

Applying a Descriptive Model to Identify Determinant Factors on Quality of Higher Education: The Case of Ethiopian University

¹Kefelegn Gulint, ²Tigist Adam

¹Lecturer, Department of Information Technology, Debre Berhan Polytechnic College, Ethiopia, ²Lecturer, Department of Information Technology, Debre Berhan University, Ethiopia

Corresponding Author: Kefelegn Gulint

Abstract: Currently, employing data mining techniques for conducting studies in different areas, such as marketing, health, education, and in other many areas is very important. Because, the huge collection of data in these areas need to be analyzed for extracting hidden knowledge that assists in making sound decision. Data mining tasks can be classified into two categories: descriptive and predictive. Descriptive mining tasks characterize the general properties of the data in the database. Predictive mining tasks perform inference on the current data in order to make predictions. In this research, descriptive data mining task is used. In our country, higher education institutions are expanding from time to time. This expansion also increases the alumni data in the institutes. In this area, different researches were done on quality of education using these educational data. However, there is no research that has been done in identifying determinant factors on quality of education using data mining techniques in Ethiopian higher education. That is the reason, why the researcher is motivated to do this research.

The dataset for this research is collected from Ethiopia Higher Education institutions. Data collection methods which are used include questionnaires, observation and interviews. Moreover, previously stored data from quality assurance directorate office is also used for the study. After the data is gathered, it is prepared for mining tasks. The preparation is done using traditional statistical soft wares, such as SPSS and MS-Excel, and preprocessing techniques of Weka software. The data mining process is carried out on twenty attribute, which are selected by Weka and one class. These attributes are analyzed by Apriori algorithm. The result of this study depicted that the main determinant factors of quality education are If TLECRooms = Agree and LRPWork= Agree and SProgress= Agree and SAttended= Strongly Agree, then the quality of education is Excellent. Thus, the researcher concludes that conducting studies by employing data mining techniques using educational data is very important so as to identify challenges on improving quality education.

Key words: Classification based Associator, Educational Data Mining, Apriori, filtered Associator

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I. Introduction

Ethiopian Higher Education

Education is a very vast concept; there is no best way to define it. It does not have a single purpose, it serves multiple objectives, and relative importance of each of these objectives can be very personal. The varied emphasis is a result of the diverse economic, social, spiritual, cultural, and political realities of our individual lives [3]. However, education, in its general and more of formal sense, is most of the time considered as a form of learning in which the knowledge, skills, and habits of a group of people are transferred from one generation to the next generation through teaching, training, research and so on [3]. It is commonly divided into stages such as kindergarten, primary school, secondary school, and higher learning education, which is mostly, within the kingdom of teaching, such as vocational education and training, undergraduate and postgraduate studies [8]. According to Ethiopian Higher Education Proclamation (EHEP), higher education is available through certain college-level institutions, including vocational schools, trade schools, and other profession colleges that award academic degrees or professional certifications [8].

In the previous Ethiopian Higher Education Proclamation (EHEP) No. 315/2003, Higher Education was defined as education offered to students who attend programs after they have completed secondary education [9]. This means that all programs that lead to the award of certificate, diploma, first degree, second degree, medical specialist, and/or doctorate (PhD) degree were components of higher education. However, the currently active Ethiopian HEP defines higher education as “education is the arts of sciences offered to undergraduates and graduate students who attend degree programs” [9]. Thus, higher education in the current Ethiopian context is defined as educational programs which exclusively constitute undergraduate and graduate level studies.

The field of data mining is concerned with finding new patterns in large amounts of data. Widely used in business, it has scarce applications in education [2]. Educational data mining is used for predicting student performance and other learning techniques to remove the drawbacks in educational sector and improve the performance of students [10]. Data mining describes the criteria of finding various patterns in data that are not explicitly part of the data. These patterns are interesting which can be used to tell us something new. Educational data mining emerged as an independent research area in recent years. Data related to the field of education industry and mining of all such education data is called educational data mining [10]. It consists of data of student, teacher, faculty, courses, teaching hours, colleges and universities [8]. Educational data mining (EDM) is defined as the area of scientific inquiry centered around the development of methods for making discoveries within the unique kinds of data that come from educational settings, and using those methods to better understand students and the settings which they learn in [8] [9]. Educational data mining methods often differ from the broader data mining literature, in explicitly exploiting the multiple levels of meaningful hierarchy in educational data [4].

