Sharing a baseline: project report

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Summary

We report on the Sharing a baseline project, which coordinated interactions between school classes in different countries with radio astronomical observatories, reflecting the links between global telescope networks. The project aimed to increase science capital for 14-15-year old learners through connected classes with each other, and leveraging the global aspects of radio astronomy. The project involved classes, facilities, scientists, and activities in five European countries in 2024, with a project extension in 2025 to include South Africa.

Observatory visits in Finland (left) and Spain (right).
Credit: Aalto University/J. Tammi; IGN/C. García Miró

Background

Radio astronomy is a scientific enterprise which explores the universe primarily using impressively large, ground-based telescopes. Increasingly, radio astronomical measurements are made in coordinated international networks. Many of radio astronomy's scientific achievements use these networks – applying *very long baseline interferometry* (VLBI) to achieve high angular resolution. High-profile examples are the first images of black holes and high-precision measurements of how Earth's rotation is changing. At the same time, the newest radio astronomical facilities are being located at remote locations, for example the telescopes of the SKA Observatory and ALMA.

Effective public engagement with radio astronomy can combine local access to engaging facilities with awareness of international connections. We proposed Sharing a baseline to explore and share methods of engagement with school classes located close to radio astronomical observatories, and to test new ways of working with international public engagement that could be developed further as the SKAO telescopes in Australia and South Africa become operational.

Sharing a baseline was awarded funding from the SKA Observatory (SKAO) and the International Astronomical Union (IAU) under a joint scheme with the IAU's Office for Astronomy Outreach (OAO), organised through its network of national outreach contacts (NOCs). The scheme aimed to support the development of freely accessible public outreach content and resources about radio astronomy, and to foster new international collaborations between outreach experts and astronomers in the SKAO's partner countries and beyond. The phase 2 proposal is provided in Appendix 4.

Team

The project was carried out by a team of astronomers and communicators from several radio astronomical facilities, composed of coordinators for each of the participating nodes, plus a representative for the Joint Institute for VLBI ERIC (JIV-ERIC, or JIVE). The team, and the participating nodes, were assembled after a request for participation was sent out to JIVE's outreach contacts during 2023.

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In addition, all nodes involved other colleagues to support the project in different ways.

Team members for the 2024 project only are marked with (*). Robert Cumming was both NOC and SKACON representative for Sweden at the start of the project. Other national NOCs and SKACON representatives were signatories to the proposal and/or kept informed by email of project progress. JIVE communicator Jorge Rivero González suggested the project in April 2022 and collected the participants in November 2022.

Partners

Chalmers University of Technology, Sweden. Provided project management and administrative assistance.

JIV-ERIC. Provided support with proposal and recruitment of the project team, economic resources and communication support.

Project nodes and locations

The initial project involved activities in five European countries, organised in six *nodes*, each pairing an observatory with a school class. The 2025 extension involved one pairing, connecting two countries in Europe and Africa.

Year(s)	**Country, node**	**Observatory**	**School, distance from observatory**
2024	Finland, FI	Metsähovi Radio Observatory	Jorikinteen koulu, Kirkkonummi, Finland, 19 km
2024	Italy, IT-M	INAF Medicina	Liceo A. Volta, Lodi, Italy, 230 km
2024, 2025	Italy, IT-S	INAF Sardinia Radio Telescope	Liceo Euclide, Cagliari, Sardinia, Italy, 42 km
2024	Netherlands, NL	ASTRON, Dwingeloo; LOFAR	Wolfsbos, Hoogeveen, Netherlands, 20 km
2024	Spain, ES	Yebes Observatory	IES Brianda de Mendoza. Guadalajara, Spain, 18 km
2024	Sweden, SE	Onsala Space Observatory	Sannaskolan, Göteborg, Sweden, 40 km
2025	South Africa, ZA	Hartebeesthoek Radio Observatory	Leokeng Secondary School, Modderspruit, North West, South Africa, 52 km

Target audience

Our main target group was school students aged 14-15 years. We wanted to reach learners who have not yet chosen what to study at high school, and their path in life remains open.

The project was also aimed to benefit outreach and communications staff involved in the SKA and other international projects by testing ways of involving the public and schools in radio astronomy facilities. We aimed to provide opportunities to share schools and outreach activities among member institutes of the European VLBI Network, working together with IAU NOCs and SKACON members.

Activities

At each node we planned three core activities.

- **Scientist visit to school (duration 1-2 hours)**. A scientist visits a school class. They introduce radio astronomy, why it's important, and how international cooperation is key to both scientists and telescope networks, and the Sharing a baseline project itself.
- **Observatory visit (duration 2-4 hours).** The school class visits a radio astronomical observatory. Activities to be tested: students document the visit, record questions to astronomers, creating a video ready for sharing with a school class in another country, with messages and/or questions; remote observing with small radio telescopes like SALSA/Spider; working with astronomical images or other accessible data.
- **Online meet-up (duration up to 1 hour)**. Classes in two different countries meet each other, share experiences, content they have created, and results of collaborative work.

In addition, most nodes also carried out other activities related to the project. See Appendix 1 for a table of all the project activities.

Observatory visit to Hartebeesthoek, South Africa, during the 2025 extension. Credit: SARAO

Deliverables

This report is our main deliverable. We include lessons learnt, including feedback from project participants and assessment of the students' response to the project. We include recommendations for scaling up the project to involve other countries in the future (for example the member nations of the SKAO).

Outcomes

We tested activities that could work in a coordinated way across international boundaries and with different age groups, by testing a number of different activities in different locations. We expected challenges in terms of differences between classes in different countries – in age, context, and experiences. We expected to work with language barriers. In this report we make a preliminary assessment of what worked well and what worked less well.

In particular, we tried connecting classes digitally with each other, known as *virtual exchange* (O'Dowd, R., 2021, doi: 10.1080/09588221.2021.1902201), and found ways of working that show future potential. We want to benefit large projects like the SKAO in identifying activities that communicate the global connections that modern science is dependent on, and to pave the way for larger-scale projects that also link communities using radio observatories.

Italy-Sardinia: Class learning about fast radio bursts.
Credit: INAF/S. Casu

Project activities and how well they worked

We left each node free to decide on the details of activities. The first nodes to make contact with schools shared what they had done, and these early examples were sometimes reused by other nodes.

