Royal Institution mathematics Masterclasses: a sixth-form-to-primary connection

Rachel Dorris

Abstract The Royal Institution (Ri) offers STEM Masterclass projects for sixth-form students. Schools taking up this opportunity bring an exciting volunteering project to their STEM sixth-formers, who undertake Ri training and small-group work to develop workshop activities. The project culminates with the sixth-form students delivering fun STEM Masterclasses to a young audience via Ri primary Masterclasses run at their school. The three big wins of Masterclasses are: a win for primary students taking part in the inspiring workshops; a win for sixth-formers who gain invaluable life and subject skills as they develop and lead the workshops; and a win for secondary schools seeking ways to connect with local primary schools.

The Royal Institution (Ri) runs a UK-wide STEM outreach programme delivering extracurricular enrichment workshops to over 6000 students per annum. The Masterclass workshops, generally delivered by enthusiastic volunteers from academia, industry and education, provide students with an in-depth learning experience of the subjects and their applications.

The Ri has over 35 years of experience working with volunteers and collaborators to deliver this programme. We focus on the enthusiasm of the individuals to connect with and inspire the audience of young people; training and supporting speakers to deliver high-quality Masterclass workshops regardless of previous experience.

Masterclasses are run in collaboration with regional organisations – mainly educational institutions such as schools and universities, but we also work with organisations from heritage and industry. Each Masterclass group will reach out to schools local to them and invite them to nominate a small group of students to attend the Masterclasses.

The new 'sixth-form-to-primary' projects and digital resources offered by the Ri brings the opportunity for schools to run a primary Masterclass series with a built-in project for STEM sixth-form students. The projects represent an excellent opportunity for sixth-form students to develop vital life skills under the free tutelage of STEM outreach experts from the Royal Institution.

All of the lessons were so fun and because of that I can't pick a favourite. I definitely won't forget this experience EVER! (Eleanor, primary child)

All of us thoroughly enjoyed working with the younger children because they were all enthusiastic and polite. I think they learned a lot that day. I would be really excited to deliver another session in the future. (Student session leader)

Figure 1 Ri Christmas lectures

Structure of Ri Masterclasses

Generally, Masterclass series delivered to primary schools have the following framework:

- One Masterclass series consists of a course of six workshops spread over a few months during term time. Students see a different topic each week, delivered by a different workshop leader (or small group of sixth-formers working together to deliver a session).
- Each series focuses on one of mathematics, engineering or computer science.
- Students are nominated by their teachers and are expected to attend the whole series, providing an extended extracurricular learning opportunity.

- A series will draw on several schools in a sensible catchment area and reach out to teachers in those schools to nominate students – the more schools involved, the better!
- Masterclasses are hands-on, interactive and in-depth. During the workshops, students investigate the beauty and relevance of each topic, seeing applications and links to other areas beyond the school curriculum.

The format of secondary and primary Masterclasses differs slightly.

Specifics of secondary Masterclasses:

- Age: generally year 9 (age 13–14), but can be run for other age groups.
- Session format: half-day (2.5 hours) workshops on Saturday mornings.
- Workshop leaders: STEM experts from industry, academia and education join the programme as Masterclass speakers to deliver the workshops.

Specifics of primary Masterclasses:

- Currently we mainly offer mathematics at primary level, though they can have a 'maths in science' focus, bringing other subjects into the lessons such as physics, engineering or computer science.
- Age: Normally year 5 (age 9–10), but can be run for other age groups on occasion.
- Session format: 1.5–2 hours, often during school hours (if run at a school). Sometimes it is an after-school club or on Saturday mornings.
- Logistics: When student groups come together during school hours for Masterclasses, they are accompanied by an adult from their own school (generally a teacher, TA or volunteer governor/parent), as would be done for a normal school trip. In this way, barriers to participation for disadvantaged students are significantly reduced compared with Saturday morning classes for which the families are required to bring the students. Secondary schools adopting this model can opt to bring their own older students in as helpers, providing a volunteering and enriching opportunity to this additional group, such as using the sixth-form-to-primary model.
- Workshop leaders: Sessions are commonly run at primary and secondary schools by teachers who deliver many of the Masterclasses themselves but regularly rely on Ri resources and input from older school students. In addition, some visiting speakers from academia and industry, and STEM outreach presenters, also visit groups to deliver primary Masterclasses.

