Team Selection Project

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Integer Programming formulation
Parameters and definitions:

- $i \in \{1,2,3,\ldots,s\}$ students - data had 75
- $j \in \{1,2,3,\ldots,p\}$ projects - data had 14
- $x_{ij} \in \{0,1\}$ - 0 if student i is not on project j, 1 if student i is on project j
- $y_{ii'j} \in \{0,1\}$ - 0 if student i and $i^{'}$ are not both on project j, 1 if student i and $i^{'}$ are both on project j
- $p_{ij} \in \{0,1,5,1000,10000\}$ - penalty for placing student i on project j, conditioned on student i's preferences
- $r_{ii'} \in \{0,100\}$ - penalty for placing student i with student $i^{'}$, when anti-preference was expressed by i against $i^{'}$ or potentially negative penalty for placing student i with student $i^{'}$, when positive preference expressed by i for $i^{'}$

Constraints:

- $l_j \leq \sum_i x_{ij} \leq u_j$ - capacity of project j; $l_j = u_j$ potentially.
- $\sum_j x_{ij} = 1$ - students assigned to only 1 capstone
- $y_{ii'j} = x_{ij} + x_{i'j} - 1$; $0 \leq y_{ii'j} \leq 1$; $y_{ii'j} \leq x_{ij}$, $y_{ii'j} \leq x_{i'j}$ - IP formulation to more clearly define $y_{ii'j}$

Objective function characterization

$$\sum_i \sum_j p_{ij} x_{ij} + \sum_i \sum_{i'} r_{ii'} y_{ii'}$$

We wish to minimize the objective function because we incur costs for "bad" choices - allocations that go against either the will of the faculty or the students involved. The ideal optimal is a cost of 0, but rarely is this achieved, if ever.

Further exploration:
With regards to allowing students a fixed budget to "bid" on their respective preferential projects, we could allow the following auction structure.
Rules:

- Initial polling is conducted to see which projects are anticipated to have most demand. Truthful reporting is potentially incentivized, or optimal.
- Students bid a total of \$100 among the projects, and are allowed to bid only on the projects they want to be a part of, commensurate with their interest.
- There could be an upper bound on bids $\frac{100}{\text{number of high demand projects}}$ to prevent people from bidding completely on a single project, and thereby force them to diversify.
- If we wanted to allow group-friendly strategic moves, we could allow "pools" of bids, but we would need to try not to disadvantage singleton bidders too much.
- If it turned out that a bidder bid on their top x project choices but landed none of them in the final allocation, they would have to be randomly placed into other projects according to other metrics, like ability/role/preferences/antipreferences. This would ensure that bidders would also bid on a variety of other less desirable projects with weights according to their bids, instead of just focusing on 2-4 projects that they really like.
- In the current setup of rating projects $\{1,2,3,4,5\}$, dollar allocations could be \$20 for 1^{st} choice projects, \$10 for 2^{nd} choice projects, \$5 for 3^{rd} choice projects, \$2 for 4^{th} choice projects, and \$1 for 5^{th} choice projects, but perhaps normalized to fill the complete budget of \$100.