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Tailoring Student - Team Project Allocation through Consultative Multi-Stage Process

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ABSTRACT

CONTEXT

Engineering student capstone projects utilise the expertise of final-year students to tackle real-world problems within multi-disciplinary teams, serving as a bridge between academia and industry. Each semester, up to 1,000 students across 2 campuses and 8 specialisations are assigned to various team projects, supervised by faculty from six engineering disciplines.

PURPOSE

Previous allocation methods led to fragmented and labour-intensive processes for project administrators. This inconsistency also resulted in varied experiences for engineering students and their supervisors across the faculty. To enhance the quality of the educational experience, the aim has been to improve student satisfaction with allocation outcomes while incorporating supervisory guidance for effective team composition. This paper examines the effectiveness of a semi-automated, consultative, multi-stage process for assigning engineering students to multi-disciplinary team capstone projects.

METHODOLOGY

The student-project allocation process has continued to evolve, now using a strategic multi-stage preference system that involves both students and supervisors. This paper will describe how student allocation into capstone project teams is implemented, highlighting recent revisions to the process. Notably, a new strategy has been introduced to encourage more students to join single-member teams. The effectiveness of these measures will be evaluated by analysing the efficiency of matching student preferences with projects, which serves as an indicator of student satisfaction with their allocation outcomes. Additionally, we will investigate the distribution of allocated students based on team specialization and across the various disciplines hosting projects, offering insights into the impact of these initiatives.

ACTUAL OUTCOMES

Only two rounds are needed to allocate 97% of students to their preferred projects. Analysis shows that these improvements have resulted in several benefits: prioritising fairness for both students and supervisors through a transparent and structured approach, promoting interdisciplinary engineering projects, and ensuring consistent treatment in project allocation.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

The algorithm and multi-stage allocation process allows us to move away from a ‘first come first served’ FYP allocation to allow better student experience. These efforts contribute to the United Nations goal of providing inclusive and equitable quality education and lifelong learning for all.

KEYWORDS

Algorithm, Final Year Project, Team Allocation

Introduction

Background

Final Year Projects (FYP) are integral to engineering education, allowing students to apply their knowledge in practical scenarios. Students are encouraged to pursue projects that align with their strengths, showcase their skillset, or extend into the area of expertise of their expected career path. Once allocated, supervisors guide their student team as they navigate through a project using research, implementation, and reflection processes, culminating in a demonstration of their knowledge, skills, and contributions to their respective fields. Traditionally, students worked individually with an academic advisor, contributing to their advisor's research portfolio. However, this approach faced challenges due to the scale and complexity of allocating projects, often relying on inefficient manual methods, such as spreadsheets (Hussain et al., 2019).

The allocation of projects, assessment procedures, resource access, support and supervision, and overall management are crucial factors that significantly impact students' learning experiences during their final year projects (Teo, 1998). Project allocation involves evenly distributing workloads among staff while aligning projects with student demands, which becomes challenging when manually allocating final year projects for a large student body.

Recognising the importance of the student experience in their allocation of project (Yuan et al., 2024), as well as a need for a more effective system, Monash University restructured its FYP process in 2021, adopting a centralised, consistent, faculty-wide approach aimed at fostering collaboration and multidisciplinary projects. This shift aligns with the United Nations Sustainable Development Goals (2016, 2017), as outlined in Table 1, which emphasises quality education, reduced inequalities, and strong institutions.

Table 1: Integration of Sustainable Development Goals in Monash University's FYP Framework

UN SDG 4: Quality Education	UN SDG 10: Reduced Inequalities	UN SDG 16: Peace, Justice & Strong Institutions
Target **4.4:** By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship	**Target** **10.3**: Ensure equal opportunity and reduce inequalities of outcome, eliminate discriminatory laws, policies, and practices	**Target** **16.6**: Develop effective, accountable, and transparent institutions (Indicator: population satisfaction with public services) **16.7**: Ensure responsive, inclusive, participatory, and representative decision-making (Indicator: inclusivity in decision-making by sex, age, disability, and group)