Ri Masterclasses: our UK-wide reach

	2018	2019 projection
Subjects – Computer Science, Engineering and Mathematics	3	3
Series	164	190
Masterclass sessions	902	1000
Masterclass Students	6,276	>7,000
Age range of students (years old)	9 - 17	9 – 17
6th form training days	8	>15
Schools ran 6th form-Primary model	13	>25
6th form students delivered Ri Masterclasses	155	>250

Figure 2 Our programme has an extensive UK network, from Aberdeen to Truro

Teacher involvement

With over 165 Masterclass series running annually around the UK, there are already many opportunities for educators to get involved. One of the most important roles is for teachers to nominate their own students to attend existing Masterclasses arranged nearby. Most regional groups really appreciate teacher involvement, so any teacher who can take the time to visit a Masterclass and support the students' learning is most welcome – a great opportunity to observe what the students are getting up to and gaining subject development to boot.

For schools sending primary students to Masterclasses run during school hours, a teacher or other adult from their school must accompany the pupils, and remain with the group throughout.

Teachers looking for more opportunities to get involved could help to organise or supervise a local series, or even set up a brand new one to serve their community.

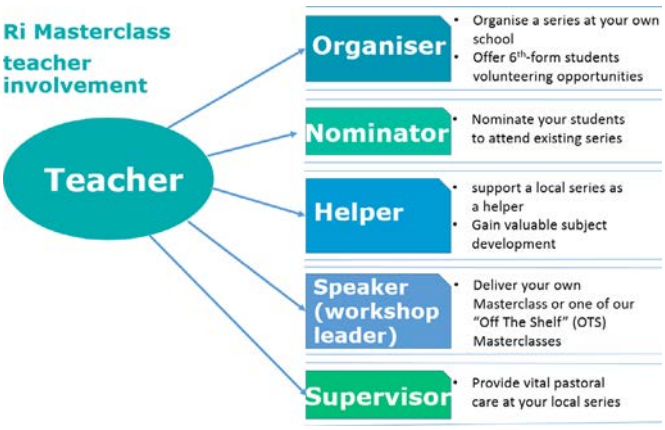

Figure 3 Ways for teachers to get involved with Masterclasses

Sixth-form-to-primary Masterclasses

In this model, secondary school teachers appreciate the opportunity to bring primary school students into

their school for a fun enrichment opportunity, while connecting those students with some of their STEM sixth-formers (or S6 in Scotland). This is run as a formal sixth-form-to-primary Masterclass project.

Sixth-form students follow the project structure laid out in Box 1, culminating in them leading the Masterclass workshops.

Box 1 Sixth-form-to-primary Masterclasses project: a typical structure

1 Attend Masterclass Speaker Training workshop (scheduled several months prior to the start of the Masterclass series). The Ri team visits schools to facilitate the development session that kick-starts the sixth-form project. This represents an excellent opportunity for students to develop vital life skills under the free tutelage of STEM outreach experts from the Royal Institution. Training includes:
   - presentation skills;
   - workshop content development;
   - an introduction to the Ri resources;
   - a light touch on classroom management and inclusive teaching techniques.
2 Several weeks undergoing group study and teacher-supported time developing content and writing workshop, during which some time spent practising activities with peers.
3 Attend first Masterclass session in series as a helper. This allows sixth-formers to see a Masterclass in action prior to them delivering one. The Ri tries to send one external speaker, a Masterclass 'veteran', to deliver this first session to showcase a high-quality Masterclass to all.
4 Deliver their own primary Masterclass in pairs or small teams.
5 Possibly continue to help at other Masterclasses.

At the end, the primary students and sixth-formers receive an Ri Masterclass certificate. Sixth-formers also receive an Ri pin badge and an invitation to a sixth-form day at the Ri.

Figure 4 Ogden Trust case study at Chipping Campden School

This model can also work for other groups such as sixth-form or FE colleges or with year 10 students, provided that the hosting school can give sufficient support – please ask the Ri team for more information on this and on how the Masterclasses can be tailored to your needs.

The three big wins of masterclasses

The many benefits of getting involved with STEM outreach programmes are well documented. The sixth-form-to-primary Masterclass model brings the following specific benefits.

Primary students win:

- an extended maths enrichment activity, providing the confidence boost this brings and raising their science capital;
- inspiration of seeing maths, both pure and applied, and developing an appreciation of its beauty and utility;
- interaction with positive role-models who are studying maths and STEM subjects at higher levels;
- experience attending a local secondary school (helps primary students with secondary transfer).

Sixth-form students win:

- enrichment of their own subject knowledge;
- life skills, including time management, project organisation, teamwork, leadership and communication skills – all gained through development and delivery of workshop presentations and activities, underpinned by structured training from the Ri;
- safe environment: support from their teachers to help them develop and deliver the activities;
- access to Ri resources;
- the enjoyment of sustained interaction with younger children;
- a great volunteering opportunity, an excellent addition to their CV/UCAS form.

Schools and teachers win:

- bringing in sixth-formers to deliver some or all of the activities helps to spread the workload that teachers would otherwise have if they chose to deliver all Masterclass sessions themselves;
- an opportunity to connect with primary schools in their community;
- development opportunities for teachers;
- an opportunity to join a long-standing UK-wide outreach network and forge links with the Ri.

