

Maths Arcade: stretching and supporting mathematical thinking

Mathematical Sciences HE Curriculum Innovation Project

Edited by Noel-Ann Bradshaw and Peter Rowlett



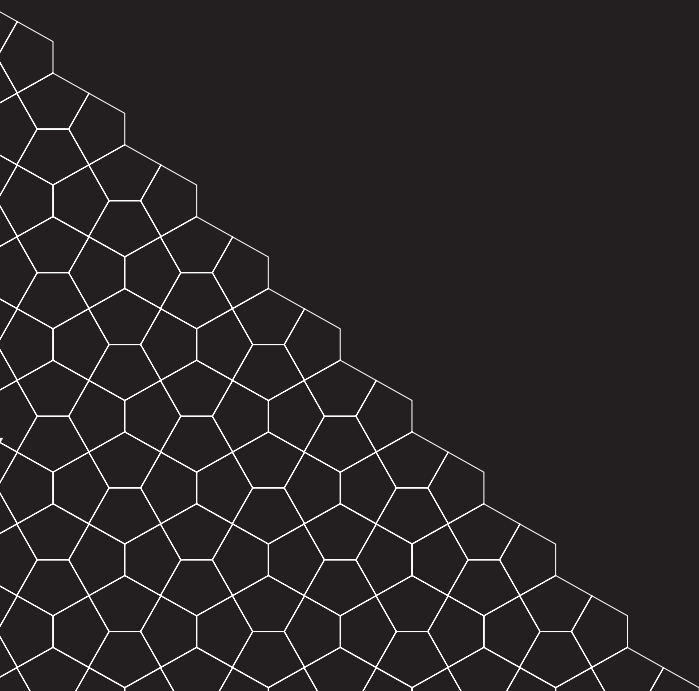
Maths, Stats
& OR Network



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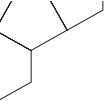
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University of Greenwich and MSOR
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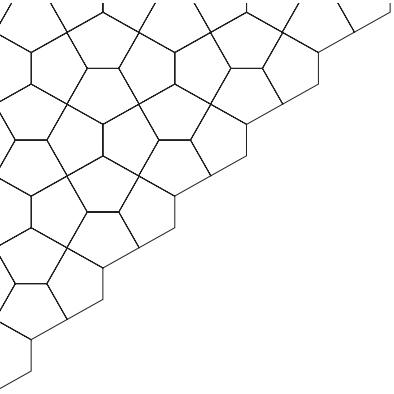
“The link between maths and board games is probably more that the games can give you insights into the mathematics, rather than maths giving you insight into games. I mean, the maths does give you some insight into games but it’s almost the other way round. By playing various games and analysing them mathematically you actually get more understanding of the maths. So you can learn a lot about logic just by analysing the whole structure of what is a strategy, for example, let alone what is a good strategy.”

Professor Ian Stewart FRS, interviewed on *Math/Maths Podcast*, www.pulse-project.org, 18 June 2012 (22:20).



Contents

Introduction	7
University of Greenwich – the original ‘Maths Arcade’	11
University of Manchester ‘Maths Arcade’ – Including postgraduates, outreach and iPad apps	15
University of Salford ‘Maths Arcade’ – As a project activity	17
Sheffield Hallam University ‘Maths Arcade’ – Feedback on a trial and plans to include in peer assisted learning	19
Photos of the Maths Arcades in action	20
University of Leicester ‘Maths Arcade’ – Student maths society involvement and plans for a competition	23
University of Bath ‘MASH Café’ – Cross-disciplinary peer support and problem solving	25
University of Nottingham ‘Puzzled’ sessions – Enhancing drop-in support, open days and community outreach	27
Keele University ‘Maths Arcade’ – Plan of action for Mathematics Society involvement	29
Maths Arcade start-up guide	31
Appendix – List of games, puzzles and other resources	35



Introduction

The Maths Arcade is an innovative activity which aims to simultaneously support struggling learners, stretch more confident learners and encourage the development of a staff-student mathematical community.

This booklet contains details of the original Maths Arcade at Greenwich, established in 2010/11, including some discussion of the advantages of running an Arcade. Case studies from seven other Maths Arcades established in 2011/12 are presented: Manchester; Salford; Sheffield Hallam; Leicester; Bath; Nottingham; and, Keele. Authors were asked to focus on where their Maths Arcade differs from the others, in order that a range of approaches are presented. Also provided are some notes from the experience of setting up the original Maths Arcade at Greenwich in the form of a 'start-up guide' which raises some questions you may like to think about when setting up your own Arcade, and a list of games and other resources used.

The core aims for a Maths Arcade are:

- a) to help support struggling learners;
- b) to stretch more confident learners; and,
- c) to encourage staff and student interaction in a social and mathematical context.

In general, these aims are achieved through a drop in session where a wide variety of strategy games and puzzles are available for students to play with each other and with staff. Staff members present are also able to offer tutorial support. The Maths Arcade can be used as a place for peer mentors to meet their mentees, if such a scheme exists. Games and puzzles might be simply played, to develop a mathematical-themed social environment, or strategies and modifications to the rules might be analysed, to develop students' mathematical thinking.

Beyond this, each Maths Arcade has a slightly different implementation adapted to suit local circumstances and most have included additional aims and objectives in addition to the core set. Some examples are given below; further details are in the case studies.

Competitions: The case studies from Greenwich, Leicester and Sheffield Hallam all discuss the use of competitions around the Maths Arcade. Greenwich used a weekly puzzle as part of a termly competition. Leicester plans to run a games event where groups of students compete against each other in playing the Maths Arcade games. Sheffield Hallam used the Arcade to launch a speed Rubik's Cube competition.

Use in curriculum activities: The games, and particularly their analysis, could be used to develop project activities in an appropriate module on game theory, OR or computer programming. The case study from Salford describes the analysis of games as part of a formal student project.

Cross-disciplinary activities: The case studies at Bath, Greenwich and Nottingham used the Maths Arcade to develop activities with other disciplines. At Bath this was a shared, cross-disciplinary session encouraging students from different disciplines to collaborate on analysing the games and develop cross-discipline peer support groups. Greenwich and Nottingham worked to encourage schools of engineering to run their own Maths Arcade sessions.

The original Maths Arcade was set up by Noel-Ann Bradshaw at the University of Greenwich in September 2010. This was funded initially by a University grant for innovative teaching and later by the Maths, Stats and OR (MSOR) Network. As a result of dissemination of the Greenwich Maths Arcade via events at Greenwich [1], Birmingham [2] and Exeter [3], other Arcades have been started elsewhere with and without support from the MSOR Network. In 2011/12 the MSOR Network started a coordination project to provide a focus for training

and collaboration between Maths Arcades and to produce this booklet giving case studies of different implementations.

The Maths Arcades at Salford, Sheffield Hallam, Leicester and Keele had their games and puzzles (but no funding for, for example, staff time) provided by the MSOR Network. The Maths Arcades at Greenwich and Manchester received support from their own universities, augmented with partial support from the MSOR Network. The MASH Café at Bath was supported by the National HE STEM Programme South West Spoke, augmented with partial support from the MSOR Network. The Maths Arcade at Nottingham was wholly financed by an internal university grant. All eight Maths Arcades benefitted from meetings, training and coordination provided by the MSOR Network. The MSOR Network support for the Maths Arcade was provided as part of the National HE STEM Programme.

The concept of the Maths Arcade has also been rolled out to some schools and non-mathematics faculties such as business and engineering (more details can be found in this booklet and other publications [4] [5] [6]).

This guide presents ideas for different ways that universities have implemented the Maths Arcade concept. This is a concept which does a lot of good simultaneously and is fairly adaptable to different needs. It is not expensive to set up. A page supporting the Maths Arcade user community will be maintained on the Institute of Mathematics and its Applications website via www.ima.org.uk/viewItem.cfm?cit_id=384191. We hope that this community will continue to grow as others are inspired by this booklet to try their own Maths Arcade activities. If you do so, please get in touch (N.Bradshaw@gre.ac.uk) to connect to the wider community.

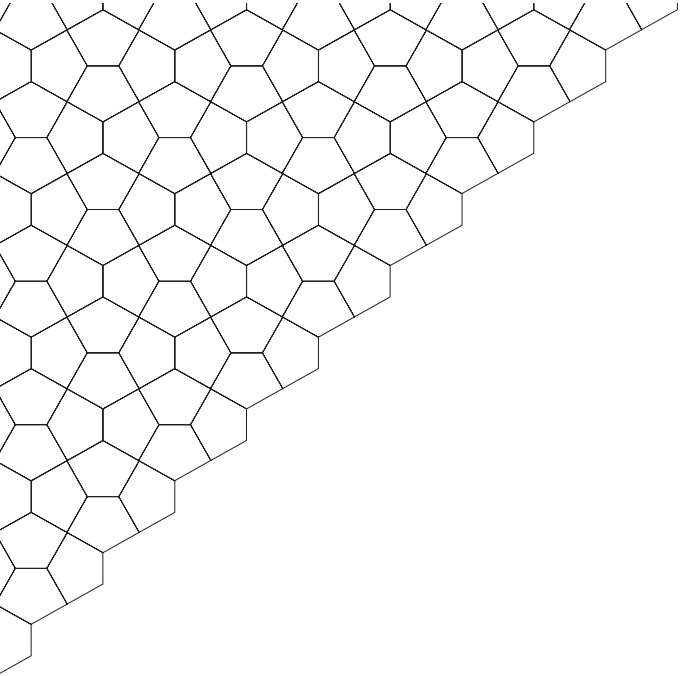
Noel-Ann Bradshaw and Peter Rowlett, June 2012

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University of Greenwich – the original ‘Maths Arcade’

Noel-Ann Bradshaw

Stretch and Support

The Greenwich Maths Arcade was a project devised 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 necessary mathematical concepts.