The development of an online project advertising platform, integrated with an automated student allocation algorithm (which is the main focus of this paper), addresses the common challenges of project allocation while enhancing the learning environment for students, supervisors and administrators alike. This innovation not only streamlines the allocation process, but also supports the cultivation of T-shaped engineers (Crosthwaite, 2021). By promoting interdisciplinary collaboration, students acquire a diverse skill set that combines deep expertise in their specific engineering domains with broader insights from other fields. This approach enhances teamwork, innovation, and motivation for project work (Winder, 2023), ultimately preparing graduates to meet the complex, interdisciplinary challenges present in today’s engineering landscape.

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How does it work?

The FYP process begins with academics posting their projects on a dedicated website, including details like project descriptions, IDs, student requirements, and whether it is a group or individual task. Students review these listings and rank up to seven preferred projects via a Google form. After collecting student preferences, the data is used to create ranking sheets for supervisors, who then rank students based on their own criteria. This replaces the 'first come, first served' model with a merit-based, preference-driven system. Finally, an algorithm matches students to projects, considering project IDs, group size, student preferences, and supervisor rankings, aiming to assign each student to one of their preferred projects.

The motivation behind this system is multi-faceted. First, it seeks to offer students optimal opportunities to showcase their skills and develop career readiness. Second, it ensures the allocation process can scale efficiently across the faculty. Lastly, it balances student preferences with supervisor needs, resulting in a fair and effective allocation process.

Methodology

In each semester's cohort, up to one thousand students across two campuses and eight specialisations, are allocated into one of the various student team projects guided by supervisors from six disciplines of engineering. In this section, we describe the details of the allocation process, including the algorithm used and the data analysis conducted to evaluate its efficacy. Most visualisations will focus on the first semester of each year, as the larger cohort size and longer administrative timelines favour a complete multi-stage implementation of the algorithm.

Overview of Algorithm

The allocation process, shown in Figure 1, is conducted in two rounds. In Round 1, students explore a variety of projects, including both multidisciplinary team projects and individual projects. They rank up to seven projects based on their preferences. Supervisors are notified of these choices and rank the students based on their own criteria. The algorithm, which gives a slight edge to student preferences, then matches students to projects, resulting in one of three outcomes:

1) No project allocation,

2) Allocation to a team project with multiple members, or

3) Allocation to a team project alone.

Students who end up without a project or in a solo assignment are invited to participate in a second round. In this round, the project list is updated to remove any fully allocated projects and those with no initial applicants, while new projects may be added. The second round mirrors the first, with the goal of allocating every student to a project that fits their interests and needs. Any remaining students are then manually allocated by department staff.

The project allocation process is performed in two stages like this primarily in Semester 1, due to larger cohorts enrolled in Semester 1 and limitations in time for Semester 2. Round 2 is omitted for Semester 2 offerings of the FYP.