Scientist visits the school class. At each node a visit to a school was carried out, and a scientist gave a general talk about radio astronomy. The visits were planned to be before the observatory visit, but in one case (Sweden) happened after. The scientist was sometimes a staff member who the class had met before, sometimes not. In some cases (IT-Sardinia, Netherlands, South Africa), more than one scientist visited the school. Presentations were occasionally reused between nodes: for example, the presentation given in Spain was shared and adapted for use at the school visit in Sweden.

Class visits the observatory. Observatory visits followed local traditions for school visits at each node, but some took the opportunity to try out new ideas. The class visiting Metsähovi (FI) made solar observations and maser observations, for example. The class visiting the Sardinia Radio Telescope (IT-Sardinia) in 2024 stayed overnight on site; while the visit to Onsala (SE) was the standard two hours long.

Sharing digital content. We encouraged project participants and students to document their visits with photos and video recordings. We wanted to share this material between countries to enhance the shared experience.

We found during 2024 that while some of this material was created, almost none was shared with the project, and we suspected that this was because we didn't create shared resources or routines for participants to follow.

In the 2025 extension we tried to make sharing easier, and decided that material could be shared either by email to the project leader, or via a WhatsApp group made up of the team members. Of these, only the WhatsApp group was successful, collecting a number of photos and clips from South Africa, both the visit to the school and the class's visit to the observatory.

Fact-finding on radio astronomy topics. Early on in the 2024 project we found that schools and teachers at all nodes wanted students to carry out their own fact-finding projects in small groups (2-5 people) for presentation to an audience of their peers. We shared lists of possible topics (based on the first, Spanish example) and offered introduction and support. For many students this project work became an important part of their engagement with Sharing a baseline. The result of this work was in many cases in the form of text – usually material collated from online sources and books – which the students were keen to read out and present using for example Powerpoint. For the students and teachers, these group project presentations were an important part of what they wanted to share with classes in other countries. Since each group presentation needed at least several minutes, this was a challenge within the tight format of the online meetups.

Other activities. The project led to new activities at some nodes. In Finland, a suite of new experimental activities were tested; see below for details. In IT-Sardinia, the class carried out an activity using computers to analyse data from the Sardinia Radio Telescope on fast radio bursts. In the Netherlands, the class visited a geological park close to the LOFAR telescope and carried out experiments there.

In the 2025 extension, the IT-Sardinia node repeated the fast radio burst activity. Due to scheduling constraints, the South African node didn't carry out any other project activities.

Online meetups. We wanted classes in different countries to meet each other, share experiences, content they have created, and results of collaborative work. The online meetups were scheduled to happen after earlier activities. Expectations were high but so were risks, and we were trying something very new for almost everyone.

In particular, we made some preparations for language challenges. For the IT-M/SE meetup, interdisciplinary work was carried out in the Italian school, involving the participation of English teachers as for the language skills required for communicating online with foreign peers. During the meetup itself, Sweden-based Italian-speaking astronomer Teresa Margheri helped with real-time translation.

Based on the experience at the time, and our evaluation forms, we assessed the success of our meetups. We recorded all of them using Zoom. All four (ES/FI, SE/IT Medicina, NL/IT Sardinia and later ZA/IT Sardinia) succeeded in our basic aims of giving participants a feeling that they were part of an international context doing similar activities connected to radio observatories.

While working with the first 2024 meetups, we shared what we had learnt. This dramatically improved the quality of the experience for participants in the later meetups. We were able to encourage successful content (for example young people on camera communicating to peers),and minimise less successful content (scientific facts; adults presenting information) and avoiding problems (ensuring translation support, training technical systems; being careful about timing).

The online meetup in 2025 was arguably as successful as those in 2024, despite more challenging circumstances (short time for preparation and very different contexts for the two classes involved).

Deviations from the original project implementation

During 2024 there were no major deviations from the planned project implementation.

Some planned deliverables have not been completed. We envisaged providing a roadmap for scaling up the project, and specific adaptations for the context of the SKAO.

We have not produced written resources in several languages as we had planned. While we shared and reused some resources (slide presentations about radio astronomy), we didn't work on creating coordinated resources during the project.

We expected to collect videos from students. While we encouraged students to document their activities, this didn't result in material that we can share publicly. During the first year of the project we identified a need for infrastructure or repositories for sharing images and videos. During the 2025 extension, initial tests using simple routines for sharing images and videos made it clear that dedicated staff resources is more important than routines and repositories.

We planned to create an educational activity about radio astronomy and VLBI, tested and ready for submission to IAU astroEdu platform, and this also turned out to be over-ambitious. While each node carried out its own educational activities, we didn't coordinate or document these efforts.

Extension 2025 including South Africa

During 2024 we made contact with colleague Anton Binneman, SKACON representative for South Africa, and discussed the possibility of adapting the Sharing a baseline concept in the future.

After activities were completed in 2024 we decided to use the remaining funds and interest among project partners to extend part of the project into 2025, selecting one node to work with South Africa.

We chose Hartebeesthoek Radio Observatory as the South African node, with Simphiwe Madlanga and Marion West as coordinators. HartRAO is similar in many ways to the European observatories we had worked with, and is in a similar time zone. The observatory works with JIVE and the European VLBI network, is close to major cities but in a completely different province from the site of the SKAO facilities in South Africa.

We offered the possibility of participating in the extension to the existing European nodes. Of these, Italy-Sardinia volunteered to join, again with Silvia Casu as coordinator.

Challenges

Distributed international team. We met the challenges of an international team by regular online meetings (Zoom), shared online documents (Google Drive) and follow-up by email and messaging services (WhatsApp). We worked with colleagues from the participating countries based in other institutions. Teresa Margheri (Chalmers, Sweden), who played key roles in the Italy-Sweden meetup and visited the Italy-Medicina node during the project. Emanuela Orrú, Sardinian scientist at ASTRON, Netherlands, took part in activities when the Dutch school visited the observatory in Dwingeloo.

