Education and public engagement using an active research project: lessons and recipes from the SEA-SEIS North Atlantic Expedition's programme for Irish schools

Response to reviewer comments

We thank the two Geoscience Communications reviewers, Anthony Lelliott and Penny Haworth, for their thoughtful, constructive comments and criticisms. Following their suggestions, we have substantially strengthened the evaluation component of the paper and included evaluation data in the Supplement. We have also strengthened the review of the state of the art and revised a number of statements identified by the reviewers. These and other revisions are detailed below, point by point following the reviewers' comments, which we reproduce in their entirety in *italic*. Text added to the revised manuscript is indented. Where Reviewer 2 re-iterates comments by Reviewer 1, we repeat our response where needed for completeness and clarity.

Reviewer 1.

Interactive comment on "Education and public engagement using an active research project: lessons and recipes from the SEA-SEIS North Atlantic Expedition's programme for Irish schools" by Sergei Lebedev et al.

Anthony Lelliott (Referee)

1. Does the paper address relevant scientific questions within the scope of GC?

Yes, the paper is relevant, and clearly relates to Geoscience Communication.

2. Does the paper present novel concepts, ideas, tools, or data?

The project itself is novel: scientists working with school students and teachers has been done before but not a project quite like this.

The authors need to flesh out the section stating "We reviewed best practices of previous EPE projects connected to active research and looked for any ideas that could be applicable to ours" (p. 4, line 106-7). We need to hear a summary of such best practices and/or the ideas applicable.

Following these suggestions, the section has been expanded substantially. The sentence quoted by the reviewer is now followed by this new text:

> "Teacher-scientist collaboration aiming to promote hands-on, inquiry-based science teaching is, generally, an established approach. In seismology, specifically, the Princeton Earth Physics Project (PEPP) installed seismometers in schools across the US for use in teaching and in science projects (Nolet, 1993; Steinberg et al., 2000; Phinney, 2002), and a number of seismology-in-schools programmes operate elsewhere around the world (e.g., Bullen, 1998; Virieux, 2000; Blake et al., 2008; Denton, 2008; Courboulex et al. 2012; Balfour et al., 2014; Zollo et al., 2014; Tataru et al., 2016). Collaborative, teacher-scientist research projects improve, on the one hand, the scientists' awareness of classroom practices and, on the other hand, the teachers' understanding of scientific research, exposing each group to the other's culture and highlighting the advantages of integrating scientific inquiry into the curriculum (Gosselin et al., 2003). In the joint scientist-

teacher-student research projects, the participants particularly enjoy being part of authentic research in which they could take initiative and feel a sense of ownership (Jarrett and Burnley, 2003). Scientist-educator partnerships can produce new teacher resources and lesson plans, incorporating cutting-edge research (Madden et al., 2007).

Recent trends in Earth-science outreach (e.g., Drake et al., 2014; Tong, 2014) include the use of video projects in the science classroom (Dengg et al., 2014; Wade and Courtney, 2014) and storytelling via diverse media (Barrett et al., 2014; Moloney and Unger, 2014). Hut et al. (2016) reviewed the theory of effective geoscience communication through audio-visual media, in particular television, and identified six major themes and challenges: scientist motivation, target audience, narratives and storytelling, jargon and information transfer, relationship between scientists and journalists, and stereotypes of scientists among the general public. Live video has already been used extensively in the practice of EPE coupled with marine research: ship-to-shore video events have been performed for a number of years by the International Ocean Discovery Program (IODP) (Kulhanek et al., 2014; IODP, 2019). We were able to use the idea successfully in our programme, with a specific focus on ship-to-classroom video link-ups and with our own event templates (Section 3.2).

McAuliffe et al. (2018) reported on the creation of a science book for 7-12 year olds. The book showcased the importance of STEM in today's society and aimed to give the children their first conceptions of STEM career pathways. Importantly, children were co-creators in the content development, character design, and "try at home" activities offered in the book. As a result, 93% of parents of participating children felt that the children became more interested in science than they were before. The Irish research examples used in the book were also found to shift the perception that major scientific discoveries could only take place abroad (McAuliffe et al., 2018).

Further insight into the state of the art in the relevant EPE practice can be gained through direct communication with the practitioners. Contacting and talking to a lot of people—teachers, researchers, EPE and communications experts—was of key importance for the present programme. Best practical ideas and essential partnerships emerged from some of these discussions.”

3. Are the scientific methods and assumptions valid and clearly outlined?

These are not very clear. The paper is more of a show and tell than providing data about the evaluative aspects of the project. p. 12 line 382: The authors say “No primary data sets were used in producing this article”. However, Can they not provide the evaluation data?

This is a case study, and showing and telling the reader how the programme was developed is an essential part of the paper. The evaluation aspects of the study are, of course, also essential. Following the reviewers’ suggestions, we have substantially improved the presentation of the evaluation aspects in the revised version of the manuscript. Evaluation-survey data are now provided in the Supplement.

4. Are the results sufficient to support the interpretations and conclusions?

No, not in several cases. My main issue is that the authors tend to make claims unsupported by any data.

We accept the criticism and revise the statements pointed out by the reviewers as detailed below, so that they are more precise and do not suggest inferences unsupported by data.

For example: p. 6, line 194: Most presenters on the ship and at DIAS were female. This helped all-girl classes and girls in co-educational schools to connect to and identify with their own role models among the scientists. How do you know this? What data is there to support your assertion?

We saw this with our own eyes, the girls discovering that they could have a fun and informative discussion with young female scientists and developing a connection with them. We do not have statistical data for this, however. We thus rephrase the sentence as follows:

> "This offered opportunities to all-girl classes and girls in co-educational schools to connect to and identify with their own role models among the scientists."

The revised statement is weaker but it is certainly accurate.

p. 7, line 225: The feedback from the participating teachers and students indicated that the competition was enjoyable and increased the students' interest in STEM. Where is the data to support this? How do the teachers actually know that the students' interest was increased? Is this not just the teachers' opinions about a project they liked?

After this sentence in the text, we have added a reference to Section 4 (Evaluation), where this is explained. In Section 4 (Evaluation) itself, we now explain in greater detail how these inferences were made. The new text on this reads:

> "The evaluation relating to the drawing competition was informal, based on the feedback from the primary school teachers and students themselves. The bulk of the feedback came in the form of 24 thank-you cards from 7-8 year old students from Abbeyleix South National School, Co. Laois, Ireland. It was clear that the children were encouraged to write the cards by their teacher and that the teacher must have mentioned a number of things that could be included in the cards. However, different children opted to include different things in their text, and the phrasing was their own, different in different cards. Nearly all the students wrote that they enjoyed learning about the seismometers and the project, with some mentioning explicitly that they explained what they had learned to their parents. All were pleased with their prizes, and happy that everybody got a prize. Some wrote that they would like to work with the SEA-SEIS researchers in the future.
>
> This evidence would not yield robust statistical inferences (only one class, influenced by their teacher) but, even though the evidence may be regarded as anecdotal, we consider it encouraging and useful. It confirms that young primary school students are curious about and receptive to the general ideas of Earth science research, and that rewarding every participant with a prize is an effective approach in primary school competitions. It also highlights the key role of an actively participating teacher and the importance of a teacher network in order for such competition to reach a broad, national scale."

p. 11, line 338-9: This contributes to increasing the students' interest in STEM and STEM careers. How do you know this?

This became clear on a number of occasions during our ship-to-class video links. We do not have statistical data on this, however. We thus rephrase the sentence in a weaker form:

> “This, in turn, is likely to contribute to increasing the students’ interest in STEM and STEM careers.”

Line 368: Survey responses from the teachers confirm that the engagement is not only enjoyable but has a lasting positive impact. How do you know this?

“Lasting impact” here was used correctly in the context of the sentence: whereas the enjoyment of the activity is limited to its duration, its effect (the encouragement of the students’ interest in STEM) is more lasting. We can see, however, how this can get misleading if interpreted differently. We thus remove “lasting impact” and rephrase the sentence in the Conclusions as follows:

> “Survey responses from the teachers confirmed that the video links encouraged the students’ interest in STEM.”

The survey responses that support this statement are included in the data now provided in the Supplement.