Benefits of working with the Ri

Masterclasses are free to schools and students. We offer a tailored approach with bespoke support from our dedicated team based at the Ri, experts in maths, engineering and computer science.

Support for all Masterclass groups throughout the UK includes:

- handbooks on all good-practice aspects, including safeguarding and data protection;
- a full invitation pack to send out to schools, with letter templates including consent forms for parents/carers;
- training opportunities for new groups, sixth-formers, teachers and new workshop leaders;
- anyone working in STEM or STEM education can become a Masterclass speaker regardless of prior experience of outreach – we provide development opportunities to all newcomers, and support while they develop their own workshop activities;
- follow-on events and conferences at the Ri in London and other Ri school opportunities;
- provision of an Ri-funded external speaker to new groups;
- Ri certificate of attendance for participants;
- Lots of lovely activity resources!

Figure 5 Ri certificate of attendance issued to each student and sixth-former involved

Activity resources

The activity resources provided by the Ri represent a step-change in accessibility of Masterclasses, enabling many more children to benefit. Easy to pick up and run, they are perfect for busy teachers and as a starting point for sixth-formers:

- Primary Masterclasses book: lots of ideas and lesson notes for you to create your own workshops. Ask the Ri Masterclass team for a free copy.

Figure 6 Primary Masterclass resource book

Figure 7 A primary Masterclass group enjoying 'Calculating Colours', an activity from the primary resource book

Figure 8 Off-the-shelf Masterclass resources, available to download and use in Masterclasses and any classroom setting from the Ri website at www.rigb.org

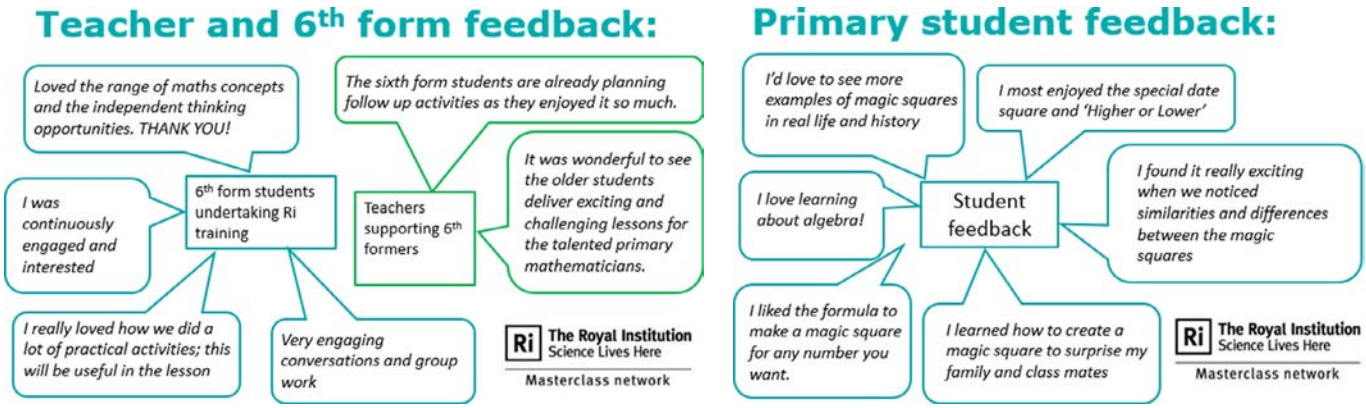

Figure 9 Feedback from teachers and sixth-formers, and from primary students

- Off-the-shelf (OTS) Masterclasses: Ready to go workshops with all digital resources including presentation and worksheets, step-by-step explanation of how to run the workshops, background information for leader and helpers, and ideas for further activities.
- These resources, such as Mobius bands, Sierpinski's triangle, Magic Squares, and so on, are a perfect starting point for sixth-formers and teachers coming new to Masterclasses – use an existing 'OTS' workshop, or lift ideas from these resources, or even just use them as a quality benchmark when developing something brand new.

Conclusion

The Ri Masterclasses offer young people a fun and inspiring way to explore STEM subjects. With the addition of our new sixth-form-to-primary Masterclass projects and digital off-the-shelf resources to our programme, we are allowing high-quality Masterclass activity across the whole UK to really take off.

Figure 10 Masterclass students tackling challenges with fractals, amorphic art and colour combinations, etc.; image credits: Tim Mitchell or the Royal Institution

Rachel Dorris is a Clothworkers' Fellow in Mathematics at the Royal Institution and has overall responsibility for the Ri mathematics, engineering and computer science Masterclass programmes.
Email: rdorris@ri.ac.uk