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Chapter 8: Maths Sparks: Promoting student engagement and developing skills in presentation, communication and team-work



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Figure 1: Undergraduate students working with post-primary pupils during Maths Sparks workshop in 2017

Initiative Name	Maths Sparks: Problem Solving Workshops
Universal Design Principles	<ul style="list-style-type: none"> - A community of learners - Instructional climate - Flexibility of use
Discipline	Mathematics
College	Science
Programme Learning Outcomes	<p>Following their participation in this programme, the student should be able to:</p> <ul style="list-style-type: none"> - Design a mathematics workshop for senior post-primary pupils, which includes clear learning objectives and associated mathematical tasks aligned to those objectives - Communicate their knowledge of mathematical content, relevant to a specifically designed workshop, to senior post-primary pupils (both to small groups and large audiences) - Work effectively as part of a team in collaboratively designing content, activities, and facilitator information for a mathematics workshop - Critically reflect on their sense-of-belonging to or engagement with the mathematical community through working with undergraduate students across Stages 2 – 4 and academic staff in the UCD School of Mathematics & Statistics

Introduction to Maths Sparks

Two prominent concerns of mathematics education at third level are: improving the engagement of undergraduate students who have chosen to study mathematics and developing these students' communication skills. Maths Sparks: Problem Solving Workshops is a mathematics enrichment programme where workshops are designed by undergraduate students and presented to post-primary pupils. This programme is run by the UCD School of Mathematics & Statistics and is funded and supported by Science Foundation Ireland and UCD Access & Lifelong Learning. Undergraduate students apply to volunteer in the programme, which is run over the course of one semester, with the opportunity to develop their skills of designing a mathematics workshop, working in a team, facilitating mathematical learning, presenting to a large audience and communicating their knowledge of mathematics. Each two-hour workshop is designed by a group of two to three students, under the guidance of academic staff in the UCD School of Mathematics & Statistics, and is presented as part of a series of workshops to senior post-primary pupils.

Why Universal Design for this initiative?

In undergraduate programmes, such as DN200 in the UCD College of Science, where students have opportunity to consider various degree pathways, it has been suggested that a sense of community between staff, students, and peers can promote and enable student engagement and success in Higher Education, particularly in mathematics (Duah & Croft, 2011; Good, Rattan, & Dweck, 2012; Thomas, 2012). We set about developing a mathematics enrichment programme for post-primary pupils, where undergraduate students would engage with one another and with academic staff in designing mathematics workshops. These workshops would then be delivered, over a series of four to six weeks, to senior post-primary pupils (circa 70) from schools (the majority of whom have DEIS¹ status) in the vicinity of UCD. With this programme, we hoped to foster an appreciation of, and interest in, mathematics for post-primary pupils which could, in time, lead them to consider choosing a mathematical programme at third level. Simultaneously, we hoped this programme would begin to develop a **Community of learners** among staff and students within the UCD School of Mathematics and Statistics.

¹DEIS – Delivering Equality of Opportunity in Schools – are designated as having lower socio-economic status by the Department of Education & Skills

Students who participate in the Maths Sparks programme are undergraduate students who have either chosen to study a mathematics based degree pathway (Stages 3 and 4) or are considering pursuing a mathematics-based pathway (Stage 2) in the UCD College of Science. Through their participation in Maths Sparks, we hope to assist students in developing their presentation, communication and team-work skills, as well as enhancing their engagement in a mathematics degree pathway.

Designing and implementing the programme

In designing this programme, we have attempted to develop a constructive and collaborative **Instructional climate** for participating students. Once accepted to take part in the programme, volunteers are asked to consider mathematics topics they would like to develop as a workshop. At the first meeting of volunteers (between 10 to 15 students) and programme directors (the authors), these ideas are pitched and reviewed by the group in an informal environment. Students then assemble themselves into similarly themed or like-minded groups and begin designing their workshop.

As part of the design process, each undergraduate team is encouraged to contact and work with a member of academic staff, whose research or teaching relates to their chosen topic. Such collaboration aims to further develop and strengthen links between students and staff in the School of Mathematics & Statistics, and also benefit students' knowledge and understanding of the content.