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 the book on Mathematical Thinking by John Mason et al. [1] for a review in *MSOR Connections* [2], 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 showed that mathematics students do not consider themselves to be confident in dealing with unfamiliar problems ([3], p. 28). 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 project began in September 2010 funded by a University of Greenwich grant for innovative teaching practice. 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’ grabbed the attention of new first 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:

- 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, fill or shape, or four round pieces regardless of size, colour or fill. What makes this game more interesting 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. A list of games used is included in the appendix to this booklet.

Benefits to students

The benefits to students were more varied than had been anticipated. 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. Related to this, a recent report suggested that the Maths Arcade could offer a structured social element well suited to students with autistic spectrum disorders (ASD) including Asperger syndrome as it “builds naturally on shared interests and enthusiasms for exploring mathematics and problem solving” ([4], pp. 33-34).

Students particularly liked the opportunity to spend time and play these games with staff outside the classroom environment and beat them! A recent summary of evidence from the HEA reported 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” ([5], p. 8).

Many students also made use of the tutorial help that was offered at the same time. They appreciated the fact that a number of members of staff were on hand to answer student queries and set them in the right direction. Those who made use of this were often the students who 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 their 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.”

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 in 2011 despite having doubled our intake of first year students. This is something that was appreciated both 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.

Expansion

During the 2010/11 academic year the Maths Arcade obtained support from the MSOR Network as part of the National HE STEM Programme to extend and increase the provision in 2011/12. This has allowed us to run staff training sessions, purchase more games and extend our opening times to three hours per week instead of just one. 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 program these games.

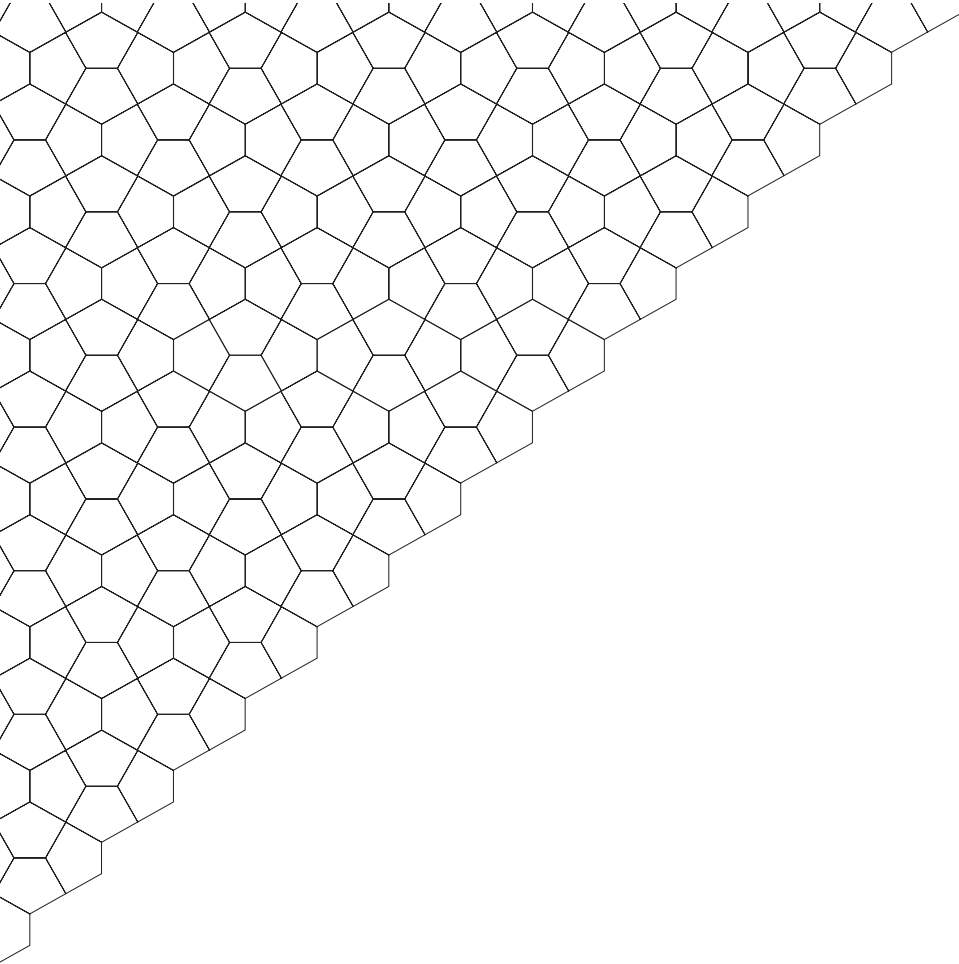
The concept of the Maths Arcade has also been taken up by other departments. Currently two departments in the Business School and one in Engineering at Greenwich have started their own Maths Arcades. Schools have also expressed an interest. The University of Greenwich now has a team of STEM ambassadors who take the games and puzzles into schools to promote the ideas behind strategic thinking.

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 two years 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 on the other hand it might and could benefit students and staff in many institutions.

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University of Manchester 'Maths Arcade' – Including postgraduates, outreach and iPad apps

Louise Walker

After reading about the Maths Arcade developed at the University of Greenwich in *MSOR Connections* [1], I was keen to pilot a similar scheme in the School of Mathematics at the University of Manchester. As well as developing students' strategy and problem solving skills the main aim of our Maths Arcade was to create a space where maths undergraduates, postgraduates and staff could meet informally to share mathematical ideas. We are lucky to have plenty of common space in our School but the undergraduate and postgraduate/staff common rooms are on separate floors. This means that postgraduates and staff have plenty of opportunity to mix socially but for most undergraduates, their main contact with staff and postgraduates is during formal classes.

The School was supportive of the idea of a Maths Arcade and so we bought some of the games and puzzles recommended in the *MSOR Connections* article and some iPads from our School budget and launched the Maths Arcade in March 2012. The idea was to pilot the scheme until the end of the academic year to get ideas for activities and find out what extra resources to buy for a proper launch at the start of the following academic year. The Arcade took place in a large classroom and we provided drinks and biscuits. Although the attendance has been quite low (about 20 people), there was a good mix of undergraduates from all four years, postgraduates and staff, and feedback from students attending the Maths Arcade has been positive. Some people came for the games and puzzles, while others wanted to talk about different areas of maths. We had some interesting discussions on topics ranging from second order logic to the integration of graduate skills into our undergraduate programmes!

Several of the students who attended the Maths Arcade are currently working with local schools and colleges as Maths Ambassadors. We were lucky to have one of the Maths Busking team [2], Katie Steckles, attend some of the sessions to share ideas and activities with the ambassadors.

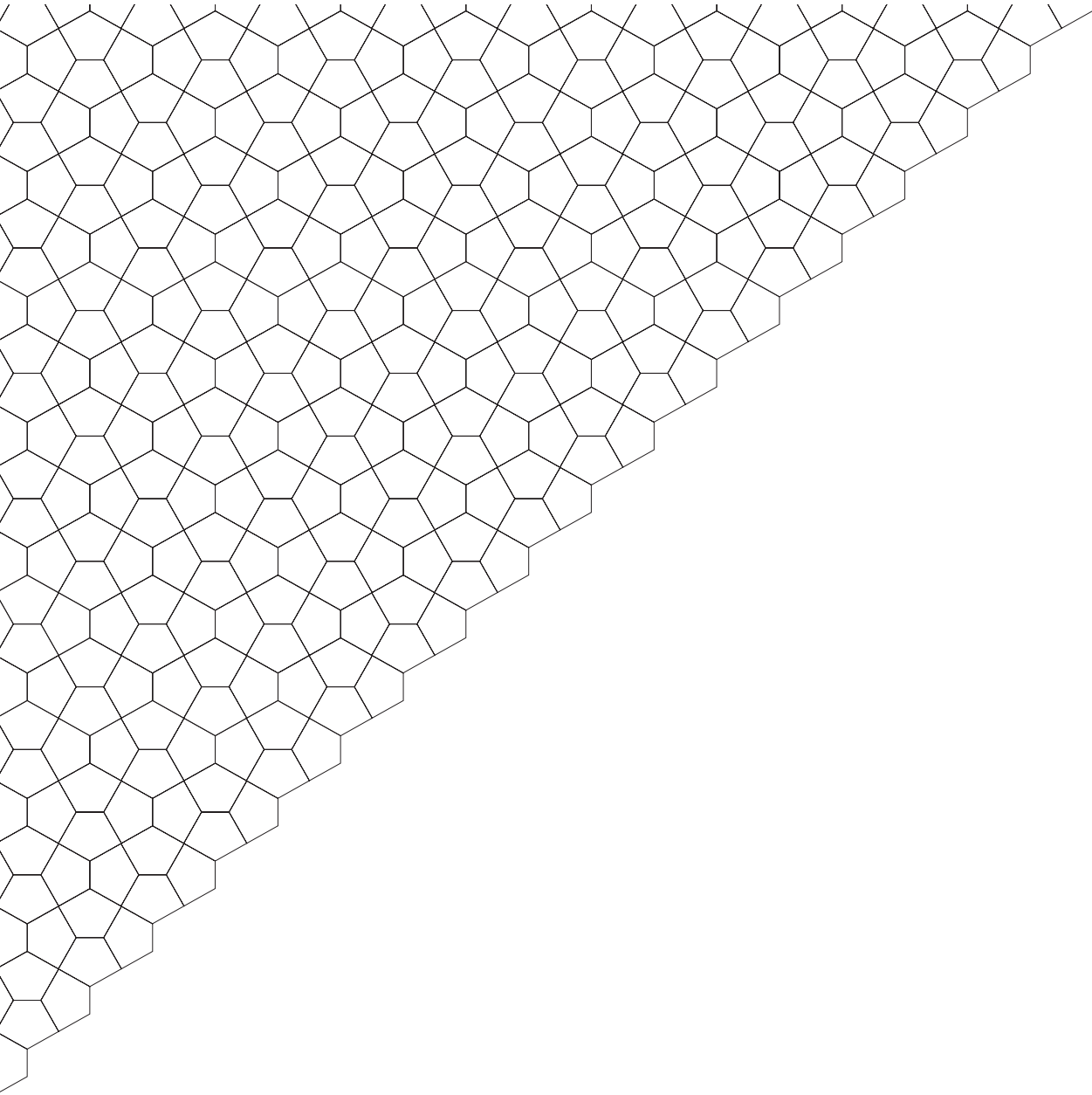
The students used the iPads to look up mathematical terms and we shared some interesting YouTube videos including one of a robot solving a Rubik's cube and an explanation of how to turn a sphere inside out. We've looked at iPad apps suitable for the Maths Arcade. These included:

- Trainyard;
- Kokono;
- Rush Hour;
- iHanoi;
- Solitaire Chess;
- Magic Cube;
- Torus Games.

