Available online at www.qu.edu.iq/journalcm
JOURNAL OF AL-QADISIYAH FOR COMPUTER SCIENCE AND MATHEMATICS
ISSN:2521-3504(online) ISSN:2074-0204(print)

Optimum Allocation of Graduation Projects: Survey and Proposed Solution

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ARTICLE INFO

Article history:
Received: 01 /02/2021
Rrevised form: 17 /02/2021
Accepted : 08 /03/2021
Available online: 13 /03/2021

Keywords:

student-project allocation survey, traditional allocation problems, Optimum approach for project allocation.

ABSTRACT

The final year project is an important part of obtaining a Graduation certificate in scientific and engineering universities. To ensure high quality in the completion of graduation projects, the project allocation process must be efficient and fair among students. Optimum allocation of graduation projects ensures a great experience for students and exceptional learning of new technologies from that projects, which may contribute to expanding students' future horizons. In this work, we review a wide range of research for the allocation project strategies that are used in various universities, in addition to the factors that have an effective impact on the selection of graduation projects by students. We also highlight the problems that these strategies tried to solve, in addition to those that they failed to solve. Finally, we present a modern idea to overcome too many problems that were presented in the literature discussion where the proposed system is based mainly on the student development level during the study stage.

MSC. 41A25; 41A35; 41A36.

DOI: : https://doi.org/10.29304/jqcm.2021.13.1.774

1. Introduction

The graduation project is considered an important part of all scientific universities to obtain a bachelor's degree. The lecturer usually suggestion a set of projects and in turn, students choose a list of preferences from the projects they prefer to work on.

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Communicated by : Dr.Rana Jumaa Surayh aljanabi.

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Several factors affect students 'choice of projects, including the popularity of the supervisor, Personal relationship with a specific supervisor, the academic position of the research supervisor, and other factors [1]. In some universities, lecturers have preferences over students in addition to their preferences for the titles of the projects they propose as these preferences are included in the final allocation of projects. In some universities, they may not be any Preferences for lecturers, whether on students or projects. There may also be restrictions on the capacity to limit the maximum number of students who can be assigned to each project and lectures where the allocation problem subject to these restrictions is called the student project allocation problem [2]. Due to the large numbers of students in some universities, It is time-intensive and error-prone to calculate an optimum allocation of students to projects manually, some of those universities tend to use central systems that automate the process of allocating students to projects by employing some algorithms that depend on effective matching technique, examples of those systems are the automated systems that used in the department of computer science At the University of Southampton [3][4] and the University of York [5][6].

In the literature, there are many strategies for solving the student project allocation problem, where each strategy focuses on addressing this problem from a specific perspective view with the presence of certain assumptions to solve that problem. Strategies, algorithms, specific assumptions, results, and problems faced by those studies are discussed in this paper.
The rest of this paper is organized as follows. Section 2 describes the literature review where several references from reputed journals and Databases are used like: IEEE, Science Direct, Web of Science (WOS), and google scholar, Section three discuss the main problem and the motivation over previous work. The proposed solution and related methodology are presented in section four, while the final section describes the conclusion.

2. Literature review

in 2003, A. A. Anwar et al [3] is one of the first researchers that concentrate on the project allocation problem by suggesting two integer programming models(individual project model and group project model). The proposed models subject to some constraints: Every student must be assigned one and only one project, the project can be assigned to a maximum of one student and, for every student, and the project assigned to a student can only be from the subset of projects selected by the student. The first model contains two sub-models that applied for 39 students and 20 staff members in the Department of Civil and Environmental Engineering, University of Southampton. The result of the sub-first model shows that (44% of the students get the first choice, 26% of students get the second choice, 15% of students get the third choice, and 15% get the fourth choice). Only one supervisor doesn't get any students to supervise. While the result of the second sub-model (49% of students get the first choice, 26% of students get the second choice, 10% of students get the third choice and 15% get the fourth choice). Only two supervisors don't get any students to supervise. The second model applied for 66 students and 40 staff members that suggest a 30 project. The result shows that 68% of students get the first choice, 22% of students get the second choice, and 10% get their third choice. The main problem of the two models is that appropriate only for a college that has fewer number of students and some supervisor doesn't have any students to supervise.