My point here is that the authors are reading too much into the evaluation data, and making assertions about the positive nature of the experience. They may be right in such assertions, but science communication research needs to be less about describing interesting projects and expecting positive outcomes, and more about interrogating the nature of the projects, and asking difficult questions about them.

Agreed. We add the evaluation data in the supplement and revise a number of potentially misleading statements so as to avoid any inferences more far-reaching than the data warrants.

It would be interesting for the authors to look further into the lack of research on the part of the students: p. 11, line 346-7: “A proportion of entries to the song-and-rap competition showed little evidence of the students researching either Earth science or the SEA-SEIS project’s scientific goals” Why was this? What are implications for future EPE projects?

We now add the following text in order to discuss and clarify this, with a practical inference for the future in the end:

> “At one end of the spectrum, one of the winning compositions referred to most SEA-SEIS seismometers by their names, also with a reference to their location and to what they were recording on the seafloor, which showed substantial research on the subject. At the other end, some of the entries showed little understanding and probably no research behind them.
>
> Drawing a line separating “research” from “no research,” however, would be difficult. The competition was developed in order to combine art and science, to get the students create science-themed art and to get them more interested in science. The pieces the students composed and recorded were free-form, and there were no correct answers they could insert into in their songs. For this reason, it is not possible to gauge precisely the amount of research students put into Earth-science research in the course of this activity.
>
> By the very nature of the art-science approach, it is not always possible to measure everything. We do draw a lesson from the first edition of this competition, however: in its future editions, it will be useful to steer students more firmly towards learning and towards communicating science and technology in their pieces.”

5. Do the authors give proper credit to related work and clearly indicate their own new/original contribution?

Yes

6. Does the title clearly reflect the contents of the paper?

Yes but it's too long. I would suggest: "Education and public engagement in a geophysical research project" – or something similar.

We appreciate the suggestion. We did put a lot of thought into our original title, however, and would very much prefer to keep it. The title suggested by the reviewer limits the scope of the work to a geophysical research project, whereas a very similar programme could be carried out, for example, with a marine geology or marine biology research project. Moreover, a part of our motivation for writing this paper came after our talk on the work in an EPE session at the last EGU meeting, when a colleague working in a space research centre asked if we had a text on our programme that we could share, so that she could use some of our approaches in her outreach work. The first part of the title thus has an appropriately broad scope. As this is a case study, however, it is also important to spell out what this programme was specifically. If the title was just "Education and public engagement using an active research project" or similar, it would give the wrong impression that this is a review covering the very broad area in some detail. Finally, the "lessons and recipes" are appropriate to mention as this is where most of the general usefulness of the paper probably is. For clarity, lessons are recipes are now mentioned and discussed explicitly and specifically throughout the text (Introduction, Discussion, Conclusions).

The title is, indeed, relatively long, but not exceptionally so: a number of titles on the Geoscience Communication Most Downloaded page (https://www.geosci-commun.net/most_downloaded.html), for example, are similar in length or longer.

7. Does the abstract provide a concise and complete summary? Yes, but needs to be edited in line with my comments under (4) above.

The two sentences with unsubstantiated inferences have been rewritten. One now states:

> "The follow-up survey showed that the engagement was not only exciting but encouraged the students' interest in Science, Technology, Engineering and Mathematics (STEM) and STEM-related careers."

The encouragement was observed by the teachers, as documented in our survey, which is now given in the Supplement.

"Lasting impact" mentioned in the original version is now removed. The sentence in the abstract has now been re-written as

> "The outcomes of an EPE programme coupled with research projects can include both an increase in the students' interest in STEM and STEM careers and an increase in the researchers' interest and proficiency in EPE."

It is now a weaker but undoubtedly accurate statement.

8. Is the overall presentation well structured and clear?

Yes

9. Is the language fluent and precise?

Yes, very well-written

10. Are the number and quality of references appropriate?

Yes, but please check the sequencing of some references (alphabetical order).

Fixed – thank you.

Minor Points

P. 4 Line 119: “imaginative names” not appropriate (sarcasm?). I would suggest replacing with “unimaginative names”.

This was self-irony. Self-deprecating humour was helpful in the public engagement programme presented here. However, seeing that this phrasing can be distracting rather than helpful in this paper, we have now removed the word “imaginative” and modified the sentence as follows:

> “The seismologists among us have a natural tendency to give their seismic stations names like S01, S02, S03, etc.”

Reviewer 2.

Interactive comment on “Education and public engagement using an active research project: lessons and recipes from the SEA-SEIS North Atlantic Expedition’s programme for Irish schools” by Sergei Lebedev et al.

Penny Haworth (Referee)

In the full review and interactive discussion, the referees and other interested members of the scientific community are asked to take into account all of the following aspects:

1. Does the paper address relevant scientific questions within the scope of GC?

Yes, the paper is relevant and clearly relates to Geoscience Communication and specifically the topic of Geoscience Education.

2. Does the paper present novel concepts, ideas, tools, or data?

I agree with Tony Lelliott’s comment that reference to “best practices” and “ideas that could be applicable to ours” (p.4, line 106-7 and line 109-10) need to be fleshed out. Although these are referenced, the authors don’t give examples or say why were they chosen or deemed to be applicable.

The section has been expanded substantially, following these suggestions. The text quoted by the reviewer is now followed by this new text:

> “Teacher-scientist collaboration aiming to promote hands-on, inquiry-based science teaching is, generally, an established approach. In seismology, specifically, the Princeton Earth Physics Project (PEPP) installed seismometers in schools across the US for use in teaching and in science projects (Nolet, 1993; Steinberg et al., 2000; Phinney, 2002), and a number of seismology-in-schools programmes operate elsewhere around the world (e.g., Bullen, 1998; Virieux, 2000; Blake et al., 2008; Denton, 2008; Courboulex et al. 2012; Balfour et al., 2014; Zollo et al., 2014; Tataru et al., 2016). Collaborative, teacher-scientist research projects improve, on the one hand, the scientists’

awareness of classroom practices and, on the other hand, the teachers' understanding of scientific research, exposing each group to the other's culture and highlighting the advantages of integrating scientific inquiry into the curriculum (Gosselin et al., 2003). In the joint scientist-teacher-student research projects, the participants particularly enjoy being part of authentic research in which they could take initiative and feel a sense of ownership (Jarrett and Burnley, 2003). Scientist-educator partnerships can produce new teacher resources and lesson plans, incorporating cutting-edge research (Madden et al., 2007).

Recent trends in Earth-science outreach (e.g., Drake et al., 2014; Tong, 2014) include the use of video projects in the science classroom (Dengg et al., 2014; Wade and Courtney, 2014) and storytelling via diverse media (Barrett et al., 2014; Moloney and Unger, 2014). Hut et al. (2016) reviewed the theory of effective geoscience communication through audio-visual media, in particular television, and identified six major themes and challenges: scientist motivation, target audience, narratives and storytelling, jargon and information transfer, relationship between scientists and journalists, and stereotypes of scientists among the general public. Live video has already been used extensively in the practice of EPE coupled with marine research: ship-to-shore video events have been performed for a number of years by the International Ocean Discovery Program (IODP) (Kulhanek et al., 2014; IODP, 2019). We were able to use the idea successfully in our programme, with a specific focus on ship-to-classroom video link-ups and with our own event templates (Section 3.2).

McAuliffe et al. (2018) reported on the creation of a science book for 7-12 year olds. The book showcased the importance of STEM in today's society and aimed to give the children their first conceptions of STEM career pathways. Importantly, children were co-creators in the content development, character design, and "try at home" activities offered in the book. As a result, 93% of parents of participating children felt that the children became more interested in science than they were before. The Irish research examples used in the book were also found to shift the perception that major scientific discoveries could only take place abroad (McAuliffe et al., 2018).

Further insight into the state of the art in the relevant EPE practice can be gained through direct communication with the practitioners. Contacting and talking to a lot of people—teachers, researchers, EPE and communications experts—was of key importance for the present programme. Best practical ideas and essential partnerships emerged from some of these discussions."