We plan to relaunch the Maths Arcade at the start of the next academic year with a special session in Induction Week for our new students together with their peer mentors. As well as the games and iPad apps we intend to have a weekly maths puzzle and create a bank of resources that can be used in our outreach activities.

References

1. Bradshaw, N., 2011. The University of Greenwich Maths Arcade. *MSOR Connections*, 11(3), pp. 26-29.
2. *Maths Busking*. Available via: <http://mathsbusking.com/> [last accessed June 2012].



University of Salford 'Maths Arcade' – As a project activity

Edmund Chadwick

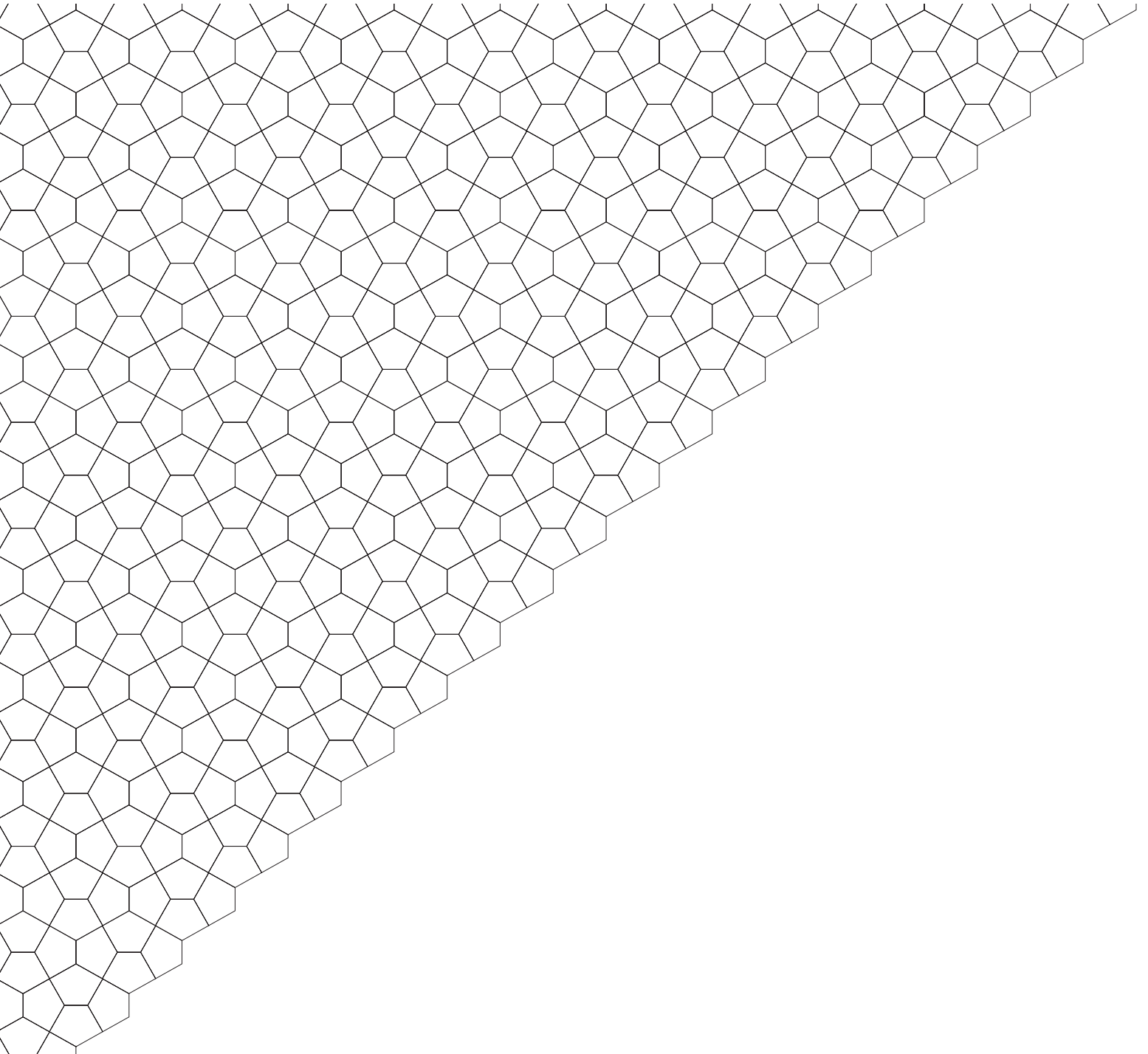
We started running the Maths Arcade at Salford in November 2011. This is run in a weekly session from 12-2 on a Wednesday which provides students with a social outlet and a focus for the discussion of mathematics puzzles of all descriptions. This also provides a convenient backdrop to any maths open days that happen to fall on a Wednesday afternoon.

In addition, the puzzles and games have been incorporated into a second year mathematics module that aims to develop problem-solving skills. Students study the various games and puzzles, in particular by playing the games against other students, and the discussion of the games themselves leads to understanding of the strategies required to play effectively.

The module assessment requires the completion of a report and also includes marks originating from their in-class involvement assessed by the module coordinator at weekly meetings. To complete the report, students focus on particular games or puzzles of interest to them, describe the rules, positions, moves, tactics and strategies for either a solution or for playing well. The students have the choice to either undertake this individually or in teams of their choosing. The teams that form generally reflect the groups that naturally arise when playing and discussing games during the classes.

One important aspect of this work is to start moving away from a linguistic description towards a mathematical description. So, one of the key elements in the report is the development of a mathematical notation that allows a full description of the game or puzzle. Students must also demonstrate an attempt at mathematical modelling using the notation in order to develop a solution or a strategy for playing the game well.

Student feedback for this activity was very positive. The majority reported enjoying the module to a higher degree than other modules, and the reports are of a standard noticeably higher than their other assessments. Given how well it trialled, the intention is to deliver this assessment permanently within this problem-solving module.



Sheffield Hallam University 'Maths Arcade' – Feedback on a trial and plans to include in peer assisted learning

Claire Cornock and Erik Baxter

A four week trial of the Maths Arcade was held just before the Easter vacation by a group of five staff at Sheffield Hallam. The Maths Arcade was advertised to the students via email and mentioned in tutorials. Opinions of the Maths Arcade were sought from all students; feedback was received from five out of the nine students who had attended during the trial and from 21 who didn't. The students who did attend described the atmosphere as "fun", "chilled" and "enjoyable". They all liked the games and wanted to attend again. Despite the low numbers, there has been a great reaction generally from the students about the Maths Arcade. Based on the feedback from those who didn't attend the trial the low numbers were because of workloads (48%) and timetabling (43%), with specific comments including:

- *"If I wasn't busy, and in year 1 or 2, I probably would have come along as it does sound interesting and fun!"*;
- *"It is on a Wednesday which is a day when we are off uni."*

Of the students who didn't attend, 38% were interested in attending in the future and 38% are undecided.

As requested by the first year students we held a Rubik's cube championship. Students from different year groups took part in the competition, which attracted a supportive audience of students and staff. Our champion was incredibly quick, completing the cube in roughly 40 seconds in each round.