Later P. R. Harper et al [4] in 2005, suggest using Intelligence genetic algorithms as a solution to the problem of student-project allocation. These models only take the preferences of students into account but do not take into account the preferences of staff with consideration to the workload of supervisors, number of projects, and number of students. Furthermore, they could only optimize an individual objective function that rejects decision-makers from trade-off through the preference of the students and the supervisor's preferences. The proposed GA provides a various number of goods and feasible solutions to be chosen from, but the main drawback after tested with the real data as it requires multiple iterations and constant change in the mutation factor to reach the fittest solution, in the experiment result in the best fitness require 49,000 iterations to obtain. The use of the genetic algorithm is a good

attempt to solve the problem of allocating projects, but on the other hand, the authors didn't solve several issues such as random allocation and allocation of one project to more than one student and don't take into account the grade point average (GPA) preference factor to choose students for the allocation process.
D. J. Abraham et al[7] In 2007, concentrate on addressing the problem of FYP allocation from a student-oriented or supervisor oriented. The authors present two linear algorithms: One from the viewpoint of the preferences of the lecturers, and the other from the viewpoint of the preferences of the students. The use of these algorithms would guarantee an optimum solution, they either providing the students with the optimum solution or providing the supervisors with the optimal solution, without allowing decision-makers a chance to trade-off. Also, the algorithms do not take supervisors' workload into account, as well as the probability of generating inconsistent solutions. Often, it should be taken into account that Supervisors specifically rank students who would not be feasible if the students are not known by the supervisors, or for the students that have the lower grade point averages GPA, it may be unreasonable, since many will end up in the last positions in supervisor ranking preference list. Many fitness functions are determined for the genetic algorithm, so the results have been compared with an ideal integer programming solution. Fitness values that are provided by the genetic algorithm ranged from 85% to 93% of the ideal solution.

D. F. Manlove et al [2] in 2008, proposed that the students and supervisors have preferences over a set of projects with some constraints like a capacity limit over the projects and supervisors. The purpose of the capacity constraints is to overcome the supervisor's workload problem and to make the project implementation consistency with an appropriate number of students. The researchers show, under these conditions, that there can be different cardinalities in stable matches, and thus the aim is to find the stable matching with the highest cardinality. The authors showed that the process of reaching an optimum stable matching is NP-hard, but they supply a guaranteed performance by using approximation algorithm with student-oriented (i.e. ensuring just 1\2 of the maximum stable matching cardinality) and polynomial complexity. **in 2012 K.Iwama el tl [8]** upgrading an approximation algorithm of the previous work where the performance ratio has been optimized. where the ranges of the performance warranty from 1.11 to 1.50, To optimize the allocation**, in 2018 F. Cooper et al [9]** upgrading the approximation algorithm by present the 3/2-approximation algorithm with a linear-time for maximum satisfaction of student project allocation and an Integer Programming technique that optimally addresses max allocation, which is a nontrivial Kiraily's Extension The HRT algorithm, their focuses on representing a procedure that reaches a stable linear-time solution. The authors compare the approximation algorithm using randomly generated data experimentally with the IP model and find that The performance of the approximation algorithm easily surpassed the 3/2 bound, producing a consistent matching in all cases within 92 percent of ideal, with the percentage for several situations being much higher. The primary objective of their algorithm is to minimize the time needed to find the solution rather than finding the optimal solution. In other situations, it is much more important to find the optimal stable match than the execution time, yielding this algorithm unsuitable in the same situation.

L. Pan et al [10] In 2010, use goal programming (GP) to tackle the student-project allocation as a multi-objective hierarchical matter. The list of preferences over the projects that are available is provided by the students and the supervisors. The objective of this study has been to assign the maximum number of acceptable projects to higher grade point average (GPA) students. The outcome of (GP) consists of both the manual solution presented by the coordinators of college departments and the greedy algorithm. In the goal programming, it was noted that all students are assigned their first or second preference choices with a round of 87% of the first choices allocated to the students. The student preferences were better met, although the average GPA of the students who were assigned projects using GP was slightly lower than those of the greedy algorithm and the manual solution offered by the department. The main problem of the proposed work is that they did not provide an effective solution to the problem of allocating projects where each student must create a list of preferences for all the presented projects to specify a project for that student. That the presented solution is appropriate only from the presented case (when having more than a hundred student and projects, the proposed solution would be illogical)