Educational Data Mining

Educational data mining is the application of data mining. Educational organizations are one of the important parts of our society and playing a vital role for growth and development of any nation [4]. It is an emerging interdisciplinary research area that deals with the development of methods to explore data originating in an educational context. Educational data mining is an emerging trend, designed for automatically exploring the unique types of data from large repositories of educational related data [5]. Data mining is the field of discovering novel and potentially useful information from huge data. Educational data mining can help both students and management to determine improving the quality of education and students' performance. Student data mining is the mining of student data or data related to the students; for example, courses assignments, marks, and student background. It helps the students for a better progress and to determine the quality of higher educational process. The student data mining process allows to have a better perspective on the student progress throughout the educational processes and at the same time to analyze the information related to the specifics of the programs, courses, and course assignments [6]. This innovative approach allows the decision making process to use the what-if scenario when analyzing the student data and other education related information in order to improve educational processes. The data related to the students' progress is retrieved from the students' records, imported into the data mining system, analyzed, and exported back. The educational data mining allows identifying and locating details about educational processes that need improvements or those that perform very well and could be used as good examples (and encourage). Educational data mining can assist in the design of the educational content. It can help in improving student academic performance. These findings can be used both to help teachers in managing their class, understand their students' learning behavior and reflect on their teaching and to support learner reflection and provide proactive feedback to learners [7].

From the perspective of management, it helps in optimizing the organization by the maintenance of education infrastructure and to analyze and determine the factors affecting the quality of education. One of the significant facts in higher learning institution is the explosive growth of educational data. However, the amounts of data are increasing rapidly without any benefit to the management. The main objective of any higher educational institution is to deliver quality education for students, to make outcome based research for surroundings, to improve the quality of managerial decisions and to communicate quality education. Good description of student's success in higher learning institution is one way to reach the highest level of quality in higher education system. Even though there are some researches that were done on students' performance in higher education in our country, they could not solve the quality problems since the researches focused on a single subject. That is why this research is necessary to determine the factors that affect the quality of education and students' performance [6].

II. Related Literature

There are a number of researches done to apply data mining techniques in education domain in general and to improve students' academic performance.

Al-Radaideh et al. [19], applied decision tree as classification method to evaluate student data in order to find which attributes affect their performance in a course. Three different classification methods namely, ID3, C4.5 and the Naïve Bayes were experimented. The outcome of their results indicated that Decision Tree model had better prediction than other models. Accordingly, Radaideh et al. state that the decision tree model is used to predict the final grade of students who studied the different course in Yarmouk University, Jordan in the year 2005.

Abu Tair & El-Halees [29], use educational data mining to discover hidden factors that may affect the students' performance; to this ends they carried out a case study using educational data mining (EDM) techniques and algorithms to determine factors in order to improve graduate students' performance, and to

overcome the problem of low grades of graduate students. They applied DM techniques on fifteen years graduate students data collected from the college of Science and Technology. They are used association rule analysis, classification and clustering to extract important knowledge from the large educational dataset and to improve graduate students' performance especially low grades graduated students using the main factors are departments of the student and they use such attributes, High school Degree, Midterm Marks, Lab Test Grade, Semester Performance, Assignment, Measure of Student Participant, Attendance, Homework, and Final Grade Mark for the research.

Baradwaj and Pal [24] use classification techniques for the evaluation of student's performance by selecting 50 students of MCA departments. In the University student's data like attendance, class taste, presentation, project, assignment marks from the students' previous database was used to predict the performance of students at the end of the semester. The ID3, C4.5, and ADT decision tree classification algorithms were utilized to predict the quality of education and quality of student's performance. Accordingly those researcher explanations are used to evaluate the performance of student's apply different data mining techniques. Those researchers are stated that about the higher institution education (HIE) on educational data mining (EDM) is to analyzed and predict students regarding enrolment of students in a particular course. And also list different attribute that affecting the performance of students. And also apply different technique to extracting important knowledge. Here are some of the gaps of the research, those researchers are used small amount of dataset for the research, which attribute are best for the research are not mentioned, which algorithm are best are not mentioned and also to predict the quality of education which attribute are best are not mentioned.

Kovacic [29] research work is presented a case study on educational data mining to identify up to what extent the enrolment data can be used to predict student's success. The algorithms CHAID and CART were applied on student enrolment data of information system students of open polytechnic of New Zealand to get a decision tree for classifying into successful and unsuccessful students. The accuracy obtained with CHAID and CART was 59.4% and 60.5% accuracy respectively.

