

Design and Implementation of a Data Warehouse for Managing an Educational Institution

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Abstract - Developing the work mechanism in educational institutions is one of the most important factors that affect the quality of education and its outcomes. The effective work mechanism contributes to improving efficiency and productivity. In this work, the database stored in (The representative of the Iraqi Ministry of Education in Erbil / Specialist Supervision Unit) is transformed into a system for managing the data warehouse of the educational institution by exploiting the database available in the institution and linking this data. By identifying the necessary presences in this system and representing the relationships between the presences to facilitate the process of extracting, converting, and uploading this data to the system designed for the purpose of taking advantage of modern technology to support the decision maker in this educational institution. The proposed system helps the institution's director quickly access and review historical data on a specific subject and analyze it for the purpose of making strategic decisions related to the educational process according to the available information accurately and without fatigue or boredom.

Keywords: Data warehouse management system, Database management system, Educational Supervision.

I. Introduction

Modern society has witnessed a technological revolution in all fields, and this is evidence of the continuous dedication of many people who work constantly to ensure that human services and activities are implemented with ease and absolute mastery. For one to be confident of future success, knowledge is essential and a crucial element while starting out in any field and the information to be reviewed must come from reliable sources just like all other elements and factors one takes into consideration before making a decision. In the digital world, people often prefer to extract information from a group of databases called data warehouses [1].

In the recent past, most organizations stored their vital data in relational databases. However, the demands of these organizations today are different than in the past, as a data warehouse has arisen out of necessity and as a result of

business dynamics and increasing competition. It requires the availability of the necessary information at the right moment to institutional managers to enable them to manage the institution effectively [2].

The new model known as (data warehouse) provides tools and structure for various institutions, applications, and managers to make strategic decisions. A data warehouse contains subject-specific, subject-specific, historical, standardized, and non-volatile time-varying data. It will help in the decision-making process. These sets of data are subjected to a variety of processes, including multidimensional data analysis, aggregations, and summaries [3].

II. Related Works

Researchers (Moscoso-Zea, Paredes-Gualtor, & Luján-Mora) conducted a study on several research papers on the topic of data warehouses in education. They applied a qualitative and quantitative approach based on a research method to obtain a comprehensive view of data warehouses (DWHs) in education. The study revealed a set of facts, including that Kimball's methodology is the most widely applied approach for DWH design in education, and that the star schema is the most implemented approach for data warehouse design. The study also showed that there are many universities that implement DWH as a strategic initiative. The outputs of DWHs are used to improve the learning and teaching process, as the knowledge generated from the warehouse provides guidance to decision-makers to improve academic operations [4].

Researchers (Suman, Khajuria, & Urolagin) also discussed the strategic challenges faced by educational institutions around the world. They stated that these challenges can be successfully addressed by analyzing the huge amounts of data stored in multiple, unorganized, and unstructured operational databases in educational institutions.

They also highlighted the need for these institutions to adopt data warehouse technologies to be able to benefit from the knowledge stored in different archives. They discussed data warehouse (DW) technologies, data source integration,

requirement analysis , data design , development, implementation, and deployment [5].

III. The Project Problem

Due to the technological development and the widespread use of devices and programs in the administrative field , especially in educational institutions, and the large amount of data and problems that occur in managing this data in traditional systems , this proposed electronic system was designed to manage the data warehouse of an educational institution (the representative office of the Iraqi Ministry of Education in Erbil - the specialized supervision unit) to solve the problems facing the official in quickly obtaining accurate information before the decision-making process in the specialized supervision unit , which serves the success of the educational process.

IV. Specialized Educational Supervision

It is considered an important detail in the educational process and is a specialized technical work , as the Ministry of Education works to provide the required numbers of supervisors and prepare special programs to qualify and train them to accomplish the tasks assigned to them. In addition to that, achieving the goals of the educational process and advancing the reality of education in schools . By providing educational staff , coordinating with them , directing them to implement the teaching plan , developing their capabilities , distributing them to schools , and following up with them to deepen the positives and evaluate the negatives and address them, as well as exchanging experiences among them , standing beside them, and creating an environment suitable for education by directing school administrations, their educational and teaching staff, and their students to implement the systems and instructions . Issued by the Ministry of Education and coordinating its relevant educational activities to move the wheel of education towards progress and keep pace with development in all specializations. [6](Mubarak & Al-Zubaidi, 2009).