M. M. El-Sherbiny et al [11] In 2012 , present an artificial immune algorithm to overcome the problem of allocation. The authors design the problem where there are several students and a set of projects, and Students have preferences in choosing which projects they will undertake. Students must be paired with one project in this work, and a project should be matched at most once. The authors analyze the output of various mutation operators on the Problem, although they concentrate on swapping projects amongst students based on various factors, such as time. As would be seen, both moving operations (Give the student to another supervisor) and exchanging operations (students among supervisors) are taken into account by the proposed mutation operator without breaking each supervisor's workload constraints. as compared with the genetic algorithm (GA)[4], the AIASPAP overcome many issues that are presented in the GA like the number of projects that are allocated to more than one student, random allocation problem that is not including in the student preference list, besides, find solutions with more quality by the AIASPS, but in the running time, the GA is outperformed to the AIASPAP that are represent the main drawback of this model.

A. Kwanashie et al [12] In 2015, concentrate on fixing the problems of Final years project allocation in which only the preferences of students are presented, but only the higher and lower quotas for supervision are considered for Supervisors. In this work, Effective algorithms are proposed that aim to provide optimum solutions in a single-sided optimization situation (i.e. student preferences). To do that, they suggested algorithms that ensure that greedy maximum matches or maximum matches are found. The proposed algorithm has two goals: The first is to find the greatest match in terms of the number of assigned students and maximizing the number of first and most preferred choices assigned to students. The second goal is to reduce the number of students given their least-preferred options with the greatest match. This research does not support lecturers' preferences and therefore enhances a single side objective requirement. Matches founded do not fundamentally ensure that all students are matched with supervisors\project.

H. O. Salami et al [13] In 2016, proposed a to upgrade genetic algorithm that is used by **P. R. Harper**, in which students have their full preferences over the supervisors. In the proposed system, the author introduces the Students' Preference Matrix (M) with L lecturers and S students and using Workload Lecturer Vector (A) with length L that represents the number of Lecturers as a constraint to handle the supervisor's workload. By using a specific GA operator (crossover, selection, mutation) with a specific fitness function to produce an optimal and sub-optimal solution and by using fitness function to select the best solution. Three crossover operators may be used with the proposed genetic algorithm that is (one-point, two-point, and partially mapped crossovers) with three selection operators is (rank-based, roulette wheel, and binary tournament). A correction function was used to fix invalid offspring after one-point and two-point crossovers since offspring often had duplicate genes meaning that one student had multiple supervisors. The most advantage of the proposed GA it produces multiple allocations solutions that are either optimum or semi-optimum. However, it sometimes requires many iterations to reach the ideal solution.in other cases in each iteration, it reaches near-optimal solutions and never gets the optimal solution this is the main drawback in the proposed GA. the proposed GA was tested for project allocation in the computer science department (CPT) it reaches the optimum fitness value (50.00) after 0.48 seconds.

R. A. Knight et al [14] In 2016, Suggested a Project Allocation framework Relying on the "student-led" allocation system for students' proposals. Students design their projects in this framework and ask one lecturer to be their supervisor. Students directly contact supervisors, and it is up to the lecturer to accept to supervise or recommend the student to some other supervisors. H. Chang in 2005[15] discuss the same approach, where independent students need motivation and occasional encouragement rather than complete supervision for becoming autonomous and independent learners for students reaching the end of their degrees, It also reduces work pressure on the supervisors since most project aspects are complete by the student. The main disadvantage of the student-led model is that raises a variety of problems for the undergraduate community as a whole, where most undergraduate students face difficulties to select a research subject because undergraduate students seldom have in-depth knowledge of any specific field to determine a topic rationale. Another problem that this model generates is many students' attraction to the most popular supervisors and their avoidance to choose the less popular supervisor or those they do not know during the study course, this problem may affect the supervisor's workload problem. In the Academic-led model, the supervisors provide a list of projects that they willing to supervise, the students then provide a list of preferences over the projects, then the project allocation process is carryout. The main drawback of this model is a tradeoff between the student project preferences and the supervisor workload, where the student might be allocated any one of their preferences to solve the supervisor's workload and garnering that all supervisors have at least one student to supervise.