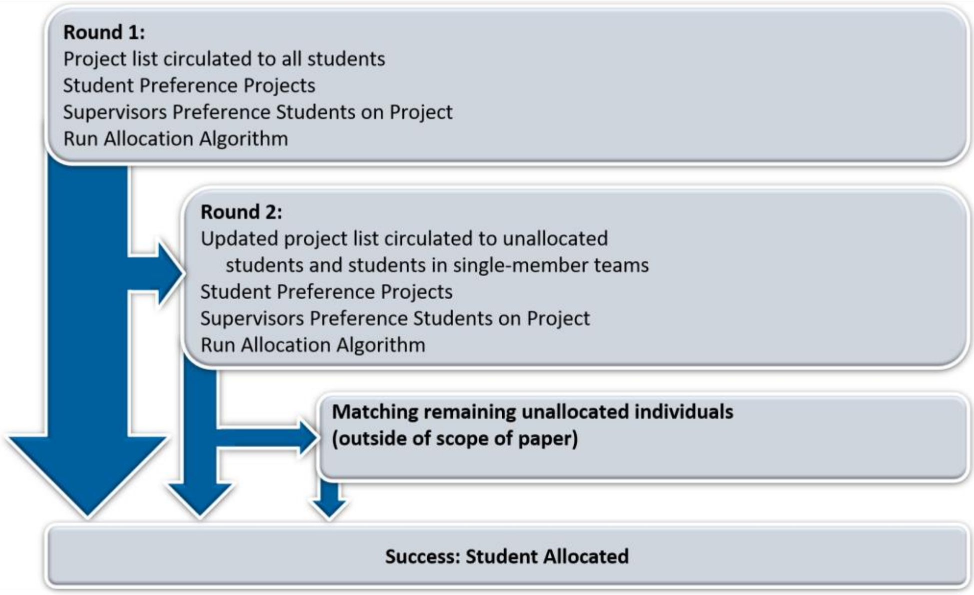

Figure 1: Flow diagram of FYP students through the project allocation process.

Data Analysis

The data relating to project allocations in Semesters 1 and 2 since 2022 has been processed and analysed as follows. Throughout the analysis, we may alternate between considering cohorts of students based on their areas of specialisation or their engineering department.

Preferencing

An analysis of the efficacy of the allocation process was conducted to determine how student preferences for project allocations vary across disciplines and years. Normalised stacked bar charts were constructed to visualise how project preferences are distributed across different ranks and departments. This analysis helps gauge student satisfaction and identify areas for improvement.

Student Projects by Field of Study and Department

Our goal was to monitor how different departments participate in supervising Final Year Projects (FYP). To do this effectively, we need a visualisation technique that enables straightforward comparisons of departmental supervision of student project choices over various years. By constructing and inspecting the side-by-side heatmaps, we gain valuable insights into departmental patterns and student interests.

Team Size

We compared team sizes from the first round of FYP allocation to their sizes at the end of the second round. Scatterplots are useful for this analysis because they visualise the relationship between two variables by plotting data points based on their values, enabling quick identification of patterns and trends.

Team Composition

Team composition involves a complex dataset with multiple variables that capture the number of students from each specialisation forming a FYP team. Specialisations considered for this analysis include Civil, Chemical, Mechanical, Electrical & Computer Systems, Materials, Software, Environmental, Mining & Renewable Energy, Materials Science and Engineering, Aerospace, and Biomedical Engineering. Principal Component Analysis (PCA), developed by Pearson (1901), simplifies complex data by reducing the number of variables and focusing on the most important ones. This makes it easier to explore, visualise, and prepare for further analysis. In this study, PCA was used to examine the relationships between student specialisations and supervisor disciplines, and monitors changes over time (coinciding with changes to processes to the team allocation process). Specifically, PCA was used to determine whether adjustments to the team allocation process have balanced or shifted the representation of disciplines, providing a means to assess the diversity of student specialisation within FYP team composition. The three most influential patterns in the composition data of the teams are represented by **P1**, **P2** & **P3**. **P1** highlights an overall distribution of disciplines across all teams. For example, it shows which disciplines are generally present in more teams, represented by individual data points on the PCA plot. **P2** and **P3** provide additional layers, showing how the presence of different disciplines varies across different teams.

In these PCA plots, colour coding was applied so that a visual inspection may reveal clusters of coloured dots that indicate the characteristics of teams based on their supervising departments. When teams from the same department (represented by the same colour) group together, it suggests that they share similar characteristics or expertise. Conversely, well-separated clusters of different colours show distinct profiles and strengths among various departments. The shape and size of these clusters reflect the uniformity or diversity within each department's teams, and changes in cluster positions over time reveals evolving team dynamics and departmental characteristics.

Results and Discussion

Our analysis of student project allocations has uncovered insights into how the allocation process is performing. By examining normalised stacked bar charts, heatmaps, scatterplots, and Principal Component Analysis (PCA), we've identified key trends across different disciplines and over time. These insights help us understand student preferences and departmental roles better and highlight potential improvements for the allocation process.