3. Are the scientific methods and assumptions valid and clearly outlined?

a. The GC scope requires that authors provide qualitative and quantitative evidence – not solely anecdotal reporting and provide quantitative analysis of reach and impact. Whilst the paper is an uplifting account of how the project was implemented, I agree with Tony that the paper is more show and tell and this primarily anecdotal: for example, in line 121, the authors note that "Having more time for the competition would have been beneficial", but do not say why? What had they hoped to achieve? Would having had more time significantly have changed/ improved the results?

To respond first to the specific question in the end of the comment, having more time would be beneficial because more schools would be able to participate. By the start of the expedition, most teachers may have had only two periods—the first two of the school year—with the classes that they could propose the participation in the competition to. Some have not participated because there seemed to be too little time, and one school submitted their entries too late, after the winners were already selected and announced. To make this clearer, we have now expanded these statements as follows:

> "Two weeks is a short time for a teacher who may meet their science or geography class only once a week. Having more time for the competition would have been beneficial as more classes would be likely to participate. However, this was not possible as the expedition started shortly after the beginning of the academic year."

Regarding "show and tell," this is a case study, and showing and telling the reader how the programme was developed is an essential part of the paper. The evaluation aspects of the study are, of course, also essential. Following the reviewers' suggestions, we have substantially improved the presentation of the evaluation aspects in the revised version of the manuscript. Evaluation-survey data are now included in the Supplement.

The reviewer's "primarily anecdotal" suggestion is a gross exaggeration. The piece of our text given as an example has nothing anecdotal about it: it is an explanation of the general problem presented by the start of an expedition close to the beginning of the school year. This argument has now been expanded and clarified further.

b. Lelliott indicates that the authors tend to make claims unsupported by any data – see e.g. p.6 line 194 – the assertion is that the girls in all-girl schools identify with female scientists as role models; this assertion is extended to include boys in the abstract (page 1 line 25, "both girls and boys…were presented with engaging role models"), and although teachers attested to the positive response of their pupils, the statements are anecdotal rather than substantiated with provable data.

We saw this with our own eyes, the girls discovering that they could have a fun and informative discussion with young female scientists and developing a connection with them. We do not have "provable" data for this, however. We thus rephrase the sentence as follows:

> "This offered opportunities to all-girl classes and girls in co-educational schools to connect to and identify with their own role models among the scientists."

The revised statement is weaker but certainly accurate.

In line 199 also page 6, the authors refer to broadened "impact" of the event through pupils talking to their friends and parents about the experience – this certainly can be said to broaden the "reach" of the event, but should not be assumed to be indicative of impact unless that impact can be established and substantiated.

"impact" replaced with "reach"

Further, at line 225, there is reference to the competition as having "increased the student's interest in STEM" – again there is no data to prove this.

After this sentence in the text, we have added a reference to Section 4 (Evaluation), where this is explained. In Section 4 (Evaluation) itself, we now explain in greater detail how these inferences were made. The new text on this reads:

> "The evaluation relating to the drawing competition was informal, based on the feedback from the primary school teachers and students themselves. The bulk of the feedback came in the form

of 24 thank-you cards from 7-8 year old students from Abbeyleix South National School, Co. Laois, Ireland. It was clear that the children were encouraged to write the cards by their teacher and that the teacher must have mentioned a number of things that could be included in the cards. However, different children opted to include different things in their text, and the phrasing was their own, different in different cards. Nearly all the students wrote that they enjoyed learning about the seismometers and the project, with some mentioning explicitly that they explained what they had learned to their parents. All were pleased with their prizes, and happy that everybody got a prize. Some wrote that they would like to work with the SEA-SEIS researchers in the future.

> This evidence would not yield robust statistical inferences (only one class, influenced by their teacher) but, even though the evidence may be regarded as anecdotal, we consider it encouraging and useful. It confirms that young primary school students are curious about and receptive to the general ideas of Earth science research, and that rewarding every participant with a prize is an effective approach in primary school competitions. It also highlights the key role of an actively participating teacher and the importance of a teacher network in order for such competition to reach a broad, national scale."

c. An example where a conclusion can be linked to the project under discussion to avoid it reading as an unsubstantiated assumption, can be found on page 10, line 332: adding the words "We found that" to the sentence, "Inviting students to become co-creators gets them engaged with enthusiasm" and providing some examples to illustrate the claim, would substantiate the statement which otherwise should be referenced to be considered valid.

"We found that" added.

Further, how do the authors gauge that "They [the students] are, then, motivated to learn more…" or that "This contributes to increasing the students' interest in ST and STEM careers" (lines 338-39)?

The sentence has been rephrased in a weaker form:

> "This, in turn, is likely to contribute to increasing the students' interest in STEM and STEM careers."

4. Are the results sufficient to support the interpretations and conclusions?

a. Reference to sample size (numbers), where it is made, is imprecise – e.g. Reference is made in the abstract to "18 link-ups", but in line 126 the authors state that "Around 20 schools… participated" – is this 18 -19 schools, 21 schools? The authors need to be consistent in stating the size of the sample set. Should it be the intention to use this paper as a benchmarking exercise for future engagements of this sort, it will be difficult to interrogate data and draw meaningful comparisons. I suggest they indicate exactly how many schools, how many pupils and how many teachers participated – they have provided a distribution map of the schools involved in the project which is useful, and obviously worked closely with teachers at the schools, so substantiated data should be really available.

These numbers are different because they refer to different components of the EPE programme. There were 18 live video link-ups from the ship to classrooms. Prior to that, there was a seismometer naming competition, to which 20 schools sent entries. These different activities are covered clearly in the text, each in its own subsection.

More generally, we agree that precise numbers are preferable and have replaced "~20 schools" with "20 schools" (having verified the number). We have also included the results of our evaluation survey in the supplement. This gives the numbers of students participating in different video links.

b. Page 8, lines 251-254: In interpreting the results of the competitions, the authors refer to "many" students having "made an effort to research the subject" – again finite number should be available – this could provide useful comparative data for later competitions. On page 11, line 345-347, "the number of participating schools was lower than expected ", and "a proportion of entries showed little evidence of the students having researched…" – But, how do they confirm this is the case and if so what were the factors behind this? Investigating these questions could provide very valuable insights for geoscience education and communication going forward.

To clarify this, the following text now concludes the subsection 3.4:

> "At one end of the spectrum, one of the winning compositions referred to most SEA-SEIS seismometers by their names, also with a reference to their location and to what they were recording on the seafloor, which showed substantial research on the subject. At the other end, some of the entries showed little understanding and probably no research behind them.
>
> Drawing a line separating "research" from "no research," however, would be difficult. The competition was developed in order to combine art and science, to get the students create science-themed art and to get them more interested in science. The pieces the students composed and recorded were free-form, and there were no correct answers they could insert into in their songs. For this reason, it is not possible to gauge precisely the amount of research students put into Earth-science research in the course of this activity.
>
> By the very nature of the art-science approach, it is not always possible to measure everything. We do draw a lesson from the first edition of this competition, however: in its future editions, it will be useful to steer students more firmly towards learning and towards communicating science and technology in their pieces."

More generally, we very much agree that more work on mixing art and science will be valuable for geoscience education and communication. But, by the very nature of this approach, it is not always possible to measure everything precisely.

c. In 'Conclusions', Page 11, lines 367-68, the authors affirm that "Survey responses from the teachers confirmed that the engagement…has a lasting positive impact": I would contend that a single survey with teachers only cannot be said to do this – a claim for "lasting…impact" needs to be measured over time through at least one follow-up survey conducted sometime after the engagement; firstly with pupils (to ascertain retention of knowledge and impact on their view/ understanding of geosciences) and teachers – with regard to how the engagement has supported or augmented their curriculum-based work in the classroom and influenced (especially in the case of high-school pupils) their performance and results.

“Lasting impact” was used correctly in the context of the sentence: whereas the enjoyment of the activity is limited to its duration, its effect (encouragement of the students’ interest in STEM) is more lasting. We can see, however, how this can get misleading if interpreted differently. We thus remove “lasting impact” and rephrase the sentence in the Conclusions as follows:

> “Survey responses from the teachers confirmed that the video links encouraged the students’ interest in STEM.”

The encouragement is evidenced by the evaluation-survey responses included in the Supplement.