V. Research Methodology

In this work, the research methodology consists of the following steps:

- 1) Literary review related to data warehouses .
- 2) Surveying the organizational structure , work mechanism, and how to obtain the institution's private data.
- 3) System analysis and design : In this stage, the system was analyzed to know the project's goals and purpose, as well as the process of collecting the required data and knowing the inputs and the processing mechanism to obtain the outputs in a way that suits the project's goals ,

and then designing the descriptive model for the database that will be adopted to form the data warehouse.

This was done through:

- a) Defining Entities: In the second stage, tables were created and their properties were determined . Names were chosen Schedules carefully to avoid problems during project design. Eight tables were created : (administrator, teacher, school, course, subjects, etc.).
 - b) Determining the Relationships Between Entities : At this stage , the relationships between the entities and their attributes were determined , and controls for the number of contributions between the entities (Cardinality) were adopted.
 - c) Complete description of the database structure using the Existence-Relationship Diagram (ER_Diagram).
 - d) Converting the descriptive model (presence - relationship) to the logical model or what is called the relational model.\
 - e) Applying normalization steps : In this stage , normalization steps are applied to the tables that make up the relational model in order to obtain a consistent database model free of repetition and distortion.
- 4) Designing the data warehouse through:
 - a) Database analysis with a multi -dimensional model and facts.
 - b) Design a model between a fact table and multidimensional data tables.
 - 5) Programming the system using programming languages:
 - a) Designing the application interface through the use of the programming language (Visual Studio 2022 Visual C#).
 - b) Designing a database system using Structured Query Language (SQL Server).
 - c) Designing a data warehouse system using Structured Query Language (SQL Server).
 - d) Design and prepare report forms for the system by using the special tool (DevExpress), which is used with the language program (Visual Studio 2022 Visual C#).

VI. Entity Relationship Diagram

All the entities that were challenged in the design of this proposed system are represented by applying the relationship rules between entities, attributes, and constraints, with the type of relationship between them mentioned in Figure (1), which shows the entity relationship diagram (ER_Diagram) for the database system.

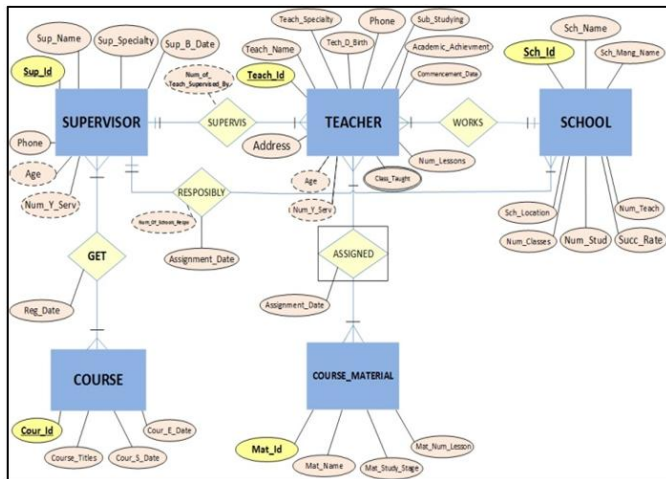


Figure 1: Relationship diagram of the database system (ER_Diagram)

VII. Converting the Entity-Relationship Model to a Relational Database

The ER_Diagram was converted to a relational database schema by applying a set of steps and rules. Figure (2) shows the relational database for the system.