Limited staff focus for an unusual project. For project members, Sharing a baseline was one of many competing activities, and attendance at project meetings was patchy. We

compensated by sharing meeting minutes, and in some cases recordings of meetings. Despite this some project members reported not being clear about what was required of them. This may be a sign that the project was not clear in its aims and not clear enough in its objectives so that staff could interpret and make independent decisions.

Choice of age group, schools and classes: We wanted to reach students who were old enough to be able to communicate with each other in English, but young enough not to have chosen their path in life. We found out quickly that our countries' education systems differed in how possible that compromise was. In the Netherlands and Italy, students already face a choice of aiming towards higher education, and towards science, before age 15. Our school classes in those countries were chosen from schools with an academic or science focus.

Scheduling and coordinating visits. Project members shared plans via meetings and email, and each node handled communication with each school. It was challenging to coordinate activities in the right order, and scheduling was sensitive to individual issues (for example, a missing bus on one occasion in Italy-Medicina). For the 2025 extension, we attempted to simplify this, choosing a two-week period in which all activities would be carried out. Still, we weren't able to keep to this schedule, due to delays in South Africa in getting the necessary permissions for the school to carry out its observatory visit.

Choosing core activities from many desirable options. During the initial phases we discussed many possible coordinated activities, from coding exercises to science journalism, art and writing. We chose not to require any core activities, but this created uncertainty; school classes wanted better instructions on what, if anything, to report during the online meetups. Meetup hosts – the project members for the two nodes at each meetup – didn't have a formal requirement to define the meetup programme.

Lack of best practice knowledge for virtual exchange. While project members had experience of videoconferencing with adults, none of us had worked with this sort of activity for school classes. As far as we know, the teachers were also new to the idea. Some had unclear expectations of what to do. We were unaware of best practices for virtual exchange for our context during the project.

Self-evaluation

We have tested a format for international collaboration between observatories and schools, intended to be straightforward to implement and result in increased science capital for the learners involved. Here we assess how well we achieved this.

To assess our success, we collected feedback from project colleagues and teachers, and their responses give some indications of the projects impact on the learners. While we didn't collect evaluation information directly from learners, we tested a simple online form with some learners in Spain and Italy.

From these responses, and from our own experience of the project, we know that the students had the opportunity to visit an observatory, learn about radio astronomy, and interact with scientists. We also know that they were aware of being part of an international project.

During the meetup sessions they were able to see and interact with peers in another country. The meetup experience had the potential to reinforce the science capital that the students gained during the rest of the project, helping them to reflect on all the experiences related to Sharing a baseline. From our observations and survey responses, we don't know

whether this happened, but we have reason to be optimistic. Based on recordings of the meetups and reports from staff who were present, many students reacted positively during at least part of the meetups. While observatory visits were a more clear-cut highlight for most, the meetups were still seen as positive experiences.

Reports from the meetups and the recordings make clear, however, that they were all affected by technical issues and the limitations of standard videoconferencing software. For this reason alone, we might expect negative judgements from those participants who are used to personal video conversations or meetings in other contexts.

The evidence of positive response from the students therefore gives us confidence that the meetup experience did indeed provide extra value for the participants, and is worth exploring further.

Our attempts to realise online interactions across borders met with many of the same challenges that other virtual exchange programmes for young people have faced (Dooly, M., 2022 https://doi.org/10.14705/rpnet.2022.59.1407; Hinshaw et al 2022, *Journal of International Students* 12.S3: 1-16; Gutiérrez, B.F. et al. 2021, *Mentoring handbook for virtual exchange teachers*, Stevens Initiative https://www.stevensinitiative.org/resource/mentoring-handbook-for-virtual-exchange-teachers/).

Netherlands: Geology activity during class visit to De Hondsrug UNESCO Global Geopark. Credit: Chalmers/M. Brendel

Netherlands: Sardinian astronomer Emanuela Orrú presenting radio astronomy at ASTRON in Dwingeloo. Credit: ASTRON/M. Brendel

Sweden: question and answer session in the visitor centre during class visit to Onsala Space Observatory. Credit: Chalmers/R. Cumming

Feedback and evaluation

Evaluation form, team, colleagues and teachers

For our team, colleagues and teachers, we collected feedback on the 2024 project using an online form (Appendix 3.1). We received 12 unique responses, with at least one answer from each node. Adding the 2025 extension we modified this form only slightly (Appendix 3.2) received four additional unique responses, from two coordinators (both South Africa) and two teachers (South Africa and Italy).

The response pattern was as follows:

	coordinator	teacher	scientist or other staff	learners
Finland	1	1		
Netherlands	1	1	1	
Italy-Sardinia	1			5
Italy-Medicina	1			
Spain	1	1		5
Sweden	1	1	1	
2025 extension				
Italy-Sardinia		1		
South Africa	2	1		

Fulfilment of project aims. We asked about agreement with the following statements. (In parentheses number of responses, from *strongly agree* to *strongly disagree*).

- The students experienced an observatory first-hand (13,1,1,0,0)
- Because of the project, the students learned more about science (7,9,0,0,0)
- The project activities helped students to understand radio astronomy (6,9,1,0,0)
- The students understand more about scientific research than they did before the project (6,9,1,0,0)
- The students had direct contact with an astronomer or other scientist (13,3,0,0,0)
- The students think more positively about natural sciences than before the project (4,6,6,0,0)
- The students valued participating in the project (7,5,4,0,0)

Response to activities. Of these, the most positive responses were for *School class visiting observatory* and *Video meeting with school in another country*. (In parentheses number of responses, from *very positively* to *very negatively*.)

- Scientist visiting school class (8,4,2,1,0)
- School class visiting observatory (9,4,2,0,0)
- School class working on group projects (4,5,4,0,0) [not applicable for South Africa in 2025 extension]
- Video meeting with a school in another country (8,6,1,0,0)
- Learning about radio astronomy (6,5,3,0,0)
- Learning about other topics related to the project (4,8,2,0,0)

Adult participation. We asked the adults involved about how they experienced participation in the project. In general, they felt they understood the project and were able to use contacts and skills to do the work well. One teacher felt that they didn't have support from colleagues. Few used material from other countries. (In parentheses number of responses, from *strongly agree* to *strongly disagree*).