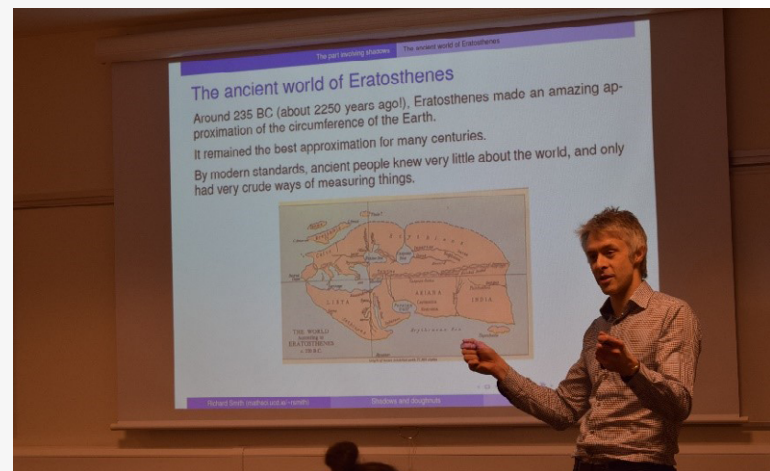


Figure 2: Dr Richard Smith, workshop design mentor, presenting at Maths Sparks 2017

With the objective of positively influencing post-primary pupils' attitudes towards mathematics, each workshop is designed with three guiding features (Verschaffel et al., 1999):

1. Participating pupils should be encouraged to communicate their mathematical thinking as part of a variety of classroom organisational forms
2. Pupils should work on contextualised and meaningful problems
3. Positive beliefs about mathematics should be promoted.



Figure 3: Student volunteer facilitating pupil learning, 2017

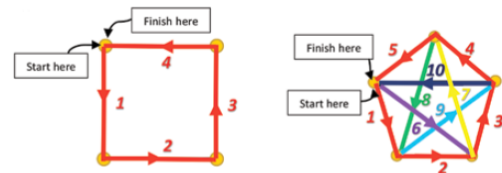
In each workshop, there is an emphasis on pupils communicating their mathematical thinking or “sense-making” (Schoenfeld, 1992) as an important feature of their mathematical learning. A variety of classroom organisational forms are included, where pupils work individually, in pairs, or in groups on a mathematical task. The topics and tasks included in each workshop are designed to be contextualised and meaningful to the learners and include high-level cognitive demands, where pupils engage with conceptual ideas underlying mathematical procedures (Boston & Smith, 2009). Throughout each workshop, undergraduate students facilitate pupil learning in, for example, asking guided questions and act as positive role-models of mathematics. In addition, throughout each workshop positive messages about the uses of mathematics and practices of mathematicians are promoted (Boaler, 2016). In considering **Flexibility in use**, undergraduate teams have autonomy in

choosing the topic, content and activities included in each workshop.

Over the course of four weeks, each undergraduate team presents their workshop to the undergraduate group for peer review. In this collaborative environment, suggestions are made on the content and tasks to be included in each workshop and students continue to modify and edit their content as appropriate. As a final review, one of the programme directors assesses the workshop content (including presentations, activity sheets and content for other students who will act as facilitators) and resources are then prepared for presentation.

Note 3: Examples of zero odd vertices and two odd vertices

If a graph has no vertices of odd degree then you must *start and finish at the same vertex* to complete an Euler path



If a graph has two vertices of odd degree then you must *start at one of the odd vertices and finish at the other odd vertex* to complete an Euler path

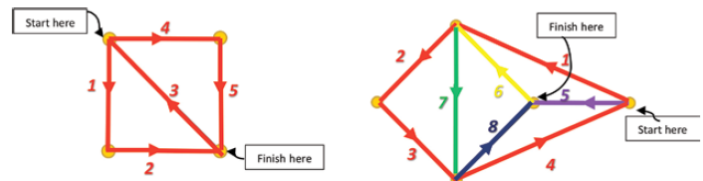


Figure 4: Sample of Graph Theory facilitator notes from Maths Sparks 2016 booklet

Workshops are presented by each undergraduate team to attending post-primary pupils over the following four to six weeks (depending on the number of workshops and volunteers).

Evidence of impact: how do we know it worked?

Maths Sparks: Problem Solving Workshops has now completed its third series and feedback from students has been overwhelmingly positive. Written feedback has been collected from participating volunteers and selected comments are included below.

Undergraduate student engagement

Students have shared reflections on their increased engagement in the School of Mathematics & Statistics as a result of their participation in the programme and commented on a greater sense of belonging to the school as a result of their participation in the programme:

“I feel a greater sense of community in the School of Maths. Just becoming friendly with Maths Sparks people has helped this.”

- Student volunteer, 2016

“I feel more comfortable around maths lecturers/staff.”

- Student volunteer, 2016

Students have also commented on the positive element of getting to know others from different pathways and stages of study. This has been particularly important for Stage 2 students who have yet to decide on their degree pathway within the College of Science.

“Great way to build up links between UCD students of different stages.”

