

CAN I WORK WITH YOU? THE IMPACT OF GROUP ALLOCATION CONSTRAINTS AND THE OPPORTUNITY FOR STUDENTS TO WORK WITH ONE ANOTHER

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ABSTRACT

Engineering and Product Design units typically present one of the few opportunities for students to work with one another to design solutions to real-world problems. As a student in a cohort, you may want and/or feel you should have an equal opportunity to work with any other member in your cohort. However, there is increasing pressure to identify ‘optimal’ group allocations brought about by student preferences, engagement and the need to meet institutional policies such as no lone gender/home/overseas working. These are diametrically opposed and to understand the compromise that needs to be made, this paper reports a numerical study into the effects of constraints on group composition and the resulting opportunity for individual students within a cohort to work together. The results identify the significance of the compromise that needs to be made and highlights the need for more detailed and comprehensive of different combinations of constraints is required to understand their effect on the opportunity space.

Keywords: Group allocation, protected characteristics, constraints

1 INTRODUCTION

Engineering and product design education necessitates group activity as it is rarely the case that a design project for a complex problem is conducted in isolation. The also present one of the few opportunities' students will have throughout their degree programmes to work with one another. While their delivery is resource-intensive, they provide key contributions to the development of employability skills in graduates, such as teamwork, communication, planning, and decision-making [1, 2].

Group activities are also essential for the development of project management skills, such as the identification and distribution of tasks, design data management, negotiation and persuasion, conflict resolution and empathy with team members. It also engages the students in 360-degree constructive feedback methodologies and the need to work effectively as a team to deliver on a project's goals to achieve academic excellence over and beyond that of their personal academic excellence. Group activities also enable peer-to-peer learning that can complement the learning from the academics running the exercise [3]. The Accreditation of Higher Education Programmes (AHEP) framework set by the Engineering Council in the UK features specific Intended Learning Outcomes (ILOs) on Engineering and Project Management, Teamwork and Communication.

To conduct an activity, design educators must allocate students to groups. While seemingly trivial, group allocation remains a topic that dominates the start of many group activities. A default strategy an educating might take would be to simply select at random thereby providing everyone an equal opportunity to work with one another. However, students can be sensitive to personal characteristics, work ethic, academic capability, and social cliques that may drive their feelings on the suitability of the group allocation [4]. And institutional policies may require certain criteria to be satisfied such as a no-lone gender in a group.

The problem can be regarded as a constraint satisfaction problem where design educators must decide on a method that can satisfy known constraints while acknowledging unknown unknowns exist that might lead to one or more student's being dissatisfied with their allocation. Further, there can exist times where the Intended Learning Outcomes (ILOs) of a course may be in conflict with the constraints that individual students may want satisfied resulting in what colloquially might be termed a ‘no win’ scenario. This is where the students may be dissatisfied with a process that might prove to be more

beneficial to their learning and development in the long-term. In these situations, design educators need to provide clear justification and rationale for the allocation process, so students are on-boarded from the beginning.

With the context set, this paper contributes a study into the compromises that need to be made between ensuring fair opportunity for students to work with another while adhering to increasing number of constraints and large cohort sizes. This was achieved through the development of a numerical model that evaluated random selection against a constraint-based solver of no lone A/B working in a group constraint.

2 RELATED WORKS

There are an increasing number of considerations, strategies and metrics that design educators can deploy in making evidence-based decisions on their group allocation strategy. This section summarises some of the considerations and methods that design educators may consider when allocating groups.

[4] surveyed 165 first-year university students revealed that a major concern for cohorts with 1st and 2nd language English speakers was that the group work was assessed as a group rather than individually.

[5] studied the effects of five group allocation strategies based on grades and programmes of study. They found that groups allocated on grades and programmes of study performed better than self-selected groups. Self-selected groups resulted in poorer attitudes to the course, educators and their colleagues.

[6] used feedback from students on the engagement and contributions of their colleagues and used this to allocate students in subsequent projects. They proposed students with similar levels of engagement and contribution should work together. It resulted in positive feedback from the students and little change in the average scores across the unit. A positive correlation was observed from groups that engaged more with the activity.