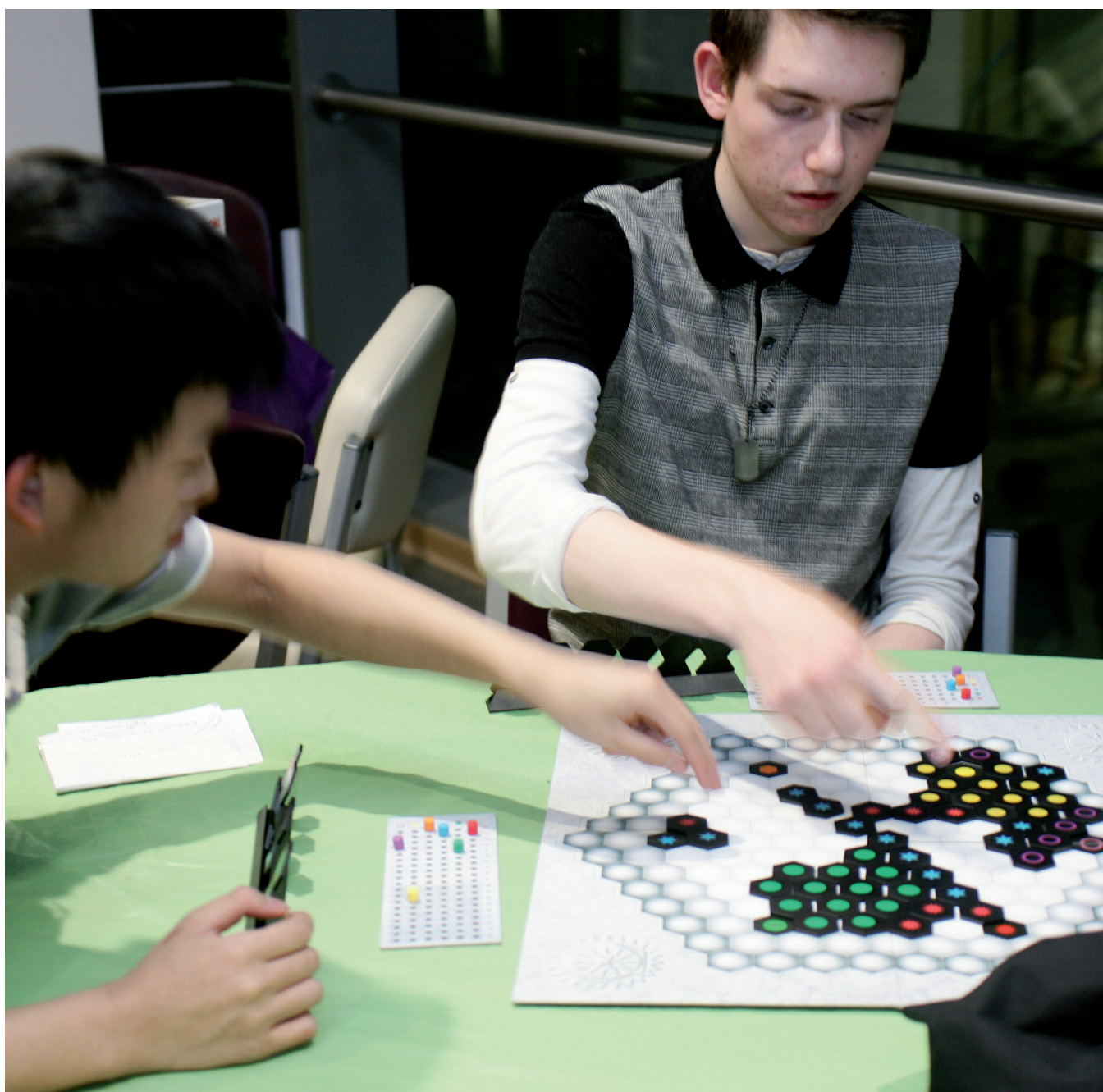
As part of the BSc Mathematics programme the first year students take part in a peer assisted learning (PAL) scheme which involves working on a group project with leadership from a final year student (PAL leader). The Maths Arcade will be brought to the PAL introductory session during induction week. This is the session when the first year students meet their PAL leader and the staff member allocated to oversee the process. The PAL leaders and staff will be introduced to some of the games before this session and will be encouraged to use the games as ice breakers. Subsequent Maths Arcade sessions will be optional and will be at a time convenient for the first year students, but ideally at a time when students from other year groups are also available. Having a session in which the Maths Arcade is introduced will hopefully reduce the number of students who don't think it sounds interesting (currently 19%).

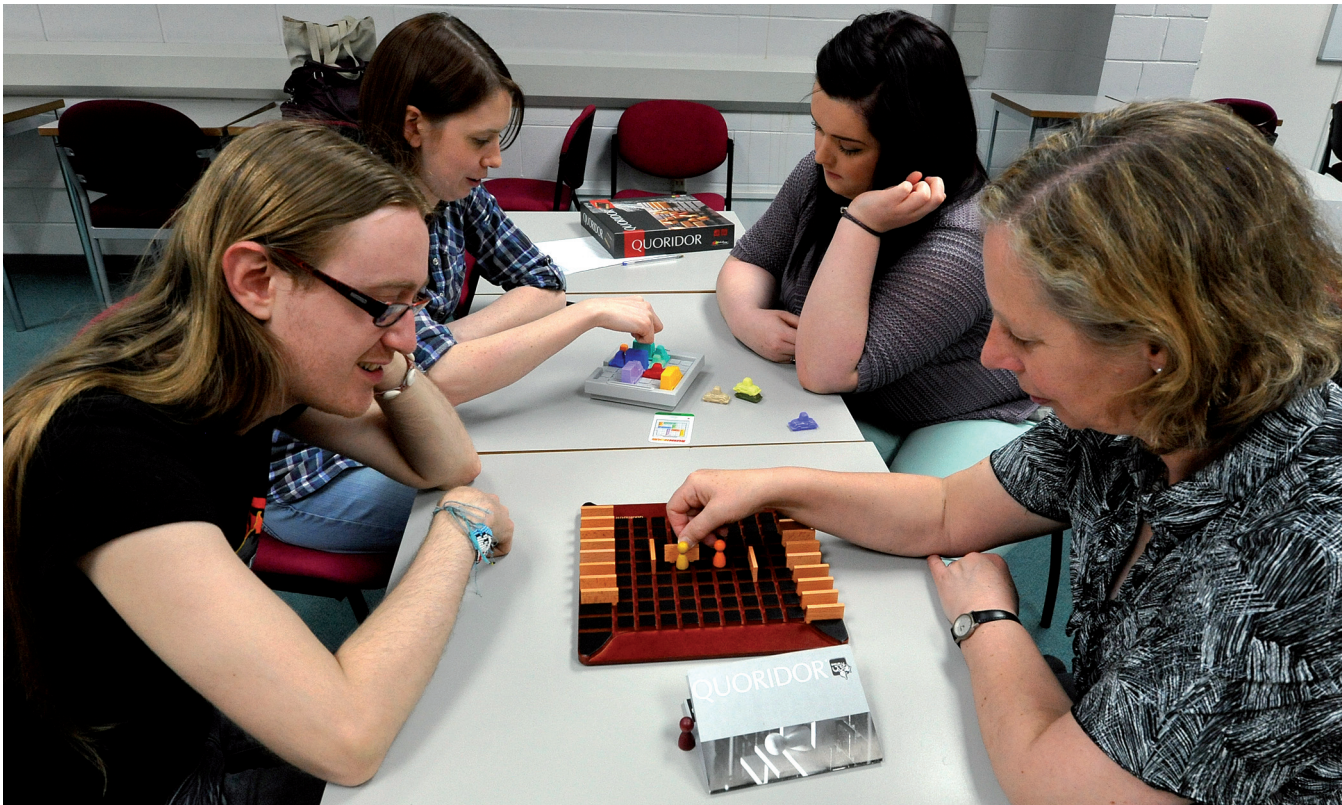
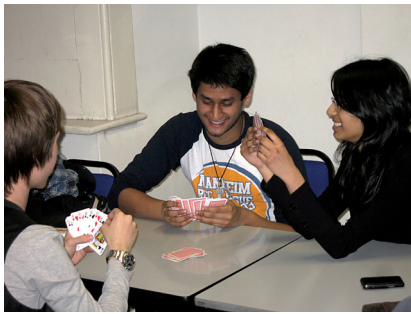
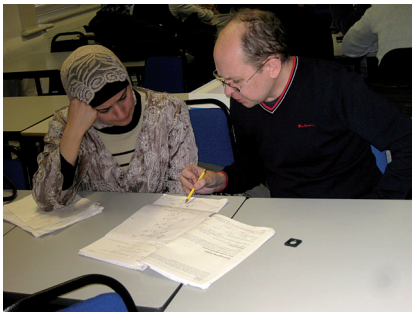
Other future plans include providing details of sessions on printed timetables, advertising the maths help side of the sessions (43% of those who didn't attend would be likely to attend if they could get help on tutorial questions) and holding more championships.