P. Plan et al [16] In 2016, Proposed an algorithm that offers two alternatives for students, where students may either select one project from the collection of project titles provided by lecturers or suggest their project idea. Furthermore, most colleges recommend that FYP be carried out in teams where the workload for supervisors can be greatly minimized and the allocation process much simpler. Yet, this approach is primarily implemented so that through their FYP, students can learn and improve leadership, communication, and teamwork skills. By implementing the team project approach, one of the essential problems of student project allocation can be solved as no allocation method can guarantee first preferred choice students when the number of students is substantially higher than the number of projects, it becomes normal for more than one student to be attracted to the same project.

R.Calvo-Serranoa et al [17] In 2017, suggest using the model of mixed-integer linear programming (MILP) that contains two sub-model to solve the problem of FYP allocation by Focusing on Two opposing goals: the level of student satisfaction and the level of academic satisfaction. Therefore, student contentment is maximized by two conditions: allocation to their preferred lecturer and their preferred project topic, which offers more flexibility to the model and thus eventually leads to better solutions. The satisfaction of the academics is maximized by applying the supervisor workload constraints where the number of students that are allocated for each supervisor is equal to or less to the supervisor's workload. the two-sub model was tested in the Chemical Engineering and Analytical Science of The University of Manchester where data used to contain 53 students and 29 academics offered 53 projects, the results of the first model(MILP M1) only 37 from 53 students are satisfied where the satisfaction score is (291). While in the other heuristic model (MILP M2) 47 from 53 students are satisfied where the satisfaction score is (324). Because the model focuses on the level of student satisfaction, the weight of a load of supervising the supervisors may be unfair, and that some supervisors do not have any students to supervise this is one of the problems of this model.

S.Modi et al [18] In 2018, proposed to use Gale Shapley Stable Marriage Algorithm to Allocation the project to the student depends on matching between two sets of preference lists (student preference over project list and supervisor preference over student list). This algorithm aims to provide a stable matching between two sets. The Problem of this algorithm arises when the supervisor or student provides an incomplete preference list when some supervisor or student don't choose any each other (the basic Gale Shapley Stable requires the two sets should be equal). The author presents the Extended Gale Shapley Stable Marriage Algorithm which doesn't require the two sets to be equal. The strength of this algorithm is in its ability to provide stability in matching an equal number of involved parties. The main problem in this algorithm arises when many students choose the same supervisors as their first choice, thus creating a workload problem for each supervisor. Also, the proposed algorithm didn't solve the popular projects problem and popular supervisor's problems that is the main cause of the overloading problem.

Victor Sanchez et al [19] In 2019, authors upgrade the genetic algorithm by adding a near Pareto multi-objective to solve the problem of the allocation of students to the supervisor. The author presents Pareto's optimal genetic scheme for allocation that aims to provide trade-off options for human decision-makers. The proposed algorithm presents novel operators for the mutation process that can provide either explore the design of the allocation process (i.e. Students that each lecturer supervises) or the allocation process itself. Furthermore, introduced two novel operators for the crossover operation particularly for the students-supervisors allocation: the Hopcroft Karp and the greedy structural preservation operators. The objective of the two operators is to maintain the structure of one of the parents. The Hopcroft Karp operator also maintains the material genetic of original parents while the greedy operators provide new genetic material, this is the main difference between the two operators. the proposed work was tested for real data collected from the Coventry University, which contain 150 students and 30 supervisors, the lower supervisory for each supervisor is set at least 1 student, the average optimality of the best solutions for the students ranges from 88 to 89% of the best fitness, while for the supervisors ranged from 93 to 94% for the best solutions. From outcome conclude that in a short period, even for large cases of problems, the proposed genetic algorithm can provide solutions that are very similar to the optimal solutions.

Also in 2019 S. Hussain et al [20] conducted a general study on the methods and strategies used to allocate the projects used in several previous researches studies. The authors concentrate on the project allocations in transnational education (TNE) contexts in the two largest TNE programs in Chinese universities with a focus on solving the most prominent challenges and difficulties that are faced. The first programme is based on the agreement between staff and student before project allocation that is known as offline methods that are used in the joint programme between Queen Mary University of London, U.K., and Beijing University of Posts & Telecommunications China. The second programme is based on the project Assignment through a matching algorithm that is known as an online method that is used in the joint programme between the University of Glasgow, U.K., and the University of Electronic Science and Technology of China, China. The authors discussed the important characteristics, strengths, and weaknesses of both programs, with a focus on the important factors that affect both programs in terms of student's size, Project Proposal Presentation, Project Themes, Supervisor's Profile, Industrial Projects/Community-Based Learning, and Staff Load Balancing.