Project Allocation Rounds Breakdown

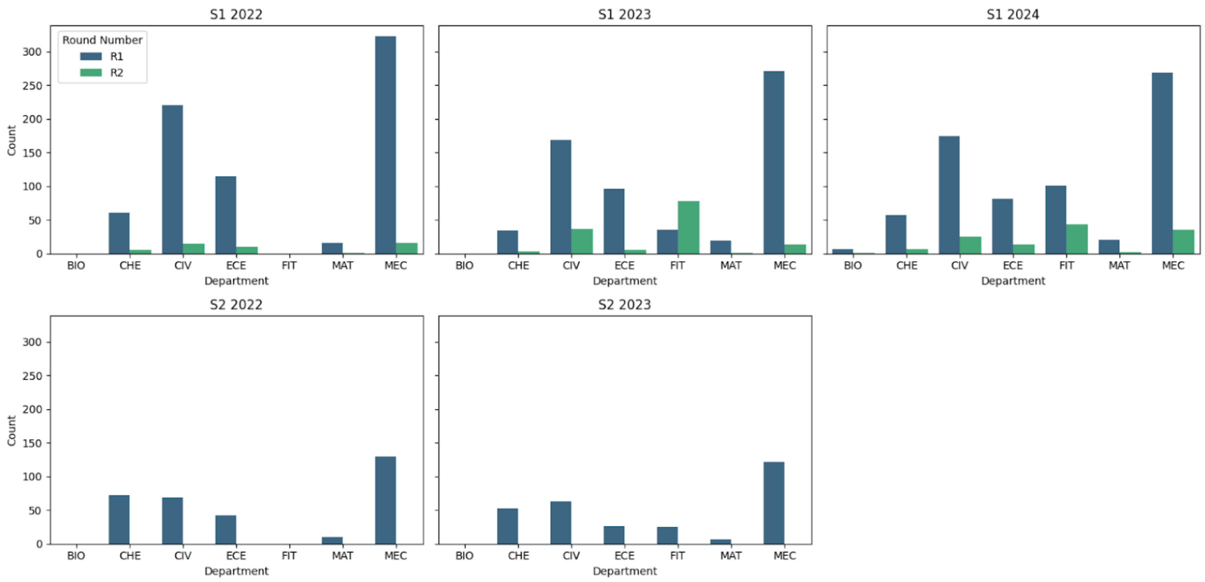

Figure 2: Side-by-Side Bar Charts of Student Department Counts by Round: The bar charts display the number of students from each department participating in two rounds. The first chart shows data for Round 1 (R1), while the second chart represents Round 2 (R2). The absence of data for Round 2, particularly in Semester 2 offerings, indicates no student participation.

Figure 2 presents side-by-side bar charts displaying the number of students from each department participating in two rounds of allocation. In 2023 and 2024, disciplines like Civil Engineering (CIV) and Chemical Engineering (CHE) had more students allocated in Round 1 compared to Round 2, reflecting a higher number of students receiving their preferred choices early. In contrast, the Faculty of Information Technology (FIT) had more students in Round 2, indicating that many students missed out on their preferences in Round 1 or were placed in Round 2 due to being the sole member of a team project. Mechanical Engineering (MEC) also showed a high likelihood of achieving Round 1 allocation. In 2024, there was a trend towards more balanced distributions across rounds for disciplines like Biomedical Engineering (BIO), Electrical and Computer Engineering (ECE), and Materials Engineering (MAT).

Going Back for Seconds: Growth of Team Sizes in Multi-Round Allocations

Scatterplots help us examine the relationships between the project team sizes after each round.