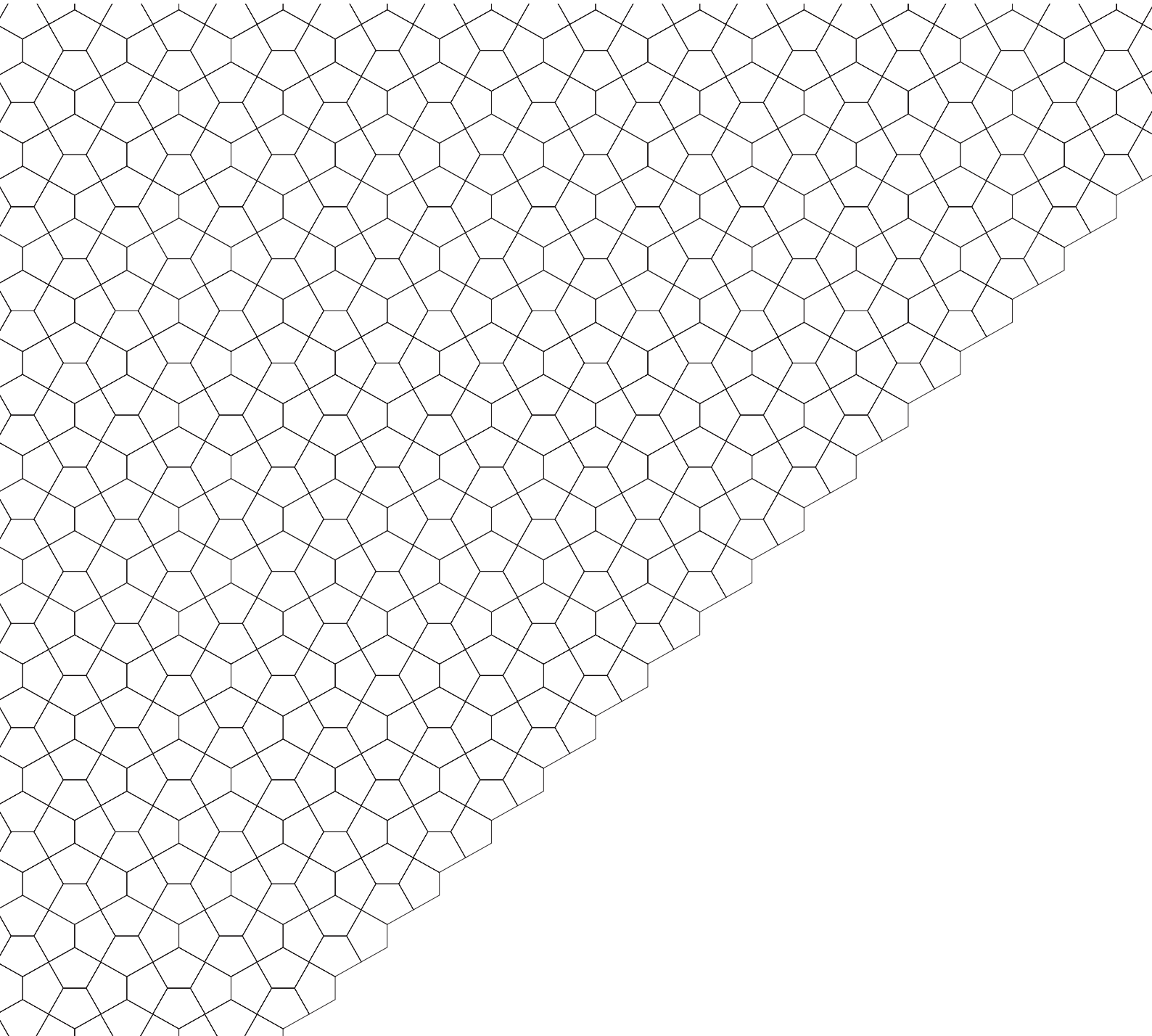


Maths Arcades in action

Clockwise from top left: Sheffield Hallam University, University of Greenwich, University of Greenwich, University of Greenwich, Sheffield Hallam University, University of Greenwich and University of Bath







University of Leicester 'Maths Arcade' – Student maths society involvement and plans for a competition

Jeremy Levesley

When the call came out for the Maths Arcade I contacted colleagues in the department responsible for Learning and Teaching, and for Student Support, and also Greg Matthews, the Chair of the Student Mathematics Society (SUMS). I asked them if they thought that the Maths Arcade was a good idea, and the unanimous response was affirmative.

We have a ready-made machine for organising the playing of the games inside our House System. The Department is divided into four houses Euler, Gauss, Newton, and Noether, the purpose being to produce a small world feel for the students. Each house has a student president and a staff head. All staff and students in the department are attached to one house, staff being attached to the house of their personal tutees.

Various departmental activities and competitions are organised at the house level. The Maths Arcade has been delivered through the House Hour, which happens fortnightly. In principle, each house has around 120 students, and around 30 students typically attend the hour, which has refreshments provided. The games have been brought along to the hour and staff and students have played.

Having been one of the players I can say that it provides a nice even playing field in which staff and students can compete. Students enjoy the opportunity of being better than staff, and we enjoy the chance of being shown to be human!

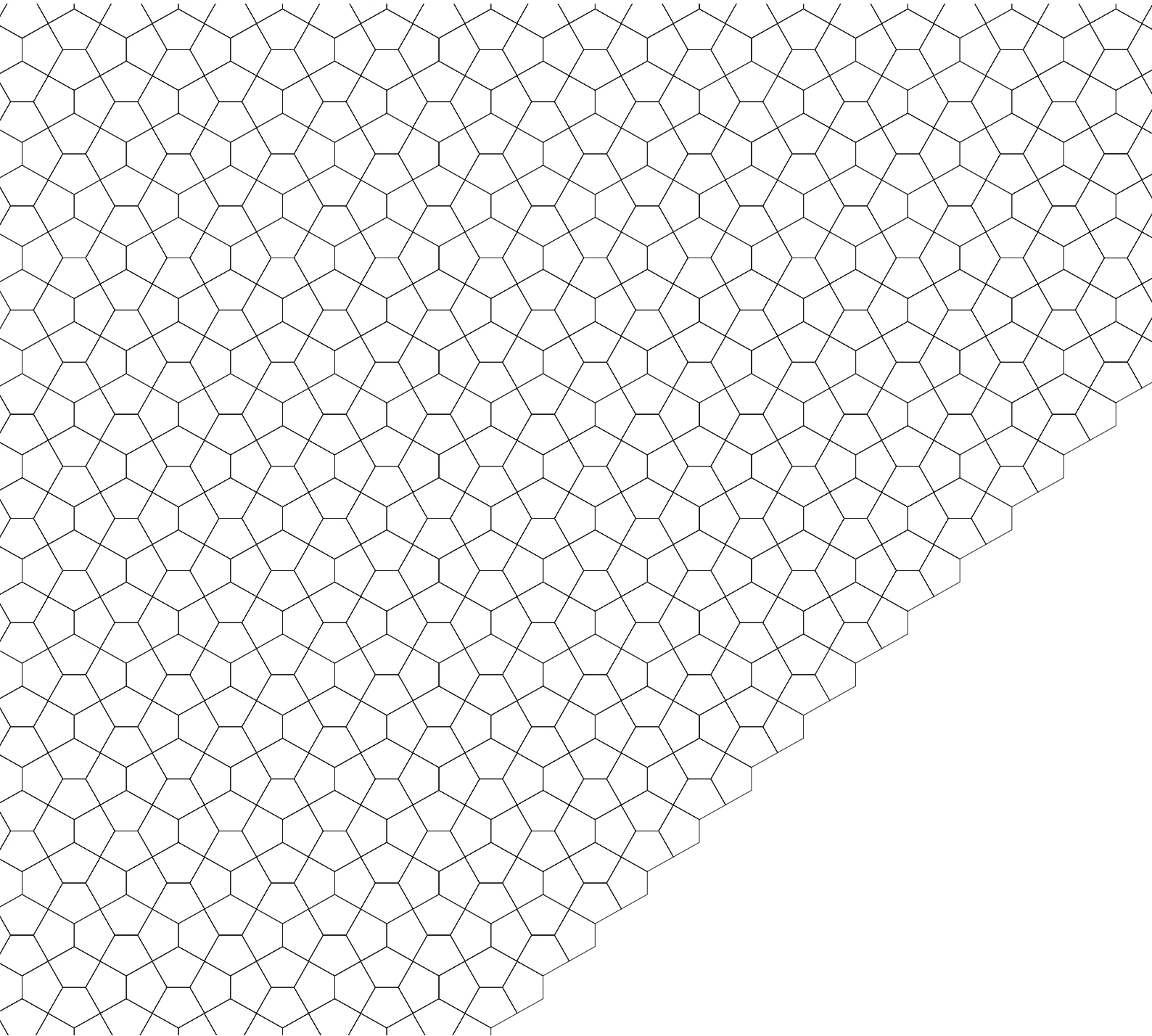
The intention is that a small number of games will be used in an inter-house competition, with house points being awarded to the winners (just as at 'Hogwarts'). Students have been learning the games during the spring term, and the competition will take place in the summer term.

The role of SUMS has been crucial in this. Greg and his colleagues have played a number of the games to try to find ones which are appropriate for the House Hour and competition. They have looked after the storage of the games and delivery to and from the House Hour. The running of the competition is under their control.

There is mixed take up by staff of House Hours, and other personal tutor related activities. We will discuss in Departmental Management Group the issue of making House Hour directed time for staff with inclusion on the workload allocation model.

I will finish off with quotes from staff and students concerning the playing of the games:

- *"The games were a good way of getting to know other students as well as lecturers and it was fun thinking through the strategies of the games."* Lucy Harris, student
- *"The games were given a good reception by students. By choosing games that no one had seen before it meant that everyone was learning the games and developing their strategy at the same time which resulted in lecturers and students learning from each other and neither having a distinct advantage. The games allowed students to get to know lecturers in a more informal way."* Greg Mathews, student
- *"Thoroughly enjoyed playing the maths arcade games, a great collection of logical games that I found are simple to understand but very challenging to master."* Chris Cuthbert, student
- *"I thoroughly enjoyed playing against the students where they had as much chance of winning as I did. It allowed for us to interact in a more relaxed but equally intellectual way. The games were good too."* Jeremy Levesley, lecturer.