Later in 2019, V. Paunovic et al [21] combined several techniques from the previous studies to solve the problem of project allocation: genetic algorithm, Integer programming, 3/2 approximation algorithm, and Mixed-integer linear programming. In addition to adopting the fuzzy approach (distance among student degrees) to generate many master lists (ranked student list based on GPA) that the allocation process depended on it with help of the Genetic algorithm as the main builder and tester. Matching is done between the student preference list (depending on the master list) and available project list using the greedy approach but sometimes using the extended preference list that represents the random projects (generated from the remaining projects that don't choose by any students). the algorithm generates many solutions depend on the number of master lists, and the evaluation process for the generated solutions is done by using fitness value were the best solution that has the highest fitness value.The proposed algorithm was tested with real data containing 519 students and 244 projects, the best allocation reached within 25,000 iterations, where 79% of students are allocated from their preference list while 21% are randomly allocated from the extended preference list. Reaching the best allocation required a lot of running time. The main problem of that work is random allocation. Furthermore, the proposed fuzzy distance may don't affect the population generates process when the student's GPA is closed.

P. Kenekayoro et al [22] In 2020 , discusses three different population-based technique for student project allocation, the first technique Gravitational Search Algorithm (GSA) which based on the two-newton law for gravity where the solutions are expressed as A particles with M value that represent the Mass measured by its fitness, and the gravitational standard G that reduced as the GSA continuous processes. The second technique is the ants' colony optimization algorithm where the SPA problem is represented as a diagram with virtual node .its representation as a weighted graph, with the edge weight determining the degree of pheromone mark on that path. The solution to the optimization problem is identified when an ant crosses the diagram successfully. The genetic algorithm with the tournament selection is the third technique, chromosome length represents the number of students to be allocated projects, while the meaning of each allele reflects the project that has been assigned to the student in that place. three algorithm was tested with dataset that contain 68 student and 44 projects area and 9 supervisor ,where AVGMIN,MAX fitness value for each algorithms after 10 iterations is that (GA: MIN= 58.93,MAX= 99.85,AVG=78.47),(GSA: MIN=100.54, MAX=119.46,AVG= 107.15) and (ACO: MIN=54.91, MAX=74.62, AVG=64.05) .The main limitation of the GSA and GA is that it demands more fitness estimates for each generation iteration and is much more likely to be stuck in a local minimum, while the lower rate of evaporation in the ACO means that the ACO demands further iterations to converge into a solution.

3. Problem Discussion and Motivation over Previous works

The previous study discusses many strategies and algorithms to deal with the project allocation problem with reliance mainly on the preferences lists of both students and lecturers (traditional allocation approach). After a deep analysis of the previous studies that depend on the traditional method of appropriation, it was found that it faces several problems, some of which have already been solved and others remain a challenge for subsequent studies to solve. The most prominent of these issues are:

- Random allocation is the main problem that is appeared in the literature where several students who have a medium or low GPA where the traditional allocation process may be unfair to some of those students. Balancing the workload for some supervisors may also contribute to the random allocation problems, on the other hand, they directly affect student satisfaction level.
- Balancing the max/min supervisory task for each supervisor where some supervisor reaches maximum workload while other supervisor doesn't have any student to supervise, furthermore (supervisors carrying administrative position in their universities should be assigned a fewer supervisory task are commensurate with the pressures of administrative work). Solve this problem in traditional allocation may suffer from increasing the random allocation.
- Popular project titles problem that attracts many students to particular projects and whose work to complete differs from what is expected of the title. This problem can consider one of the main reasons for the supervisors' workload problem and random allocations problems.
- Traditional allocation methods may not contribute to improving the quality of the completed projects, where project selection relates to the student's own beliefs.