[7] reviewed design group allocations highlighting that many students prefer self-selection as they can bring their own views on the performance of their peers to bare on the problem. The study also highlighted that many often stick with the same individuals from their very first exercises when randomly selection was used. This indicates a sense of community and comradeship was developed and that it provides the potential to work better together in future projects. [8] highlighted the importance of placing constraints on characteristics such as the 2010 Equality Act legally recognised nine protected characteristics – Age, Disability, Gender, Marriage and Civil Partnership, Pregnancy and Maternity, Race, Religion and Belief, Sex and Sexual Orientation. No-lone working policies are increasingly commonplace and [8] confirmed the benefits of individuals not feeling isolated based on these characteristics. [8] also showed that the introduction of a no-lone gender in groups within their design teaching showed marked improvement in engagement and student satisfaction.

The related work revealed there are a considerable number of objective and subjective factors that a design educator can include in their group allocation strategy, summarised in Table 1. The related work also suggested that no one technique has emerged as a dominant solution and that much of the reflection on the success of the group allocation has been on analysing changes in the distribution of marks awarded and/or student satisfaction in the group allocation strategy. Many also raise the point that if a managed group allocation process is involved and is driven by learning objectives such as inter-disciplinary and/or diverse teamworking, then the assessment should provide opportunities for groups to articulate how they achieved this so it can be assessed independently of the output. A potential gap identified by the authors is that none of the prior work reflects on how strategies influence the opportunity for any two students within a cohort to work together, which may result in unequal opportunities for student learning. We propose that this quantitative metric can provide insights into the group allocation strategies discussed in this section, and whether they are under or over constrained.

Table 1. Considerations, Strategies and Metrics for effective Group Allocation

#	Consideration	Description	Ref
1	Protected Characteristics	The 2010 Equality Act legally recognised nine protected characteristics – Age, Disability, Gender, Marriage and Civil Partnership, Pregnancy and Maternity, Race, Religion and Belief, Sex and Sexual Orientation – and our cohorts increasingly feature a diverse composition of these characteristics. In line with these characteristics, educational institutions may include policies that declare that groups should include two or more individuals of a protected characteristic. An example of this in practice is no lone gender within a group. That is to say no one female or male in a group of males or females. Rationale for such policies often relate to well-being and safeguarding.	[8, 9]

2	Academic Performance	Can be used by educators to either group similar performing students or have groups that feature a range of capabilities thereby providing students with a different learning environment and experience.	[5]
3	Academic Engagement	Can be used by educators to either group similarly engaged students or have groups that feature a range of engagement thereby providing students with a different learning environment and experience.	[6]
4	Peer Assessment	Students assess their peers that can be used to assess the ability to work with one another	[6]
5	Interests	Students provide their interests where educators can then form groups that provide the right combination of interests to complete the activity thereby avoiding conflicts in students all wanting to do the same element of the project.	
6	Programme of Study	Educators can use this to foster inter-disciplinary working practices	[5]
7	Language Proficiency	Communication can be a barrier in students being able to work together effectively. Equally overseas students often view educating in another country to improve their language skills and desire diversity in group allocation. Home students can also see this an opportunity but could also feel it may reduce productivity which they often negatively associate with achieving higher marks.	[4]
8	Resource Availability	Units have fixed resources to support groups and these need to be factored in when allocating groups. E.g., supervisors.	
#	Strategy	Description	Ref.
1	Random	This does not consider any of the considerations and typically uses a uniform distribution to allocate students to groups.	[10]
2	Self-Selection	Empowers the students to determine their own groups. Conflicts have to often be resolved by the students themselves. Students who do not mind or do not want to debate can be offered to be randomly allocated to a group	[7]
3	Constraint Satisfaction	Educators provide pro-formas that features one or more considerations for students to fill in and/or gathers the data from internal systems that is then fed into a constraint-based solver whose objective is to find the best fit group allocation.	
4	Buddy + Constraints	Combines self-selection and constraint satisfaction for a best of both approaches.	
#	Assessment Metrics	Description	Ref.
1	Student Satisfaction	Using post-unit surveys to gather student satisfaction on the reasoning and effectiveness of the group allocation strategy.	[5, 8]
2	Mark Distribution	Comparing marks following a group allocation strategy change to see the effect on the attainment.	[5]

