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Designing and Developing of Education Class Grouping Applications Base on Genetic Algorithms

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ABSTRACT

The student learning class grouping application is a crucial service within the academic lecture system to facilitate learning and make it easier for educators to choose strategies and teaching methods to optimize academic achievement. In this grouping application, a genetic algorithm is implemented to optimize the distribution of learning classes, adopting the concept of biological evolution where the initial population of learning groups is considered as "individuals" with information about different grouping criteria. Through the process of selection, crossover, and mutation, these individuals undergo evolution from generation to generation, where those with the highest fitness value (according to the specified criteria) are passed on to the next generation, while those with lower fitness values may be eliminated. This evolutionary process continues until an optimal learning group is obtained, with a combination of suitable and best criteria to achieve the desired intra-heterogeneous and inter-homogeneous characteristics in learning.

1. INTRODUCTION

The application for grouping study classes is one of the important services in the lecture academic system [1][2][3]. At this time there is no academic system that provides services for the formation of student study class groups [4][5][6], especially the electronics department of Padang State University has not yet provided services for forming student study group groups. At this time, grouping of study classes is only done based on entry and the study group will not change until the end of the lecture (homogeneous group) as a result, the lecture objectives have not been achieved [7][8][9].

Formation of study groups for routine activities in the world of education. Class grouping is very important to facilitate learning [10][11][12][13][14][15], facilitate teachers in choosing learning strategies and methods[16][17]and optimizing academic achievement [18][19]. Grouping is usually done by considering the assumption that students will develop optimally if they are given an environment with the same academic ability [20][21][22][23]. This is reinforced by another assumption that students with high potential will compete with each other [24]. This competition is positive to stimulate achievement [25]. Likewise students with low academic ability will develop according to their potential [26]. Another consideration is the right of every student to get the best service at school [27]. Grouping is a way to provide the best service for students.

In developing this learning class grouping application using data mining with genetic algorithm optimization methods that will be applied to website-based applications. Golberg, DH, 1989 stated that to arrange study groups, genetic algorithms were used as a solution seeker [28][29][30]. Some things that need to be considered are the chromosome coding used, the selection method used, the crossover and mutation methods used, evaluation, and so on [31]. Determined student profiles are utilized to categorize student learning classes, and these profiles serve as criterion for creating learning classes [32]. The profile is in the form of entry point, gender, religion, academic setting, where they are from, language value, Science, Social Studies, mathematics, GPA, and parents' financial ability [32][33]. By optimizing the genetic algorithm, the resulting study groups form intra-heterogeneity and inter-homogeneous study groups [34].

2. METHOD

The data used is from students of the Electronics Engineering Department, studying in the Electronics Engineering Education program at the Faculty of Engineering, Universitas Negeri Padang.

This research applies the Waterfall method in application development. The Waterfall method is a traditional approach that adopts sequential stages in software development, following a linear (sequential) flow from analysis to delivery. In the context of this application development, the stages are explained as follows:

Figure 1. Waterfall proccess

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2.1. Analysis

2.1.1. System Analysis

2.1.1.1. Running System

Current system analysis is an analysis that describes the work system that is being implemented for Informatics Education Student Learning Class Grouping in the Department of Electronic Engineering as follows:

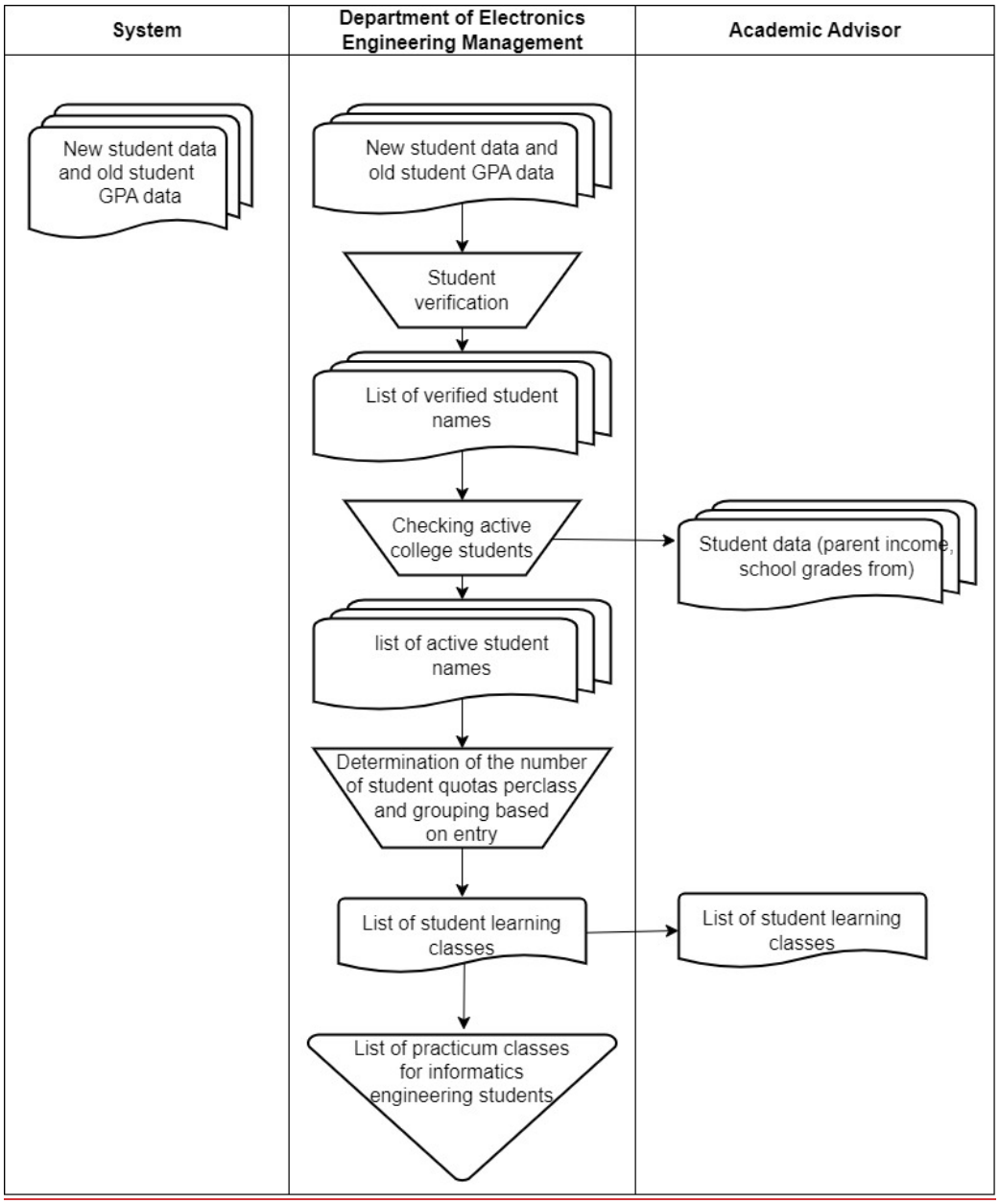

Figure 2. Running System Flowmap

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2.1.1.2. Proposed System

The proposed system analysis is a research technique on an ongoing system by describing the components of the system with the aim of designing a new system or updating an existing system. The following flowmap analysis is proposed in this system:

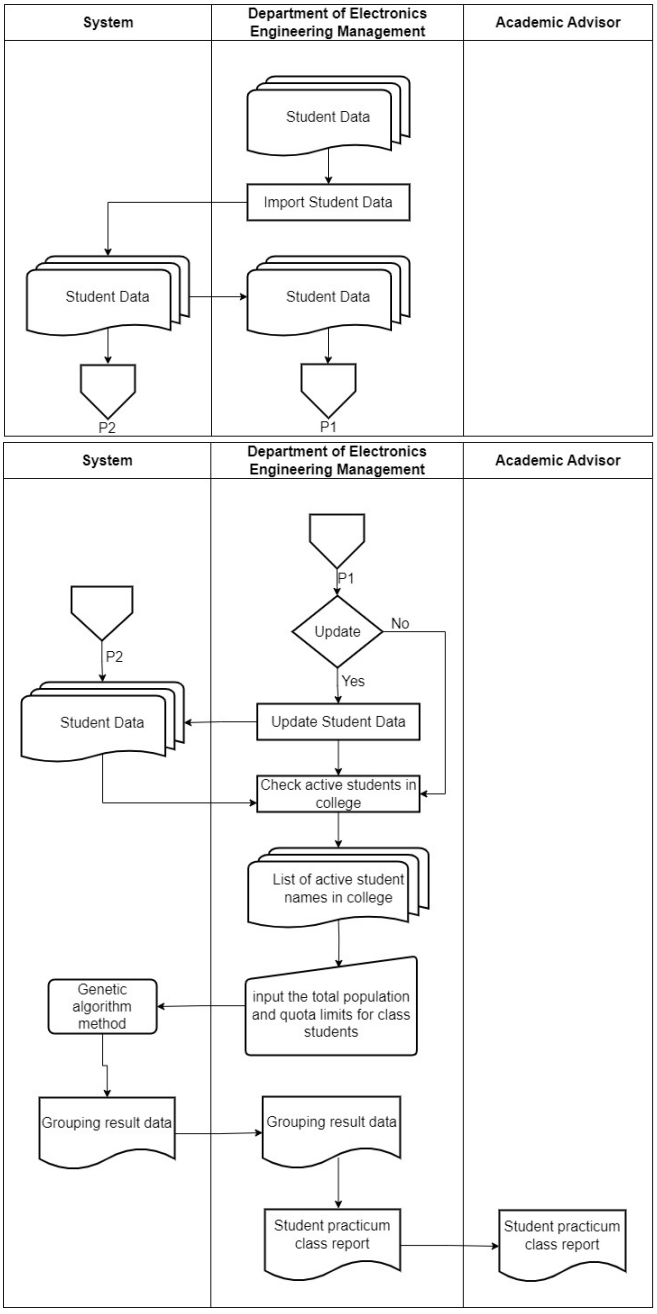

Figure 3. Prpoposed System Flowmap

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2.1.1.3. Requirements Analysis

Functional Requirements Functional requirements analysis describes the process or any service performed by the system. System expected to provide services:

Table 1. Functional Requirements

No	Service Type	Information
1.	Login Service	Used by the user to log into the system for data security.
2.	Update Service	Used by electronics department management to update data.
3.	Logout Service	Used by the user to exit the system.
4.	Service	Used to carry out the Grouping process of grouping students using the genetic algorithm method.
5.	Report Print Service	Used by the user for making reports from the results of grouping new student learning classes.
6.	Genetic Analysis Service	Used to display the results of data processing during the Genetic Algorithm process.