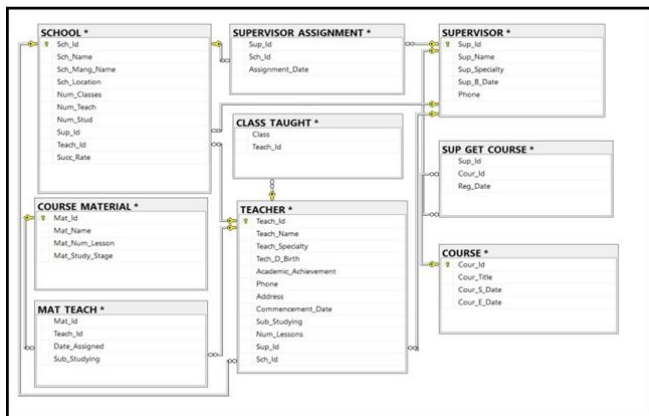


Figure 2: Relational database model of the system

VIII. Data Warehouse Definition

A data warehouse (DW) is a large data warehouse where data can be stored and combined from different sources in a well-organized manner and helps in the decision-making process through appropriate data analytics[7]. As data warehouse technology has characteristics such as subject-oriented and integrated, by integrating data from different sources[8], and changing over time (Time- variable) so that data is stored over different time periods such as weeks, months, quarters, and years. Non-volatile, since the data in the data warehouse is historical data that is classified as permanent and cannot be erased, edited, deleted, or changed [9];[10]. Therefore, enterprise data management, data warehouses are referred to as a set of targeted decision-making systems to enable the information specialist (leader,

administrative officer, or analyst) to improve decision-making and make decisions faster, and thus (DW) systems act as a tool Important in the field of business intelligence, as it is used in managing enterprise data by most medium and large organizations.

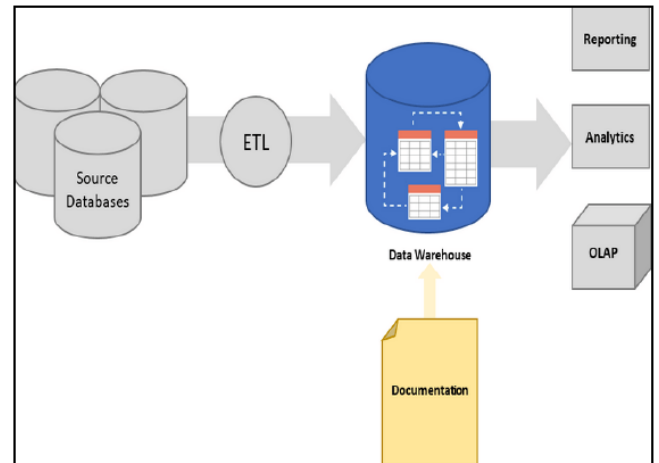


Figure 3: Data Warehouse (11)

IX. Design Data Warehouse

The proposed system was designed using the Star Schema model, which is widely used in the field of designing data warehouse systems, including educational institutions. The design was based on the data available in a main table known as the Fact Table, and surrounding the main table is a group consisting of three tables called Dimension Tables, as Figure (4) shows the star schema data warehouse system.

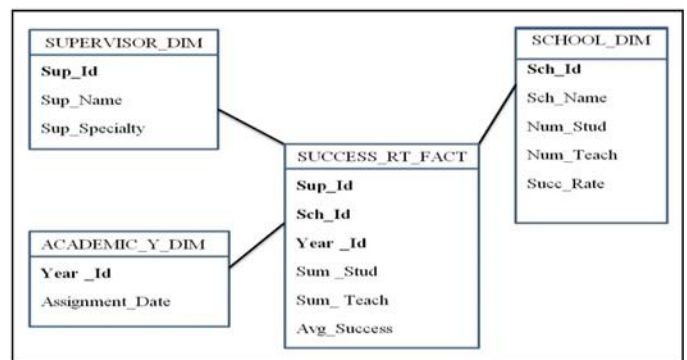


Figure 4: Shows the star schema data warehouse system

X. System Flow Chart

Through the flow chart the use of the designed system is clarified starting with the login process to the proposed system. The process begins with one step (enter your username and password). If the user name and password are correct, you will move to the step (the main window of the system), passing to all interfaces of the system. If the user name or password is incorrect, the step will be moved to

(Login Failed) and then the system will be terminated and exited. Figure (5) also shows the flow chart of the designed system.