3 STUDYING THE INTERPLAY BETWEEN OPPORTUNITY AND CONSTRAINTS

A study modelling the effect of introducing a generic no lone A-B policy on the probability of any two individuals working together within a design cohort was developed to investigate the trade-off between opportunity and constraint-based satisfaction. The no lone policy can be commonly found and could be based on a protected characteristic (e.g., gender) or any other characteristic where individuals in a cohort could identify or be characterised as either A or B.

The first step in the study was to generate a baseline for comparison. This was achieved by determining the probability of working together when individuals in a cohort are randomly allocated to groups. This was derived analytically and further validated by a numerical Monte-Carlo model.

The analytical model was derived by first considering a student from a cohort population, P , and determining the likelihood of another student being selected as part of that group. Considering a group cannot be considered a group if members are less than 2 then the likelihood of the other student being selected in the next available opportunity is:

$$p = \left(\frac{1}{P-1}\right) + \sum_{i=2}^n \left[\left(\prod_{j=1}^i \left(1 - \frac{1}{P-j}\right) \right) \left(\frac{1}{P-i}\right) \right] \quad (1)$$

where p is the probability of individuals working together, P is the cohort size and n is the group size. The numerical model created to validate the analytical model's logic used a list of integers with each integer value representing an individual. The list was then randomly shuffled and 'chunked' into the desired group sizes. The model then iterated through the groups where it checked whether individual '0' was in the same group as individual '1'. This was repeated 10,000 times to capture the probability of the two individuals working together and compared with the analytical model with least squares fit to determine whether they corroborated.

The second model introduced the concept of their being a mutually exclusive characteristic where individuals could identify as either 'A' or 'B' and that a policy existed where design educators ensured groups never contained exactly one individual with an 'A' or 'B' characteristic.

This was modelled using a function that accepted the number of 'A' and 'B' students and the desired group size. Integer IDs were then generated for the 'A' and 'B' populations, respectively,

autoincrementing to avoid ID conflicts. Two IDs from both populations were tracked as the groups were allocated.

The two populations were randomly shuffled, and individuals within the two populations were paired up to ensure the no-lone working conditions were satisfied. This also meant that the algorithm was only suitable for even sized cohorts and groups, and this was deemed satisfactory as the study was interested in the general trends across cohort sizes and distribution of individuals across the ‘A’ and ‘B’ populations.

The pairs were then combined into a single cohort list, shuffled and then allocated into groups based on their order within the shuffled list. The algorithm then checked whether the marked IDs (e., A1, A2, B1, B2) were within the same group. The algorithm then returned True or False conditions for the cases of whether A1-A2, A1-B1, and B1-B2 appeared in the same group.

A Monte-Carlo simulation was run 10,000 times for group sizes of 4 and 6 and population sizes of 60, 120 and 180 to gain insight into the probabilities of students working together. The values attained were compared to the random allocation to demonstrate the effect of introducing the policy had on the opportunity of students being able to work together.

4 RESULTS

Figure 1 presents the results from the analytical (dashed) and numerical (continuous) modelling of the random allocation of students to groups. It also shows the effect of group size and cohort size. The results show that the likelihood drops off either exponentially or by some power-law as the cohort size increases with group size translating the curve but with decreasing effect. The numerical modelling confirms the analytical model accurately captures the probability of students being able to work with one another.