Non-functional requirements are any features that must be in the system. This requirement too needed to know the specification requirements for system. Requirements specification involves analysis hardware/hardware analysis software/software, user analysis.

Table 2. Non-Functional Requirements

No	Requirement Type	Information
1.	Login Module	This module functions to provide login information carried out by user
2.	Data Storage Module	This module functions to manage and store data related to student biodata, values and family data.
3.	Module Import File .xlx	This module functions to import files in .xlx or .csv format which contain student data into the system.
4.	Export File .pdf	This module functions to export file student data files resulting form the grouping process form the application.
5.	Genetic Algorithm Module	This module functions to perform grouping by applying the genetic algorithm method.
6.	Display Module	This module contains views that can be accessed in the system.

2.2. Design

2.2.1. System Planning

2.2.1.1. Context Diagrams

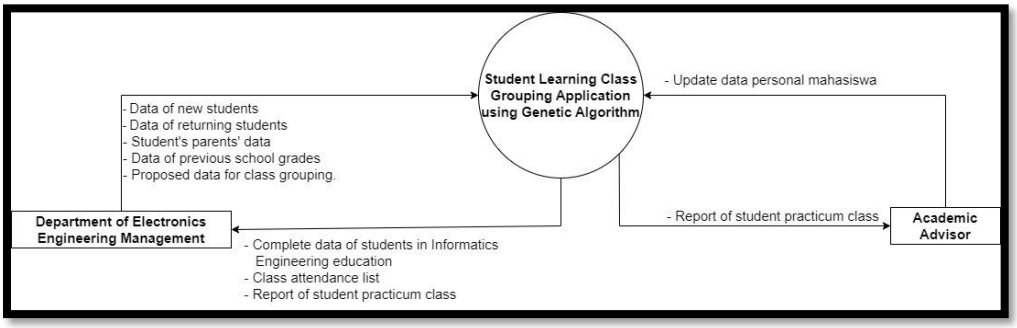

Figure 4. Context Diagrams

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The context diagram in the aforementioned image describes the user's input and output to the system. Users include teachers, academic counselors, and the administration of electronics departments. Student data is first retrieved from the academic system service by Department Management Electronics, then imported by the Management Department. Students then update information about their initial school grades and their parents' bios for new students. Finally, class reports for student practicum studies that can be viewed by department management, PA lecturers, and students are produced using the full student data. These reports are processed as proposal data and used in the genetic algorithm method of grouping.

2.2.1.2. Use Case Diagrams

Use case diagram is a diagram that describes the relationship between actors and the system. The following is the use case diagram design for this system:

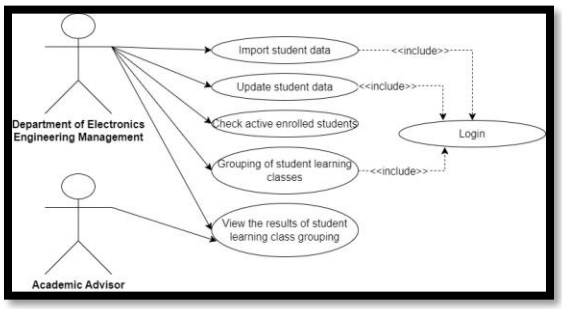

Figure 5. Context Diagrams

2.2.1.3. Genetic Algorithm Design

The following is an overview of the genetic algorithm using a flowchart:

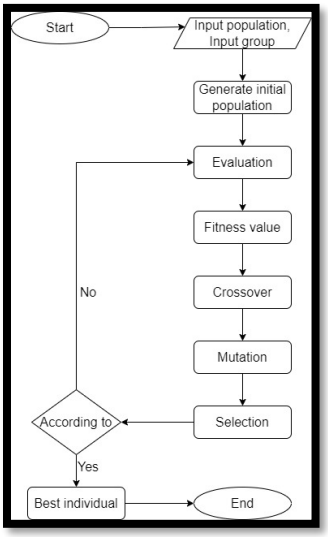

Figure 6. Genetic Algorithm Flowchart

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Figure 6 providing a visual representation of how the algorithm progresses through generations, evaluating fitness, performing crossover and mutation, and iteratively improving the solutions to reach an optimal outcome.

2.2.1.4. Database

The database design used in this study employs a MySQL database consisting of six tables: the Table of Origin, School of Origin, Income Path, Parental Income, Student Information, and Grouping Results. Figure 7 illustrates the database schema, providing a clear visual representation of the relationships and attributes within each table, facilitating efficient data organization and retrieval for the research study.

