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Visualizing the Academic Performance of Tertiary Student Using Sashimi Model

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ABSTRACT

Data visualization made use of grade records and output charts that provide insights into the trends and ratios of the students' academic performance. Using Sashimi Model, the system exhibited efficiency despite the bulkiness of data. The researcher allocated databases for the imported data, for all the necessary, filtered data, and system housekeeping. Algorithms are created to develop several designs like data flow diagrams, entity-relationship diagrams, and architectural design. The results showed taken from the charts that many students successfully passed the subjects enrolled during the second semester class compared to the first semester and summer.

Keywords: Grade records, Output charts, Cumulative, Trends, Student academic performance.

1. Introduction

The Chief Information Officers and Information Technology individuals in an organization concluded that full utilization of their data leads to their organizations' success [1]. According to the IBM recent estimates, 2.5 billion Gigabytes of big data are created every day, which is growing continuously, and it was estimated the amount would grow 44 times from 2020 onwards [2]. However, most companies failed to use their massive amount of data and were not able to utilize them in a meaningful way [3]. They are more concerned about storing their massive data than analyzing, interpreting, and presenting them significantly. On the contrary, companies that utilized the data and adopted data-driven decision-making have five to six percent more productivity than those who are still using the traditional way [4], [5].

One way to utilize the data fully is to apply the concept of data visualization. Data visualization is invaluable for explaining the significance of data to people who are visually oriented. Data visualization means presenting data graphically, whether through charts, graphs, or maps. It presents information clearly and effectively. It also exposes trends, tendencies, and abnormalities that might remain unnoticed [6]. Besides, data visualization does not need to be sophisticated to look good nor boring to be functional. A simple yet concise visualization of data will be very effective in decision-making [7].

It is undeniable that as an organization grows, data also grow. It is also true with Misamis University. Misamis University, a privately owned institution situated in Ozamiz City, maintains a high volume of data through its Management Information System. On the 85 percent of the respondents indicated in a Capgemini study, the primary obstacle is not the growing number of data but on managing it in a real-time situation [8], [9]. Therefore, it is evident that the management should be concerned with the huge amount of data and be concerned with proper data utilization and manipulation.

The researchers implemented visualization on student grade records, addressing how these data are passively stored in the database. This visualization might expose trends and patterns, which could be helpful for the decision support of the colleges. The study utilizes Sashimi methodology, which is a waterfall with overlapping phases to realize all the processes involved in the system.

The study visualized the students' academic performance in Misamis University, addressing the issue of passive utilization of grade records. For this to materialize, the researcher will create designs in facilitating the visualization using several tools for data visualization.

2. Theoretical Framework

2.1 Review of Related Literature

Data have flooded, doubling every 18 months [10]. This avalanche of data has pushed the organization to the breaking point [11]. A study by Bapat in 2017 was found out that organizations comprising the two-thirds population of North American executives must address issues on big data in improving their decision-making ability. It revealed that the big data and lack of ability in managing it effectively caused the slowing of decision making [10], [11]. As the organization grows, the amount of collected information also grows. Patterns, trends, and correlations necessary to perform the job well become more and more challenging to find if these data are delivered in spreadsheets of tabular reports [12], [13]. Thus, data are increasing, and more organizations are dealing with complex sets of data with lots of variables that are relevant in visualizing data for future use [14]. Neubeck and colleagues (2016) introduced and developed highly interactive graphic modules run on the web on data visualization on patients' health records applying internet graphic component which provides a way of browsing their historical data with ease. The study developed a framework that shows where the data came from, how it was processed to create visualizations [15]–[17].

In 2020, several researchers in the Philippines had used georeferenced data-enabled visualization through maps to on crowdsourcing and mapping data for humanitarianism [18]. In 2018, Asor and company studied data visualization on road accidents in Los Baños, Laguna, Philippines [19]. Ecleo and Galido surveyed LinkedIn profiles using data visualization for workers in data science [20]. Lemenkova (2020) applied visualization tools in the geophysical settings in the Philippine sea margins [21]. In 2020, research implemented data visualization of selected threatened forest tree species in the Philippines by developing a georeferenced database, giving point to the importance of visualization in tracking plant species and prioritizing scarce resources for conversation [22]–[26]. Rajib and colleagues (2016) simulate and visualize data on the web using SWATShare. Seaborn provides a high-level drawing interface for statistical graphical presentation [27], [28]. Indeed, data visualization continues to develop and advance even in the various fields of research.