As far as the “researchers – both experienced and early career”, there are a number of considerations that could be used to generate conclusions regarding the success of the outreach:

i. E.g. On page 9, line 299, researchers’ communications skills are described as, “often not their greatest strength, to begin with”: As individuals, how confident were the researchers on this project about being involved in geosciences engagement and communication before the project? Had this changed afterwards? Why? What are some of the take-home messages that other researchers undertaking engagement might find useful?

The main take-home message relating to researchers in EPE, which we emphasize very clearly in the paper, is that “EPE coupled with active research projects can channel the academic researchers’ drive and creativity into the development of spectacular, novel EPE programmes” (Section 5.1). This does not take anything away from other EPE approaches, or from (undoubtedly useful) communication training, which may come to mind here, but highlights the potential of EPE programmes coupled with active research projects, which is the focus of this paper.

Regarding the change in attitude and confidence of the particular researchers involved in this project (that is, a few of this paper’s co-authors), we think that the dataset emerging from a survey within our group would probably lack statistical significance, because of its small size and the probable biases due to the participants’ enthusiasm for the project. A study across a number of projects, conducted by an independent EPE researcher, would be more suitable to identify useful patterns and analyse them, but this is beyond the scope of this paper.

ii. What were their expectations before the engagement? Did they feel these had been met? Where were the gaps? The authors answer this to some extent by mentioning that the programme should offer more activities (line 356) and broaden the target audience (lines 358-60) in order to achieve their aim (stated in line 353), but it would have been interesting to know how they are going about this – they mention that funding for expansion is “—being sought at the moment” (line 361), so they must feel that the programme was sufficiently successful to demonstrate the need. Who are the targeted funders? Motivating the need for enhanced and broader STEM awareness could be pitched to a variety of potential funders (government, the private sector, industry) but would need to address not only the educational but also societal and economic benefits. How does “the real impact” of the programme move beyond generating “enthusiasm” among researchers and address broader issues to which they can commit their energies and work with societal actors in order to provide answers?

We agree that the need for enhanced and broader STEM awareness could be pitched to a variety of potential funders. And yes, the programme was successful and demonstrated the potential of the approach. In order to grow, expand and produce greater impacts, it needs more resources. We have written a proposal for funding that could support this, now submitted to the Discover Programme of

Science Foundation Ireland. There are various ideas in there that we are fond of, but at this stage the proposal is still under review and the ideas have not yet been implemented, so we should probably avoid talking too much of future plans and focus instead on what has been done in the present programme.

We have now included a new, second-to-last sentence of Section 5.5 to outline our general ideas for the expanded programme:

> "Using the approaches, lessons and recipes from the present programme, this can be addressed through the work with schools supported by the development of an effective teacher network, through presenting science through arts, and through the use of a pervasive digital platform."

Regarding specific details on a pending grant application (funder, programme, etc.), we probably should not go into them in the paper.

5. Do the authors give proper credit to related work and clearly indicate their own new/original contribution?

a. At line 159, the authors indicate they were "keen to use the available best practice" which is acknowledged and credited. However, the reader is not able to compare their approach with other examples as those examples aren't articulated.

Following the suggestion, we have now modified this and following sentences:

> "Following IODP, we started the video link-ups with an introduction from the ship that set the stage for a question and answer session with the students in the classroom. In contrast to the IODP video events, which, with rare exceptions, are led by educators (Kulhanek et al., 2014), all our video links were led by PhD students onboard. We also had to develop our own template for live video events. Because the weather during our expedition was mostly stormy—which is often the case in the North Atlantic,—the initially planned live tours of the ship, as often performed on RV JOIDES Resolution's scientific cruises (Kulhanek et al., 2014), would have been dangerous for the presenters and had to be abandoned."

Later, on p.12 line 382, they say that "No primary data sets were used in producing this article". Some of the best practice examples may have provided a potential source for comparative data and there are enough statements of "fact", or implied measures of comparison, in the article that could be supported by data.

We have now provided the evaluation data in the Supplement.

b. Not having explained what, in their view, constitutes best practice earlier in the article (ref line 106-7), it is not clear why the project leaders decided to develop a template of their own – was this because there were no examples/reports of live video events available from the best practice examples they had chosen? This would provide an opportunity for them to discuss the implied gaps in the literature and how and why their approach is new, different and an innovative departure from established geoscience communication practice.

We have now expanded substantially the overview of the state of the art in the beginning of Section 3 (following the lines mentioned by the reviewer), as detailed above. We also give an example of where we had planned to follow the templates of RV JOIDES Resolution's scientific cruises but had to depart from them and develop or own. To make this clearer, we expand the sentence in the second paragraph of Section 3.2 as follows:

> "Because the weather during our expedition was mostly stormy—which is often the case in the North Atlantic,—the initially planned live tours of the ship, as often performed on RV JOIDES Resolution's scientific cruises (Kulhanek et al., 2014), would have been dangerous for the presenters and had to be abandoned."

6. Does the title clearly reflect the contents of the paper?

a. To an extent, but I'm not convinced that the content has fully articulated the "lessons and recipes" referred to in the title.

For clarity, lessons are recipes are now mentioned and discussed explicitly and specifically throughout the text (Introduction, Discussion, Conclusions). The added new text is as follows.

End of the Introduction:

> "We describe the best practice developed in the course of the programme, draw lessons from its development, discuss some general inferences, and aim to identify useful templates and recipes for EPE projects that connect researchers to school students and to the general public."

Beginning of the Discussion:

> "In this section, we focus on the lessons and recipes provided by our EPE programme."

End of Conclusions:

> "This case study offers useful lessons and recipes for EPE programmes coupled with active research projects. First of all, it highlights how the research projects and the researchers working on them are a rich resource for EPE. Researchers can be effective EPE leaders, with the EPE programmes channelling their drive and creativity into the development of effective, novel EPE activities.
>
> Secondly, it illustrates the importance of an EPE team with diverse backgrounds and complementary expertise and skill sets. In EPE with primary and secondary schools, the most essential partners are the school teachers and principals. The development of a network of actively engaged teachers is a pre-requisite of successful EPE with schools and should, if possible, be initiated at the earliest stages of the programme. Beyond that, our programme capitalized on contributions of not only scientists and teachers, but also engineers and technicians and a sound artist. Effective national media campaign around the start of the SEA-SEIS Expedition and EPE programme was orchestrated by our communication manager, working with a partner PR firm. Our digital media presence was maintained primarily by the team's digital journalist, his expertise increasing its effectiveness greatly.
>
> Thirdly, the programme demonstrates the value of co-creation by the EPE team, teachers and school students. Close collaboration with the teachers was essential in planning and developing the programme activities. Getting the school students co-creating with scientists in the course of the school competitions got them engaged and genuinely interested.
>
> Finally, our project can be seen as a template for a multi-faceted, "low-cost, high-gain" EPE programme. Recognising that the school curricular are already packed, so that teachers find it difficult to allocate a lot of time to extra material, we offered them the flexibility of activities that could be fit into just one or two periods or integrated into the Earth science part of the

> curriculum, according to their needs at the time. We offered a series of different, inter-related but independent activities (the naming competition prior to the expedition, live video events during the expedition, and the song and drawing competitions after the expedition). Some classes participated in only one of the activities, others—in two or three, with the teachers choosing what was the most suitable for them. In the sense of the minimum required classroom time commitment, the activities were low-cost. The high gain, relative to the amount of class-time investment and in terms of increasing the students' interest in STEM and STEM careers, is achieved thanks to the captivating adventure aspect of the project's fieldwork, engagement of students through co-creation with scientists, and direct, live-video communications between students and scientists."

Also, in the end of Abstract, we add new text that does not mention the words lessons and recipes (to avoid their excessive repetition) but summarizes briefly the main areas where the lessons and recipes are offered by the programme:

> "The programme shows how research projects and the researchers working on them are a rich resource for EPE, highlights the importance of an EPE team with diverse backgrounds and expertise, and demonstrates the value of co-creation by the EPE team, teachers and school students. It also provides a template for a multi-faceted EPE programme that school teachers can use with flexibility, without extra strain on their teaching schedules."

b. I agree with Tony Lelliott that the title is too long: Suggestion: "Ship to shore – live video involves Irish schools in an active geophysical research project in the North Atlantic."