- Student volunteer, 2017

“This is fantastic as knowing new people from various degree pathways exposes you to each of your potential options in the future, as well as encouraging discussion about topics you yourself may not have experienced.”

- Student volunteer, 2016

Developing communication and presentation skills

Throughout the three series, students have reported an increase in their confidence to present their mathematical knowledge - an important skill highlighted by the Higher Education Mathematics Curriculum Summit (Groves, 2012). Asked to reflect on their experiences students have responded:

“Overall, I thought Maths Sparks helped me to explain ideas and concepts. I really learned how to break ideas into their simplest form so that they could be easily explained and understood.”
- Student volunteer, 2017

“I feel that I’ve learnt to communicate my own ideas more coherently and concisely.”
- Student volunteer, 2017

“I feel I am much more confident in my approach to communicating maths.”
- Student volunteer, 2016

Participation in the programme has also had a positive impact on their skills in facilitating pupil learning:

“I have learned better techniques in assisting learners and trying to get them to figure out things for themselves without giving the answers”
- Student volunteer, 2017



Figure 5: Student volunteer working with pupils during Maths Sparks 2017

Team-work

Participating in Maths Sparks has assisted students in learning more about working in a team. While students have commented that there is a “great team spirit among facilitators” (Student volunteer, 2017), students appear to have developed their collaborative and cooperative skills:

“I really enjoyed working in a team with people with very different interests to me... there aren't many opportunities to work in a team while studying maths at third level so it was enjoyable to take part in something like this.”

- Student volunteer, 2016

“Working with others has shown me that the overall result of a group is greater than the sum of the individual parts...different people have different strengths and each member adds a unique part to the overall project.”

- Student volunteer, 2016

“Preparing for the workshops in a team meant I had to have confidence in the other team members to complete their work as well as the responsibility of my own work.”

- Student volunteer, 2016



Figure 6: Students and pupils investigate the properties of a Möbius Strip

Recommending the programme to other students

The vast majority of student volunteers would recommend this programme to their peers because of the skills they feel they have gained.

“I would recommend others to take part as it is a very enjoyable and rewarding experience. I have learned so much from these last few weeks that I can use again both in college and work.”

- Student volunteer, 2017

A number of students have commented on how their participation has assisted them in work interviews, since their experiences have provided them with contexts to discuss their ability to communicate mathematics and work as part of a team.

“I’ve had several interviews and all interviewers have had an interest in this programme.”

- Student volunteer, 2017

However, the workload requested of volunteers is something to keep in mind and is an issue we hope to address in future years with further advanced preparation of workshop content.

“Workload may be stressful around mid-term exams, but overall very manageable.”

- Student volunteer, 2017

It is important to note here that student volunteers are recognised for their participation in each of the Maths Sparks: Problem Solving Workshops with an addition to their transcript and (from 2017) with a digital badge awarded by UCD.

Finally, we would like to conclude with reflecting comments from one student volunteer in 2017:

“I would love to do this again! The enthusiasm from the other UCD students and the pupils themselves is infectious.”

- Student volunteer, 2017

Advice to others for implementation

- While this programme has been situated within the School of Mathematics & Statistics, a similar initiative could be run in other subjects. We have developed a resource book which gives an overview of the initiative and also details the problem-solving tasks used with students. This resource, as well as a video documenting the 2016 programme, can be found on the Maths Sparks website and may be of interest to others who wish to develop a similar programme.
- We highly recommend that students apply to volunteer through an application process where they articulate their reasons for wanting to participate in the programme.
- Communication with schools would not have been possible without building on the relationships with schools and teachers developed by UCD Access & Lifelong Learning. Also, since this programme targeted pupils from DEIS schools, it was important to arrange transport to and from schools directly to UCD - UCD Access & Lifelong Learning played a key role in organising this transport.
- As the workshops are held after school, it was important to provide refreshments in the form of sandwiches, water and snacks to attending post-primary pupils.

- While developing the initial Maths Sparks: Problem Solving Workshops programme took an investment of time, we have found it of benefit in developing a student-staff community within our school. In addition, it has proven to be a very positive experience for undergraduate students who have opportunity to communicate and share their passion for the subject and also work with their peers within the school.

Acknowledgements

Funding of this programme plays a key role in providing transportation, refreshments, and workshop materials. We are very grateful to SFI Discover, UCD Access & Lifelong Learning, UCD College of Science, and the UCD School of Mathematics & Statistics for their continued support of this programme.

More information on Maths Sparks and resources available for download can be found at: <https://www.ucd.ie/mathstat/mathsparks/>

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