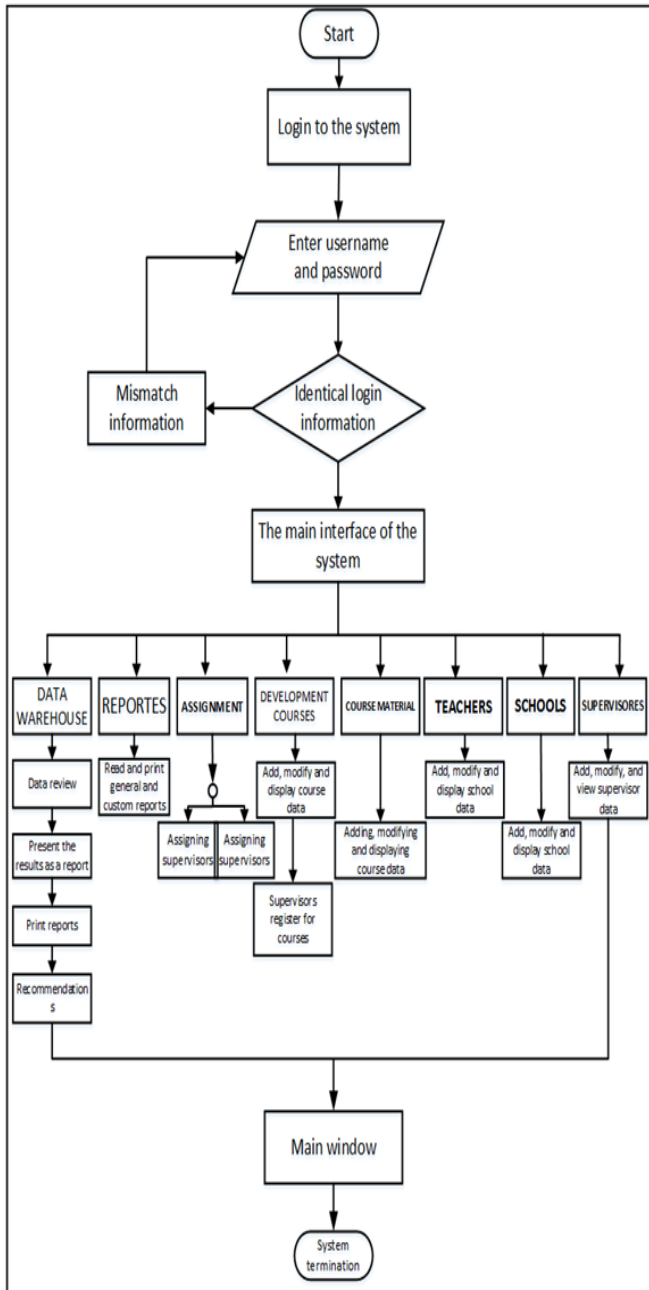


Figure 5: Shows the flow chart of the designed system

XI. The Main Window of the System

After logging in to the system correctly, the main interface of the system appears, which is considered one of the most important interfaces, through which the required sub-windows are opened for the purpose of entering and modifying data, and their contents can be viewed and used through the buttons in this window shown in Figure (6). So that it can be used in a way that suits work through the existing buttons and existing functions.



Figure 6: The main window of the system

11.1 Data Warehouse Button

When you click on this button, the special window for the data warehouse appears, through which you can review the historical information available in the Specialist Supervision Unit's private database. This window includes six buttons: (review the fact table, submit the fact table as a report, review success rates) For schools, reviewing student preparation for schools, reviewing teacher preparation, proposing recommendations) where the text written in the button indicates the function of the button that it performs when pressed, as shown in Figure (7), the fact table window for the data warehouse.