In this paper, we proposed a new allocation method depends on machine learning technique to analyze student development information in an academic semester course and artificial intelligent decision-making tools to determine an appropriate project for each student. In the proposed system most problems in the literature are solved where a project is allocated automatically depending on the student's academic level rather than relying on the lists of preferences for students or supervisors. The proposed system improves the level of student satisfaction when the allocation mechanism is dependent on their level of education and is similar to all students without any biases. The problem of random allocation will be eliminated because every project is allocated based on accurate data related to student's abilities. The proposed system also contributes to improving the quality of the completed projects, since the allocation of projects is based on the level of creativity in a specific scientific field for each student. as well as eliminate the problem of popular projects title, taking into account the supervisor workload where the workload(max/min) is automatically controlled for each supervisor based on the number of supervisory tasks specified in advance.

4. Proposed Solution

As mentioned in the above section, the idea of this paper is to present a new solution for student project allocation that trying to overcome some problems presented earlier .the proposed system is divided into three-phase (preprocessing, evaluation part, and allocation phases) as shown in the figure1.

4.1 Preprocessing phase

During the course stage, students receive many scientific materials related to several fields, some of these materials are affiliated with or derived from a major scientific field.

In the proposed allocation system, the first phase is a pre-processing of the data must be carried out to prepare it for the next phase, where the important data are determined according to the main fields of science. Student degrees, Lecturers 'evaluations, observations during the study period, and the special test results can be adopted in this phase[23][24]. After the process of identifying the important materials, these data must be processed to determine the scientific fields in which the student creativity depending on some preprocessing techniques like feature extracting, data wrangling, and data editing techniques[25][26].

4. 2 Evaluation phase

There are several artificial intelligence algorithms that can be used to make decisions (like Decision Tree, Rule Mining, multi-criteria decision analysis (MCDA)...etc.) [27][28][29] that are based on the preprocessed information from the previous phase to determine the prioritizations over the science fields for each student.

4. 3 Allocation phase

In the third phase, an appropriate project is allocated based on the results of the prioritization of the decision-making algorithms in the second phase. Therefore, each supervisor must determine the scientific a field for each project when they submit to the committee responsible for allocating projects. Figure (1) show the proposed system layers.

