Dynamic Graduation Project Allocation Based on Student-Teacher Profile Compatibility

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***Abstract* – Selecting an appropriate graduation project and supervisor is an important step for BSc and MSc students; a good compatibility between the student and the teacher, in terms of personality and supervisory style, contributes to enhanced achievement, engagement and well-being. Nevertheless, few approaches have been proposed in the literature to use these compatibility factors for providing student-teacher matching recommendations. In this context, we propose a system called Smart Project Allocation (SPA) which facilitates the supervisor selection process by providing personalized suggestions based on comprehensive student and teacher models (including personality, supervisory style and topics of interest). In addition, the platform provides a mechanism for automatic project allocation, which dynamically assigns projects to students in a more efficient, fair and transparent manner than the traditional manual approach.**

Keywords – personalized supervisor suggestion; student-teacher compatibility; learner model; teacher model; personality; supervisory style; automatic project allocation

I. INTRODUCTION

The graduation project, also known as the Bachelor or Master thesis, plays a significant role in the academic life of a student. Therefore, choosing an appropriate topic and supervisor is an important step in this process. A good supervisor will provide the required expertise for the student project, including personalized knowledge sources [12]; in addition, they would provide guidance and support throughout the project completion process. Furthermore, a positive and warm relationship between the student and the teacher enhances both the student's achievement and the teacher's well-being; the engagement level of both parties is also increased [8].

The traditional approach for graduation project selection usually implies that teachers propose a list of topics and students contact them in order to express interest in a particular topic; alternatively, students may come up with their own project theme, within the area of expertise of the teacher [3, 12]. Generally, the process implies several message exchanges between the two parties (and sometimes several rejections) until a project theme is finally assigned. A first come first served approach is often used, which does not provide the optimal allocation. Furthermore, students sometimes choose a teacher without having enough information regarding their personality and work compatibility, which can lead to an unsatisfactory supervision relationship [12]. This is particularly relevant, as the student-supervisor relationship was found to have an important impact on students' subjective well-being [7].

Therefore, an alternative to the manual approach is to provide an automatic mechanism for student-teacher recommendation, to facilitate supervisor selection. In this context, several approaches / platforms have been proposed, such as [3], [10], [12]. However, these systems have several limitations: most of them only take into account the domain of expertise or research interests of the supervisor, neglecting other important compatibility factors, such as personality and supervisory style, which contribute to the success of the student-teacher collaboration. Furthermore, many platforms are dedicated to the recommendation of supervisors for PhD students, without having a component for automatic project allocation. In order to address these challenges, we designed and implemented a system called Smart Project Allocation (SPA) which integrates both components and relies on more comprehensive student and teacher models (including personality, supervisory style and topics of interest) for providing personalized recommendations.

The rest of the paper is structured as follows. An overview of related work and a rationale underlying the factors used for the student and teacher models is provided in section 2. The mechanism for personalized suggestions and dynamic project allocation is described in section 3. The approach is illustrated in section 4. Finally, section 5 concludes the paper, outlining future research directions.

II. RELATED WORK

In what follows we discuss two of the main factors that impact the student – teacher compatibility (personality and supervisory style) and overview some related works which are aimed at matching students with the most appropriate supervisors.

Personality is an important feature in the student-teacher matching process [8, 9]. Pancorbo et al. [8] found that students tend to prefer teachers with similar personality types. The authors performed a study based on Big Five personality model [5], which involves the following traits: *Openness*, *Conscientiousness, Extraversion, Agreeableness*

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and *Neuroticism* (or *Emotional stability*); results highlighted that students tend to feel more interested and involved in the courses that are taught by teachers with whom they share similar personality characteristics. In addition, the teachers that have a higher score for the Agreeableness and Conscientiousness traits are more likely to be preferred by their students [8]. Similar evidence of the student-teacher personality match was provided in [9], which also revealed that Conscientiousness was the most desired trait in teachers, followed by Agreeableness, Extraversion and Openness, with Neuroticism being the least desired trait.

The *supervisory style* also plays an important role, consisting in the principles that are present in the teacher-student collaboration (supervisor-supervisee relationship) [2]. Starting from a comprehensive literature review, Gatfield [4] proposed a conceptual model based on the level of support and structure provided by the supervisor. Thus, four supervisory styles were determined: *Laissez-faire* (low structure and low support), *Directorial* (high structure and low support), *Pastoral* (low structure and high support), and *Contractual* (high structure and high support) [4].