3. Operational Framework

The conceptual framework of A Personal Health Record Using Rich Internet Application Graphic Components serves as a basis for this research framework [31]. The research, as mentioned above, developed and integrated a highly interactive graphic component into the patient's health records by providing ease of access and pleasant wat for a patient to browse through their historical data. It also implemented a client-server system where the server does much of the processes. It emphasized the importance of maintaining a good application performance by rendering the graphical representation for viewing purposes rather than processing large files.

Moreover, the framework for this research is presented in Figure 1. All the necessary data comes from the grade database of the Management Information System of Misamis University. All the enrolled subjects of the specified academic period are filtered and then categorized by a curriculum, emulating a course's curricular prospectus. Central tendency measurement of the performance of the student on the categorized subjects is then calculated. The statistical data, which serves as visualization input, is then passed to the client.

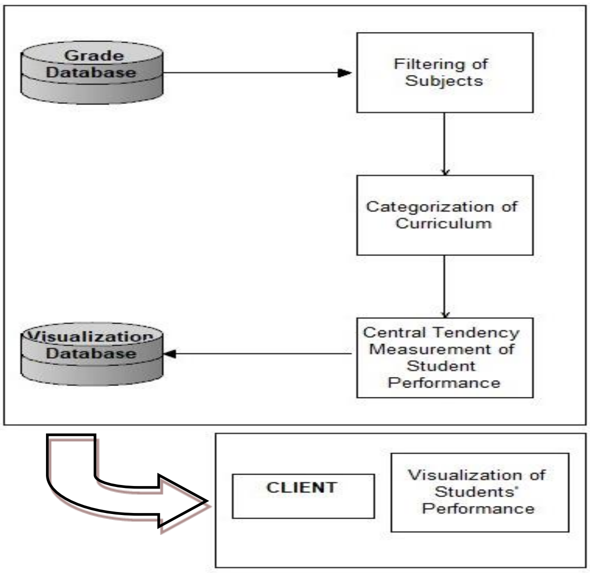

Fig.1. Research Framework

Because filtering of enrolled subjects and calculating central tendency measurement of student performance on the categorized subjects are heavy and time-consuming processes, it is deemed proper to implement a client-server system where the server does much of the heavy processes, moreover, to maintain good application performance, rendering of the graphical representation of the statistically treated data rather than processing large files.

The Misamis University offers several curricular programs. It is necessary to categorize the enrolled subjects into curriculum, seemingly emulating the subjects' arrangement on the curricular prospectus, which enables visualization by curriculum possible. After the categorization, the academic performance of the students on the categorized major subjects undergoes statistical treatment. Their central tendency measurement is calculated.

3.1 Sashimi (Waterfall with Overlapping Phases) Methodology

A software development methodology is a framework used to structure, plan and control the different processes. The methodology used is Sashimi Methodology. Furthermore, it is a modified waterfall methodology that features overlapping phases, just like Japanese sashimi's overlapping fish [29], [30].

In this methodology, information of problem spots can be acted upon during phases that would typically precede others in the pure waterfall model. This iterative model helps alleviate many of the problems associated with the traditional philosophy of the waterfall model [31].

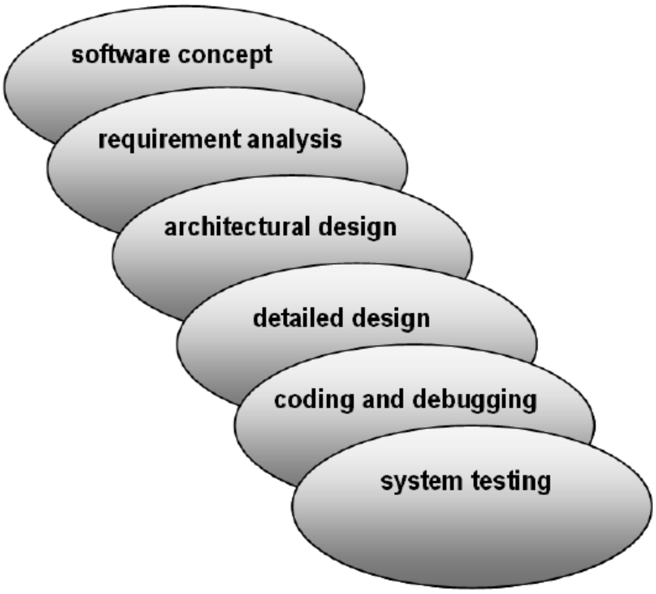

Fig.2. Sashimi Methodology

The researchers adapted the Sashimi Model in developing the system, which includes the requirements analysis phase, design and architecture phase, development and coding phase, and quality assurance and software testing.