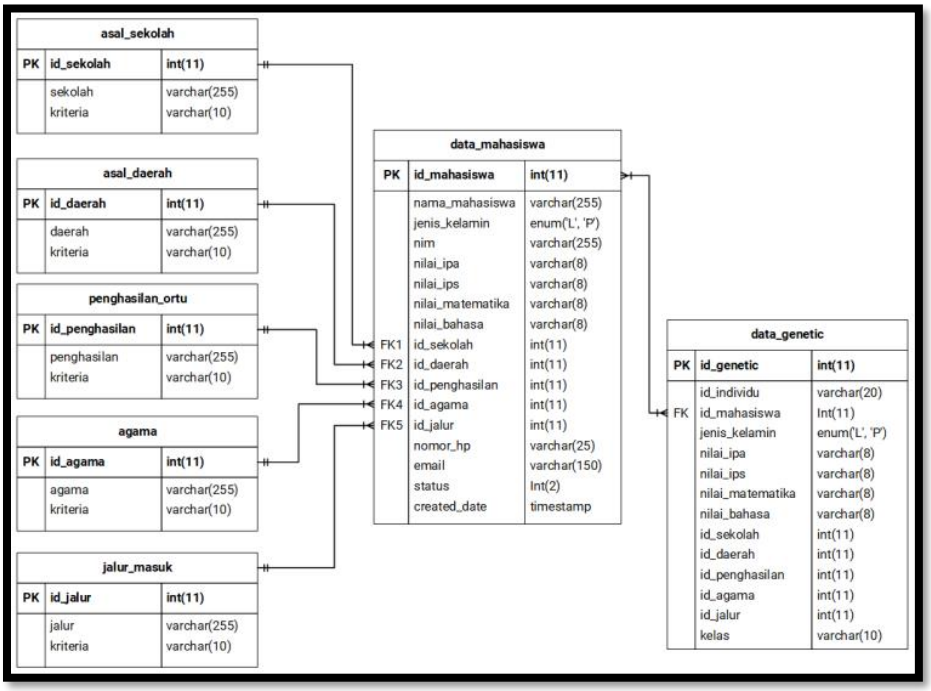

Figure 7. Database

3. RESULTS AND DISCUSSION

3.1. Login Screen

When department administration and lecturers attempt to access the student learning class grouping program, the login screen will be the first page to appear.

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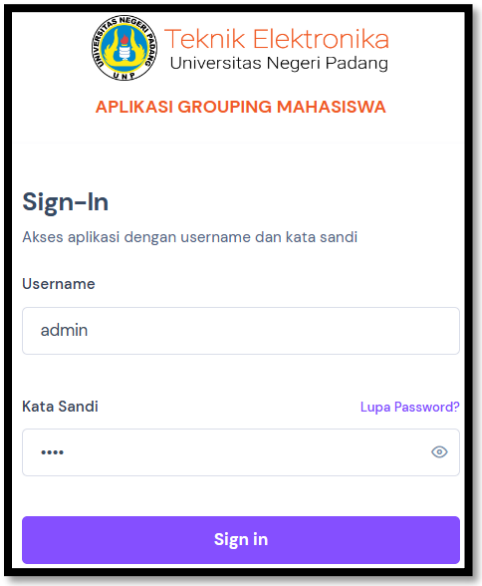

Figure 8. Login Page

3.2. Management of the Department of Electronics Engineering

3.2.1. Dashboard Page

After the electronics department management logs into the app, this page will be displayed. This page contains student statistical data.

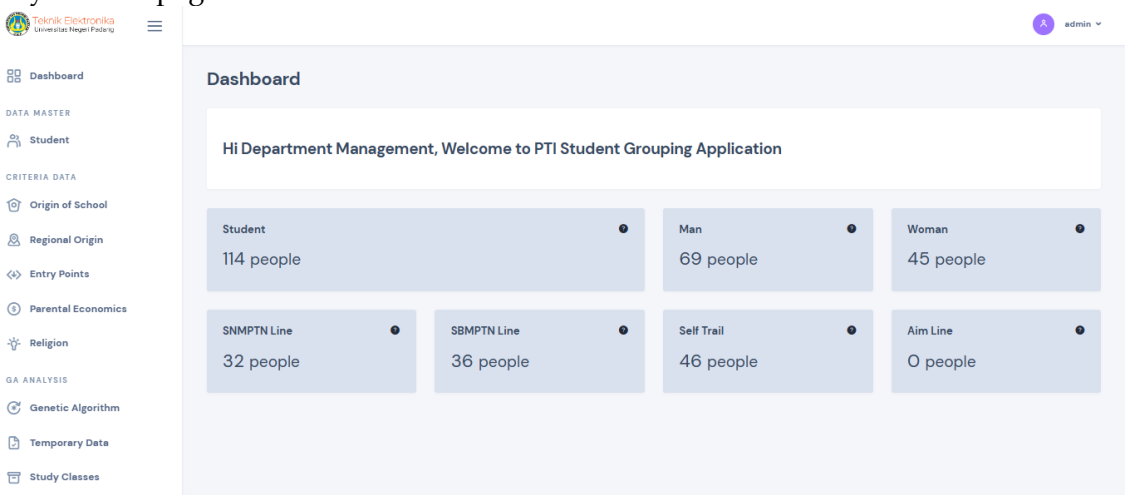

Figure 9. Dashboard Page

3.2.2. Student Data Page

The Student Data page displays student data that has been entered by the Department's Management. On this page, there are 3 buttons, namely the add data button, import data, and reset student data. Each button has a different function. Add data button

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to display a modal containing the form for adding data, Import data button to display a modal containing the .csv or .xlxs file upload form.