While these two factors have an important impact on the student supervision process, affecting the perceived satisfaction of both parties involved, few attempts have been made to integrate them in student-teacher matching platforms.

A notable exception is reported in [12], which takes into account students' and teachers' personality in order to recommend appropriate supervisors. More specifically, the recommendation system is integrated in an online research network community. Four dimensions are considered for computing a suitability score between a student and a supervisor: relevance, connectivity, quality, and personality. The weight of each dimension is set based on the importance assigned by each student. Preliminary results showed that the personality-based matching approach outperformed the method without personality matching. While this approach is very interesting, it only provides recommendations for suitable supervisors and does not perform an automatic allocation.

Such an automated thesis supervisor allocation is proposed in [3]. A machine learning based approach is devised, starting from the current manual allocation procedure adopted at the Engineering Institute of Technology, Perth, Australia. A decision tree model is used, which takes into account features like supervisor's specialization, research area, academic background, industry experience, but also their time flexibility, their availability to have meetings on-line or on-campus and their readiness to provide detailed guidance. While these last features cover some aspects of the supervisory style of the teacher, the personality is not considered and the model is limited to the specific conditions of the particular university case.

Another system that aims at recommending thesis supervisors is reported in [10]. Each student submits a thesis proposal and the system returns a list of potential supervisors ordered based on the relevance of their expertise. The process has two phases: indexing, in which teachers submit their academic papers in the system; and recommending, in which content matching is performed between these papers and students' thesis proposals. Hence the recommendation is based only on the topics of interest and does not consider the personality or supervisory style of the teacher.

As can be seen, the works presented above consider a limited set of features for matching students and teachers; furthermore, they are either based on recommending supervisors or on automatic allocation, but not both. By contrast, the system that we propose takes into account a wider range of factors for suggesting suitable supervisors and projects, both objective (i.e., topics of interest and complexity level) and subjective (i.e., personality and supervisory style). In addition, the platform combines the recommendation process with an automatic project allocation approach, as described in the following section.

III. Designing a Mechanism for Dynamic Project Allocation

A. Student and Teacher Models and Compatibility Scores

The SPA system was developed to provide an improvement for the traditional allocation method of the graduation thesis subjects by customizing the allocation mechanism based on the stakeholders' profiles. In the first stage, the system provides personalized suggestions to students based on the compatibility between the learner profile and the supervisor profile as well as the specific project topic. In the second stage, the system automatically allocates the projects based on the students' and teachers' preferences.

In order to compute the compatibility scores, the SPA system builds a *learner model* and a *teacher model*, which include the following features: *personality*, *supervisory style* and *topics of interest*.

Regarding *personality*, the Big Five traits model was chosen [5], as it is the most widely used taxonomy [6]. The 50-item IPIP version of the Big Five Markers inventory[1] was used; the questionnaire, together with its scoring method, were implemented in the SPA system and made available for both students and teachers to take at the beginning of the project allocation process. The results of the test consist of 5 different scores, one for each Big Five Personality trait (each of them on a 10 to 50 scale). Thus, a continuous scale is used, not leading to a rigid labelling / pigeonholing approach.

Subsequently, a *personality compatibility score (PC)* is computed, based on the similarity between the personality traits of a student (s) and a teacher (t), using the following formula:

$$PC_{s,t} = \left[1 - \frac{(|a_s - a_t| + |c_s - c_t| + |n_s - n_t| + |o_s - o_t| + |e_s - e_t|)}{200}\right] * 100$$

[1] https://ipip.ori.org/new_ipip-50-item-scale.htm

where: a_s, a_t are the Agreeableness scores; c_s, c_t are the Conscientiousness scores; n_s, n_t are the Neuroticism scores; o_s, o_t are the Openness scores; e_s, e_t are the Extraversion scores (for student *s* and teacher *t,* respectively).

In case a user did not fill in the personality test, then a default average value will be used for each trait score (i.e., the value 30).