We appreciate the suggestion. We did put a lot of thought into our original title, however, and would very much prefer to keep it. The title suggested by Reviewer 2 would limit the stated scope of the programme to only one of its elements, the live video links, which would not be accurate, given that three school competitions before and after the video links have broadened the scope of the programme substantially and made it substantially more original. A part of our motivation for writing this paper came after our talk on the programme in an EPE session at the last EGU meeting, when a colleague working in a space research centre asked if we had a text on our programme that we could share, so that she could use some of our approaches in her outreach work. The first part of the title thus has an appropriately broad scope. As this is a case study, it is also important to spell out what this programme was, specifically. If the title was just "Education and public engagement using an active research project" or similar, it would give the wrong impression that this is a review covering the very broad area in some detail. Finally, the "lessons and recipes" are appropriate to mention as this is where most of the general usefulness of the paper probably is. For clarity, lessons are recipes are now mentioned and discussed explicitly throughout the text (Introduction, Discussion, Conclusions).

The title is, indeed, relatively long, but not exceptionally so: a number of titles on the Geoscience Communication Most Downloaded page (https://www.geosci-commun.net/most_downloaded.html), for example, are similar in length or longer.

7. Does the abstract provide a concise and complete summary?

a. Yes, but it should be edited to address some of the comments above: e.g. see ref to "boys and girls" being "presented with engaging role models"

We have, indeed, presented the school students with engaging, female and male role models – the young, enthusiastic PhD students with whom the school students often had exciting discussions. We have only anecdotal evidence for the effect that this has had, and for this reason we do not talk of this. But the fact that role models were presented is not in doubt.

b. I suggest some of the chosen adjectives in the abstract should be changed to avoid implied assumptions or bias: e.g.

i. 'Profound' impact (line 17) – the content doesn't show that the impact of the project has been 'profound'.

The sentence neither states nor implies that our project had a profound impact. This introductory sentence emphasizes the importance of the goals we are setting for ourselves: "Engagement with schools, in particular, can have a profound impact, showing the students how science works in practice, encouraging them to study science, and broadening their career perspectives."

ii. Line 20-21 – the relative pronoun 'them' in "…which got 'them' enthusiastically engaged" is unclear – who became enthusiastically engaged – the students or the researchers?

"them" has been replaced with "the students"

8. Is the overall presentation well-structured and clear?

Yes.

9. Is the language fluent and precise?

a. On the whole the article is well-written.

b. Some of the expression/idiom is unfamiliar to me – e.g. line 133 "curriculum-facing discussions" – are these curriculum-'based' or curriculum-'relevant'? If the discussions are 'relevant' to the curriculum they could require some interpretation, critical thinking and application by the students; whereas curriculum-'based' discussion would be more guided and possibly require less application and critical thinking. What did the students learn from these discussions?

"curriculum-facing" is, indeed, not commonly used. What we meant was "curriculum-aligned." Upon further reflection, however, we would like to simply remove the "curriculum-facing." We know that some of the teachers were teaching plate tectonics and volcanoes at the time of the competition, and discussing geoscience and geoscientists for the competition fit in nicely with the curriculum for them. But other teachers were not, so that the degree of curriculum alignment varied and a general statement on this would have to be weak and thus not very useful. The sentence now reads:

> "The teachers used this to have discussions on geoscience and marine science, as well as Irish and international Earth scientists and explorers."

c. Tone: there are two instances where the 'tone' could be interpreted as indicating a 'bias' on the part of the authors:

i. On p.4 line 119, the use of the word "imaginative" in the context denotes a certain implied irony – whilst the intention may be to instil some humour, it falls flat. On the other hand it could be interpreted as a typographical error for "unimaginative".

This was self-irony, not bias. However, seeing that this phrasing can be distracting rather than helpful in this paper, we have now removed the word "imaginative" and modified the sentence as follows:

> "The seismologists among us have a natural tendency to give their seismic stations names like S01, S02, S03, etc."

ii. On p. 5 line 136-37, the parenthetical reference to the deployment of "Charles" and "Harry", "inevitably, in the UK waters", whilst attempting humour, could be seen as inappropriate in a scholarly work. It assumes also that a global readership would understand and accept the 'joke'.

"(deployed, inevitably, in the UK waters)" has been removed. The sentence now reads:

> "…, and Charles and Harry–after the American seismologists Charles Richter and Harry Hess."

d. Minor errors:

i. Line 370 – insert the word "can" after "research project" for the sentence from line 369 to read "The outcomes of an educational programme coupled with a research project can include…"

"can" inserted, modifying the sentence.

ii. Line 378 – "form" should read "from".

Typo fixed – thank you.

10. Are the number and quality of references appropriate?

Yes. However, the formatting of the reference list is not reader-friendly and makes the references difficult to tell apart. I suggest that the second and following lines of the references are indented to set the references apart.

We have used the Geoscience Communication manuscript template exactly as it is.

11. Additional comments:

a. I couldn't find any reference to ethical clearance for the research as required by the scope of GC. As the authors are gathering data from schools, and teachers and pupils are case subjects, the research proposal should have received ethical clearance. Is this an oversight?

A new Ethics subsection has been added:

> "3.5 Ethics.
>
> The study complied with the Guidance for developing ethical research projects involving children (Department of Children and Youth Affairs, 2012). No personal information on children was collected. No interactions of project participants with children in the participating schools took place, other than the live video link-ups between the researchers and the classrooms, which were conducted by the teachers on the classroom side. The photographs of the children were supplied by the teachers, who confirmed the consent for their use in the online publication. Data collected in the evaluation survey of teachers were undertaken in accordance with good practice. The survey was anonymous by default. Contributors to this study were under no obligation to become the paper's co-authors."

b. Protection of minors:

i. Is it acceptable to use photos of under age children on an online platform?

Schools in Ireland and Italy obtain consent from parents for the use of their children's images, which is usually in the schools' promotional materials and social media. The photos used in our paper and similar ones have been used by the schools in their Tweeter feeds, for example. The teachers have sent the photos to us so that we could publish them. The teachers have shared only the photos for which they have parental consent, which we have confirmed with them.

Education and public engagement using an active research project: lessons and recipes from the SEA-SEIS North Atlantic Expedition's programme for Irish schools

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Abstract. An exciting research project, for example with an unusual field component, presents a unique opportunity for Education and Public Engagement (EPE). The adventure aspect of the fieldwork and the drive and creativity of the researchers can combine to produce effective, novel EPE approaches. Engagement with schools, in particular, can have a profound impact, showing the students how science works in practice, encouraging them to study science, and broadening their career perspectives. The project SEA-SEIS (Structure, Evolution and Seismicity of the Irish Offshore, www.sea-seis.ie) kicked off in 2018 with a 3-week expedition on the Research Vessel (RV) Celtic Explorer in the North Atlantic. Secondary and primary school students were invited to participate and help scientists in the research project, which got the~~m~~ students enthusiastically engaged. In a nation-wide competition before the expedition, schools from across Ireland gave names to each of the seismometers. During the expedition, teachers were invited to sign up for live, ship-to-class video link-ups, and 18 of these were conducted. The follow-up survey showed that the engagement was not only exciting but ~~had a lasting impact, increasing~~ encouraged the students' interest in Science, Technology, Engineering and Mathematics (STEM) and STEM-related careers. With most of the lead presenting scientists on the ship being female, both girls and boys in the classrooms were presented with engaging role models. After the expedition, the programme continued with follow-up, geoscience-themed competitions (a song-and-rap one for secondary and a drawing one for primary schools). Many of the programme's best ideas came from teachers, who were its key co-creators. The activities were developed by a diverse team including scientists and engineers, teachers, a journalist and a sound artist. The programme's success in engaging and inspiring school students illustrates the EPE potential of active research projects. The programme shows how research projects and the researchers working on them are a rich resource for EPE, highlights the importance of an EPE team with diverse backgrounds and expertise, and demonstrates the value of co-creation by the EPE team, teachers and school students. It also provides a template for a multi-

faceted EPE programme that school teachers can use with flexibility, without extra strain on their teaching schedules. The ~~programme's~~ outcomes of an EPE programme coupled with research projects can include both an increase in the students' interest in STEM and STEM careers and an increase in the researchers' interest and proficiency in EPE.