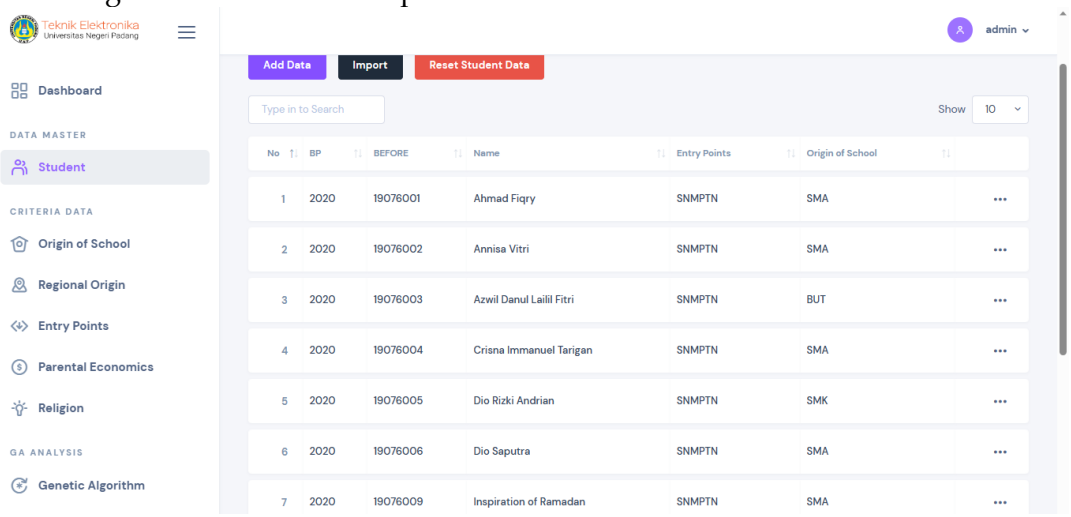

Figure 10. Student Data Page

3.2.3. School Origin Data Page

The school a data page is one that shows the school origin criteria data which will be used as criterion data in the grouping process using the genetic algorithm used by the department management admin.

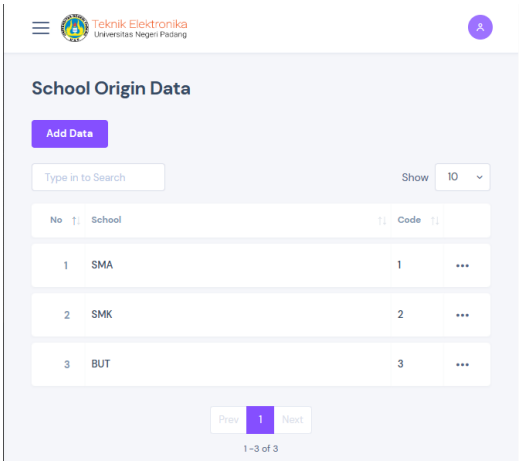

Figure 2. School Origin Data Page

3.2.4. Student Data Update Page

If necessary, the student information update page is where the most recent student data is updated.

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Figure 3. Student Data Updatae Page

3.2.5. Regional Origin Data Page

This page shows regional origin criteria information which will be used as criterion data in the grouping process using the genetic algorithm used by the admin manager of the department.

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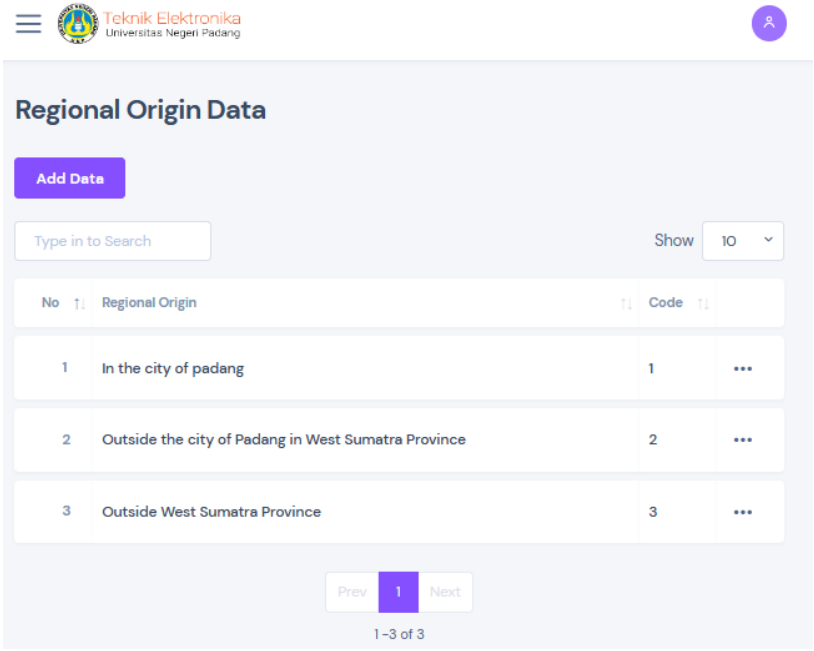

Figure 4. Regional Origin Data Page

3.2.6. Form Import Page

The import.xlx form page is the page used to import student files in the .xlx format.