As mentioned in the previous section, the *supervisory style* of the teacher plays an important role in a satisfactory mentoring relationship. Therefore, the SPA system includes the model proposed in [4], based on four supervisory styles: *Laissez-faire*, *Directorial*, *Pastoral*, and *Contractual*. At the beginning of the project allocation process, each teacher is asked to fill in their own supervisory style, and each student is asked to select their preferred supervisory style (using a dedicated form).

Subsequently, a *supervisory style compatibility score (SC)* is computed, based on the similarity between the supervisory style of the teacher and the preferred supervisory style of the student, using the following formula:

$$SC_{s,t} = \begin{cases} 100\%, if\ the\ supervisory\ styles\ are\ identical \\ 50\%, if\ the\ supervisory\ styles\ are\ related \\ 0\%, if\ the\ supervisory\ styles\ are\ opposite \end{cases}$$

where the pairs of opposite supervisory styles are (*Laissez-faire*, *Contractual*) and (*Pastoral*, *Directorial*) and the pairs of related supervisory styles are: (*Laissez-faire*, *Directorial*), (*Laissez-faire*, *Pastoral*), (*Directorial*, *Contractual*), (*Pastoral*, *Contractual*).

Finally, the system also asks the students and teachers to select their topics of interest (*domain keywords*). A *domain compatibility score (DC)* is thus computed as the ratio between the number of common domain keywords that were chosen by both the student and the teacher and the total number of domain keywords that were selected by the student.

An overall *student-teacher compatibility score (STC)* between each student *s* and teacher *t* is computed, using the following formula:

$$STC_{s,t} = PC_{s,t} * w_P + SC_{s,t} * w_S + DC_{s,t} * w_D$$

where: w_P, w_S and w_D are the weights associated to each compatibility score (personality compatibility score, supervisory style compatibility score and domain compatibility score respectively). The values of these weights can be configured by the administrator of the SPA system (such that their sum is 1), according to the particular requirements of the study program.

In addition, a more specific compatibility score between the student and each project is also computed by the system. This is based on the compatibility between the student and the teacher who proposed the project, but also on two project-specific features: domain and complexity level. Thus, a *project domain compatibility score (PDC)* is computed as the ratio between the number of common domain keywords between the student and the project and the total number of domain keywords that were selected by the student. Furthermore, students can also specify the desired complexity of their project, by choosing one of three levels: *Easy*, *Medium*, *Advanced*. Thus, a *project complexity compatibility score (PCC)* is computed based on the similarity between the complexity level chosen by the student and the actual project complexity level specified by the teacher, using the following formula:

$$PCC_{s,p} = \begin{cases} 100\%, if\ levels\ are\ identical \\ 50\%, if\ levels\ are\ adjacent\ (i.e.\ Easy\ \&\ Med, Med\ \&\ Adv) \\ 0\%, if\ levels\ are\ opposite\ (i.e.\ Easy\ \&\ Adv) \end{cases}$$

Hence, an overall *student-project compatibility score (SPC)* between each student *s* and project *p* is computed, using the following formula:

$$SPC_{s,p} = PC_{s,t} * w'_P + SC_{s,t} * w'_S + PDC_{s,p} * w_{PD} + PCC_{s,p} * w_{PC}$$

where: *t* is the teacher who proposed project *p* and w'_P, w'_S, w_{PD}, w_{PC} are the weights associated to each compatibility score (personality compatibility score, supervisory style compatibility score, project domain compatibility score and project complexity compatibility score respectively). The values of these weights can be configured by the administrator of the SPA system (such that their sum is 1), according to the specific requirements of the study program.

B. Project Allocation Mechanism

Starting from the compatibility scores presented in the previous section, the SPA system provides an automatic project allocation mechanism. The process has several phases:

1. Configuration phase – the administrator adds the students' and teachers' information into the system, configures the allocation settings and starts the first allocation iteration.
2. Profile customization phase - the students and teachers fill in their profile by taking the personality test, choosing the preferred supervisory style, selecting their topics of interest (domain keywords), as well as their preferred complexity level (in case of students).
3. Projects proposal phase - the teachers can add new project themes, delete or edit the existing projects. For each proposed project, the teacher provides its complexity level and the domain keywords that can be used to describe it.
4. Options sending phase - the students visualize the proposed projects, sorted according to the corresponding compatibility score and can send their preferred options (maximum 3 projects). Apart from selecting a project proposed by the teacher, the student can also propose their own desired theme, in accordance with the topics of interest of the corresponding teacher.
5. Options sorting phase - the teachers visualize their received options from the students and sort them based on their availability and preferences. The system also provides access to the compatibility scores of the students, in order to help teachers make their decisions.
6. Automatic allocation phase – once the options sending and sorting deadlines have passed, the automatic allocation mechanism is triggered, which includes two steps that are sequentially performed, as described next.