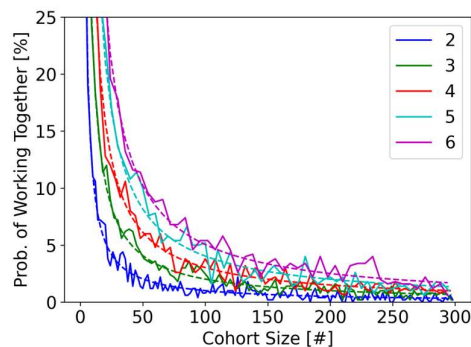


Figure 1. Probability of working with another individual across different population and group sizes

Figure 2 shows the probabilities of A and B students working together with the introduction of the no-lone working policy. All reveal the same pattern with the group size and cohort effectively translating the pattern across the probability range. When there is a population with low A then A-A becomes very likely, B-B tends to the same value as random selection and A-B is less likely than random selection. Moving to a 50-50 split of A and B makes the opportunity of A1-A2 and B1-B2 equivalent and higher than random and A1-B1 below random. A1-B1 remains constant across A-B ratios suggesting that the implemented algorithm trades A-B working for A-A and B-B working to conform to the no lone working constraint.

Increasing the group size for the same cohort population sizes increases the opportunity of individuals working together as one would expect given there emerges multiple opportunities for the individuals to be paired up. In contrast increasing the cohort size reduces the opportunity, flattens the curves around the 50-50 ratio and makes the biases more extreme where there are very low proportions of A or B (> 15%).

Figure 3 shows the same results but as a delta against the random selection value in order to quantify the difference. In the 4, 60 cases, a difference of 2% was observed between random and the opportunity of A1-B1 working together and a 2% increase in A1-A2 and B1-B2 when they are equally distributed. Much smaller differences are observed when the group and cohort sizes increase with a less than 1% difference in the 6, 180 for the majority of cases.