3.1.1 Requirements Analysis Phase

In this phase, a discussion with the stakeholders was made to determine the development requirements. Certain questions were answered like; who is going to use the system? What data should be the input of the system? What should be the output of the system? What should the system be like? After the requirement gathering, the researchers did research and found some related kinds of literature that contribute a lot to the research and in developing the system. The researcher also had a discussion with some personalities regarding the best technique that is used in getting the academic performance of the specified group of students based on their class performance. All the gathered information gave the researcher a better understanding of the study's different aspects, especially on data visualizations. To create the visualization, the researcher came up with a framework (Figure 1) that shows how these data are being processed. The framework shows different processes made on the server-side and then transferred these processed data to the client. The server processes include" Data Filtering and Central Tendency Measurement, and the process on the client-side is JavaScript-based visualizations. Data filtering is the process of removing all the unnecessary data. The data stored in the grade database were filtered, removing all the grades that did belong to the major subjects and all the other unnecessary data. The filtered data were analyzed using mean measurement, also known as average.

$$M = \frac{\sum x}{N} \qquad (1)$$

Where:

x = the values/grade of the students

Σ = the sum for each value of x

N = total number of values

M = mean

The computer mean of a specific subject is interpreted as:

Range of the mean - Interpretation

1.000 – 1.667 - Very Satisfactory

1.668 – 2.334 - Satisfactory

2.335 – 3.000 - Fair

3.001 and up - Poor

3.1.2 Design and Architecture Phase

In this phase, designs and architectures were made based on the gathered requirements in the previous phase. It includes the architectural design, database design, and structured charts, data flow diagrams, screen design, and the software and hardware requirements that the researcher used in the development of the system.

3.1.2.1 Architectural Design

The developed system's architectural design has a client-server architecture wherein the client machine is capable of sending requests to the server, and the server will send a response for the client's request, both of which are connected under a local area network.

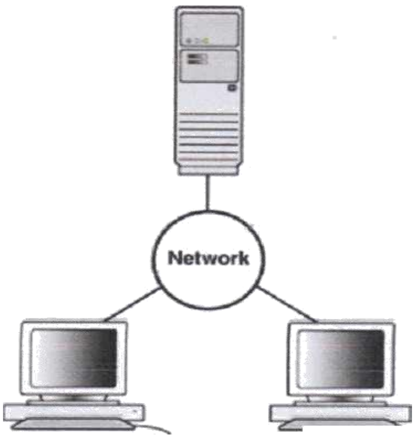

Fig.3. Client/Server Architectural Design

Figure 3 presents the client/server architectural design on the student academic performance visualization system. The Management Information System (MIS) of Misamis University acts as the server and the college dean as the client. MIS hosts the system and shares the resources with the client. MIS handles all the records of the students' academic performance that serves as the system's input. It can also filter, categorize, and get the mean of the grade records from the grade database and then store it in the visualization database. The client can generate visualizations out from the data from the server.

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3.1.3 Data Flow Diagram

Data Flow Diagram (DFD) is a tool used to give a clear representation in describing how the data has been processed. It defines how the data are being processed, stored and how the data flows. It shows where the inputted data came from and where the data are stored after some processes. In Yourdon's (2019) convention of creating DFD, four symbols are used – rectangle for the external agent, circle for a process, two horizontal parallel lines for the data store, and arrows for data flow.

The external agent is the source or destination of the data outside the system. The process is a step-by-step instruction that transforms inputs into outputs. A data store is a collection of data at rest that are stored for later use. Data flow is flowing data from one place to another, such as input or output, to a process [32].

A context-level data flow diagram is an overview of the entire organizational system that shows system boundaries, external entities, and the major data flows between the system and the entities. Context Diagram shows the entire system as a single process.

The context diagram contains two external entities, seven data flows, and a single process. The external entities are the Administrator and the College Heads, College Deans, and Department Chairman. The Administrator manages and maintains the data in the database. To further show the system's flow, DFD level 0 is created to understand the flow further.