In the first step, the options received by each teacher are ordered according to their preferences in phase 5. If an option is the first choice of the student and is also placed on an eligible spot on the teacher's list (i.e., on one of the first *n* positions, where *n* is the number of spots available for that teacher), then that option will be accepted and the student will be notified accordingly. The other options sent by the student will be marked as inactive and if the teacher does not have any more available spots, then all other options received by them will be marked as rejected.

In the second step, if there are still students who do not have a project allocated, then they are ordered based on their average grade. Next, for each student (starting with the one with the highest average grade), a priority score is computed with respect to each option they sent, using the following formula:

$$Priority_{o\_s,t} = TP_{o\_s,t} - TA_t + SP_{s,o\_s}$$

where: $TP_{o\_s,t}$ is the place assigned by teacher t for student s's option o_s in the options sorting phase; TA_t represents the number of available spots from teacher t's list; SP_{s,o_s} is the place assigned by student s for option o_s in the options sending phase (i.e., 1, 2 or 3).

The option with the minimum priority score is accepted and the student is notified accordingly. Subsequently, all the other options sent by the student are marked as inactive and if the teacher does not have any more available spots, then all other options received by them will be marked as rejected. If at the end of the second step there are still students who do not have a project allocated, then the whole process starts again and the remaining students can send a new set of preferred options out of the available project proposals.

This mechanism ensures an efficient, fair and transparent allocation process. First of all, the compatibility between the student and the teacher contributes to a better communication and collaboration during the supervision process. Secondly, the structured allocation approach saves both students' and teachers' time, who would otherwise have to exchange numerous emails to complete the selection process. Furthermore, this replaces the traditional "first come first served" approach, leading to a more equitable allocation which takes into account both students' and teachers' preferences. Finally, since the option lists are handled internally by the system, neither the students nor the teachers have access to each other's preferences, which avoids cumbersome situations.

The mechanism described above was implemented in a web-based system called SPA (Smart Project Allocation). From a technical point of view, the SPA system was built using the ASP.Net Core 3.1 framework; a three-layered architecture was adopted (presentation layer, application logic layer and data access layer). Microsoft SQL Server 2019 was used as relational database management system and the user interface was based on HTML, CSS and JavaScript.

IV. Illustrating SPA Functionalities

As mentioned in the previous section, the SPA system includes three user roles: administrator, teacher and student. In what follows we illustrate some of the platform functionalities, according to each role.

A. Administrator View

The platform administrator can perform the following main functionalities:

- *Initialize the system*: add/delete/edit the information of the students and teachers (inserted manually or imported from an Excel file).
- *Customize the recommendation and allocation mechanism*: define the weights used for computing the compatibility scores and set various deadlines.
- *Supervise the allocation process*: trigger the automatic allocation mechanism, start a new allocation iteration if needed, monitor the status and visualize the results.

B. Teacher View

The teacher has access to the following main functionalities in SPA:

- *User profile*: edit account, take the personality test (and visualize the results), choose the preferred supervisory style, manage the topics of interest / domain keywords.
- *Project management*: the teacher has the possibility to propose project themes, as well as edit and delete them. In addition to the title, a description, complexity level and domain keywords need to be specified for each project.
- *Options management*: the teacher can visualize the options received from the students and sort them based on their preferences and their availability (as each teacher can supervise a limited number of students). The teachers can also view the compatibility scores of the students, including their subcomponents (personality, preferred supervisory style, topics of interest) and can thus make more informed choices. A part of this functionality is illustrated in Fig. 1.