- I understood the aims of the project (9,6,1,0,0)
- I knew who to contact (12,4,0,0,0)
- I had support from colleagues (8,6,0,1,1)
- I had good background knowledge (5,10,0,0,0)
- I was free to choose how to work (10,5,0,0,0)
- I knew what was expected of me (6,7,1,1,1)
- I was sure I could do the job well (3,6,4,1,0)

- I used my own skills to help the project (9,6,1,0,0)
- I used material from one of the other countries (2,4,2,5,1)

Adult personal experience. For the adults, the experience of scientist visiting the school class was the most positive.

- Scientist visiting school class (12,3,0,0,0)
- School class visiting observatory (9,3,2,0,0)
- School class working on group projects (5,3,6,0,0) [not applicable for South Africa in 2025 extension]
- Video meeting with a school in another country (6,9,0,0,0)
- Students learning about radio astronomy (8,8,0,0,0)
- Students learning about other topics related to the project (6,7,1,0,0)

Evaluation form for learners

We didn't systematically collect evaluations from learners. In June 2024 we tested a very simple online form (Appendix 3.3), sharing with project participants. This led to five responses each from students in Spain and Italy-Sardinia.

These were generally very positive. We asked respondents to name one enjoyable and one less enjoyable activity. Among the preferred activities were the visit to observatory, anechoic chamber, visit to aerospace facility INTA, visiting the Sardinia Radio Telescope, video meeting with Netherlands, working with computers, meetup and lessons with scientist. For the less enjoyable activities, several actually answered "none". Others were visit to a control room and scientist visiting school (but with caveat "It wasn't boring at all but it was obviously less exciting than talking to people from other countries or visiting a radio observatory").

Netherlands: Teacher introducing engineer Des Small during class visit to ASTRON. Credit: Chalmers/M. Brendel

Evaluation form for adult participants

Here we collect comments on the project and suggestions for improvements from the adults who filled in the form.

Teachers

“It would be great and the project would be easy to participate in if the amount of extra work for the teacher would stay as small as possible.” (teacher Finland)

“I think a very good idea should be sharing the science results with all the countries instead of sharing them with only one country.” (teacher Spain)

“This year we had our students work on the projects for 2 hours a week. Next year we would like to work on the project for 1 whole week. I hope this will be possible.” (teacher Netherlands).

“Some students were more enthusiastic about the project than others. It was difficult to get the group's presentation in such a way that every student would have participated equally in making the presentation” (teacher Finland)

“More structure for the whole project [is needed]. Agree in advance which programs the students will use when they want to film their [project] work before [sharing in video] meetings. On several occasions, the students did not find material for their work. It would be good to have examples of books, magazines, brochures and factual sources online. During the observatory visit, more concrete tasks for the students to do would be good.” (teacher Sweden)

“More structure [is needed]; agreeing which [digital tools] the students should use; use the students' textbooks as a starting point for [addressing] radio astronomy.” (teacher Sweden)

Italy-Sweden: Screenshots from online meetup between school classes in Lodi, Italy (left) and Göteborg, Sweden (right). Credit: Chalmers/R. Cumming

South Africa-Italy Sardinia: Silvia Casu (coordinator Italy-Sardinia, right) addressing school classes at Hartebeesthoek Radio Observatory and (off-screen) in Cagliari, Sardinia, during the meetup between school classes in Italy and South Africa in May 2025.
Credit: SARAO/S. Madlanga

Team members and colleagues

“This year the project was a pilot one, and the main "road" was not perfectly clear to me from the beginning.” (team member Italy)

“The project was a bit demanding on my time, it required many visits to the school.” (team member Spain)

“I would also [prefer to] work with younger students, at least one year younger, as these students were too busy and found it difficult to find time for extra projects.” (team member Spain)

“It would have been better to contact the school earlier, before the start of the term, to include the Sharing a Baseline project in their curriculum.” (team member Spain)

“Start with setting up an end date (deadline) for the presentations (so schools should be connected to one another at the start) and work back from that point. Finding a date and time on which both our school and the other school were available, proved to be very difficult and this point got tackled only far near to the end of the project.” (team member Netherlands)

“We didn't have any scientific data for the students to work with, but I think that would have really been better.” (team member Netherlands)

“The joint activities between schools/countries need to be developed and designed way more beforehand. Also rehearsed from the technical point of view.” (team member Finland)

“I would like the products expected from the students to focus on new skills rather than new knowledge, that can be retrieved via other means (e.g. web) and doesn't much effectively report about their engagement and growth during the project. One idea could be to ask students of paired countries to work together on these products.” (team member Italy)

Sweden: In January 2025, five students from Sannaskolan returned to Chalmers University of Technology for an event celebrating Sweden's membership of the SKAO. Above: meeting university vice president, astronomer Susanne Aalto. Below from left: Elof Manninen, Ludvig Holmgren, teacher Annamaria Hjelmqvist, Irma Rodhe Wiese, Jana Pettersson and Tora Hellervik. Credit: Chalmers/Anna-Lena Lundqvist

"The school we worked with here in South Africa comes from a rural setting and they had never heard of or been to an astronomy research facility. They were quite intrigued but as can be expected there was some element of intimidation, amidst the awe." (team member South Africa)

"Either all schools must experience a first-time encounter with the research facility or all schools must have had prior exposure to the domain otherwise there is too much variance and less chance for synergy in terms of shared knowledge and experiences. There was value for both parties but not necessarily in a way that matches outright." (team member South Africa)

"The project promises to grow and develop in more inclusive and nuanced ways if allowed to /…/ I am keen to contribute to future initiatives and grow the network and community of practice." (team member South Africa)

"It is also quite apt and significant that HartRAO is part of VLBI networks, working with institutions in other continents, and now the Sharing a baseline initiative offers this collaboration of learner classrooms connecting between the Northern Hemisphere and

Southern Hemisphere. That has great parallels and meaningful nuances." (team member South Africa)

"A strong request from the students was to continue with the project /…/ Having the funds, it would also be very nice to be able to organise face-to-face meetings, so as to create networks between the students." (team member Italy)

"At least a couple of students changed their mind about their future studies, they are now much more interested in STEM studies." (team member Spain)

Recommendations for expansion

While the project will not continue in its current form, members have indicated interest in being involved in any future continuation of the project.

