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## The University of Greenwich Maths Arcade

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### Stretch and Support

I had been exercised for some time about how to stretch our most able students and those who have more prior mathematical knowledge, whilst at the same time support those with weaker backgrounds or who take a little longer to grasp the mathematical concepts we teach. When the opportunity came to put in a bid for University funding I devised a project designed to address these two ambitions.

The objectives included providing a weekly drop-in session where students could play various strategy board games and puzzles designed to hone and develop strategic thinking, alongside providing a safe place for them to obtain help on tutorial work. Having read John Mason et al's book on Mathematical Thinking for a review in Connections [1] I was aware that the ability to strategize does not always come easily to our students. Interestingly, and perhaps unexpectedly given the nature of the subject, the 2011 National Student Survey shows that mathematics students do not consider themselves to be good at problem solving [2]. Problem solving is one of the key employability attributes that we tell our students they will develop on a maths degree, so anything that can be done to aid and increase this is well worth doing.

The proposal was presented with the help of two, then second year, students to a University 'Dragons' Den' style panel. The panel were slightly sceptical but were won over, in part, by the students' enthusiasm and dramatic skills.

The project began in September 2010. Having researched a number of strategy games and puzzles a wide-ranging selection was assembled and leaflets were produced to advertise the "Maths Arcade". An initial lecture on "How to Think Mathematically" [3] grabbed the attention of new year students and helped to draw the first students in. Attendance over two terms was fairly constant with about 25-30 attending each week. This included a core group of about 15 who came most weeks, with others coming less regularly on different occasions.

### Which Games?

The intention was not to start another Chess Club but rather to increase interaction between students and to get them talking about the games and the strategies involved rather than just enjoying playing competitively. There are a number of quite unusual board games on the market. One of the students' favourites so far is "Quarto" which contains playing pieces with four different attributes:



Fig 1 – Students playing Quarto at Maths Arcade

- Size – Tall and Short
- Colour – Light and Dark
- Fill – Hollow and Solid
- Shape – Round and Square

The aim is to be the player to complete a row of four containing the same attribute, for example four tall pieces regardless of colour, shape etc. What makes this game harder is that you do not choose which piece to play but your opponent chooses your piece for you. So a winning strategy might be to try to engineer a situation where your opponent is only left with pieces that give you a win. This is easier said than done as it is hard to keep track of all the different possibilities that might produce a win. No two games are the same and there are numerous ways that the students can investigate winning strategies.

### Benefits to students

The benefits to the students were more varied than I had imagined. The weekly puzzle and board games stretched the most able but also provided new students who did not initially know each other with an occasion to socialise and mingle with their peers in an unthreatening situation. Maths students are often socially shy and this gave them an opportunity to form friendships in a safe environment. In particular students liked the opportunity to spend time and play these games with staff outside the classroom

environment and beat them! A recent report by the HEA [4] says that “interacting with staff has been shown to have a powerful impact on learning, especially when it takes place outside of the classroom and responds to individual student needs.”

Many students also made use of the tutorial help that was offered at the same time. They appreciated the fact that a number of staff were on hand to answer student queries and to set them in the right direction. Those who made use of this were often the students that would not have visited something branded as a “help session” because they do not like to acknowledge, even to themselves, that they are having difficulties with the material. Staff benefitted from being able to get to know a number of students in a relaxed and informal setting.

### Student Feedback

As part of the Personal Development Planning, first year students were asked to write about a maths event in which they had participated and this could include the Maths Arcade. About two thirds of the cohort chose to comment on this. The only negative comments received were that one hour was not enough and it might be better after lectures rather than before. Positive comments included:

*“I like to go to the Maths Arcade because all of my tutors attend it”*

*"The people who were once strangers to me when I first started [attending the Maths Arcade] are now some of my closest friends."*

*"I felt somewhat dubious about the word 'enjoyable' being used but I'm glad to say I was quickly proved wrong."*

*"[It is] a really good way to meet people and get to know the lecturers in a more informal environment."*

*"Attending Maths Arcade has been a major help for me this year and a huge factor in me having such successful and enjoyable studies."*

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## Evaluation

The Maths Arcade has been particularly successful in attracting a large cross-section of maths students. Other extra-curricular activities such as the Maths Society have tended to interest a particular type of student whereas this appealed to students of all backgrounds and mathematical ability. The most rewarding aspect of the Maths Arcade is that our retention and progression rates, though always being good, were noticeably higher last year, which was appreciated by department and University senior management. Of course there are many other contributing factors but it is believed that the Maths Arcade played a substantial part in this.

## National HE STEM Programme Support

Partway through last year the Maths Arcade obtained support from the National HE STEM Programme to extend and increase the provision. This has allowed us to run staff training sessions, purchase more games and extend our opening times to 3 hours per week instead of 1. This support has also enabled us to share our positive experiences with the University's School of Engineering.

During the first year the focus of the Maths Arcade was on social interaction. One extension that is being made this year is to encourage the students more explicitly to analyse these games mathematically. They could work out whether the person who moves first is more likely to win, examine how to force a winning position, see what happens when the rules are modified slightly, and even design their own

strategy games. We also have some excellent computer programmers attending these sessions who are being encouraged to programme these games.

A report on the extension of the Maths Arcade will be presented at the end of the project in May.

