Team machine – optimising teams mathematically

Conan Hom and Dr Paul Bergey on a team building tool used by universities rated in the top 50 globally

Creation of teams in an academic learning environment can be a challenge. Team Machine is a tested, twenty-first century decision-support tool that is purpose built to meet this challenge by optimising the selection of members of teams in order to meet education goals.

Background

Teams have become an important element of the workplace and classroom. The high performance of such groups is thus important to teachers and employers. Researchers have found detractors to performance may be in communication, free riding and doing it all yourself attitudes. Heterogeneity of team members can have competing effects. A diverse membership can provide a diversity of knowledge and perspectives useful for innovation and problem solving. However, a homogeneous membership may have less intra-group conflict.

In the classroom, the student project team is becoming more utilised as a learning method. Perhaps unlike the business world, however, assigning members to teams so that the teams are fair and balanced is often, if not always, critical. Thus, the objective is to assign members to teams in such a way that the learning objectives are accomplished with teams that are similar to each other (in performance potential) but where the membership within each team reflects the diversity of the student body.

The Team Machine Model

Team Machine is based upon the bin-packing approach which seeks to put *n* items (students) with individual "weights" into *k* bins (teams) so that each bin has the same totals in weights and number of items. The "weight" is a vector of attributes (e.g., undergraduate grade point average, work experience, GMAT score, or ethnic background) representing a student's academic performance potential and demographics. To favour balanced teams, the student assignments are chosen to minimise the squared deviation of the average student potential in a team to the average student potential of the student population. Slight adjustments may be made if the attributes include categorical items such as gender or personality type. The importance of the attributes can also be weighted.

The Team Machine Tool

Team Machine has been operationalised as a Microsoft Excel add-in application. Its graphical user interface and spreadsheet layout are designed to allow the novice user to utilise, with ease, the functions and features of Team Machine – even though the underlying functionalities are mathematically complex. Once relevant data is selected (from spreadsheets), Team Machine automatically computes the necessary equations to utilise the bin-packing approach. The user may also modify the model and make adjustments based upon their own judgment.

In attempting to make the optimal selection of members for each team, the Team Machine can employ several algorithms such as the People Sequential Heuristic (PSH) – a sorting approach for one or two criteria; the greedy randomised adaptive search procedure (GRASP) for more than two criteria; and the genetic algorithms (GA) where elements of potential solutions are exchanged with elements of other potential solutions or are 'mutated' (randomly altered) to eventually arrive at a solution through a 'natural selection' process, based upon a mathematical objective function GA uses GRASP results as a starting point while GRASP, in turn, uses PSH results as a starting point. Computing power and time may be factors to consider in selecting algorithms. PSH is simple and fast, while GA, generally the best of the three, requires the most computing power and time.

TM in the field and testing

From the Fall of 2004 through 2012, TM was exclusively used to form teams for incoming classes of the Master of Business Administration (MBA) program at a large US university with positive effects upon students, administrators and faculty.

In addition, team selection by TM was compared to team selection by a team research subject matter expert. Given TM's superior processing capability, it was hypothesised that TM would be better at creating optimally balanced teams. The performance of the teams for three pre-TM entering MBA classes, where the teams were chosen by a subject matter expert, was compared to the performance of the TM-selected teams for three entering MBA classes. Performance data was based upon team assignments from eight core subjects. The

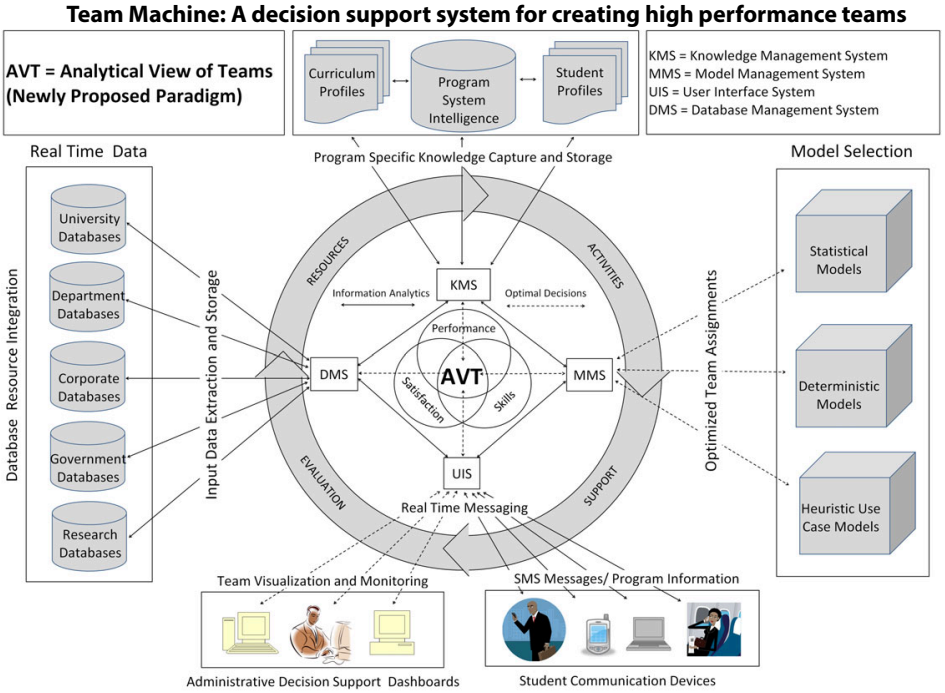
results of a two sample *t*-test indicated that the higher mean score of the TM selected teams was statistically significant ($p \leq 0.5$). To determine if grade inflation was a factor, the overall GPA of the students in the pre-TM and post-TM classes were compared. The research showed that there were no significant effects related to grade inflation. In the classes where TM was applied, there were favorable student comments, both solicited and unsolicited, about the team selection process and team experience.