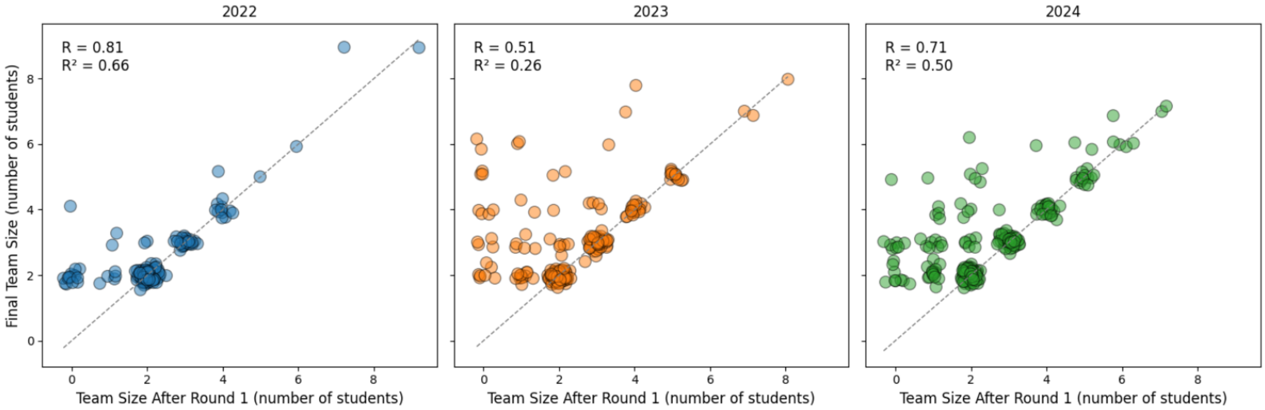

Figure 3: Scatterplots showing the growth of team sizes across allocation rounds for Semester 1 in the years 2022-2024. The dotted line represents the point where team sizes remain unchanged after Round 1. Teams that start at a size of 0 after Round 1 were introduced only in Round 2.

Figure 3 scatterplots of team sizes across allocation rounds for Semester 1 in the years 2022-2024. These plots reveal that team sizes have consistently increased since 2022, with notable concentrations of 2-3 students. In 2024, team sizes ranged from 2-5 students, indicating effective use of Round 2 to fill vacancies.

Tracking Students' Preferencing of Allocated FYP, by Department

Normalised stacked bar charts allow us to compare the proportion of projects supervised by each department, revealing shifts in departmental involvement.

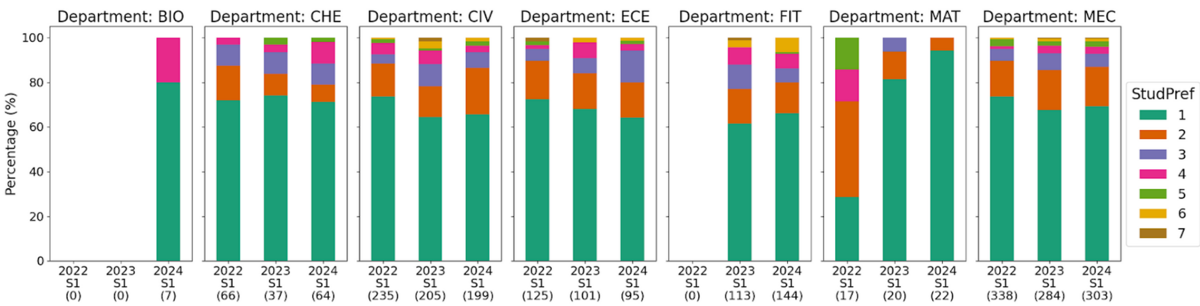

Figure 4: Normalised stacked bar charts illustrating how student preferences vary over the years and across disciplines, with percentages (%) representing the relative allocation of preferences at each rank.

Figure 4's normalised stacked bar charts illustrate how student preferences vary over the years and across disciplines. In 2024, 94% of Materials (MAT) students were allocated their top choice of project, up from 28.6% in 2022. Chemical Engineering (CHE) students were consistently allocated to their top-ranked projects. Civil Engineering (CIV) students maintained steady allocation to their top two preferences. Electrical and Computer Engineering (ECE) students showed more varied allocations, with a broader range of rankings being offered. Mechanical

Engineering (MEC) students, with the largest cohort of 303 in 2024, exhibited allocations from their first through to their seventh preference, indicating students were either preferencing very popular projects (Winder 2023) or there are not enough projects available. This is out of scope of this paper and is recommended for future analysis.

Bridging Disciplines: Supervision Trends

Heatmaps show yearly variations in student project choices, highlighting patterns and changes in preferences.