1 Introduction

STEM subjects are recognised by a large majority of people in Ireland as essential for the country's prosperity (SFI, 2015). Yet, most people are not comfortable with STEM, perceiving the subjects as too specialized. Careers in STEM and, specifically, Earth science do not appear attractive to most school students, in large part due to the lack of information on and exposure to them (Neenan and Roche, 2016). Among specific sections of the public and school students, women's and girls' interest in STEM and careers in STEM is still relatively low, and students in disadvantaged areas have insufficient resources and role models to motivate their interest in STEM (SFI, 2015).

These barriers to STEM engagement are not unique to Ireland (e.g., Tytler et al., 2008), although in Ireland, in particular, the public interest in science and the pride in the national achievements in science have long been well below those for the arts (Ahlstrom, 2019). The world-class research performed in Ireland today in many areas of science is something the country can be proud of and inspired by, adding to the public interest in STEM in the long term. In a more immediate and direct sense, however, research projects themselves and the researchers who work on them represent a rich resource for Education and Public Engagement (EPE).

Getting involved in an ongoing research project offers an appealing gateway to STEM to both school students and adults. Interactions with researchers reveal them to the public as friendly, "normal" people, enthusiastic about their jobs. These interactions are effective in alleviating the common stereotype of scientists as isolated, aloof and focussed on obscure or highly specialized experiments. The exposure to real researchers can thus increase the students' interest in STEM and in careers in STEM.

In this paper, we present, as a case study, an EPE programme developed around a major research project. Started by researchers, the programme grew to include school teachers as co-creators and expanded to the national scale. We describe the best practice developed in the course of the programme, draw lessons from its development, discuss some general inferences, and aim to identify useful templates and recipes for EPE projects that connect researchers to school students and to the general public.

2. The SEA-SEIS research project

2.1 Background

About 90% of the Irish territory is offshore, most of it to the west of Ireland. Beneath the ocean, spectacular mountains and deep valleys show elevation ~~differences~~ variations of up to 3-4 km. There are extinct volcanoes, with remarkable biodiversity on their slopes. Ireland's largest sedimentary basins are also here, as are its greatest natural hazards: undersea slope failures have caused tsunamis in geologically recent past (e.g., Salmanidou et al., 2017; Georgiopoulou et al., 2019).

In the project SEA-SEIS (Structure, Evolution And Seismicity of the Irish offshore), ~~researchers~~ Earth scientists from the Dublin Institute for Advanced Studies (DIAS) are investigating the dynamic processes within the Earth that have shaped the seafloor and caused intraplate volcanic eruptions in the Irish offshore and the broader Northeast Atlantic (Lebedev et al. 2018, Steinberger et al. 2019, Lebedev et al. 2019a, 2019b). In order to investigate the structure and flow of the rock within the Earth's crust and mantle, 18 seismic stations have been installed at the bottom of the North Atlantic Ocean. The ocean-bottom seismometers were deployed from the RV Celtic Explorer between 17 September and 5 October, 2018, to be retrieved 18-20 months later. The network covers the entire Irish offshore, with a few sensors also in the UK and Iceland's waters (Fig. 1).

This major project represents the first successful attempt to instrument a large area of the Atlantic Ocean with ocean-bottom seismometers. It is particularly significant for Ireland, an island nation with extensive coastlines and a special place for the sea in its culture and history. In addition to its pioneering science, the project also features state-of-the-art technology: the compact, ocean-bottom seismometers can withstand the enormous pressure at the bottom of the ocean while recording its tiniest vibrations, as small as nanometres in amplitude.

2.2 The 2018 SEA-SEIS Expedition

The 2018 SEA-SEIS expedition covered over 5,000 km in 18 days in the North Atlantic Ocean. Its main purpose was to install the 18 ocean-bottom seismic stations. It also offered spectacular EPE opportunities and provided a focus for the EPE programme that we have developed.

Scientists onboard included the Chief Scientist (SL) and seismology (RB, JdL, CGG) and geology (LB) PhD students. The team also included the engineer who had led the development of the ocean-bottom seismometers (AS) and an expert technician from DIAS (MS). It also included a journalist and digital media expert (DF) and a sound artist (DS). The diversity of the team was its key strength. All the members joined forces in the technical and EPE work, which came across clearly to school audiences onshore.

3 Development of the EPE programme

The programme was initiated by researchers, motivated by exploratory conversations with school teachers that indicated that it would be useful and in demand. The activities were funded primarily by small amounts from research-project budgets.

Starting with the realisation that the North Atlantic Expedition was simply too good an EPE opportunity to be missed, the programme grew and expanded through contributions from researchers and other members of the team onboard the Celtic Explorer and from teachers at secondary and primary schools. The programme benefited immediately from synergy with established EPE projects. The Marine Institute, which operates the Celtic Explorer and has its own, long-running EPE programme (Joyce, 2009; Joyce et al. 2018) offered berths on the ship to a journalist (DF) and a sound artist (DS), who then made important contributions to the development of our programme. Some of the teachers of the Irish Seismology in Schools network (Blake et al., 2008) participated in the programme and also made contributions to its development.

We reviewed best practices of previous EPE projects connected to active research and looked for any ideas that could be applicable to ours. ~~(e.g., Gosselin et al. 2003; Jarrett and Burnley, 2003; Madden et al., 2007; Drake et al., 2013; Hut et al., 2016; McAuliffe et al., 2018; IODP, 2019).~~ Teacher-scientist collaboration aiming to promote hands-on, inquiry-based science teaching is, generally, an established approach. In seismology, specifically, the Princeton Earth Physics Project (PEPP) installed seismometers in schools across the US for use in teaching and in science projects (Nolet, 1993; Steinberg et al., 2000; Phinney, 2002), and a number of seismology-in-schools programmes operate elsewhere around the world (e.g., Bullen, 1998; Virieux, 2000; Blake et al., 2008; Denton, 2008; Courboulex et al. 2012; Balfour et al., 2014; Zollo et al., 2014; Tataru et al., 2016). Collaborative, teacher-scientist research projects improve, on the one hand, the scientists' awareness of classroom practices and, on the other hand, the teachers' understanding of scientific research, exposing each group to the other's culture and highlighting the advantages of integrating scientific inquiry into the curriculum (Gosselin et al., 2003). In the joint scientist-teacher-student research projects, the participants particularly enjoy being part of authentic research in which they could take initiative and feel a sense of ownership (Jarrett and Burnley, 2003). Scientist-educator partnerships can produce new teacher resources and lesson plans, incorporating cutting-edge research (Madden et al., 2007).

Recent trends in Earth-science outreach (e.g., Drake et al., 2014; Tong, 2014) include the use of video projects in the science classroom (Dengg et al., 2014; Wade and Courtney, 2014) and storytelling via diverse media (Barrett et al., 2014; Moloney and Unger, 2014). Hut et al. (2016) reviewed the theory of effective geoscience communication through audio-visual media, with a particular focus on television, and identified six major themes and challenges: scientist motivation, target audience, narratives and storytelling, jargon and information transfer, relationship between scientists and journalists, and stereotypes of scientists among the general public. Live video has already been used extensively in the practice of EPE coupled with marine research: ship-to-shore video events have been performed for a number of years by the International Ocean Discovery Program (IODP) (Kulhanek et al., 2014; IODP, 2019). We were able to use the idea successfully in our programme, with a specific focus on ship-to-classroom video link-ups and with our own event templates (Section 3.2).

McAuliffe et al. (2018) reported on the creation of a science book for 7-12 year olds. The book showcased the importance of STEM in today's society and aimed to give the children their first conceptions of STEM career pathways. Importantly, children were co-creators in the content development, character design, and "try at home" activities offered in the book. As a result, 93% of parents of participating children felt that the children became more interested in science than they were before. The Irish research examples used in the book were also found to shift the perception that major scientific discoveries could only take place abroad (McAuliffe et al., 2018).