We believe that the activities we have tested in Sharing a baseline could be expanded to observatories and school classes in more locations worldwide. Our aim, to link classes and create science capital for young people (Archer et al. 2015, doi: 10.1002/tea.21227) while raising awareness of the international nature of radio astronomy, has only been partly tested by the activities so far. We expect that there is much more to learn about how to do this best.

Based on our experiences so far, we make the following general recommendations.

1. **Simplify and package.** To help universities and research stations collaborate with each other, set up a clearly-defined package of recommended activities to be carried out. For recruiting school classes, specify requirements and recommendations, for example in age and English skills.
2. **Plan well in advance.** Schools have time to assign roles and deal with necessary permissions and paperwork to allow participation in the project activities.
3. **Establish international links early on.** Scheduling activities requires information sharing about term dates and other constraints.
4. **Recruit colleagues to work with documentation.** Engage resources at each node to work with photos, film, text and perhaps also social media. Learners and teachers need help to use these resources to document and share their activities in ways they feel comfortable with.
5. **Follow best practices for virtual exchange and support robust meetup technology.** Meetups are critical for the success of the project. Our experience shows that preparation, practice and the robust technical solutions are necessary and should be planned ahead by both schools and observatories, using insights from other virtual exchange programmes.
6. **Standardise experimental activities.** Our nodes offered different hands-on experiment activities related to radio astronomy. Simple equipment like Sweden's online SALSA telescopes, the Netherlands' Paintcan telescope, and the SKAO's Table Top Radio Telescope, could be tested and coordinated.
7. **Consider combining with existing initiatives.** International or national schools outreach programmes may provide a useful structure for similar activities. For example, Sweden's national *Borrow a researcher* programme (https://forskarfredag.se/european-researchers-night/borrow-a-researcher/) facilitates scientists visiting schools.
8. **Consider adapting to different age groups.** Our project barely explored the potential for international contact between classes. Choice of science-related programmes in school varies widely between countries, and we don't know how

much a good match matters. In general, involving younger students could increase the project's potential impact on individual choices, while involving older students may increase the chances of meaningful communication with peers in another country.

9. **Explore diplomatic, media, and political potential.** School students' interactions with international science infrastructures have a potential to demonstrate and communicate science and its impact beyond the immediate participants. This is potentially powerful and thereby also involves risks for all stakeholders. Connections with science diplomacy initiatives and with media should be explored and developed carefully in collaboration with institute leadership and communications experts.
10. **Recommendations for the SKAO.** Expansion to the rest of the SKAO member countries means including countries like India, China and Australia, and dealing with larger differences in time zone, culture and language than we have addressed in Sharing a baseline. From our work it's clear that direct communication between classes is valuable, further experimentation is needed with asynchronous communication and with different ways of dealing with language barriers. Also, Sharing a baseline needs to find its place in networks of international public and schools outreach programmes, both with astronomy and in other contexts.

Financial information

The project received funding from the IAU (5000 EUR) and from JIVE (2500 EUR). In addition, the project was supported by substantial in-kind contributions from the participants' institutions.

Grant funding use

Each participating country in the 2024 project was encouraged to claim expenses for up to 1250 EUR. During 2024 only two nodes made claims to the project, Finland (1250 EUR to Aalto University) and the Netherlands (752 EUR). Because of the low claim rate we decided to extend the project into 2025 and offered funding to South Africa and Italy-Sardinia. However, no claims for expenses were made in 2025.

Apart from the two claims above, all expenses for Sharing a baseline were covered by the collaborating institutions' operating budgets. We identify the following reasons for this:

- The staff effort required for Sharing a baseline was low and consisted of activities already included in the participants' job descriptions.
- The largest expenses were for bus transport to the observatories. In most nodes this was covered either by the school or the host institute.
- The project was (perhaps too) successful in encouraging participating institutions to adapt ways of working that they normally employ.
- The project made no attempt to invest in merchandise, printed materials, or buying services.

In-kind contributions

Participating institutions provided staff effort in kind to the project, and covered other expenses. Here we estimate these costs. Note that these estimates are very rough and may be wrong by several tens of percent.

Staffing: In the table below, we detail estimated staff working hours. The total in-kind contribution would amount to just over 14 000 EUR, assuming an average hourly rate of 18 EUR (Table).

Node	Role	Estimated hours 2023	Estimated hours 2024	Estimated hours 2025
Finland	coordinator	8	60	
	other roles		18	
Netherlands	coordinator	8	53	
	other roles	14	83	4
Italy	coordinators	16	120	
	other roles		10	4
South Africa	coordinator			96
	other roles			8
Spain	coordinator	16	72	
	other roles		4	
Sweden	project manager	15	75	32
	other roles	3	39	
Total		**80**	**534**	**176**

Transport expenses: In addition, bus transport costs were covered by a number of nodes. A very rough estimate of these costs is 5000 EUR, including trips for observatory visits in Italy, South Africa (cost 21 kZAR = 1040 EUR), Spain and Sweden.

Remaining funds at the end of the project

By the end of the 2025 extension, the project had funds of just over 5000 EUR remaining.

We will use part of this to design and print certificates of participation to be delivered to each of the participating schools. The design and production will be coordinated by Robert Cumming at Chalmers in Sweden. Any remaining funds will be paid back to the IAU and JIVE.

Resources

The project did not produce any resources beyond the content of this report.

Communications and public relations

Communication to external audiences had a low priority for us during the project. The project led to a small amount of media coverage.

Media coverage

The following media reports were published during the project.

- *Los alumnos del IES Brianda de Mendoza, en proyecto europeo [Students of IES Brianda de Mendoza in European project]*, Natalia de Lucas, Nueva Alcarria, 2024-02-02

- *Wolfsbos leerlingen wisselen ervaringen uit met leerlingen uit Sardinië [Wolfsbos students exchange experiences with students from Sardinia]*, Paula Bansema, Hoogeveen Regio, 2024-06-06
- *Drentse leerlingen hebben astronomische ervaring [Drenthe students have astronomical experience]*, Marin Van Den Bogaerdt, Naar School, 2024, nr 42 https://openbaaronderwijs.nu/flipbook/naarschool-2024-42/naarschool-2024-42.pdf
- *Los viernes de la ciencia con Natalia de Lucas [Science Fridays, radio interview with teacher Natalia de Lucas]*, (https://cadenaser.com/audio/1705062696521/), 2024-01-12, SER Guadalajara
- *Sverige signerar SKA-konventionen [Sweden signs the SKA convention]*, Joachim Wiegert, Populär Astronomi, 2025-01-28, https://www.popularastronomi.se/2025/01/sverige-signerar-ska-konventionen/

In Finland, a local news reporter was present during the observatory visit in Finland in 2024.