Borkar [30] research work also presented about the address of student's performance evaluation using association rule mining algorithm based on various attributes of the dataset of 60 students from a single department. In this study, important rules are generated to measure the correlation among various attributes like students' graduation percentage, attendance, assignment work, unit test performance and how these attributes affect the student's university result. The most important rules generated include the first best rule is 90% of confidence and 10% confidence and the second rule is generate 87% of confidence with 10% support. But, the researcher used small amount of dataset (which contains only 60 records) for the association rule mining to evaluate them. Thus, they observed that the associations they get from Apriori algorithm are not identical with the correlation values of the attributes.

Kannammal [21], presented a systematic analysis of various features of the higher grade school public examination results data in the state of Tamil Nadu, India. To predict the performance of schools he applied classification algorithms tools. His finding helps the parents to select the right city, school, based on the factors that contribute to the success on the results of their children. His work focused on two fold factors; namely, Machine Learning algorithms to predict school performance with satisfying accuracy and to evaluate the data mining technique which would give better accuracy of the learning algorithms. He found that there exist some apparent and some less noticeable attributes that demonstrate a strong correlation with student performance. He collected data from credible data source and perform data preparation and correlation analysis and his work addressed those public examinations results data was a very helpful predictor of performance of school in order to improve the result with maximum level.

According to Rekić's [12], research work presented to identify key challenges affecting quality of education in tertiary Private Higher Education Institutions (PHEIs) in Ethiopia and how these challenges affect educational quality; frequent change in rules and regulations, lack of recognition and support for the sector, infrastructural problems, high dependability on tuition fee; shortage of qualified academic staff and enrollment of students with low academic profile are some of the challenges affecting the quality of education.

The data was obtained from five selected PHEIs leaders and administrative staffs whose institutional head offices were in the city of Addis Ababa. To conduct the study, researcher used document review, research questionnaire, interview, and field notes to enable triangulation of the findings with other publicly available information as a source of data. The analysis was made using both qualitative and quantitative data analysis tools. The finding or the results depicted that, though role of PHEIs, which was almost non-existent before two decades and was totally dominated by government institutions, has significantly increased and cover almost quarter of higher education enrollment in the country. However, there are still concerns from side of stakeholders, especially MoE and HERQA.

III. Research Methodology

Framework and Methods

In this study, to develop a description model that can identify determinant factors to improve the quality of education based on the dataset from Ethiopian higher education institutions; the researcher used a hybrid data mining model. The process starts with determining the data mining goals and ends with the implementation of the discovering hidden knowledge. Success percentage rate of any institutions can be improved by knowing the reasons to improve qualified education system. In this study, information on various parameters is collected through a structured questionnaire, personal interview, and direct observation from the instances of undergraduate courses in Ethiopian Higher Education institutions. Thus, this study is in relation to classifying the various quantitative and qualitative factors to improve the quality of education which belongs to the process of knowledge discovery of data mining. The methodology adapted is based on the in-depth study of the topic pertaining to the data mining and its application in higher education [29]. The views of various national and international conferences were taken into consideration while analyzing the data mining applications in the field of higher education [30]. Discussion with various academicians, institutions, colleges offering higher education and experts in the field of data mining helped the researcher to find and present the techniques, process and application of data mining in higher education.