Further insight into the state of the art in the relevant EPE practice can be gained through direct communication with the practitioners. Contacting and talking to a lot of people—teachers, researchers, EPE and communications experts—was of key importance in the development of the present programme. Best practical ideas and essential partnerships emerged from some of these discussions.

Shortly before the start of the North Atlantic expedition, a press release on the project was circulated by DIAS through a PR company (Alice PR). This triggered broad coverage of the project in the national media (https://sea-seis.ie/media), which then helped, to some extent, to attract schools to the programme. However, it was the direct contact with schools and announcements through national networks of teachers and principals that were the most effective.

3.1 Before the expedition: Seismometer-naming competition

The ~~researchers'~~ seismologists among us have a natural tendency ~~is~~ to give their seismic stations ~~imaginative~~ names like S01, S02, S03, etc. This is, indeed, how our offshore sites were referred to at the experiment design stage, when we determined the locations for the seismometers ~~were determined~~.

Then, just over two weeks before the expedition, we announced a secondary-school competition to name our seismometers. Two weeks is a short time for a teacher who may meet their science or geography class only once a week. Having more time for the competition would have been beneficial~~,~~ as more classes would be likely to participate. However, this was not possible as~~but~~ the expedition started shortly after the beginning of the academic year.

The competition was advertised through the email list of the Irish secondary school principals. To kick it off, we proposed the first name, Brian, ourselves. This was after Brian Jacob (Senior Professor of Geophysics at DIAS, 1989-2001), who led the work on the continental nature of the basins west of Ireland, which resulted in the Irish territory increasing by about a factor of ten.

~~Around t~~Twenty schools—nineteen across Ireland~~, plus~~ and one in Italy~~,~~—participated in the competition. Our appeal for help in an important research project has generated genuine enthusiasm in students and got them engaged with the project. The teachers used this to have ~~curriculum-facing~~ discussions on geoscience and marine science, as well as Irish and international Earth scientists and explorers. Among the winning names (https://sea-seis.ie/competitions/naming-competition), Maude, for example, was named after Maude Delap, the Irish marine biologist, ~~and~~ Tom—after Thomas Crean, the Irish seaman and Antarctic explorer~~.~~, and Charles and Harry ~~(deployed, inevitably, in the UK waters) were named~~ after the American seismologists Charles Richter and Harry Hess.

Some teachers used the competition to talk with their students of the sea in the Irish history and culture. Allód was named for the ancient Irish god of the sea, and Gráinne—for Gráinne Ni Mhaille, the "Pirate Queen," the well-known, 16th-century lord of the Ó Máille dynasty in the west of Ireland. Yet another approach was to let the students' imagination roam free, giving us names like Eve (for "eavesdropping on the Earth"), Gill and Loch Ness Mometer.

Most schools proposed multiple names, and some names were proposed by more than once school. The SEA-SEIS researchers at DIAS selected and announced the winning names prior to the start of the expedition. Apart from the merit of the names themselves, an additional consideration was to have as many schools as possible among the winners. With some winning names proposed more than once, all the schools that submitted entries by the deadline were among the winners. The students in participating classes—now well engaged with the project—were particularly interested in how their seismometer would do. Most winning classes then participated in the live video links to the ship during the expedition, and the students were keen to see the videos and photos of the deployment of the seismometer that they had named.

3.2 "It was like speaking to Indiana Jones!" - Ship-to-class video link-ups

Live ship-to-shore video links had been performed ~~by~~ in international EPE programmes before ours, in particular by the International Ocean Discovery Program~~me~~ (IODP) using its RV JOIDES Resolution's scientific cruises (Kulhanek et al., 2014; IODP, 2019). Some of the teachers we knew ~~known to us~~ in Ireland had participated in these video links and used them to stimulate their students' interest in STEM.

~~Keen to use the available best practice~~Following IODP, we started the video link-ups with an introduction from the ship that set the stage for a question and answer session with the students in the classroom. In contrast to the IODP video events, which, with rare exceptions, are led by educators (Kulhanek et al., 2014), all our video links were led by PhD students onboard. ~~nonetheless had to~~We also had to develop our own template for live video events. Because the weather during our expedition was mostly stormy—~~as~~ which is often the case in the North Atlantic,—the initially planned live tours of the ship, as performed on RV JOIDES Resolution's scientific cruises (Kulhanek et al., 2014), would have been dangerous for the presenters and had to be abandoned. Instead, we started each session with a brief greeting by a PhD student, acting as the main host on-board, from outside on the deck. This was followed with an 8-minute, pre-recorded video with introductions to the project and to the team (https://youtu.be/xb-idLyJWLI) and short videos and photos of ~~the latest~~ seismometer deployments.

With the Marine Institute's assistance, we had secured, in advance and at an additional cost, a dedicated satellite broadband connection from the ship. Following JOIDES Resolution's EPE programme's example, we used the video-conferencing software Zoom (https://www.zoom.us). During the video links, all non-essential internet activity on the ship was turned off. With all of that, the connection was of surprisingly high quality. Nevertheless, every video event also included our colleagues at DIAS as the third party in the video conference—and the co-hosts at the "DIAS HQ." They would greet the school audience at the beginning of the livestream and broadcast the pre-recorded videos using their reliable broadband connection. They were also ready to step in if the connection from the ship deteriorated, which happened once, towards the end of a video link, when the ship moved out of the area of the satellite's coverage.

After the introduction to the project, the science and the team, the students were invited to ask questions (Fig. 2). Prior to the video link, they were asked by their teachers to think of some. Most questions that were asked related to the life on the ship, to the project (its goals, hypotheses and methods), to Earth science (earthquakes, volcanoes, tsunamis and other natural hazards; plate tectonics and dynamics of the Earth interior), to the equipment, how it works and how it was developed, to what scientists do in their jobs, and to how one becomes a scientist. The Q&A sessions lasted between 20 and 70 minutes, depending on how much time the classes had and on our schedule.

Because of the limited number of video link-ups that could realistically be performed, invitations were sent only to the participants of the seismometer-naming competition (~~~~20, over half of them then requesting a slot) and to the members of the Irish Seismology in Schools network (Blake et al., 2008), operated by DIAS (~~~~45, a few of them requesting a slot). We were able to schedule and perform a video link with every teacher who asked for one.

In total, 18 video link-ups were carried out. The classes were in schools all around Ireland, and there was one connection to a school in Italy—reported on by a regional TV station (https://youtu.be/1vBFLKV8nG0). In some schools, we talked to a large class or to two classes in the same room, sometimes with students sitting on the floor in the isles. On Tory Island, Co Donegal, there were only five students in the room, but that was 100% of the students in this secondary school—and on this island. For remote schools, the video-link format opens new possibilities and makes it much easier to arrange interactions of school students with STEM practitioners.

Most presenters on the ship and at DIAS were female. This ~~helped~~ offered opportunities to all-girl classes and girls in co-educational schools to connect to and identify with their own role models among the scientists.

Both female and male students were clearly excited to chat with scientists and engineers on a ship in the middle of the North Atlantic. According to the teachers, their students would then tell the entire school as well as their parents of this experience, which further broadened the ~~impact~~ reach of the event. “It was like speaking to Indiana Jones!” was how the students of Lycée Français d'Irlande, Dublin, summarized it.

Some teachers used the engagement with researchers to accompany special Earth science projects, conducted prior to the video link (Fig. 3). Other teachers spent only one or two periods on the video link and the discussions before and after it. Given the already packed curricula, this flexibility was useful and appreciated by the teachers. The video links provided a “low-cost, high-impact” activity, inspiring the students and ~~getting them more~~encouraging their interest~~ed~~ in STEM and STEM careers but not putting excessive strain on the teachers’ schedules.

3.3 Drawing competition for primary schools

The SEA-SEIS Drawing Competition for Primary Schools ran from October to December, 2018. It was advertised on the SEA-SEIS website and in InTouch, the Irish National Teachers’ Organisation’s monthly magazine (InTouch, 2018).

We invited the students to draw one of our friendly, adventurous seismometers. ~~Talking to~~Noting the primary school children’s ~~beforehand, we noted their~~ concern for the seismometers (will they be scared at the bottom of the sea, all alone?), we made sure that~~and mentioned in~~ the competition announcement mentioned that diving deep into the sea was the~~ir~~ seismometers’ favourite thing to do. The announced evaluation criteria included relevance, artistic merit and originality.