In Spain, the students' observatory visit in February 2024 coincided with a visit from the popular science influencer Doctor Fisión. His content from the occasion includes project member Cristina García Miró but not the school class. https://www.facebook.com/reel/1844345512660705/).

Conference contribution

Robert Cumming reported on the project at the IAU's conference Communicating Astronomy with the Public in June 2024 in Toulouse, France. Link to video recording https://youtu.be/H4CYZ7y8Nag?si=EIjyglWgVQP5KB4o&t=1617.

Feedback on project coordination and management

The funding agreement documents were promised to us shortly after we received notice of the grant award on 15 June 2023. They were delivered for us to sign on 3 December 2023. We reported about project progress our contact persons at the IAU and SKAO (Kelly Blumenthal and Mathieu Isidro, respectively) during the CAP 2024 conference in Toulouse, France, and only occasionally before that. We requested permission for the 2025 extension in January 2025 which was granted swiftly.

Acknowledgements

We acknowledge the cheerful, enthusiastic participation and adaptability of all the school classes involved in Sharing a baseline, and the support, encouragement and critical response of their teachers and school leadership. We are indebted to many scientists and other staff at our observatories who contributed cheerfully to the project activities, among them Joanna Holt, Teresa Margheri, Gustav Olander, Emanuela Orrú, Des Small and Ilse Van Bemmel. RC is grateful for support and discussions with Anton Binneman, Cassandra Cavallaro, Eva Wirström and Vincent Desmaris, and to Judit Háhn and Malin Reljanovic Glimäng for expertise on virtual exchange. Special thanks to Jorge Rivero González, whose idea it was to start the project.

APPENDIX 1

Timeline of project activities

Date	Node/ Country	Activity type	Participants	Staff, other comments
2023-12	ES	Meeting with teachers at observatory		Astronomer Cristina García Miró
2024				
2024-01-07	ES	Scientist visits the school	1 class	Astronomer Cristina García Miró
2024-01	ES	Class visit to an observatory	1 class	Including geodetic VLBI observation, anechoic chamber visit, science influencer visit, led by astronomer Cristina García Miró
2024-01-17	FI	Meeting with teachers at school		Astronomer Joni Tammi
2024-02-08	FI	Scientist visits school	1 class	Astronomer Joni Tammi
2024-03-15	IT-S	Meeting with teachers at school		Astronomer Silvia Casu
2024-03-19	SE	Class visit to an observatory	1 class	Astronomer Robert Cumming
2024-03-20	NL	Scientists visit the school	1 class	Astronomers Emanuela Orrú and Ilse van Bemmel, engineer Des Small, communicator Mischa Brendel
2024-03-21	SE	Scientist visits school	1 class	Astronomer Gustav Olander
2024-03-27	FI	Class visit to an observatory	1 class	Including solar observations, RFI activity
2024-04	IT-S	Scientist visits school	1 class	Astronomer Silvia Casu, including FRB activity
2024-04-10	NL	Class visit to an observatory	1 class	Visit to ASTRON and JIVE
2024-04-15	NL	Class visit to observatory / Other activity	1 class	Visit to LOFAR and Geopark De Hondsrug
2024-04-09	SE	Other activity	1 class	Class visit to university for astronaut presentation
2024-04-16	**FI/ES**	**Online meetup**	**2 classes**	
2024-04	IT-S	Class visit to an observatory	1 class	Including overnight stay
2024-05-02	IT-M	Scientist visits school	1 class	Astronomer Stefania Varano
2024-05	IT-M	Class visit to observatory, cancelled		Participation planned with astronomer Teresa Margheri (SE)
2024-05-15	**SE/IT-M**	**Online meetup**	**2 classes**	
2024-05	FI	Other activity	2 students	2 students on work experience at observatory
2024-06-05	**NL/IT-S**	**Online meetup**	**2 classes**	
2024-06-17	ES	Other activity	1 class	Class visit to national aerospace facility INTA
2024-09-18	IT-M	Class visit to an observatory	1 class	Astronomer Stefania Varano
2025				
2025-01-28	SE	Other activity	5 students	Students and teacher visit Chalmers for SKAO celebration event
Early 2025	IT-S	Class visit to an observatory	1 class	Astronomer Silvia Casu
2025-04-15	IT-S	Scientist visits school	1 class	Astronomer Silvia Casu, including FRB activity
2025-04-16	ZA	Scientists visit the school	1 class	Simphiwe Madlanga, Marion West, intern colleague
2025-05-27	ZA	Class visit to an observatory	1 class	Simphiwe Madlanga, Marion West
2025-05-27	**ZA/IT-S**	**Online meetup**	**2 classes**	Held during observatory visit

APPENDIX 2

New project activities tested in Finland

During the classroom visit and observatory visit to Metsähovi Radio Observatory, Finland, we conducted several educational activities focused on different astronomical phenomena. The activities were designed to enhance understanding of solar activity, black holes, active galaxies, and interstellar gas clouds, with practical demonstrations involving radio observations. There were three action points:

Solar Activity and Solar Flares

- In the classroom, we explained solar activity, sunspots, and solar flares, emphasizing phenomena observed via radio waves.
- At Metsähovi, students were given the opportunity to create their own solar radio maps with the 14-metre radio telescope. They also studied the trends in solar activity and were taught how to do an aurora prediction.

Black Holes and Active Galaxies

- In the classroom, we introduced the concept of active galaxies, focusing on the supermassive black holes at their centers.
- At Metsähovi, we discussed the long-term monitoring of such galaxies and our participation in international observation projects. While no specific exercises were conducted related to this topic, measurements were demonstrated to showcase the ongoing research.