Academic Year	Sup Name	Sup Id	Succ Rate	Num Stud	Num Teach	School Name	Id
2019/2020	...	9	84	180	11	...	SC1
2020/2021	...	11	87	171	11	...	SC1
2021/2022	...	3	84	170	11	...	SC1
2019/2020	...	7	85	290	44	...	SC2
2020/2021	...	3	85	261	33	...	SC2
2021/2022	...	13	80	280	25	...	SC2
2019/2020	...	8	86	280	25	...	SC3
2020/2021	...	9	82	260	24	...	SC3
2021/2022	...	5	90	170	20	...	SC3
2019/2020	...	2	86	126	15	...	SC4
2020/2021	...	12	75	120	15	...	SC4
2021/2022	...	9	90	140	11	...	SC4
2019/2020	...	4	80	226	22	...	SC5
2020/2021	...	13	80	215	20	...	SC5
2021/2022	...	8	76	210	15	...	SC5
2019/2020	...	5	75	386	26	...	SC6
2020/2021	...	15	70	340	22	...	SC6
2021/2022	...	9	75	400	26	...	SC6
2019/2020	...	15	74	470	36	...	SC7
2020/2021	...	8	80	450	30	...	SC7
2021/2022	...	7	85	470	30	...	SC7
2019/2020	...	12	82	353	28	...	SC8
2020/2021	...	6	82	320	28	...	SC8
2021/2022	...	10	87	360	29	...	SC8
2019/2020	...	10	92	118	11	...	SC9

Figure 7: Fact table window for the data warehouse

XII. Conclusion

It is clear that data warehouse technology is not for storing and archiving data, but it can be used to analyze historical data that directors of educational institutions rely on in the process of making strategic decisions to improve the quality of education and raise the level of success in those

institutions. Expanding the use of data warehouse technology in institutions that possess huge data saves a lot of effort and speed in the process of obtaining information to support the process of planning for the future and planning for the gradual excellence of the institution in making decisions in an accurate and reliable manner. In addition, training workers in this field to benefit from the capabilities of the data warehouse in their fields of work and activities facilitates the mechanism of work and clarity of idea and work in this field. Collecting data from different sources, integrating and analyzing it in the decision center helps in obtaining information about a specific topic for the purpose of making a correct, fast and reliable decision. As is the case in this system, which was presented to decision-makers in the Specialist Supervision Department, where the work was evaluated excellently in terms of the functional performance of the system and achieving the work requirements in the educational institution.

XIII. Recommendations

Although the proposed system meets all the functional requirements in an integrated manner, the field of system development remains open to adding new features and functionalities. Therefore, we recommend the following:

- Expanding the use of the data warehouse system to improve data management and storage effectively in all departments of educational institutions. This will help improve access to data and support better decision-making.
- Utilizing artificial intelligence (AI) techniques in operations and data analysis to provide strategic recommendations for improving educational operations. AI can be used to analyze data, identify patterns, and predict trends, which will help improve decision-making and enhance educational performance.
- Developing advanced reports that provide analytical insights into the performance of teachers, educators, and students. These reports will help improve understanding of the strengths and weaknesses in the educational process, which will help in making informed decisions to improve performance.
- Training employees on how to use the database system and the data warehouse system to fully utilize the proposed system. This will help ensure that the system is used effectively and that its capabilities are maximized.
- Linking and collecting the results of reports from the directorates general affiliated with the Iraqi Ministry of Education to unify and analyze them to support strategic decision-making to raise the level of educational institutions. This will help improve coordination between the various directorates general and make more effective decisions to improve education.

- Adding the ability to create a backup on one of the approved servers automatically to ensure that it is not lost due to a technical problem or other problems such as fires and others. This will help ensure data integrity and protect it from loss.
- Using modern encryption methods and techniques to increase the security of the system and maintain the confidentiality and integrity of information. This will help protect data from unauthorized access and breaches.

We believe that these recommendations will help improve the proposed system and make it more effective in supporting the educational process in Iraq.

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Citation of this Article:

Qaddo M. Noori Alhayaly, Rayan Yousif Alkhatay, “Design and Implementation of a Data Warehouse for Managing an Educational Institution” Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 8, Issue 3, pp 36-41, March 2024. Article DOI <https://doi.org/10.47001/IRJIET/2024.803005>