Figure 5: Heat Maps of Student Supervision by Department (2022-2024): Visualising the distribution of student supervision across different departments, highlighting shifts in supervision trends.

The data in Figure 5 reveals a growing diversity in student supervision, with an increasing range of specialisations being supervised across departments from 2022 to 2024. Initially, supervision was predominantly within each department's own specialisation, but by 2023 and 2024, there is a notable shift towards a more varied mix. Departments such as MEC and ECE have maintained relatively consistent supervision of their respective specialisations, while CIV and CHE display stable supervisory patterns with minor fluctuations. Departments like MAT and CHE, although involved, displayed more modest and unchanging supervision numbers.

FYP Team Diversity Mix: Supervisor Spice and Yearly Slice

PCA enables us to reduce the dimensionality of our data, uncovering the most influential factors driving student project selections. The scatterplot representation helps us to examine the relationships between different variables, such as project topics and departmental supervision, offering a clearer picture of underlying trends.

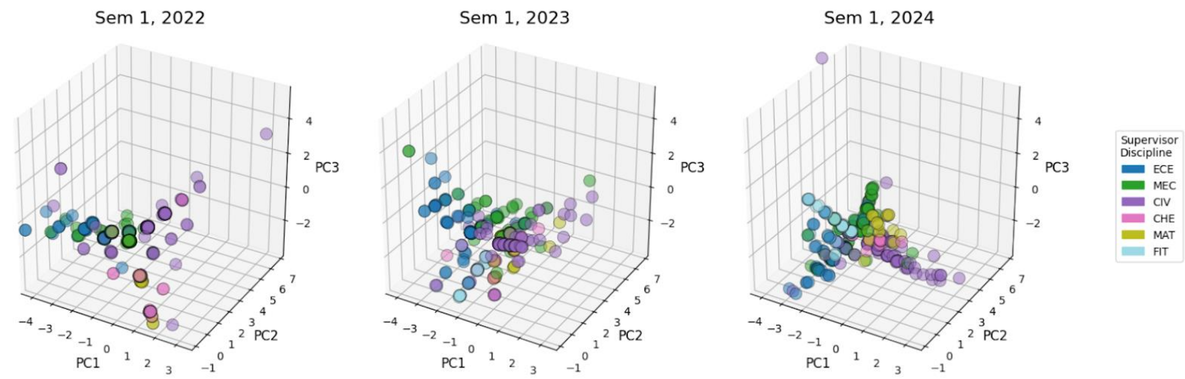

Figure 6: Side-by-Side Dot Plots of Principal Component Analysis (PCA) Results for FYP Student Teams (Years 2022-2024): Each data point on the dot plot represents a team of students working on their final year projects. The colours show which department their supervisor comes from, helping to highlight any groups or patterns in how the teams are spread out over the different years.

An initial visual inspection of the PCA plots in Figure 6 reveals a clear trend in team composition variance across disciplines since 2022. In 2022, distinct clusters of teams are associated with specific supervising departments, such as Civil, Mechanical, Electrical, and, to a lesser extent, Materials and Chemical Engineering. Over the years, the allocation process has somewhat blurred these distinctions, leading to less defined specialisation clusters. This shift suggests an increase in student specialisation diversity amongst FYP teams.

Table 2 : Brief overview of interpretations of PC1, PC2 and PC3, which represent the prominent primary, secondary, and tertiary patterns of specialisation distribution in FYP teams. Note that high values (H) show strong presence of a specialisation, while low (L) indicates strong absence. Further data available in Table 2.