Interstellar Gas Clouds

- In the classroom, we explained the study of interstellar gas clouds, including how their composition is analysed through spectra and how Doppler shifts are used to measure their movement through space.
- At Metsähovi, students participated in measurements, obtaining spectra from a few objects with a 5.5-metre radio telescope, to study their basic characteristics, including composition and motion. From these, the students were able to chart the movement of the Solar system in the Milky Way.

Additionally, in the classroom, we covered the electromagnetic spectrum, radio waves, and the general operation of radio telescopes, providing a foundational understanding.

APPENDIX 3.1

Evaluation form 2024

Sharing a Baseline: Evaluation

Thank you for participating in the pilot project *Sharing a Baseline*. In the project, we wanted to connect school classes with radio astronomy observatories in several European countries, and with each other.

How was *Sharing a Baseline* for you? Please fill in this form and help us learn from our experiences and yours.

- You don't have to answer all the questions. If you are not sure, go on to the next.
- You don't have to answer in English. Use your own language if you prefer.

Coordinators: Cristina, Ioanna, Joni, Mischa, Robert, Silvia and Stefania
Contact: Robert Cumming (robert.cumming@chalmers.se), Chalmers University of Technology, Sweden

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How we use your responses

Your answers will help us evaluate *Sharing a Baseline*, and learn how to adapt the project for the future.

1. **Permission**
   Do we have your permission to use your responses in project reports and presentations?

- Yes, it's ok to link my responses with my role and location
- No, keep my responses for general data analysis only

Your location and role

2. In which country and location did you work with *Sharing a Baseline*?
3. Which role did you have in the project? *(Select all that apply)*

- Teacher
- Other school staff
- Scientist / graduate student
- Coordinator
- Communicator
- Other: _____

How students experienced *Sharing a Baseline*

4. Thinking about the class you worked most closely with: how much do you agree with the following statements?
   (Select one option per row: Strongly agree / Agree / Neither agree nor disagree / Disagree / Strongly disagree)

- The students experienced an observatory first-hand.
- Because of the project, the students learned more about science.
- The project activities helped students understand radio astronomy.
- The students understand more about scientific research than before.
- The students had direct contact with an astronomer or other scientist.
- The students think more positively about natural sciences than before.
- The students valued participating in the project.

5. How did the students respond to the following activities?
   (Select one option per row: Very positively / Positively / Neutral / Negatively / Very negatively)

- Scientist visiting the school class
- School class visiting an observatory
- Working on group projects
- Video meeting with a school in another country
- Learning about radio astronomy
- Learning about other topics related to the project (e.g. language, culture, geography)

Your work with *Sharing a Baseline*

6. What was your main motivation for participating in the project?
7. Do you agree or disagree with the following statements?
   (Select one option per row: Strongly agree / Agree / Neither / Disagree / Strongly disagree)

- I understood the aims of the project.
- I knew who to contact.
- I had support from colleagues.
- I had good background knowledge.
- I was free to choose how to work.
- I knew what was expected of me.
- I was sure I could do the job well.
- I used my own skills to help the project.
- I used material from one of the other countries.

8. For you personally, how was your experience of the activities?
   (Select one option per row: Very positive / Positive / Neutral / Negative / Very negative)

- Scientist visiting school class
- School class visiting observatory
- Working on projects
- Video meeting with a school in another country
- Students learning about radio astronomy
- Students learning about other topics from one of the other countries

9. Anything else you'd like to tell us about your work with the project?

Your suggestions for the future

10. What changes would make *Sharing a Baseline* better?
11. Can we contact you about future projects like *Sharing a Baseline*?
    If yes, please write your name and email address here: _____

APPENDIX 3.2

Evaluation form 2025

Sharing a Baseline 2025: Evaluation

Thank you for participating in the pilot project *Sharing a Baseline 2025*. In the project, we aimed to connect school classes with radio astronomy observatories in South Africa and Italy, and with each other.

How was *Sharing a Baseline* for you? Please fill in this form and help us learn from our experiences and yours.

- You don't have to answer all questions. If you are not sure, go on to the next.
- You don't have to answer in English. Use your own language if you prefer.

Coordinators: Marion, Robert, Silvia and Simphiwe
Contact: Robert Cumming (robert.cumming@chalmers.se), Chalmers University of Technology, Sweden

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How we use your responses

Your answers will help us evaluate *Sharing a Baseline*, and learn how to adapt the project for the future.

1. **Permission**
   Do we have your permission to use your responses in project reports and presentations?

- Yes, it's ok to link my responses with my role and location
- No, keep my responses for general data analysis only

Your location and role

2. In which country and location did you work with *Sharing a Baseline*?
3. Which role did you have in the project? *(Select all that apply)*

- Teacher
- Other school staff
- Scientist / graduate student
- Coordinator
- Communicator
- Other: _____

How students experienced *Sharing a Baseline*

4. Thinking about the class you worked most closely with: how much do you agree with the following statements? *(Select one option per row: Strongly agree / Agree / Neither agree nor disagree / Disagree / Strongly disagree)*

- The students experienced an observatory first-hand.
- Because of the project, the students learned more about science.
- The project activities helped students understand radio astronomy.
- The students understand more about scientific research than before.
- The students had direct contact with an astronomer or other scientist.
- The students think more positively about natural sciences than before.
- The students valued participating in the project.

5. How did the students respond to the following activities? *(Select one option per row: Very positively / Positively / Neutral / Negatively / Very negatively)*

- Scientist visiting the school class
- School class visiting an observatory
- Working on group projects
- Video meeting with a school in another country
- Learning about radio astronomy
- Learning about other topics (e.g. language, culture, geography)

Your work with *Sharing a Baseline*

6. What was your main motivation for participating in the project?
7. Do you agree or disagree with the following statements? *(Select one option per row: Strongly agree / Agree / Neither / Disagree / Strongly disagree)*

- I understood the aims of the project.
- I knew who to contact.
- I had support from colleagues.
- I had good background knowledge.
- I was free to choose how to work.
- I knew what was expected of me.
- I was sure I could do the job well.
- I used my own skills to help the project.
- I used material from another country.