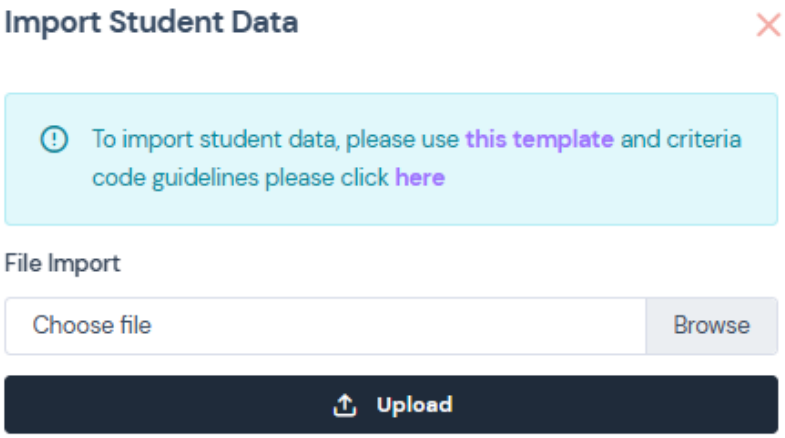

Figure 5. Form Import Page

3.2.7. Entry Path Data Page

This page shows information on entry criteria that will be used as criterion data in the grouping process using the genetic algorithm used by the department management admin. For more detailed information, show Figure 15.

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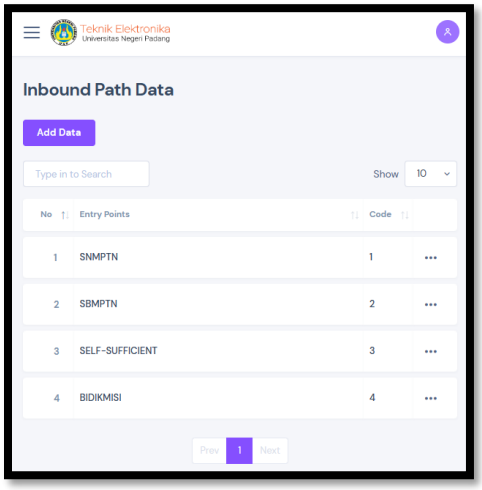

Figure 6. Entry Path Data Page

3.2.8. Parents Economic Data Page

This page provides information related to parents' economic data which will be used as criterion data in the grouping process using the genetic algorithm used by the admin managing the department. For more detailed information, show Figure 16.

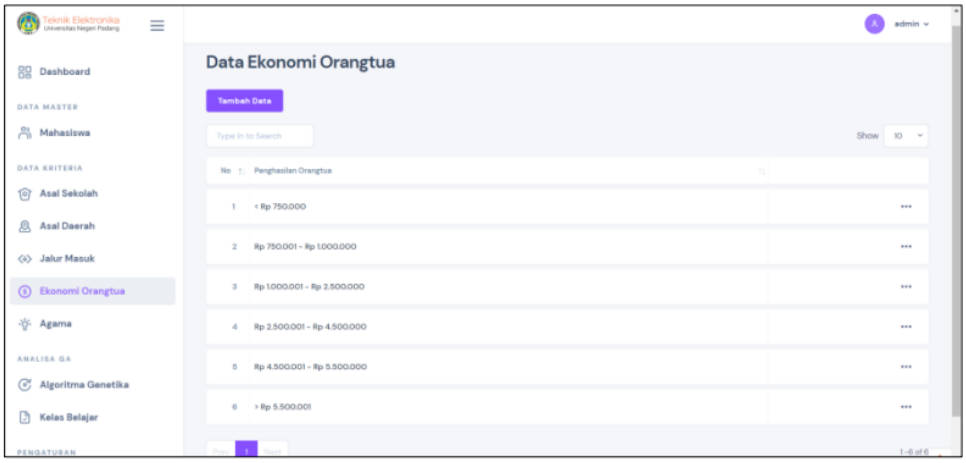

Figure 7. Parents Economic Data Page

3.2.9. Religion Data Page

This page shows religious criteria informasi that will be used as criterion data in the grouping process using the genetic algorithm used by the department management admin. For more detailed information, show Figure 17.

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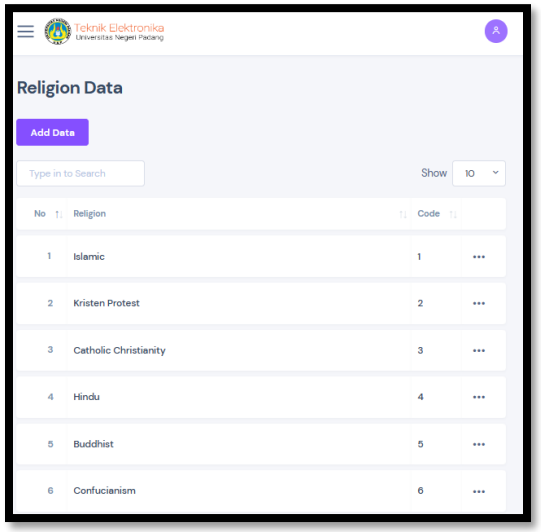

Figure 8. Religion Data Page

3.2.10. Genetic Analysis Page

This page displays a form for determining the number of population and number of classes which are useful as a reference in the genetic algorithm process. For more detailed information, show Figure 18.