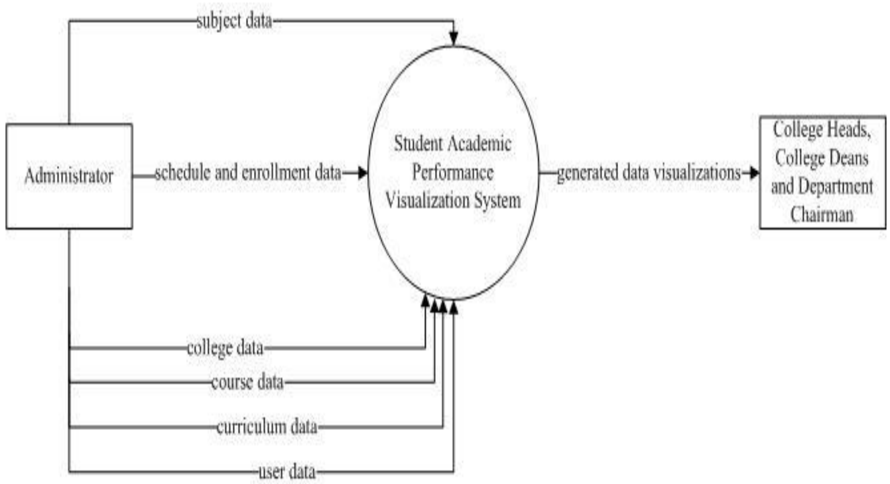


Fig.4. Student Academic Performance Visualization System Context Diagram

DFD Level 0 illustrates how the system is divided into subsystems or processes which deal with data flows from or to an external agent which provides all the necessary functionality of the system.

In the DFD Level 0, there are nine processes that present the major processes and provide more details regarding with the functions of the entire system.

The nine major processes are Import College Data (Process 1.0), Import Course Data (Process 2.0), Add User (Process 3.0), Add Curriculum (Process 4.0), Import Subject Data (Process 5.0), Import Schedule and Enrolment Data and Filter Enrolled Subjects (Process 6.0), Categorize Enrolled Subjects (Process 7.0), Analyze Data (Process 8.0), Visualize Data (Process 9.0).

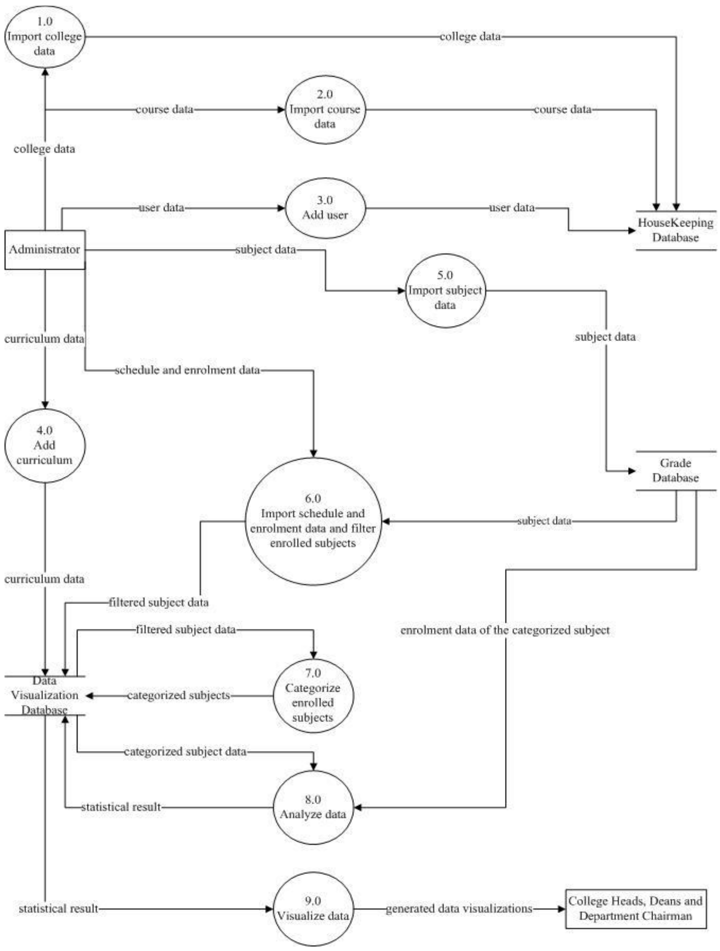


Fig.5. Student Academic Performance Visualization System Data Flow Diagram Level 0

DFD Level 1 is an expansion of a process. Process 6.0 has two sub-processes to further show how the data are being processed. The processes include Import schedule and enrolment data (Process 6.1), and Filter enrolled subjects (Process 6.2). In importing schedule and enrolment data, the schedule and enrolment data will be stored in the Grade database. The schedule and enrolment data is retrieved from the database and will be filtered according to which subjects have been enrolled. Then the filtered subjects will be stored in the Grade database.