8. For you personally, how was your experience of the activities? *(Select one option per row: Very positive / Positive / Neutral / Negative / Very negative)*

- Scientist visiting school class
- School class visiting observatory
- Working on projects
- Video meeting with a school in another country
- Students learning about radio astronomy
- Students learning about other topics

9. Anything else you'd like to tell us about your work with the project?

Your suggestions for the future

10. What changes would make *Sharing a Baseline* better?
11. Can we contact you about future projects like *Sharing a Baseline*?
    If yes, please write your name and email address here: _____

APPENDIX 3.3

Evaluation form for students 2024

Sharing a Baseline: What Was It Like for You?

Thank you for taking part in *Sharing a Baseline*! In the project, students in five countries carried out similar activities.

Which activities do you remember? Tell us about them here. Examples:

- A scientist visiting your school
- Your class visiting a radio observatory
- Working on projects and presentations
- A video meeting with a school in another country

1. Which activity did you like best?
2. Which activity did you like least?
3. What was your country / location? *(Select one option)*

- Finland
- Italy / Medicina
- Italy / Sardinia
- Netherlands
- Spain
- Sweden

4. Is it ok for us to publish your answers in our project reports?

- Yes, that's ok!
- No, read my answers but don't share.

APPENDIX 4

Phase 2 Proposal

The NOCs/SKACONs Team

1) Number of NOCs/SKACONs: 5

2) Name of the NOCs/SKACONs: Robert Cumming (NOC/SKACON Sweden), Caterina Boccato (NOC Italy), Marieke Baan (NOC Netherlands), Pasi Nurmi (NOC Finland), Cristina García Miró (SKACON Spain)

3) Countries: Sweden, Italy, Netherlands, Finland, Spain

4) Contact E-mails: robert.cumming@chalmers.se, caterina.boccato@inaf.it, h.m.baan@uva.nl, pasnurmi@utu.fi, c.garciamiro@oan.es

The Project at a Glance

1) Name of the Project: Sharing a baseline: hands-on international radio astronomy pilot for kids

2) Where the project will take place (if applicable) at schools and radio observatories in Sweden, Italy, Netherlands, Finland and Spain

3) Language(s) of the Project (if applicable) English and local languages

4) When will your project be implemented (if applicable)? 2023-24

5) Theme: astronomy as an international science

Project Overview

Project summary

In this pilot programme, observatories and their visitor facilities link people in different countries, just as telescope networks themselves are linked.

Project challenge

We want to explore how to leverage the global aspects of radio astronomy to increase science capital for kids who have not yet chosen their path in life.

We will test methods to connect radio observatories with school classes in a small number of countries and connect school classes with each other. We expect to involve observatories in Onsala (SE), Medicina (IT), Sardinia Radio Telescope (IT), Metsähovi (FI), Westerbork (NL) and Yebes (ES). Where possible, English will be our common language.

Who will benefit

We focus on school classes, and ages around 14-16 years. The main benefit should be to the young people who gain science capital by getting involved in radio astronomy. At this age, many learners have not yet chosen what to study at high school, and their path in life remains open.

Outreach and communications staff involved in SKA and other international projects will benefit from tests in ways of involving the public and schools in radio astronomy facilities.

The pilot provides opportunities to share schools and outreach activities among member institutes of the European VLBI Network, working together with IAU NOCs and SKACON members.

Role of the NOCs/SKACONs

The project team consists of NOCs and SKACONs together with colleagues at radio astronomical observatories in our respective countries. The NOCs and SKACONs are responsible for coordination and oversight, but some of us are also radio observatory staff and will be involved in all levels of activities.

Project Core Idea(s) and Deliverables

We will test run the following activities at each location, linking locations pairwise. As far as possible, we will use existing contacts (schools, teachers), and adapt and share existing activities (classroom or observatory-based).

(1) Scientist visits school class. Introduces radio astronomy, why it's important, and how international cooperation is key to both scientists and telescope networks; use kids' existing ideas, wishes and expertise to co-create collaborative activities to share with another country.

(2) Class visits observatory. Activities to be tested: students document the visit, record questions to astronomers, creating a video ready for sharing with a school class in another country, with messages and/or questions; remote observing with small radio telescopes like SALSA/Spider; working with astronomical images or other accessible data.

(3) Online meet-up: classes in different countries meet each other, share experiences, content they have created, and results of collaborative work.

Deliverables: (a) Lessons learnt, including feedback from students (comments, recommendations, ideas), (b) Roadmap report aimed at scaling up the project to involve other countries, (c) Suggestions for adapting the methods for specific networks, in particular the SKAO, (d) Evaluation/suggestions for platform for interaction between schools, (e) Resources in several languages (f) Videos from students, (g) Educational activity about radio astronomy and VLBI, tested ready for submission to IAU astroEdu platform.

Intended Outcomes

We want to develop activities that work across international boundaries and with different age groups. We will test the effects of differences between classes in different countries – in age, context, experience, and how we can learn from the differences. To deal with language barriers, we expect to involve also English teachers.

We hope our experience will benefit large projects like the SKA in testing activities that demonstrate the global connections that modern science is dependent on. We want to use a small-scale pilot to test and learn from successes and mistakes. We hope to pave the way for larger-scale projects that also link communities using radio observatories.

Project Timeline

Please present a timeline for the deliverables of your project.

Timeline: Sep-Dec 2023. Preparation with partners, overview documents/website for schools.

Jan-Mar 2024. Identify schools and make contact with teachers. Prepare resources.

Apr-Jun 2024. Implementation: three occasions per school/country. Sep-Dec 2024. Evaluation and reporting, astroEDU activity.

Project Budget

About the Funding Allocation: If your proposal is approved; how will the funding be attributed? (e.g. 2000 Euros to Institution 1 and 1500Euros to Individual 2)

Total budget 10 000 EUR (2000 EUR per country)

Requested budget 4000 EUR

Contributions:

25% JIVE:

2500 EUR (= 500 EUR for each country)

25% National Nodes: 2500 EUR (= 500 EUR per country)

50% Fundraising:

5000 EUR IAU-SKAO Outreach Funding Scheme

Specific items to be defined:

3000 EUR: Bus hire, transport from school to observatory (ca 600 EUR per country)

4500 EUR: Honorarium for student assistants (ca 100 EUR per hour, 3h per person per visit, 3 visits per country)

2500 EUR: Purchase of refreshments (eg. lunches for student assistants), prizes, materials for activities