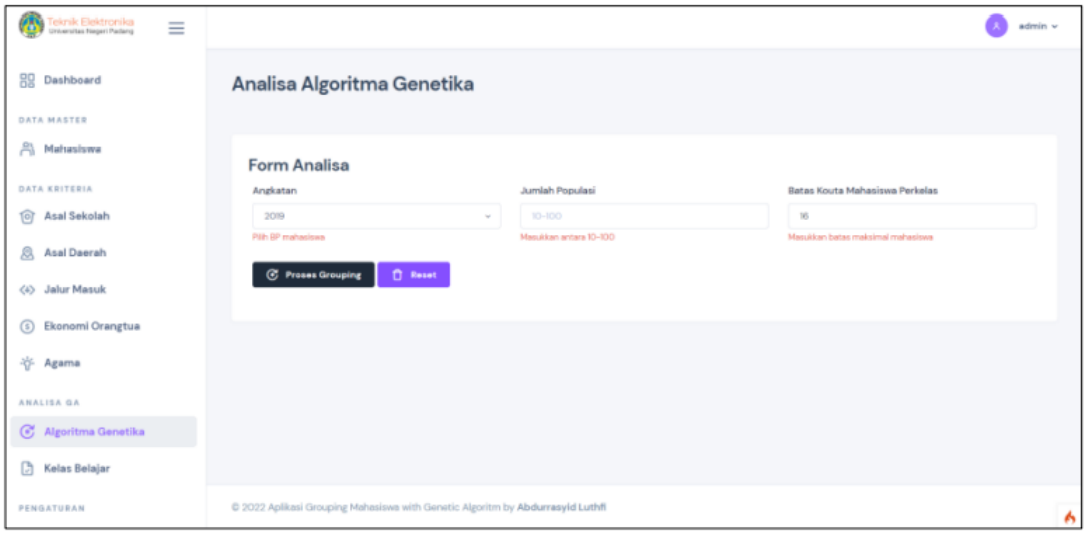

Figure 9. Genetic Analysis Page

3.2.11. Genetic Algorithm Analysis Process Page

The genetic algorithm analysis process page is a page that shows the outcomes of the the genetic algorithm analysis.

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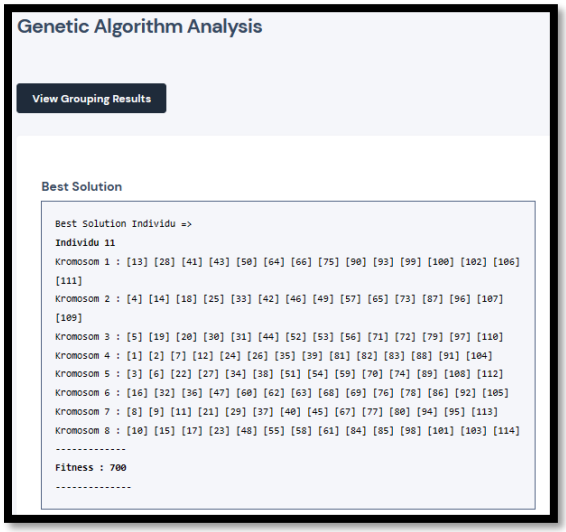

Figure 10. Genetic Algorithm Analysis Process Page

Based on Figure 19, the genetic algorithm displays the best solution data and the process log data. The best solution data contains information about the best individual obtained from the genetic algorithm process, with a fitness value of 700 and located in individual 11. Each individual corresponds to a solution and chromosome, for example, chromosome 1, 2, 3, and so on correspond to learning groups 1, 2, 3, and so on. This results in the creation of eight chromosomes, each consisting of 15-16 genes, and consequently, there are eight class grouping clusters, each containing 15 to 16 students. The best solution data has achieved a good level of inter-homogeneity within these class groups. The process log data includes the entire genetic algorithm stages, starting from the initial population, then crossover, mutation, and finally selection. Below are the graphs and tables showing the results of student class grouping.

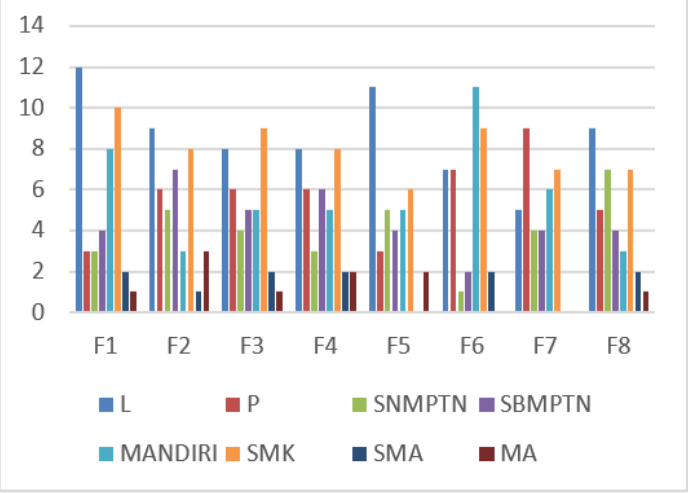

Figure 11. Graph Result Grouping Genetic's Algorithm

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Table 3. Grouping Distribution K-means Clustering