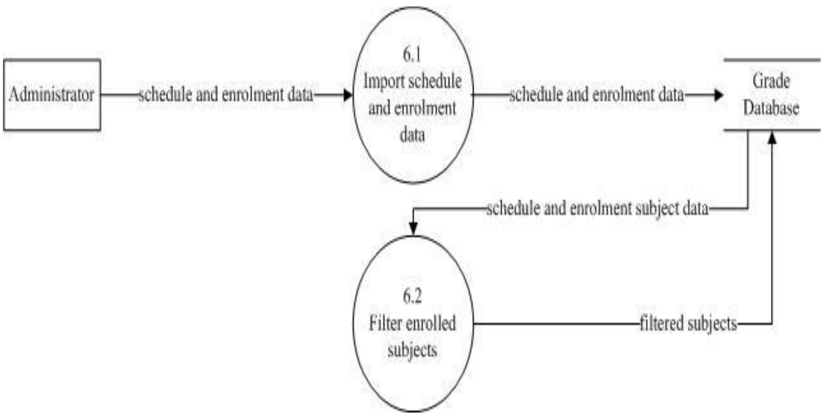


Fig.6. Import Schedule and Enrolment data and Filter Enrolled

Subjects Process Expansion

Process 7.0 has three sub-processes. The processes include Search enrolled subjects of the college (Process 7.1), Select subject data (Process 7.2), and Add subject data to a specific curriculum (Process 7.3). This expansion is created to show how categorization of subjects is processed. From the Data Visualization Database, all the subjects are retrieved in Process. 7.1 then search for the major subjects of the college in Process 7.2. The subjects that are selected are then added to a curriculum. These categorized data is then stored in the Data Visualization Database.

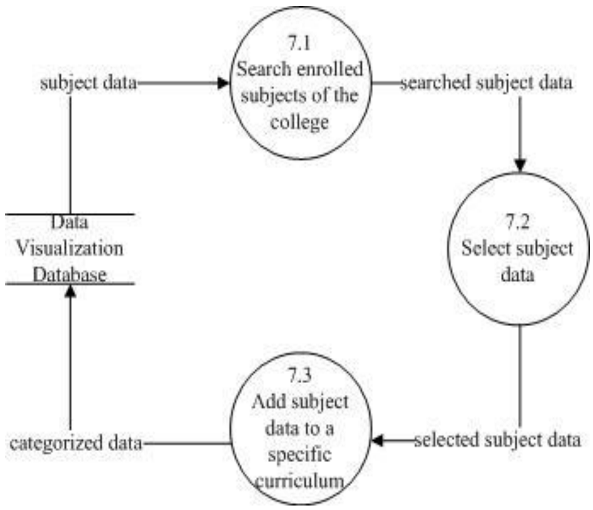


Fig.7. Process 7.0 Expansion DFD Level 1

Process 8.0 has two sub-processes: Search enrolment data of the categorized subjects (Process 8.1) and Compute mean (Process 8.2). The enrolment data of the categorized subjects will be retrieved and then these data will be analyzed by getting the mean of the grades in the enrolment data. Then the statistical result is stored in the Data Visualization Database.

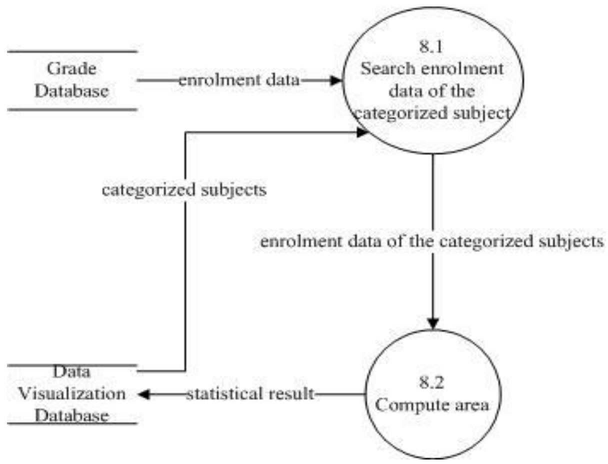


Fig.8. Process 8.0 Expansion DFD Level 1

3.1.4 Entity-Relationship Diagram

The researchers included the Entity-Relationship Diagram (ERD) of the grades database (Figure 3.9) and showed only the needed attributes in fulfilling this research. This database is just a simulation of the grade database in the Management Information System since the developed system is in its partial implementation.