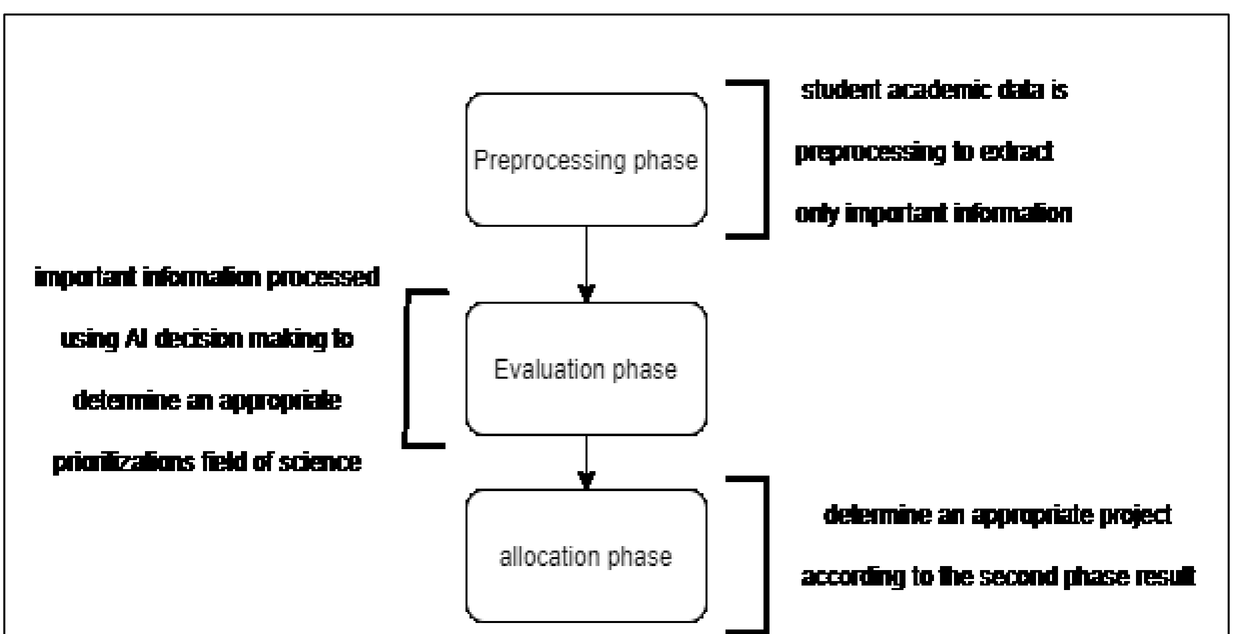

Fig. 1 - Block Diagram of the proposed solution phases

5. Conclusion

In this paper, an overview of the strategies and algorithms that are used to allocate the final year project for students is provided. The focus of this paper is on the problems that the previous studies tried to solve in addition to other limitation issues that would not take into account. Although good solutions were presented by previous studies, some problems were not finally solved, such as the problem of random allocation, in addition to some other problems associated with the traditional allocation mechanism that are used in the allocation process, such as the problem of popular project, unknown supervisors, completed project quality and the problems of supervisors workload that has an administrative position. In this paper, we proposed a new approach based on a novel idea, Different from the traditional approach to the appropriation process, the proposed FYP allocation system focused on solving the highlighted problems of previous studies that are mainly related to the traditional allocation approach. Machine learning techniques are introduced in the proposed system in the first phase to extract important information, then artificial intelligence techniques as a decision making in the second phase that is the final allocation process are based on in the third phase.

References

[1] S. Faudzi, S. Abdul-Rahman, R. A. Rahman, J. Zulkepli, and A. Bargiela, "Optimizing the preference of student-lecturer allocation problem using analytical hierarchy process and integer programming," *J. Eng. Sci. Technol.*, vol. 15, no. 1, pp. 261–275, 2020.

[2] D. F. Manlove and G. O'Malley, "Student-Project Allocation with preferences over Projects," *J. Discret. Algorithms*, vol. 6, no. 4, pp. 553–560, 2008, doi: 10.1016/j.jda.2008.07.003.

[3] A. A. Anwar and A. S. Bahaj, "Student project allocation using integer programming," *IEEE Trans. Educ.*, vol. 46, no. 3, pp. 359–367, 2003, doi: 10.1109/TE.2003.811038.

[4] P. R. Harper, V. De Senna, I. T. Vieira, and A. K. Shahani, "A genetic algorithm for the project assignment problem," *Comput. Oper. Res.*, vol. 32, no. 5, pp. 1255–1265, 2005, doi: 10.1016/j.cor.2003.11.003.

[5] D. Kazakov, "Co-ordination of student-project allocation," *Manuscript, Univ. York, Dep. Comput. Sci.*, 2002.

[6] M. Thorn, "A constraint programming approach to the student-project allocation problem," *BSc Honours Proj. report, Univ. York, Dep. Comput. Sci.*, 2003.

[7] D. J. Abraham, R. W. Irving, and D. F. Manlove, "Two algorithms for the Student-Project Allocation problem," *J. Discret. Algorithms*, vol. 5, no. 1, pp. 73–90, 2007, doi: 10.1016/j.jda.2006.03.006.

[8] K. Iwama, S. Miyazaki, and H. Yanagisawa, "Improved approximation bounds for the student-project allocation problem with preferences over projects," *J. Discret. Algorithms*, vol. 13, pp. 59–66, 2012.

[9] F. Cooper and D. Manlove, *A 32-Approximation algorithm for the student-project allocation problem*, vol. 103. 2018.

[10] L. Pan, S. C. K. Chu, G. Han, and J. Z. Huang, "Multi-criteria Student Project Allocation : A Case Study of Goal Programming Formulation with DSS Implementation," *Eighth Int. Symp. Oper. Res. Its Appl. Zhangjiajie, China*, pp. 75–82, 2009.

[11] M. El-Sherbiny and Y. Ibrahim, "An artificial immune algorithm with alternative mutation methods: applied to the student project assignment problem," *Int. Conf. Innov. …*, vol. 36, no. Iciim, pp. 149–158, 2012, [Online]. Available: http://www.ipcsit.com/vol36/029-ICIIM2012-M0082.pdf.

[12] A. Kwanashie, R. W. Irving, D. F. Manlove, and C. T. S. Sng, "Profile-based optimal Matchings in the Student/Project allocation problem," *Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics)*, vol. 8986, pp. 213–225, 2015, doi: 10.1007/978-3-319-19315-1_19.

[13] H. O. Salami and E. Y. Mamman, "A genetic algorithm for allocating project supervisors to students," *Int. J. Intell. Syst. Appl.*, vol. 8, no. 10, pp. 51–59, 2016, doi: 10.5815/ijisa.2016.10.06.

