied</th>
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</thead>
<tbody>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grade 10 - Academic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

### Pathways # of Students Enrolled

<table>
<thead>
<tr>
<th>Co-op</th>
<th>OYAP</th>
<th>SHSM</th>
<th>eLearning</th>
<th>Dual Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009-10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010-11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### All Pass Rates

<table>
<thead>
<tr>
<th>University</th>
<th>College</th>
<th>Workforce</th>
<th>Credit Accumulation</th>
<th># of Suspensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 11</td>
<td></td>
<td></td>
<td>2009-10</td>
<td>2010-11</td>
</tr>
<tr>
<td>Grade 12</td>
<td></td>
<td></td>
<td>Year 1</td>
<td></td>
</tr>
</tbody>
</table>

### Other:

---

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

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

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

Supervisory Officer Signature: ____________________________  Date: ____________________________

Principal Signature: ____________________________  Date: ____________________________

---

Figure A.4: Annual Growth Plan Form for Secondary Schools – Second Page
Appendix B: Membership Functions

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

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

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

\[ \mu_{most}(\text{math}) = \begin{cases} 
0, & \text{math} < 40 \\
\frac{\text{math} - 40}{60 - 40}, & 40 \leq \text{math} \leq 60 \\
1, & \text{math} > 60 
\end{cases} \]……………… (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 minimalist 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?
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 student involvement 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.
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 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.

![School Council List Interface at Initial Stage](image_url)
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 Council List Interface after First Evaluation](image)

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.
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.
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.
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.

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