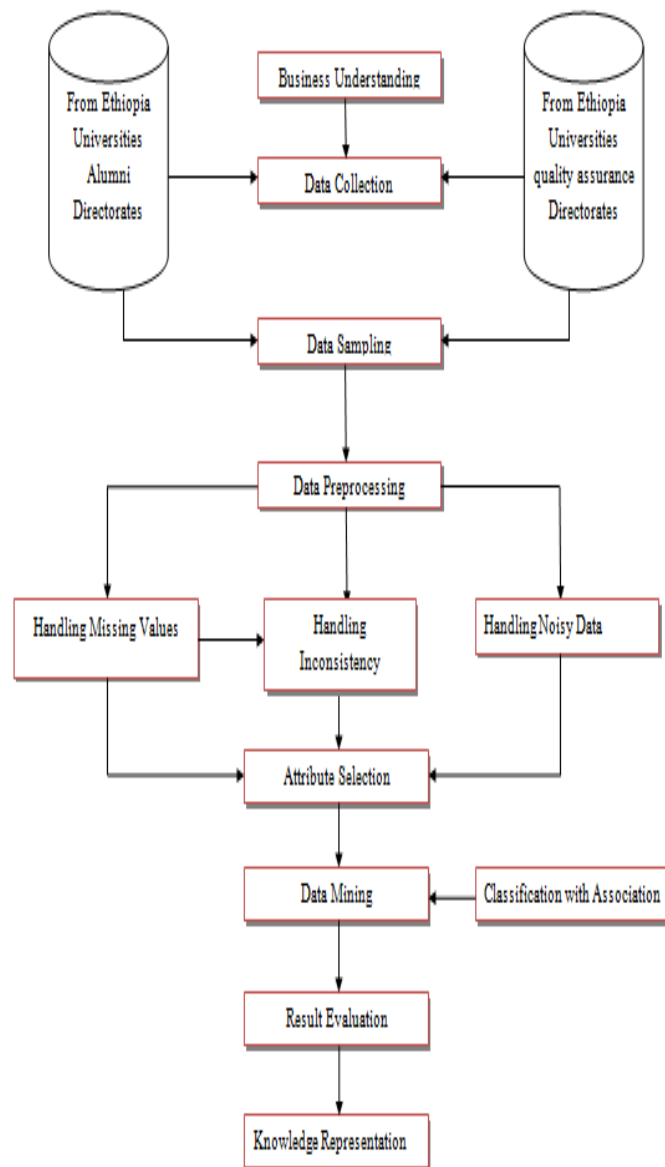


Figure 3.1 Framework for identifying quality of education

Framework Data Flow

For this study, the above mentioned framework is used. The framework is starting from domain understanding. This means understanding of the domain and analyze about the source, amounts and availability of data related the domain area. After this activity is carried out, necessary data for the study is collected. To this end, the researchers develop questionnaires for collecting data form staff of Ethiopia Universities and students using random sampling technique. After that, data is preprocessed to make it suitable for the study. It is done by selecting, cleaning and transforming data is preprocessed, data mining tasks and algorithm selection is taken place and then develop user interface for evaluation of quality higher education. At the end the interface checked by user acceptance.

The proposed system framework consists the overall actives this study. The process is starting from domain understanding on this section to understand about the problem facing on different departments, the data gathering techniques, understand the data that is found on quality assurance directorate office, understand the data and attributes type. Then, data gathering combine the database and data collected by questionnaires from different department. After combine the data, go to data understanding, on this section data cleaning, data transformation, attribute selection used to suitable for data mining. After data understanding and data preparation next to this select best data mining algorithms to determine the factors affection quality of higher education and then proceeding to build model to generate the hidden knowledge from the total dataset to integrate with the user interface Figure:3.1 shows all doing mechanisms.

IV. Implementation And Results

Experiment Overview

In this study various experiments are conducted using association rule discovery algorithm such as Apriori techniques to derive knowledge from preprocessed data based on hybrid data mining model. The objectives of conducting experiments are to create a model that is able to identify determinant factors that affect the quality of education. Total data set used for training and testing. With the aim to discover regularities in the data, the data that had undergone preprocessing was subject to the Weka data mining software. The dataset include a total of 5454 records having 20 different attributes each. Early in the preprocessing stage the attributes were discarded since they were estimated irrelevant.

Experimental Design

For building applying descriptive model to determine the factors that affect the quality of education, Association Rule Discovery (ARD) was used, specially, Apriori algorithm. Apriori is best and more appropriate for this STUDY compared to filtered Associator algorithm. The dataset has different values and different class; so, because of this the researcher chose Apriori form the above mentioned algorithm. A total of 5454 data were used for training and testing.

To evaluate the performance of the model, 10-fold cross validation was used due to its relatively low bias and variations. This means the data were randomly partitioned equally into ten parts. The learning scheme was trained ten times using nine-tenths of the total data and the remaining was used for testing. Therefore, the learning procedure was executed for a total of 10 times on different training and testing sets. In all the experiments, 20 independent variables (QCDvaluable, QCDISkill, QCDpace, QCDencouraged, QCDIncreased, QCDIConcepts, QCDIComSkill, LRPWork, LRSQuality, TLEOverall, LRMaterials, TLEmethods, TLECRooms, CContent, TLEbalance, SActively, SProgress, CWorkload, SAttended and COWclear) and one dependent variable were used. Out of these variables, the dependent variable determined the factors affecting quality of education. The experiment was done using Weka mining tool version 3.6.4 and excel data CSV format.