University of Bath 'MASH Café' – Cross-disciplinary peer support and problem solving

Emma Cliffe and **Jane White**, MASH (Mathematics Resource Centre), University of Bath
Lisa Benjamin and **Carol Lacey**, University of Bath Students' Union

MASH, the institutional Mathematics Resource Centre at Bath, in collaboration with the Students' Union (SU), set up the MASH Café in October 2011. MASH runs mathematics and statistics drop-in support for all students each afternoon during term time. MASH also runs drop-ins staffed by peer mentors for first year mathematics students and the SU organises Peer Assisted Learning sessions within a variety of disciplines. The original Maths Arcade, in addition to other aims, offered drop-in mathematics support. At Bath MASH already provided adequate drop-in opportunities. However, we offered limited opportunities for students to develop their problem solving skills. Offering strategy games in an informal café environment appeared to be a context in which open ended problem solving and peer support might naturally arise. Hence the MASH Café was set up to:

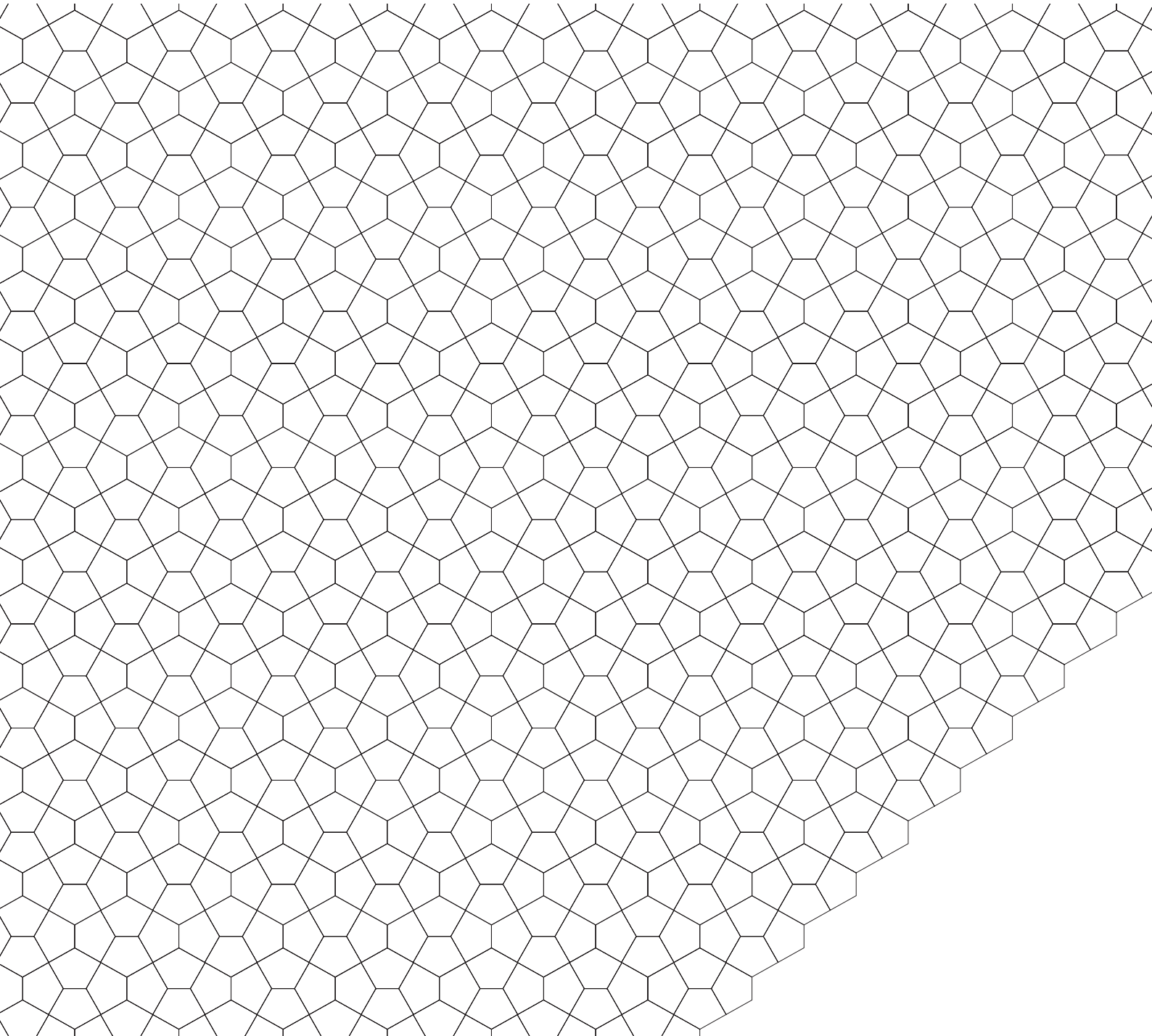
- provide opportunities for students to develop problem solving skills;
- encourage students to form cross-disciplinary peer support groups to support their mathematical development.

To attract students across a range of disciplines the Café was held in the SU building and ran 5.30-7.00pm one evening a week. Two members of staff agreed to attend despite this falling outside of office hours. It was hoped that senior students would eventually start to run the Café. The Café was funded by a small National HE STEM Programme South West Spoke transition grant which covered: strategy games chosen to promote problem solving; a storage box; table cloths; refreshments; and, advertising.

The Café was attended by seven to twelve students (not always the same students) and three staff each week. Asking attendees how we might attract other students highlighted timetabling and communication difficulties with cross-discipline activities. The teaching day at Bath runs 8.15am-7.05pm (excepting Wednesday afternoon). Most students travel across the city each day and students only came to the Café if it was shortly after a lecture and did not clash. We also had no direct method of communicating with students; many attending had not noticed the advertisements! Those attending felt the Café should run for a longer period on a Wednesday afternoon. This would require students to take responsibility for running the Café and we hope to trial this next year. A mailing list was set up and some attendees have agreed to play games at a central location during Freshers' week, advertising the Café and asking interested students to sign up to the list.

The students who attended, as well as enjoying the games, did start to pose and try to answer questions about strategies, algorithms and ideas behind game solving. Some games became favourites for this such as Solomon's Stones, Quarto, Quoridor and Hex. Individuals also brought their own puzzles and games along as the Café offered the unique opportunity to play with other like-minded people. Individuals and groups often spent the entire session attempting to understand best gaming strategies and puzzle solutions. As a result, discussions focussed on problem solving strategies, developing proofs and algorithms as well as learning and thinking styles arose spontaneously.

Comments from attendees on why the MASH Café should run include: *"fun games which make you think!"*; *"fun, intellectually strenuous"*; *"unique and fun"*; *"social and problem solving combined"*; *"it is a fun way to think about problems"*. We hope that this early success will be extended next academic year as we tackle the timetabling and communication difficulties.



University of Nottingham 'Puzzled' sessions – Enhancing drop-in support, open days and community outreach

Sally Barton

At Nottingham we have a Teaching Officer who has a role in supporting the first year students making the transition to university mathematics and this includes drop in sessions for first year students. These sessions were reasonably well attended and a postgraduate student was employed to supplement the support during the busier sessions. We were aware, however, that the students who most needed to be there often didn't come.

This year the School moved into its own building (having previously had offices across two buildings and shared with physics and engineering). The new building had better provision for student study areas and areas that were identifiable as 'for mathematics students'.

We were successful in bidding for money from the university for promoting tutor group activity and interactions between staff and students. The Head of School also requested that we bid for strategy games to use with engineering students. The money was used to provide two cupboards and a large variety of games. As well one in as Mathematical Sciences, a cupboard plus games was sited in the Engineering and Science Learning Centre (which also opened this year).

One drop-in session was moved to the undergraduate study area and has been reasonably successful. The sessions were called 'Puzzled' and were advertised as:

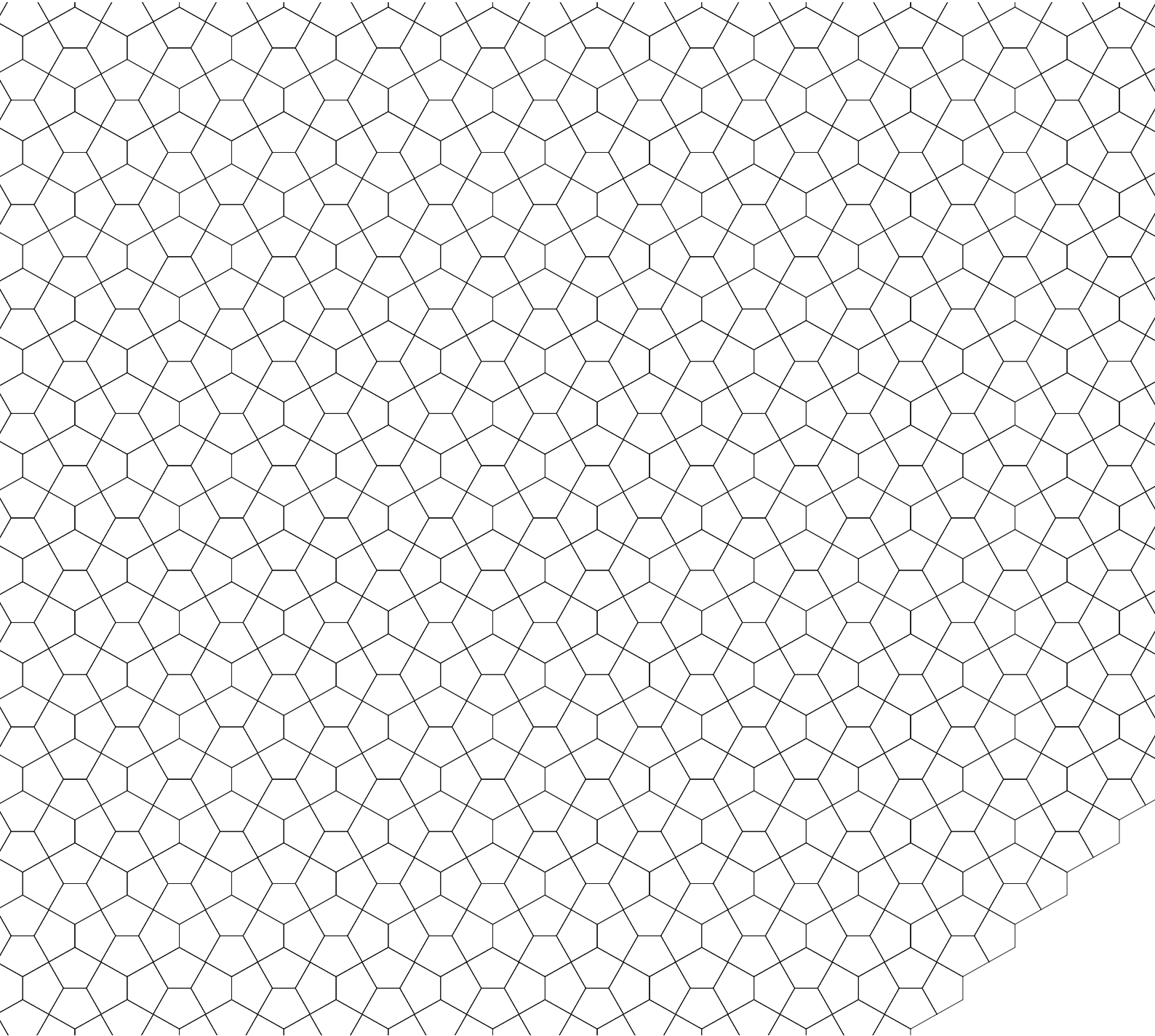
New for academic year 2011: special 'Puzzled' drop in sessions will be running where you can play puzzles. You can also bring maths problems that are puzzling you.