Class Code	total students	Male (L)	Female (F)	SNMPTN	SBMPTN	INDEPENDENT	SMA	SMK	MA
F1	15	12	3	3	4	8	3	10	2
F2	15	9	6	5	7	3	6	8	1
F3	14	8	6	4	5	5	3	9	2
F4	14	8	6	3	6	5	4	8	2
F5	14	11	3	5	4	5	8	6	0
F6	14	7	7	1	2	11	3	9	2
F7	14	5	9	4	4	6	7	7	0
F8	14	9	5	7	4	3	5	7	2

Based on the aforementioned Table 3, the application for creating study groups for Informatics Education Study Program students in the Department of Electronic Engineering, FT - UNP, has successfully achieved the desired grouping objectives. The genetic algorithm utilized by the application has effectively balanced heterogeneity within each study group, ensuring that members possess diverse characteristics and backgrounds. At the same time, it has promoted homogeneity between study groups, creating a cohesive and harmonious learning environment for each group. This approach in organizing student study groups not only enhances academic collaboration and interaction but also fosters an inclusive atmosphere that accommodates individual differences and maximizes learning potential. Overall, the application's implementation of the genetic algorithm has proven to be instrumental in optimizing the class grouping process and facilitating a more productive and engaging learning experience for all Informatics Education students at the Department of Electronic Engineering, FT - UNP.

3.2.12. Student Study Class Report Page

This page is a page to display reports on the results of the student grouping process. On this page, the user can print the results of student grouping reports.

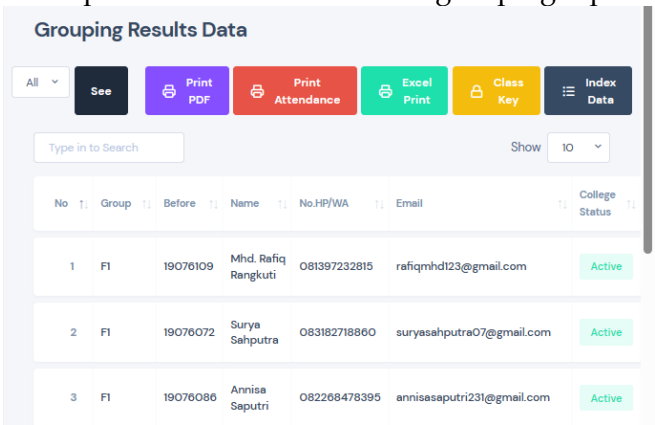

Figure 12. Academic Advisor Student Study Class Report Page

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3.3. Academic Advisor

3.3.1. Student learning class report page

This page is a page to display reports on the results of the student grouping process. On this page, the user can print the results of student grouping reports. For more detailed information, show Figure 22.

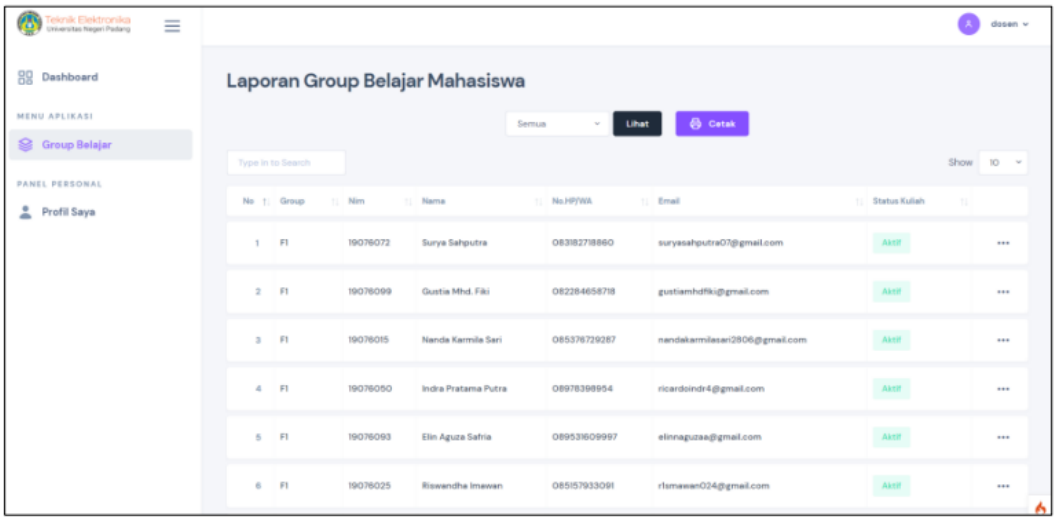

Figure 13. Academic Advisor

4. CONCLUSION

The results of class grouping using the genetic algorithm show that this application successfully creates diverse and homogeneous study groups. In the genetic algorithm process, students are represented as genes, initially initialized with relevant variable values. Subsequently, chromosomes are used to encode class or group codes, and the population represents the number of student classes. Through a series of experiments, we managed to form eight student study groups, each comprising around 15 students, while considering balanced grouping criteria. The evolution process of the genetic algorithm enables this application to achieve the best solutions by optimizing various criteria. Efficient grouping based on the diverse characteristics of students is expected to enhance the learning experience and support better academic achievement for students. The positive results obtained from using this genetic algorithm highlight the potential of this application as a means to organize optimal study groups that cater to the needs and potentials of individual students.

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