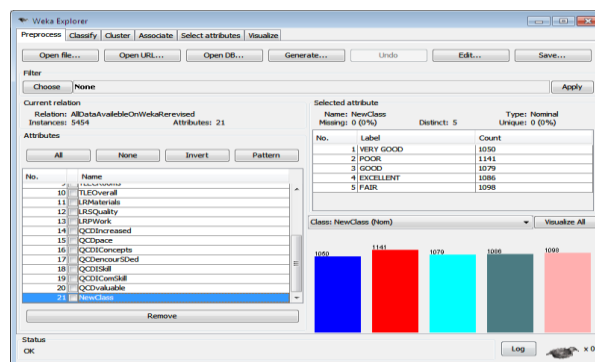


Figure 4.1 Weka Attributes and Instances

The association rule algorithm was applied on the whole dataset that had been cleaned and transformed into the .CSV format. The information on running the algorithm on the database is presented in the table below based on different experiments.

Rule

- ✓ *QCDvaluable=SD TLEmethods=DA TLEOverall=UC SAttended=SD 1092==> Class=Poor 892*
- 1. *(If QCDvaluable = Strongly Disagree and TLEmethods = Disagree Agree and TLEOverall= Uncertain and SAttended= Strongly Disagree, then the Quality of education = Poor)*
- ✓ *QCDvaluable=DA TLEmethods=UC TLEOverall=DA QCDIConcepts=SD QCDencouraged=SD 1541==> Class=Fair 1003*
- 2. *(If QCDvaluable = Disagree Agree and TLEmethods=Uncertain and TLEOverall= Disagree Agree and QCDIConcepts= Strongly Disagree and QCDencouraged = Strongly Disagree, then the Quality of education = Fair)*
- ✓ *QCDvaluable =UC TLEmethods =UC QCDencouraged=SA SAttended=AG CContent=AG COWclear=AG 1450 ==> Class=Good 892*
- 3. *(If QCDvaluable = Uncertain and TLEmethods = Uncertain and QCDencouraged = Strongly Agree and SAttended = Strongly Agree and CContent= Agree and COWclear=Agree, then the Quality of education = Good)*
- ✓ *TLEOverall =UC CContent =SA LRMaterials =AG LRSQuality = UC SAttended =AG 747 ==> Class=Very Good 703*
- 4. *(If TLEOverall = Uncertain and CContent = Strongly Agree LRMaterials = Agree and LRSQuality= Uncertain and SAttended = Agree, then the quality of education is Very Good)*
- ✓ *TLECRooms=AG, LRPWork=AG, SProgress=AG, SAttended=SA, and TLEbalance=SD 845 ==> Class=Excellent 784*
- 5. *(If TLECRooms = Agree and LRPWork= Agree and SProgress= Agree and SAttended= Strongly Agree and TLEbalance= Strongly Disagree, then the quality of education is Excellent)*

The rule indicated above reveal how quality of education is classified based on the selected attribute. It has includes 20 attribute for build a model.

Hence, instances were classified into the predefined classes of educational quality using these attribute. In fact, in classifying quality of education, QCDvaluable, QCDISkill, QCDpace, QCDencouraged, QCDIncreased, QCDIConcepts, QCDIComSkill, LRPWork, LRSQuality, TLEOverall, LRMaterials, TLEmethods, TLECRooms, CContent, TLEbalance, SActively, SProgress, CWorkload, SAttended and COWclear are involved the model.

Important and interesting findings can be identified from the above rules. For example, when TLECRooms=AG, LRPWork=AG, SProgress=AG, SAttended=SA, and TLEbalance=SD, or LRPWork=AG, TLECRooms=AG, TLEbalance=UC, SAttended=UC, then the quality of education is Excellent.

Whereas, when QCDvaluable=SD, TLEmethods=DA, TLEOverall=UC, SAttended=SD or QCDvaluable=DA, TLEmethods=UC, TLEOverall=DA, QCDIConcepts=SD, QCDencouraged=SD, then the quality of education is Poor.

In general, from these rules, even though there may be some less important relationships among the features involved in the model, most of them are interesting and useful. Therefore, the quality assurance office and other concerned bodies can benefit from these rules to facilitate and improve the services being given and to make good decisions concerning on quality of education.

User Interface

Figure: 4.2. The figure shown below, if the user or domain expert chooses or click “Yes” button or key the user interface comes with the basic attributes and their level of data. Once the user or domain experts choose the data or value entered into the software or the user interface wizard, all the necessary data are inserted in to the system. When the user or domain expert click save key, all data are saved into the database. To continue with the next data, the expert should click on the “Clear” button. It continues until all the data are entered.