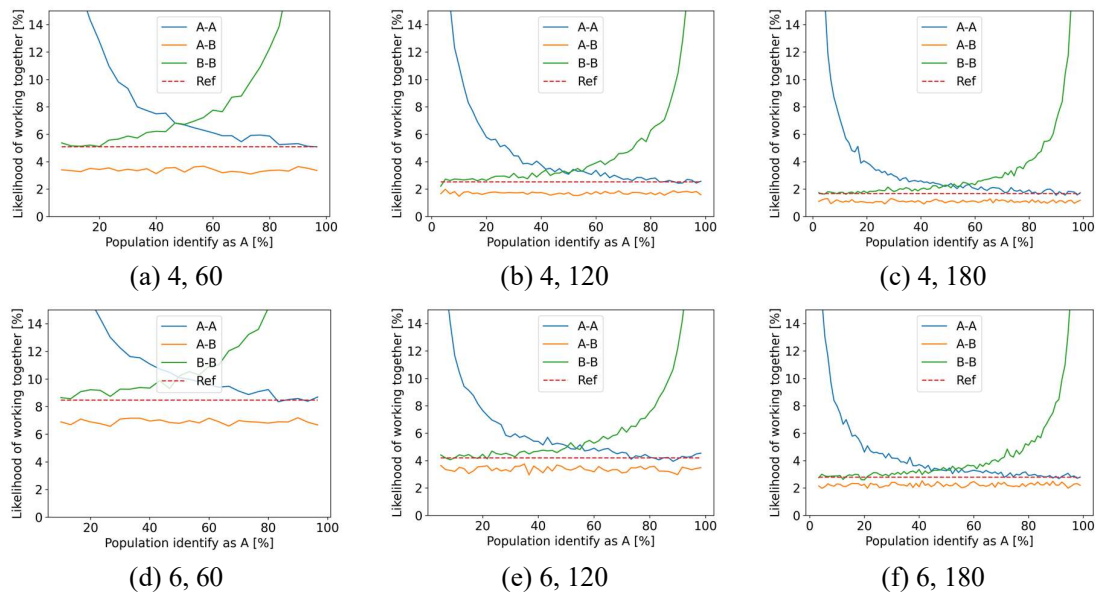


Figure 2. Opportunity for individuals working together

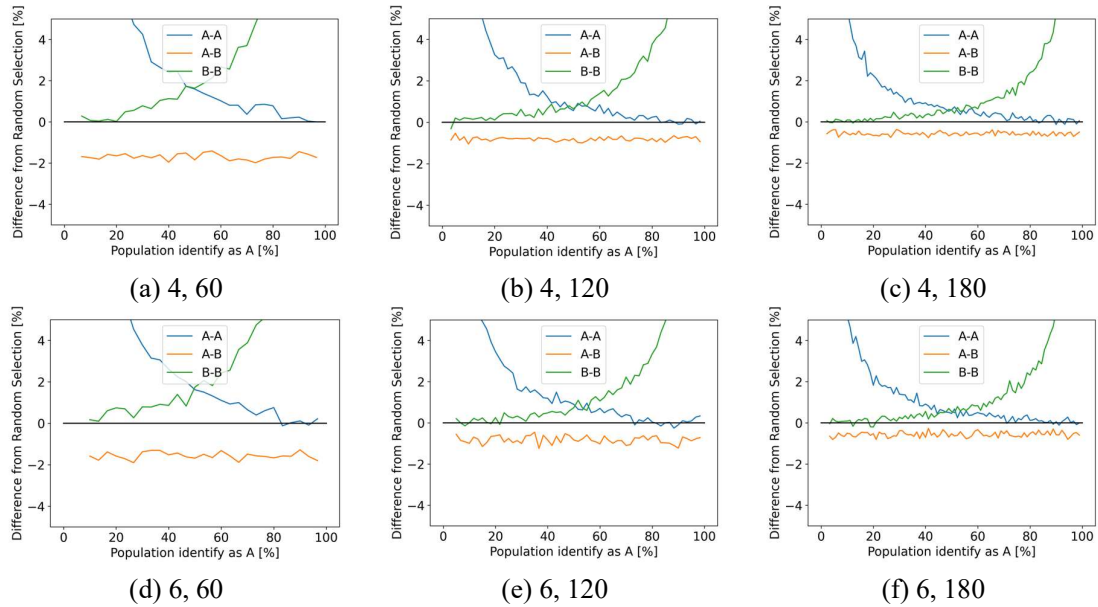


Figure 3. Difference in the opportunity for individuals to work together

5 DISCUSSIONS

The study has provided some additional metrics to complement existing work on group allocation strategies with a specific focus on how they affect the opportunity for students to work with another student within their cohort. The results have shown that constraint(s) can have a marked change on the opportunity for students to work together. The effects are more prevalent in smaller cohorts and group sizes. The study of the no lone-working constraint showed it effectively reduced the opportunity for a student to work with someone with a different characteristic. Larger cohort and group sizes are able to accommodate a greater number of constraints without significantly reducing the opportunities for any one student being able to work with another in the cohort, however this could incur other costs and complexities depending on the nature of the specific project and may not always be possible. This initial exploration into the potential effects of constraint-based group allocation has shown in a simple case that potentially significant reductions in inter-characteristic student working. As additional

constraints are added to the allocation process, it is likely that this effect will increase. Thus, it is important that this relationship is publicised to design educators, so that decisions in group allocation strategy can be made on a more informed basis.

Future work can expand this analysis to characterise the impact of multiple constraints and weighted constraints on the opportunity for any two students in a cohort to work with one another. The evidence generated from this work can accompany existing evidence on the effects of varying group allocation strategy (i.e. on safeguarding and student satisfaction) to help further inform and justify the group formation decisions made by design educators.

6 CONCLUSIONS

Group allocation is a critical step in design education where educators can configure and design the educational experience of the students. This paper has studied the effect of introducing a no-lone A-B policy for group sizes of 4 and 6, and cohort sizes of 60, 120, 180, and compared it to a random selection policy. The effects of the policy are largely felt at low cohort and group sizes with the opportunity of an A person working with a B person reduced by 2% in favour of increasing the opportunity of working with another from their respective populations. The increase followed a power-law behaviour with it increasingly significantly as their size becomes small in the relation to the cohort size. While the addition of single constraints may not shift the opportunities of students working together to a great degree, the compound effect may become profound when multiple constraints are considered and is an area of future work to be studied to ensure design educators have the information available to make further informed decisions on their group allocation strategies.

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