[14] R. A. Knight and N. Botting, "Organising undergraduate research projects: student-led and academic-led models," *J. Appl. Res. High. Educ.*, vol. 8, no. 4, pp. 455–468, 2016, doi: 10.1108/JARHE-07-2015-0054.

[15] H. Chang, "Turning an undergraduate class into a professional research community," *Teach. High. Educ.*, vol. 10, no. 3, pp. 387–394, Jul. 2005, doi: 10.1080/13562510500122339.

[16] P. Plan, "A Web-based Project Allocation System," 2016.

[17] R. Calvo-Serrano, G. Guillén-Gosálbez, S. Kohn, and A. Masters, "Mathematical programming approach for optimally allocating students' projects to academics in large cohorts," *Educ. Chem. Eng.*, vol. 20, pp. 11–21, 2017, doi: 10.1016/j.ece.2017.06.002.

[18] S. Modi, N. M. Shagari, and B. Wadata, "Implementation of Stable Marriage Algorithm in Student Project Allocation," *Asian J. Res. Comput. Sci.*, vol. 1, no. 4, pp. 1–9, 2018, doi: 10.9734/ajrcos/2018/v1i424749.

[19] V. Sanchez-Anguix, R. Chalumuri, R. Aydoğan, and V. Julian, "A near Pareto optimal approach to student–supervisor allocation with two sided preferences and workload balance," *Appl. Soft Comput. J.*, vol. 76, pp. 1–15, 2019, doi: 10.1016/j.asoc.2018.11.049.

[20] S. Hussain, K. A. A. Gamage, M. H. Sagor, F. Tariq, L. Ma, and M. A. Imran, "A systematic review of project allocation methods in

undergraduate transnational engineering education," *Educ. Sci.*, vol. 9, no. 4, 2019, doi: 10.3390/educsci9040258.

[21] V. Paunovic, S. Tomic, I. Bosnic, and M. Zagar, "Fuzzy approach to Student-Project Allocation (SPA) problem," *IEEE Access*, vol. 7, pp. 136046–136061, 2019, doi: 10.1109/ACCESS.2019.2941730.

[22] P. Kenekayoro, P. Mebine, and B. G. Zipamone, "Population Based Techniques for Solving the Student Project Allocation Problem," *Int. J. Appl. Metaheuristic Comput.*, vol. 11, no. 2, pp. 192–207, 2020, doi: 10.4018/ijamc.2020040110.

[23] O. Zughoul *et al.*, "Comprehensive Insights into the Criteria of Student Performance in Various Educational Domains," *IEEE Access*, vol. 6, no. 1, pp. 73245–73264, 2018, doi: 10.1109/ACCESS.2018.2881282.

[24] J. R. Kider, "Some Properties of Algebra Fuzzy Metric Space 2 . Basic Properties of Algebra fuzzy metric space," vol. 12, no. 2, pp. 43–56, 2020.

[25] A. Famili, W.-M. Shen, R. Weber, and E. Simoudis, "Data preprocessing and intelligent data analysis," *Intell. data Anal.*, vol. 1, no. 1, pp. 3–23, 1997.

[26] S. A. Alasadi and W. S. Bhaya, "Review of data preprocessing techniques in data mining," *J. Eng. Appl. Sci.*, vol. 12, no. 16, pp. 4102–4107, 2017.

[27] A. S. Albahri, R. A. Hamid, O. S. Albahri, and A. A. Zaidan, "Detection-based prioritisation: Framework of multi-laboratory characteristics for asymptomatic COVID-19 carriers based on integrated Entropy–TOPSIS methods," *Artif. Intell. Med.*, vol. 111, no. October 2020, p. 101983, 2021, doi: 10.1016/j.artmed.2020.101983.

[28] H. T. Phan, V. C. Tran, N. T. Nguyen, and D. Hwang, "Decision-making support method based on sentiment analysis of objects and binary decision tree mining," in *International Conference on Industrial, Engineering and Other Applications of Applied Intelligent Systems*, 2019, pp. 753–767.

[29] O. A. Raheem and E. S. Alomari, "An Adaptive Intrusion Detection System by using Decision Tree," *J. AL-Qadisiyah Comput. Sci. Math. Vol*, vol. 10, no. 2, 2018.