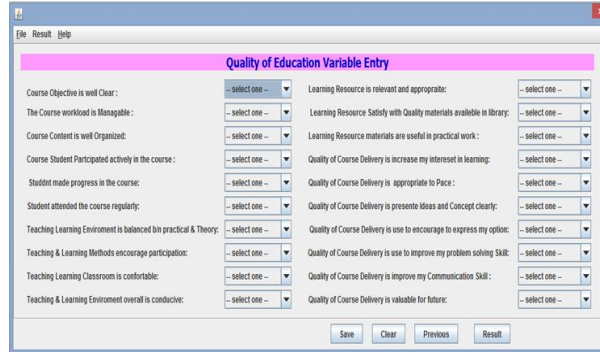


Figure 4.2 Value Entry Wizard

Figure: 4.3. This figure shows the data that the domain expert or the user inserted for each basic attributes and also each attribute values for estimated quality of higher education. The wizard has also additional button to get the summary of data related to quality of education.

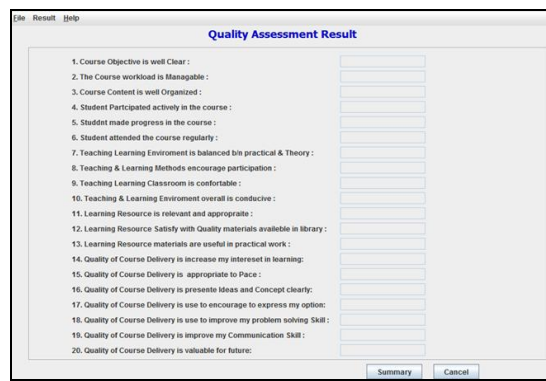


Figure 4.3 Attribute Entry Wizard

Figure: 4.4. This figure shows the aggregated result based on the quality of education data set that the domain expert or the user inserted in to the system. For example the number (255185) and (46) shown in the result box indicates the level or performance of education and the ranges calculated in percentile respectively. This is obtained by dividing the total number of instances value to the total number of records.

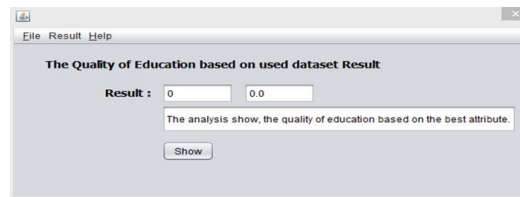


Figure 4.4 Aggregated Result Wizard

Figure: 4.5. This figure shows the quality of education result based on the determinant factors and their effect on the quality of education.

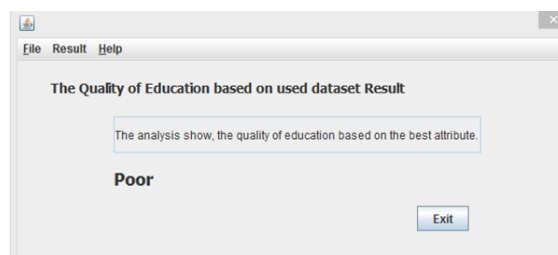


Figure 4.5 Final Result Wizard

V. Conclusion

Currently, data mining is a very helpful or significant discipline in our day to day activities; such as in marketing, health care, education, agriculture and manufacturing. It is used to analyze huge stored data by applying different techniques and tasks. By doing so, it is possible to acquire knowledge, which is vital for decision making. In general, data mining tasks can be classified into two categories: descriptive and predictive. Descriptive mining tasks characterize the general properties of the data in the database; whereas, the predictive one performs inference on the current data in order to make predictions. Thus, in this research, a descriptive data mining task was employed to identify the determinant factors affecting the quality of higher education. In our country, higher education institutions are expanding from time to time. This results a huge storage data in the alumni of these institutes. Some of them are on students' performance, school performance, and others on the quality of education on single subject. However, there is no research that was conducted on the overall quality of education in the country, specifically in Ethiopia Higher Education institutions using data mining techniques.

For this research, the data was collected from Ethiopia Higher Education institutions using different methods, such as questionnaires, observation and interview from directors, quality assurance office, departments, administrative officers and students. After the data was gathered from those parties, it was preprocessed and analyzed to make it suitable for the research. This was done by using statistical and data mining softwares which are SPSS and MS-Excel; and Apriori and filtered Associator respectively. To determine the factors affecting the quality of education in Ethiopia Higher Education institutions, the researcher initially used twenty nine attribute and five classes. From these attributes, Weka selects only twenty attributes. These attributes were analyzed by Apriori and filtered Associator association rules. The output of Apriori and filtered Associator was almost the same and the researcher considered only Apriori results.

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