The grading database has three (3) entities that include subject, schedule, and enrollment. Each entity has several attributes.

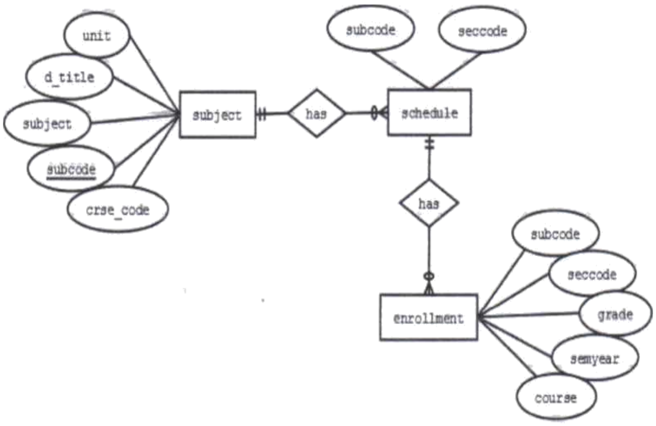


Fig.9. Grade Database ERD

For subject entity, there are four (4) attributes that define a subject wherein the subcode (subject code) is the primary key. The other attributes include subject, d title (descriptive title) and unit. For schedule entity, there are two (2) attributes that define a schedule wherein subcode (subject code) and seccode (section code). For enrollment entity, there are four (4) attributes that define an enrollment. The attributes are subcode (subject code), seccode (section code), grade and semyear (semester & year).

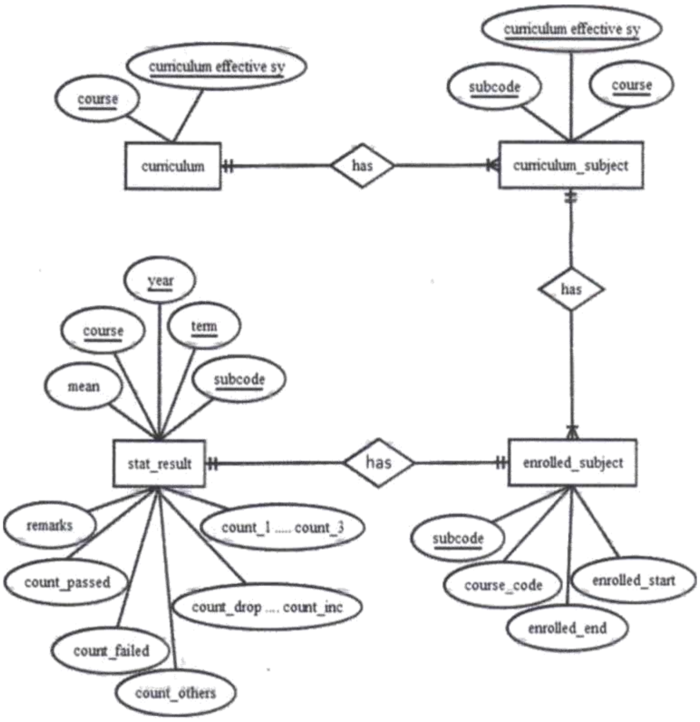


Fig.10. Visualization Database ERD

The researchers created another database called "Visualization Database" (Figure 10). All the data that were being handled and processed in the system were saved in the Visualization Database since the system does not have the permission to make changes in the grade database. The Entity Relationship Diagram of Visualization

Database has four (4) entities which include curriculum, curriculumsubject, enrolled subject and curriculum. Every entity in the figure has several attributes. Each entity has primary key which uniquely identifies each occurrence of an entity.