	Sem 1, 2022	Sem 1, 2023	Sem 1, 2024
PC1	Civil **(H)**, Chemical **(H)**; Mechatronics **(L)**	Civil **(H)**; Electrical **(L)**, Mechatronics **(L)**	Civil **(H)**, Environmental **(H)**; Nil **(L)**
PC2	Civil **(H)**, Mechanical **(H)**, Aerospace **(H)**; Mechatronics **(L)**	Mechanical **(H)**, Aerospace **(H)**; Software **(L)**	Mechanical **(H)**, Aerospace **(H)**; Software **(L)**
PC3	Civil **(H)**, Electrical **(H)**; Chemical **(L)**, Mechanical **(L)**	Mechatronics **(H)**; Software **(L)**, Chemical **(L)**	Software **(H)**, Mining & Renew. Energy **(H)**; Mechatronics **(L)**

The PCA results from 2022 to 2024 reveal interesting patterns about team composition and specialisation distribution. In 2022, the first principal component (PC1) showed a strong positive correlation with Civil Engineering (0.4) and a significant negative correlation with Robotics/Mechatronics (-0.5), suggesting that teams with more civil engineers tended to have fewer robotics engineers. By 2023, PC1 shifted to highlight Civil Engineering (0.5) and a notable negative correlation with Electrical and Computer Systems Engineering (-0.5), indicating a distinct separation between these fields. In 2024, PC1 continued to emphasise Civil Engineering (0.6) and a moderate negative association with Mechanical Engineering (-0.2), reflecting a consistent trend in team diversity. Across years, PC2 consistently shows a positive relationship with Mechanical Engineering and Environmental Engineering, revealing a tendency for teams to be more diverse when including these specialisations. Overall, these patterns highlight evolving trends in team compositions and specialisation concentrations, with Civil Engineering remaining a central component across years. For more detailed reporting of the PCA results, please refer to Table 3.

Table 3: Highlighted values indicate student specialisations that had strong positive (cyan) or strong negative (orange) contributions to the FYP team compositions, reflecting high or low representations, respectively. Values close to zero are not considered significant contributors.

PCA Vect	Civil	Chem	Mech	Elect & Comp Sys	Mtrx	Software	Environ	Mining & Renew Energy	MSE	Aero-space	Biomed
2022											
PC1	0.4	0.4	-0.3	-0.3	-0.5	0.0	0.3	-0.1	0.2	-0.3	0.0
PC2	0.4	-0.3	0.5	-0.3	-0.4	0.0	-0.2	-0.1	-0.2	0.4	0.0
PC3	0.6	-0.5	-0.4	0.4	0.1	0.0	0.1	-0.1	-0.3	-0.2	0.0
2023											
PC1	0.5	0.0	0.1	-0.5	-0.5	-0.1	0.3	0.3	0.2	-0.1	0.0
PC2	-0.3	0.0	0.6	-0.2	0.1	-0.4	0.0	0.0	0.2	0.5	0.0
PC3	0.3	-0.4	0.1	0.3	0.4	-0.5	0.2	0.3	-0.2	-0.2	0.0
2024											
PC1	0.6	0.3	-0.2	-0.3	-0.3	-0.2	0.5	-0.1	0.1	-0.2	0.1
PC2	0.0	0.0	0.7	-0.2	-0.3	-0.5	0.0	0.0	0.1	0.4	0.2
PC3	-0.2	0.1	0.1	-0.4	-0.4	0.6	-0.1	0.4	0.2	-0.1	0.1

Conclusion

The two-round allocation process, which particular affects the Semester 1 round of FYP allocations, has been effective in managing larger cohorts and ensuring that students are assigned projects that fit their interests and needs. Over the years, the changes to the project allocation process over the years have provided observable and quantifiable improvements to the number of members in team projects, diversity of teams and the fairness in being allocated to highly preference projects. We expect the project allocation process to continue evolving to streamline the process and benefit the students and supervisors involved. Further work in alignment with the UN's Sustainability Goals of inclusive and equitable quality education, reduce inequalities, and strong institutions should continue to influence us as we work to improve our processes.

In efforts to achieve more even representation of all engineering specialisations in teams on interdisciplinary projects, we recommend adjusting the algorithm to promote balanced distribution. Additionally, integrating diversity metrics can encourage a mix of specialisations within teams, aiming for a diverse range of skills and balanced student representation. This approach will enhance the learning experience and better prepare students for their future careers as T-shaped engineers.

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Generative AI was used to gain feedback on writing tone and clarity during final edits (ChatGPT). These outputs were considered, and some were adapted by the author; no direct substitutions of AI generated text were made.

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