The hope that lecturers would make themselves available in Puzzled sessions during their office hours has not happened with only two lecturers participating. We hope to change this next year: the more that students see mathematical conversations happening between staff and students, the more they realise that they too can ask questions.

The games were used and maths conversations were started ("can I ask you a question?") by students who had not attended the traditional drop in sessions. There was also interaction between staff and second year students and between the year groups. Hopefully this aspect will grow next year.

The games were also used at our open days. We have had games before but they usually are not seen in the department from one open day to the next. It was good to introduce students to, e.g., Quarto and say that they would get the opportunity to play again if they come to study maths here. Indeed small Quarto sets have been purchased for tutor groups and we will be holding a Quarto competition between tutor groups during induction week.

The engineering cupboard was not well used this year. This appears to be because it was not in place until after the main welcoming activities had ended and the cupboard was kept locked most of the time. This cupboard was used when we took part in the University of Nottingham 'MayFest'. This is community open day; a Saturday when the local community are encouraged to come onto campus for a range of activities. We were able to wheel the cupboard with the games to the venue and use it to store surplus items (and coats and bags) during the day. With games for all ages and logic puzzles, etc., we were busy all day. A parent was overheard saying to children: "I know we could stay here all day but there other things to go and see".



Keele University 'Maths Arcade' – Plan of action for Mathematics Society involvement

David Bedford

Over the last year the Department has encouraged students to form a Mathematics Society to improve both the student experience and also the relationship between staff and students. The intention was to have the Mathematics Society and staff organise drop in sessions where staff and students could play and discuss the various games as well as the opportunity for more general issues to be raised in a friendly and relaxed environment. This was going to be introduced within the new mathematics workroom which was due to be completed by Christmas 2011. Unfortunately a series of delays has resulted in this being pushed back to September 2012. Nevertheless, the success of the Mathematics Society and the willingness of staff to engage with the project mean that the Maths Arcade will commence in September 2012 with the new cohort of undergraduates.

Plan of Action

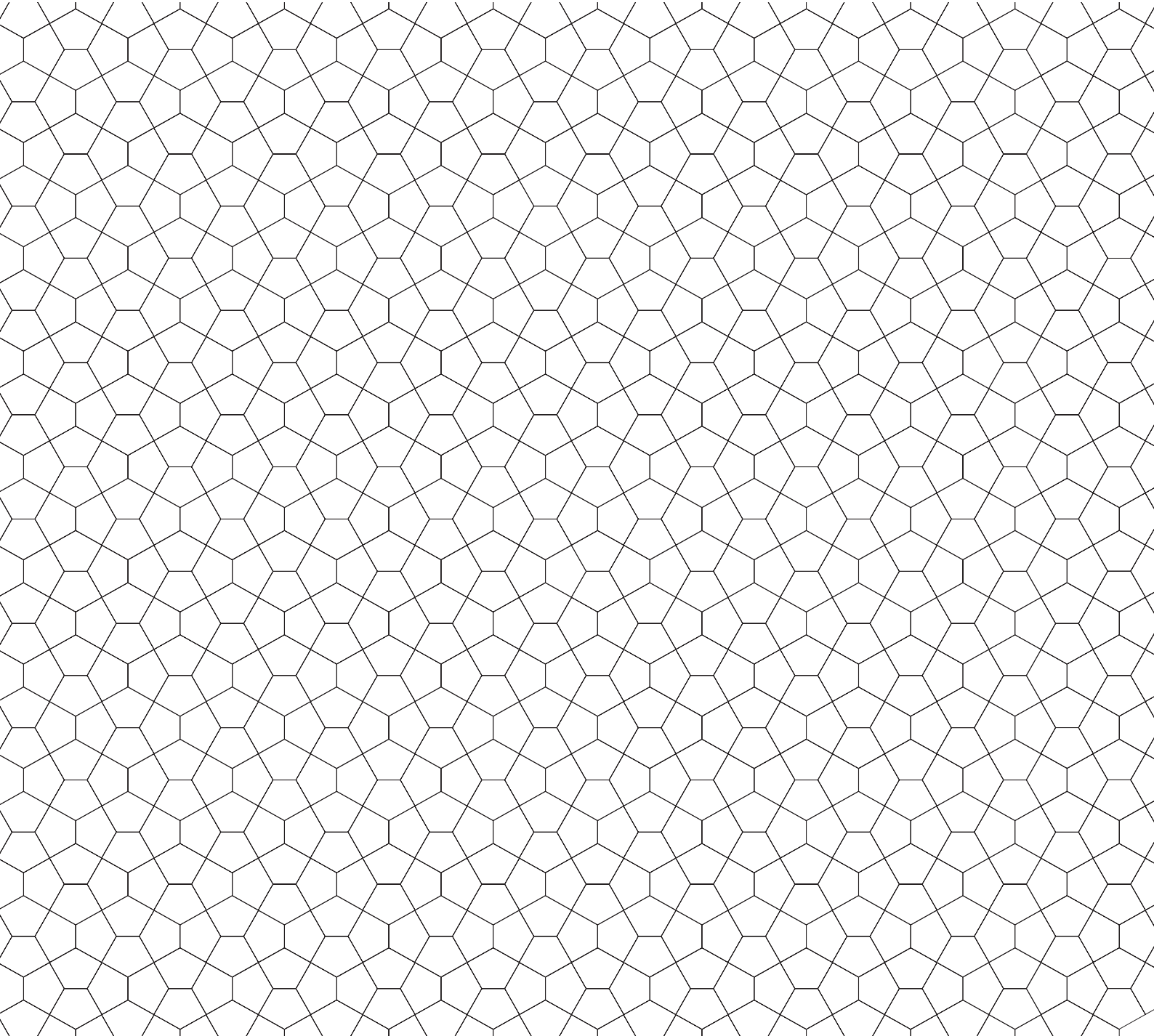
- Initial meeting arranged at the start of September with the new executive of the Mathematics Society. Ideas to be discussed are:
 - o Possible competition/prize.
 - o Student volunteers from 2nd and 3rd years to supervise the sessions.
 - o Training for new Executive and student volunteers.
 - o Organisation of a launch event.
- Ideas and Feedback Forum on the VLE.
- Arrange regular (weekly/fortnightly?) sessions.

Evaluation

- Maintain a record of student engagement.
- Feedback questionnaires at the end of each Semester of the first year.

Further Development and Sustainability

- Embedding the roles of Maths Arcade supervision into the Executive of the Maths Society.



Maths Arcade start-up guide

Noel-Ann Bradshaw

This start-up guide is based on the experience of setting up the original Maths Arcade at the University of Greenwich and focuses on practicalities.

Funding and purchasing of equipment

The initial University grant in 2010 was for £1,650. The appendix to this booklet contains a list of all the games and puzzles that were bought initially at Greenwich as well as others that have since been purchased or recommended. A mobile, lockable, storage cupboard was also purchased from this funding to store and transport the games.

Rooming

Discussions on storing the cupboard and equipment, and the timetabling or rooming of sessions need to be carried out as early as possible, depending on your situation. At Greenwich we were initially allocated a classroom seating 56. In 2011 we were allocated a larger classroom with plenty of circulation space and comfortable seating in the area outside to enable some of the games to be played in a more relaxed environment. It is necessary for students to be able to sit around tables and play the games; the Maths Arcade would not work in a fixed-seat lecture theatre.

Staffing

It is important to get the agreement and commitment of several members of staff and PhD students to turn up each week. One of the main benefits of running the Arcade is to enable staff-student interaction. Running a training workshop to show staff and PhD tutors the importance and advantage of attending and enabling them to try out some of the games is a good idea before the sessions actually start.

The Maths Arcade provides a good way to get to know a reasonable number of students well in a short space of time so staff could be encouraged to use this as one of their office hours or as a designated time and place to meet project students.

Advertising

Without promoting sessions well students are unlikely to turn up. Early promotion in the induction week works best and continued mentions in lectures will encourage new members each week. Incorporating some of the Maths Arcade games and puzzles into the start of term induction activities is a good strategy. If you organise some sort of peer mentoring scheme encourage mentors to arrange to meet their mentees there.