## Maths Arcades Elsewhere

The concept of a Maths Arcade was presented at Peter Rowlett's Ideas Exchange last May (see page 52). A number of people present were interested in running a similar provision. By the time you read this, National HE STEM Programme support will have been provided to set up Maths Arcades at several other universities. Training sessions and follow-up support will be provided to these Arcades.

## Conclusions

This idea came about because of a perceived need to simultaneously stretch and support maths students. It involved taking a risk and trying something new and untested. Over the last twelve months we have adapted our provision in regard to student feedback and have had to make changes due to University and other constraints. This project has succeeded in ways that had not been foreseen and appears to have made a real difference to student engagement, retention and achievement which demonstrates the value of trying speculative ideas. I would encourage you to try a new idea. It may not work but it just might end up benefitting students and staff in many institutions.

## References

1. Bradshaw, N. (2010). Thinking Mathematically (book review). *MSOR Connections*, 10(3), pp. 49-50.
2. Hewson, P. (2011). Preliminary Analysis of the National Student Survey. *MSOR Connections*, 11(1), pp. 25-28.
3. Mason, J. et al (2010). *Thinking Mathematically* (2<sup>nd</sup> edition). London: Pearson Education.
4. Trowler, V. and Trowler, P. (2010). *Student Engagement Evidence Summary*. York: Higher Education Academy.

## Appendix: List of games and puzzles

This list is an indication of the games available at the Maths Arcade. We tried to get a number of games that would be suitable for a group of students to play. We obtained some word games for students whose first language is not English. This list is not a definitive list as it was bought under constraints of time, money and University procurement policy. I would welcome suggestions for other items.

The classic games Backgammon, Chess, Draughts, Go, Reversi (Othello), as well as playing cards are also available at the Arcade but aren't included in the list opposite.

<b>Abalone</b>	2 player strategy game. The objective is to push six of the opponent's fourteen marbles off the edge of the hexagonal board following a set of simple rules.
<b>Bananagrams</b>	2-8 player word game. Using lettered tiles to spell words.
<b>Blokus 3D/ Blockus Giant/ Blockus Trigon</b>	2-4 player strategy game. Involves placing polyomino-based tiles onto a board to capture available space. Giant version is great for several students to play and watch.
<b>Chaos</b>	2 player strategy game. Involves stacking counters. Excellent but hard to learn.
<b>Gambit</b>	2 player strategy game. Involves sliding rows of coloured tiles.
<b>Gobblet</b>	2 player strategy game. Placing or moving already placed pieces, including larger pieces covering smaller ones, to make a row of four on a 4x4 grid.
<b>Gygès</b>	2 player strategy game. The object of the game is to move a piece to your opponent's last row. The catch is, no one owns the pieces.
<b>Ingenious</b>	1-4 player strategy game. Placing tiles on a board with a clever scoring system. Good for strategy
<b>Joggle</b>	2 player strategy game. Dice-based placement of marbles on a board. First to build a 6 marble rectangle wins.
<b>Pentago</b>	2 player strategy game. Placing coloured marbles on a 6x6 board, the quadrants of which can be rotated, to form five in a row.
<b>Pylos</b>	2 player strategy game. Placing marbles to form a pyramid according to simple rules. Whoever places the top marble wins.
<b>Q-bitz</b>	2-4 player game. Three rounds based on speed, chance and memory. Arranging cubes to make different patterns.
<b>Quarto</b>	Best game we bought! Described and pictured in the article.
<b>Quirky</b>	2-3 player strategy game. Uses coloured tokens to build equilateral triangles.
<b>Quixo</b>	2-4 player strategy game. Adding and shifting tokens to form five in a row.
<b>Quorridor</b>	2-4 player strategy game. Each player aims to move a pawn to the other side of the board but can place walls to obstruct their opponent. Good for programmers
<b>Rubik's cube/ Hollow cube/ Sudoku cube</b>	The classic puzzle and variants
<b>Rubik's 360</b>	Puzzle. Involves changing the position of six coloured balls in a central sphere to six coloured compartments in an outer sphere, by maneuvering them through a middle sphere that only has two holes.
<b>Rubik's magic</b>	Puzzle. Folding connected tiles to form a pattern.
<b>Rumis</b>	2-4 player strategy game. Involves placing blocks onto a board as part of a 3D structure to capture available space.
<b>Rush Hour</b>	1 or more player strategy game. The objective is to move a red car out of a six-by-six grid by moving the other vehicles out of its way.
<b>Solomon's stones</b>	2 player strategy game. A variant on Nim's game. Excellent for encouraging thinking and strategy and possibly not too difficult for the more able to program.
<b>Sprocket</b>	2-4 player strategy game. Using rotor pieces to create gears and lugs.
<b>Square up</b>	Like Sam Loyd's 15-puzzle. We have developed a program in Excel that produces a random 5x5 grid as the provided 4x4 is too easy. This now means that we can have 6 people play together with the program.
<b>Stratum</b>	2-4 player strategy game. Trying to cover the opponents' pieces by placing tiles.
<b>Sudoku cards</b>	2-5 player strategy game. Involves placing numbered cards according to sudoku rules.
<b>Tantrix</b>	1-4 player strategy game. Hexagonal tile-based placement. Good but hard to teach complexities of rules
<b>Tower of Hanoi</b>	The classic puzzle