The results above demonstrated that computer assisted mathematical modeling, more specifically TM, delivers benefits to both students and the school. For the students, team performance increased and qualitative feedback suggested that the student experience improved. As manual team selection is time intensive, there was significant time savings for the faculty and staff members responsible for team selection. TM also allowed for more factors to be considered than what was done by a subject matter expert.

TM is not a decision maker but a decision support tool. To arrive at a satisfactory result, human judgment is still needed to determine the factors to consider and their relative importance. These determinations are often done through an iterative process that involves evaluating each run of TM and understanding trade-offs that occur when focusing on improving the results in a particular dimension.

While Team Machine has been tested and utilised at the tertiary (primarily MBA) education level, its ability to accept different factors means it may have the potential to be adapted to other educational settings. For instance, for team formation at the primary or secondary school level, TM could utilise factors such as gender, age, academic performance scores and/or socio-economic indicators. TM also offers the potential to further research in teams, such as to develop a better understanding of what factors are the strongest indicators of team effectiveness.

Team Machine: A decision support system for creating high performance teams



To obtain a copy of TM, interested users may contact Dr Paul K Bergey at: pkbergey@gmail.com.

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Tailored tool helps maths students leap years ahead

While 42 per cent of Australia's 15-year-olds are not proficient in maths according to international standards, and the difference in ability in any one class may be up to eight year levels, there are solutions for teachers and students, according to the Australian Learning Lecture (ALL) which is run from the State Library Victoria and seeks to bring big ideas in education to national attention.

ALL's latest case study, *Maths Pathway*, showcases a personalised maths teaching program developed by two Teach For Australia Associates, which is helping students at Bacchus Marsh College to achieve significant growth in their maths skills.

"Our students are coming into Year 7 with a wide range of maths ability – from Grade 2 to Year 8 level," says Samantha Goodman, Teaching and Learning Leading Teacher at Bacchus Marsh College.

"Ideally we'd be looking at a growth rate of 100 per cent – which is one grade level's growth over a calendar year, but our students often perform above that now. Many of them are performing at an average of 160 per cent to 200 per cent."

This ALL case study shows how student data is used to personalise teaching and target

Samantha Goodman, Teaching and Learning Leading Teacher at Bacchus Marsh College

students' needs, while enabling students to track their own growth.

While an average Australian student learning from the textbook will grow 0.6 maths grade levels each year, the average growth for a student using Maths Pathway is 1.2 grade levels.

"At the start of the program the students do a diagnostic assessment to identify their strengths and weaknesses. The program then allocates worksheets based on their weaknesses, in order to build up those foundation skills before we add on higher level tasks," Goodman said.

"Teachers use the Maths Pathway data to set individual classwork at the 'Goldilocks zone of learning' – not too hard, not too easy – just right. "I might have one student learning about place value, one on algebra, one on something else because that's what they're ready for. Our teachers love the data provided by Maths Pathway because they can identify issues and work with small groups more effectively."

Maths Pathway co-founder Justin Matthys explains that the key focus of the program is the amount of growth that students display, not whether they're at a particular point at a particular time in the year.

"What we care about is not how much work the student has done, it's about how much new maths have they learned. Students who were learning nothing are now learning something, and a lot of them are learning an awful lot."

Maths Pathway got going in July 2013 when the two founders quit their teaching jobs, after 18 months of preliminary work, and set up in a shed. The first schools signed on that September, including Emerald Secondary College and Lavalla Catholic College in Traralgon. According to the Maths Pathway website, 109 schools, 912 teachers and more than 22,000 students are now using the system.

www.mathspathway.com