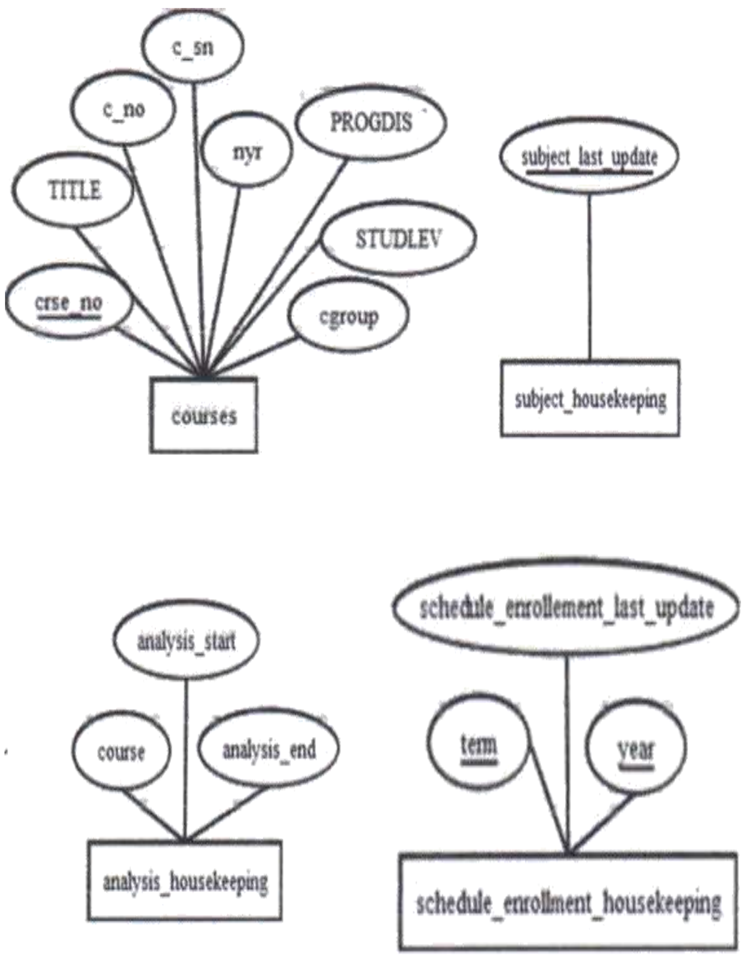
For curriculum entity, there are two (2) attributes that define an instance of a curriculum offered in which course and curriculumeffectivesy (curriculum effective school year) are the composite primary key.

For curriculum subject entity, there are three (3) attributes that define an instance of the entity. The three (3) attributes are composite primary key which includes subcode (subject code), curriculum effective sy (curriculum effective school year) and course.

For enrolledsubject entity, there are four (4) attributes. The primary key is subcode (subject code). The other attributes are subject, course code (course code), enrolled start, and enrolled end.

For stat_result entity, there are nine (11) entities that define a statistical result. The composite primary keys are subcode (subject code), term, year, course. The remaining attributes are mean, remarks, count_passed, count failed, count others, count l... count 3, and count drop... count inc.

The researchers created another database called “Housekeeping Database”. The entities in this database do not have any connection with each other. It was created for organization and management purposes. Through this database, data manipulation becomes easy.



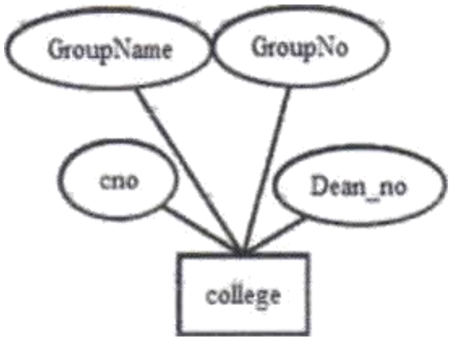


Fig.11. Housekeeping Database ER Diagram

- For the courses entity, there are seven (7) attributes. The primary key is the crse no (course number). The other attributes are TITLE, c_no, c sn, nyr, PROGDIS, STUDLEV, and cgroup.
- For the college entity, there are four (4) attributes which includes cno, Group Name, GroupNo, and Deanno.
- For analysis housekeeping, there are three (3) attributes which includes course, analysis start, and analysis end.
- For subject housekeeping, there is only one (1) attribute, that is, subj ectlastupdate.
- For schedule enrolment housekeeping, there are three (3) attributes. The composite primary keys are term and year. The remaining attribute is the scheduleenrollmentlastupdate.

Table 1 presents the different data visualization tools used in representing data.