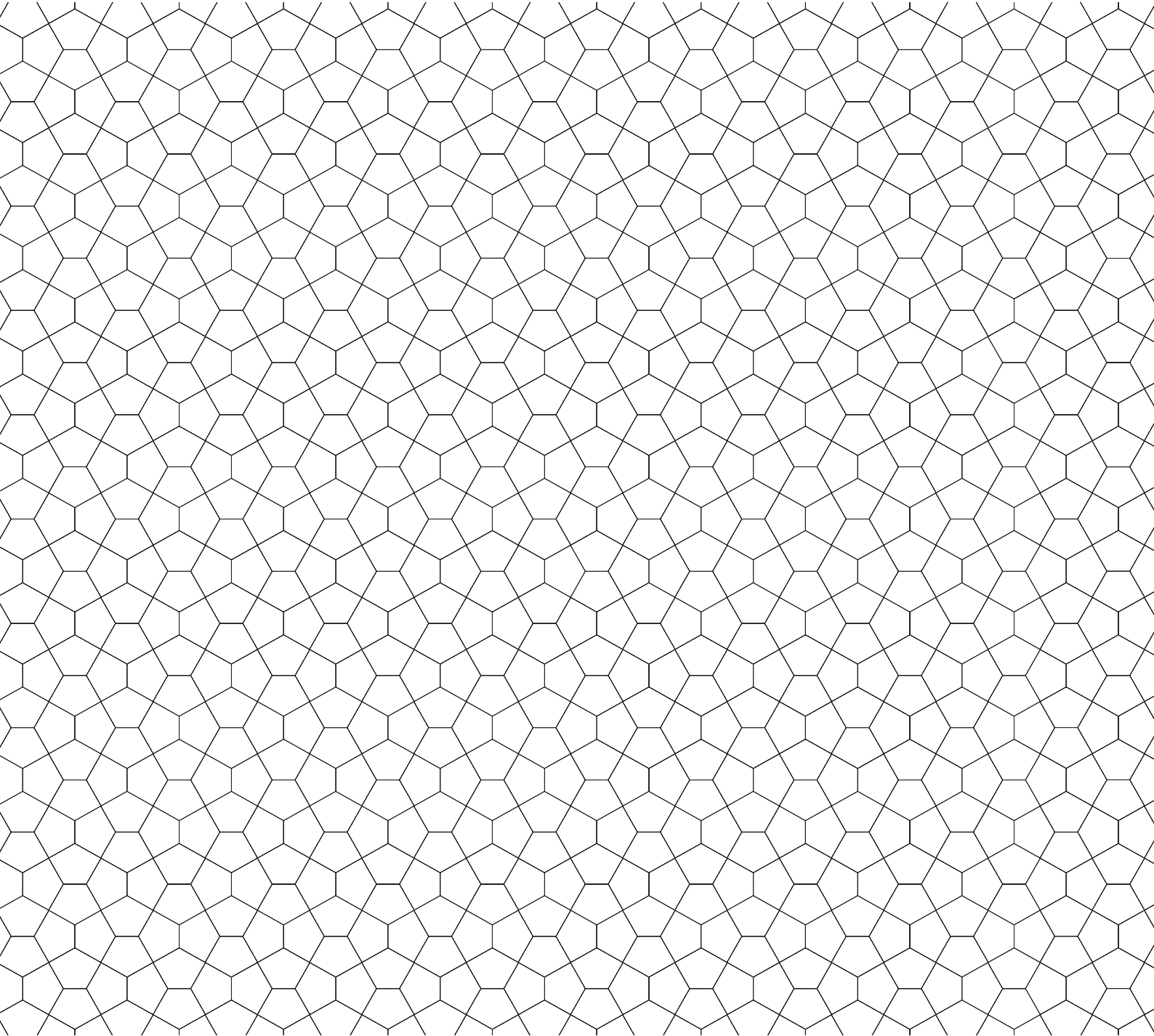
Weekly Operation

This needs commitment of a couple of members of staff to be there each week even if others attend on a rota basis. You could provide weekly puzzles, perhaps as part of a competition. There are many sources for puzzles including the Institute of Mathematics and its Applications website and books by authors such as Henry Dudeney, Sam Lloyd, Martin Gardner and Ian Stewart.

It is useful to keep a list of those students who attend for evaluation purposes.

Evaluating and feedback

It is useful to obtain written feedback on the Maths Arcade from those attending and not attending the sessions. This can be done as a questionnaire or linked into existing Personal Development Portfolio (PDP) or similar scheme. In the first year at Greenwich the most negative feedback was that there were not enough sessions, these were not long enough and they might be better taking place after rather than before lectures. Some students said they did not know what it was and were really surprised to find they enjoyed it when they did attend and wished that it could have been advertised more. There were no negatives comments concerning the content.



Appendix

– List of games, puzzles and other resources

Noel-Ann Bradshaw

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 – particularly important at the start. Some, such as Giant Blokus, have been particularly successful as students like to watch even if they are not playing. 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 (N.Bradshaw@gre.ac.uk).

Abalone	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. A good game but you don't want too many sets. Many students like this.
Bananagrams	2-8 player word game. Using lettered tiles to spell words. Good for international students if you can find a group of a similar ability to play together.
Blokus 3D/ Blockus Giant/ Blockus Trigon	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.
Callisto	2-4 player game. Looks bright and childish but students that have played it have got a lot out of it. Easy to pick up but tricky to come up with the best strategy.
Chaos	2 player strategy game. Involves stacking counters. Excellent strategy game but hard to learn. Takes longer than other games once both players understand the rules.
Gambit	2 player strategy game. Involves sliding rows of coloured tiles. Enjoyable but not one of the most popular games.
Gobblet	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. A good, easy to master, strategy game.
Gygès	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.
Hex	2 player game said to be invented by mathematician John Nash. It can be bought from Nestor Games (see below). Hex boards can also be made relatively easily or can be played on paper. See boardgamegeek for paper grid.
Ingenious	1-4 player strategy game. Placing tiles on a board with a clever scoring system. Good for strategy. Travel version is easier to play but full-size version can be watched by more students.
Joggle	2 player strategy game. Dice-based placement of marbles on a board. First to build a 6 marble rectangle wins.

MiQube	1-4 players. It can be played by one player reassembling the cube or as a board game encouraging strategic thinking. It encourages special thinking. A good review on boardgamegeek: http://boardgamegeek.com/thread/261372/review-miqube
Neuron	1-4 players. Similar to Tantrix but less complex rules. Aim is to make the longest line of your colour.
Novem	2 player tactical game. Lots of game theory involved in this. One person controls rows and the other columns and you try and capture tiles with the highest value. Strategy involves trying to work out what your opponent is going to do.
Pentago	2 player strategy game. Placing coloured marbles on a 6x6 board, the quadrants of which can be rotated, to form five in a row. Rules are easy to follow but the strategies take longer to assimilate. Excellent short game.
Pylos	2 player strategy game. Placing marbles to form a pyramid according to simple rules. Whoever places the top marble wins. Best with players of equal ability.
Q-bitz	2-4 player game. Three rounds based on speed, chance and memory. Arrange mini-cubes to make patterns. Good for encouraging symmetric visualisation.
Quads magnetic	2 player game. The tiles have different combinations of colours or lines. Players take turns placing a tile so that the colours or lines on each edge match that of adjacent tiles. The player who stops his or her opponent from being able to place a tile wins. Not played very much as yet.
Quarto	2-4 player strategy games. Object is to get a row of 4 pieces with the same attribute. The catch is that your opponent chooses your piece for you.
Quirky	2-3 player strategy game. Uses coloured tokens to build equilateral triangles. Not got the hang of this game yet! Instructions are not well-explained.
Quixo	2-4 player strategy game. Adding and shifting tokens to form five in a row. Excellent strategy game that requires 100% concentration.
Quorridor	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.
Rubik's cube/ Hollow cube/ Sudoku cube	The classic puzzle and variants. There are many books and websites explaining how to explain Group Theory using a Rubik's Cube.
Rubik's 360	Puzzle. Involves changing the position of six coloured balls in a central sphere to six coloured compartments in an outer sphere, by manoeuvring them through a middle sphere that only has two holes.
Rubik's magic	Puzzle. Folding connected tiles to form a pattern.
Rumis	2-4 player strategy game. Involves placing blocks onto a board as part of a 3D structure to capture available space. Not played much.
Rush Hour	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. There are many variations on this including online versions and apps for iPads etc. Similar to Red Donkey.
Saikoro	2 player game with lots of dice. Easy to learn and demonstrated on 'Board Games with Scott'. Involves finding a way of removing dice to trap your opponent. http://www.boardgameswithscott.com/?p=84

Solomon's stones	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.
Sprocket	2-4 player strategy game. Using rotor pieces to create gears and lugs. An excellent strategy game once you have understood all the rules – not easy!
Square up	Like Sam Lloyd'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.
Stratum	2-4 player strategy game. Trying to cover the opponents' pieces by placing tiles. An excellent game for discussing what the best strategy is.
Sudoku cards	2-5 player strategy game. Involves placing numbered cards according to sudoku rules.
Tantrix	1-4 player strategy game. Hexagonal tile-based placement. Good but hard to teach complexities of rules and time consuming.
Totemland	2-4 player. Excellent strategy game. You build totem poles but you want to have as many of your pieces on top at the end. The rules of placing pieces make this harder than it seems. Excellent game.
Tower of Hanoi	The classic puzzle

The classic games Backgammon, Chess, Draughts, Go, Reversi (Othello), as well as playing cards are available at the Arcade but are not described in the list above.

Other resources


There are several websites that I have found useful for sourcing games and finding out about them although most of the above can be purchased via Amazon.

I recommend registering with BoardGameGeek.com for their reviews and files containing English rules – necessary as often the translations provided are tricky to comprehend!

BoardGameswithScott.com is another interesting resource with video instructions for some games.

I have recently come across NestorGames.com which seems to have a good supply of unusual strategy games. If you try any please let me know (N.Bradshaw@gre.ac.uk).

The article in this booklet by Louise Walker from the University of Manchester discussed the use of iPads and recommends some apps.



The Maths Arcade is an innovative activity involving playing and analysing strategy games which aims to simultaneously support struggling learners, stretch more confident learners and encourage the development of a staff-student mathematical community. This booklet contains details of the original Maths Arcade at Greenwich, including some discussion of the advantages of running an Arcade, and case studies from seven other Maths Arcades since established at Manchester, Salford, Sheffield Hallam, Leicester, Bath, Nottingham and Keele.

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