C. Student View

The SPA system provides the following main functionalities for the students:

- *User profile*: edit account, take the personality test (and visualize the results), choose the preferred supervisory style, manage the topics of interest / domain keywords (add/edit/delete), choose the preferred project complexity.
- *Recommended projects and supervisors*: the student can visualize the suggested teachers and projects based on their compatibility scores, including the subcomponents (personality, supervisory style, topics of interest, complexity level). A part of this functionality is illustrated in Fig. 2.
- *Options management:* the student can select up to three preferred project themes, which can be custom (proposed by the student) or standard (proposed by the teacher); they

can subsequently edit, delete or submit their options until the specific deadline.

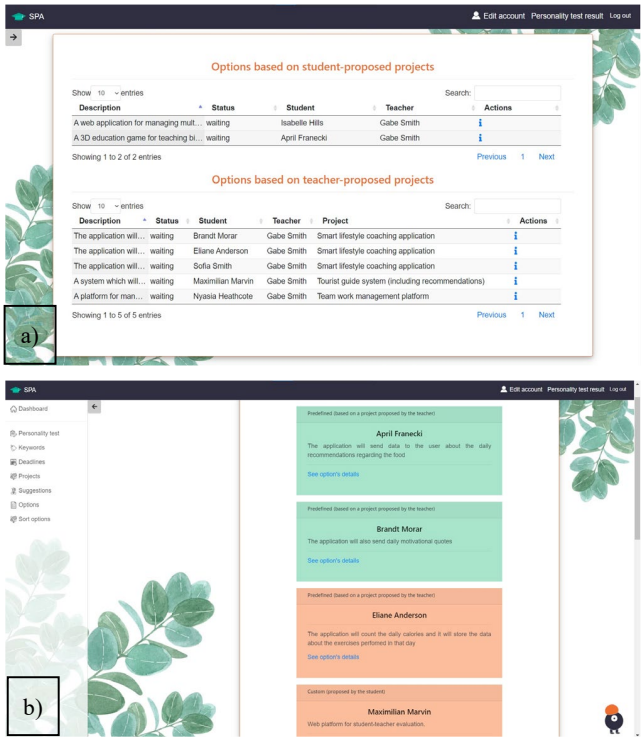

Figure 1. Teacher options management: a) The teacher visualizes all received student options; b) The teacher sorts the options in their preferred order by means of a simple drag and drop mechanism (options placed on an eligible spot are marked in green, the rest are marked in red).

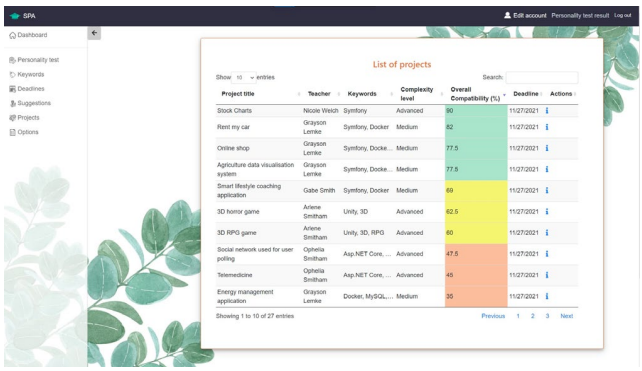

Figure 2. Project recommendation: the student visualizes all the proposed projects, sorted based on the compatibility score (recommended projects are marked in green, neutral in yellow and not recommended in red)

V. Conclusion

We proposed an approach for providing personalized suggestions for graduation project supervisors based on student-teacher compatibility, in terms of personality, supervisory style and topics of interest. We implemented this approach in a platform called SPA, which also integrates a dynamic mechanism for automatic project allocation. This alternative to the traditional manual allocation approach provides several advantages, including efficiency (saving both students' and teachers' time) and fairness (a more equitable allocation based on stakeholders' preferences).

Several extensions could be envisaged: first, the student-teacher matching approach could be customized based on students' individual preferences (i.e., the values of the weights for computing compatibility scores could be configured by each student, based on the subjective importance they allocate to each factor). Furthermore, different matching perspectives could be used, such as complementary personality matching or an individual preference for specific personality traits. In addition, the learner model could be extended to include also career personality types and preferred thinking styles [11] or cognitive styles [1].

Finally, we aim to conduct experimental studies to validate the proposed approach and assess the usefulness of the personalized project and supervisor suggestions (i.e., how students perceive these suggestions and how often they follow them) as well as the overall satisfaction with the project allocation process.

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