Table 1. Data Visualization Tools

Data Visualization Tools	**Category**	**Platform**
Data Wrangler	Data cleaning	Browser
OpenRefine	Data cleaning	Browser
R Project	Statistical analysis	Linux, Mac OS X, Unix, Windows
Google Fusion Tables	Visualization app/service	Browser
Impere	Visualization app/service	Browser

Many eyes	Visualization app/service	Browser
Tableau Public	Visualization app/service	Windows
VIDI	Visualization app/service	Browser
Zoho Reports	Visualization app/service	Browser
Data Visualization Tools	Category	Platform
Choosel	Framework	Chrome, Firefox, Safari
Exhibit	Library	Code editor and browser
Google Chart Tools	Library and visualization app/service	Code editor and browser
JavaScript InfoVis Toolkit	Library	Code editor and browser
D3	Library	Code editor and browser
Chart.js	Library and visualization app/service	Windows, code editor and browser

Among the different data visualization tools presented, Chart.js was used in the study. It creates responsive, flat designs and is quickly becoming one of the most popular open-source charting libraries.

4. Results and Discussion

This section presents the sample chart on the visualization of the specific subject. Figure 12 shows the performance of the students in every term. The different semester has a different color to have a clearer view with each of the semester. The number above every semester corresponds to their mean with the

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corresponding grade interpretation where P stands for Poor, F for Fair, S for Satisfactory, and VS for Very Satisfactory. The closer the columns to the x-axis are, the better the performance of the students are. There is also a thread line in the chart that shows the average of the subject for every school year.

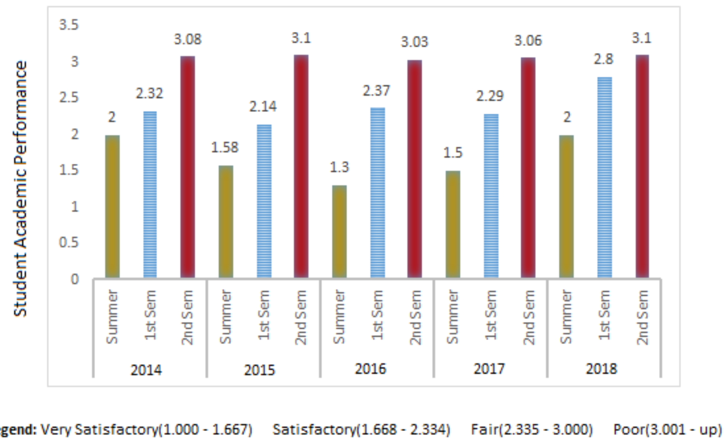

Fig.12. Sample Visualization of Student Academic Performance

Figure 13 is a sample pie chart that shows the ratio of the students who passed or failed the subject for five (5) years. Green is for passed, red for failed, and gray for non-numeric grades. This chart also shows the total number of students enrolled in the specified subject, the number of students who passed the subject, the number of students who failed the subjects, and the number of students who got a non-numeric grade.

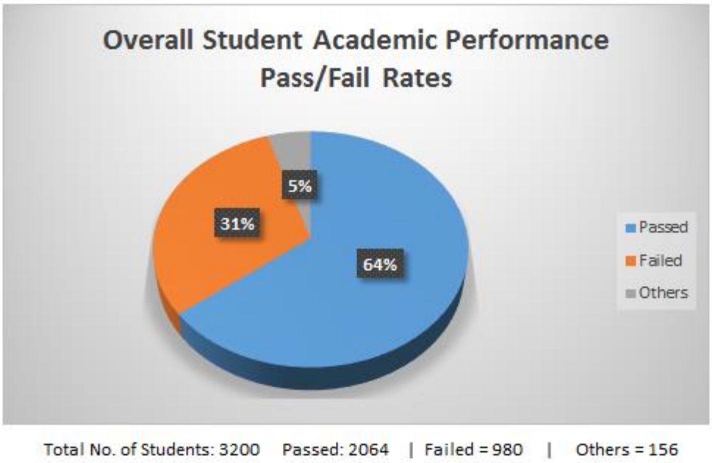

Fig.13. Overall Student Academic Performance Pass/Fail Rates

5. Conclusion and Recommendations

The data visualization on student academic performance was accomplished through a process called the system life cycle, specifically through Sashimi Model. Algorithms are created to develop several designs like data flow diagrams, entity-relationship diagrams, and architectural design, supported by some existing and related studies about the visualization of data. It is very beneficial to the college deans/heads and program heads in visualizing students' academic performance that may serve as the basis for decisions. The researchers recommend adapting the student academic performance visualization system for Misamis

University to visualize student performance. A future enhancement like the addition of grade visualization by curriculum will be added.

Declarations

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Competing Interests Statement

The authors declare no competing financial, professional and personal interests.

Consent to participate

Not Applicable

Consent for publication

We declare that we consented for the publication of this research work.

Availability of data and material

Authors are willing to share data and material according to the relevant needs.

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