We received nearly 70 entries in total (https://sea-seis.ie/sea-seis-art-18). Most of these came from two schools in different counties in Ireland and two classes in the same school in Italy. The remainder came from a few other schools in Ireland.

Because this was a primary school competition, we awarded a prize to every student who sent us a drawing. The prize was the 2019-2020 SEA-SEIS Calendar, featuring the art by the students (Fig. 4). Every drawing was printed in the calendar, with the ones ranked highest by the SEA-SEIS-researcher jury printed on a full page, and the others—a few per page.

The feedback from the participating teachers and students indicated that the competition was enjoyable and increased the students’ interest in STEM (see Section 4). The number of schools who entered, however, was relatively small. This was, in part, because primary schools already have their own art competitions and may feel they are already busy enough with those. In order to increase the participation in the future, it will be useful to communicate to schools more explicitly how the competition can raise the students’ interest in STEM, and also mention that every valid entry will win a prize, which we have not done in this case.

3.4 Song and Rap competition for secondary schools

The SEA-SEIS Song and Rap Competition for Secondary Schools ran from October to December, 2018. It was advertised on the SEA-SEIS website and through teacher networks. We invited the students to compose and record a song or a rap on a topic related to seismology, the SEA-SEIS Expedition, Earth science or exploration of the interior of the Earth. For information, we directed the students to the project website, to video link-ups with the ship if their class participated, and to further reading. Entries from entire classes or smaller groups of students were accepted. The evaluation criteria included relevance, scientific insight and accuracy, artistic merit and originality.

The competition received excellent entries—creative, imaginative, artistic, and with a variety of original takes on Earth science and seismology at sea (https://sea-seis.ie/sea-seis-rap-18). The competition Grand Prize was shared by two top entries. Runners-up were distinguished by the Jury of SEA-SEIS researchers with Special Mentions. The Grand Prize winning groups received the SEA-SEIS/DIAS branded flash drives (16GB, waterproof to 100 m depth), one for each student in the group and one for their teacher. These were appreciated by all the recipients (Fig. 5). Classes contributing entries that received Special Prizes and Special Mentions received inspirational science books and 4-colour, SEA-SEIS branded pens, also successful as prizes.

One of the teacher~~s~~ authors of this paper ~~—Céline Tirel of the Lycée Français d'Irlande, Dublin—~~ (CT) offered the production of a competition entry as a ~~(~~graded~~)~~ Technology project to one of her classes. This was a successful and effective approach, with the production of an entry comprising research on the science, creation of the piece, recording, and preparation of a report.

It was clear from the entries that many students made an effort to research the subject and learn more of the science. Others, however, seemed less interested to learn, and some succeeded in creating impressive entries in spite of that. At one end of the spectrum, one of the winning compositions referred to most SEA-SEIS seismometers by their names, also with a reference to their location and to what they were recording on the seafloor, which showed substantial research on the subject. At the other end, some of the entries showed little understanding and probably no research behind them.

Drawing a line separating “research” from “no research,” however, would be difficult. The competition was developed in order to combine art and science, to get the students create science-themed art and to get them more interested in science. The pieces the students composed and recorded were free-form, and there were no correct answers they could insert into in their songs. For this reason, it is not possible to gauge precisely the amount of research students put into Earth-science research in the course of this activity.

By the very nature of the art-science approach, it is not always possible to measure everything. We do draw a lesson from the first edition of this competition, however: ~~I~~in ~~the~~ its future editions~~ of the competition~~, it will be useful to steer students more firmly towards learning and towards communicating science and technology in their pieces.

3.5 Ethics

The study complied with the Guidance for developing ethical research projects involving children (Department of Children and Youth Affairs, 2012). No personal information on children was collected. No interactions of project participants with children in the participating schools took place, other than the live video link-ups between the researchers and the classrooms, which were conducted by the teachers on the classroom side. The photographs of the children were supplied by the teachers, who confirmed the consent for their use in the online publication. Data collected in the evaluation survey of teachers were undertaken in accordance with good practice. The survey was anonymous by default. Contributors to this study were under no obligation to become the paper's co-authors.

4 Evaluation

Formal evaluations were conducted after all ship-to-classroom video link-ups, using a SurveyMonkey online survey. The survey was anonymous by default, but the names of the school and the teacher could be given as an option. All teachers that we contacted right after the video link, on the same day, responded and completed the evaluation form. Of those contacted 3 days after the video-link (once, the ship lost the internet connection over an entire weekend), half did not respond.

Overall, the teachers rated the educational activity at 4.7 out of 5, on average. 86% reported that the video link encouraged the students' interest in science, with 14% reporting "somewhat encouraged," and none reporting "did not encourage." The respondents also reported that the video links triggered the students' curiosity, showed them that science is part of real life, highlighted the importance of collaborating and broadened their career ideas. Getting to know scientists as "open, friendly people" impressed the students. For the classes who had participated in the seismometer-naming competition, the main highlight was, invariably, seeing the deployment of the seismometer they had named.

The evaluation relating to the drawing competition was informal, based on the feedback from the primary school teachers and students themselves. The bulk of the feedback came in the form of 24 thank-you cards from 7-8 year old students from Abbeyleix South National School, Co. Laois, Ireland. It was clear that the children were encouraged to write the cards by their teacher and that the teacher must have mentioned a number of things that could be included in the cards. However, different children opted to include different things in their text, and the phrasing was their own, different in different cards. Nearly all the students wrote that they enjoyed learning about the seismometers and the project, with some mentioning explicitly that they explained what they had learned to their parents. All were pleased with their prizes, and happy that everybody got a prize. Some wrote that they would like to work with the SEA-SEIS researchers in the future.

This evidence would not yield robust statistical inferences (only one class, influenced by their teacher) but, even though the evidence may be regarded as anecdotal, we consider it encouraging and useful. It confirms that young primary school students are curious about and receptive to the general ideas of Earth science research, and that rewarding every participant with a prize is an effective approach in primary school competitions. It also highlights the key role of an actively participating teacher and the importance of a teacher network in order for such competition to reach a broad, national scale.

5 Discussion

In this section, we focus on the lessons and recipes provided by our EPE programme. We discuss the ~~EPE~~ approaches shown to be particularly important and useful~~by our programme~~. We also point out what did not work as expected and why, and consider potential next steps towards an expanded, sustainable EPE programme coupled with Earth-science research projects.

5.1 Researchers as EPE leaders

Academic researchers are a source of essential STEM expertise. They also possess genuine enthusiasm for science. Their potential capacity for EPE resource development and EPE activities is remarkable: scientists are creative, resourceful and have excellent technical and computer skills. The researchers' motivation to participate in STEM activities, however, is not universally high, for a number of reasons. The incentive structures (assessment criteria) at academic institutions prioritise research, published in top journals of the field, as well as service to the institutions, including administration and teaching (Lam, 2011; Hillier et al., 2019). In informal networks of international researchers, achievements in research are also prioritised. Outreach work can be dismissed by a colleague with a quick "Ah, it's not science." Misguided as this may be, most ~~of us~~researchers have heard this, and the opinion of the community of peers affects not only ~~researchers'~~ their self-esteem but also their employment and funding opportunities.

For the academics still keen to develop EPE activities, allocating time for this can be difficult, especially if this is unrelated to any of their current research projects. Also, even though most funding agencies encourage EPE, they often do not provide any funds for it in regular research grants.

Researchers thus tend to leave EPE development to outreach specialists and participate in the activities occasionally. They are often used as presenters in pre-designed EPE activities, which gives them opportunities for improving their communication skills (e.g., Illingworth et al., 2019)—often not their greatest strength, to begin with. However, consistently using researchers for what many of them do not particularly enjoy or excel at does not, obviously, get the best out of them, while pushing some away altogether.

EPE coupled with active research projects can channel the academic researchers' drive and creativity into the development of spectacular, novel EPE programmes. Not all research projects are equally suitable for this, and smaller projects may lack the scale and personnel. A certain proportion of research projects, however, will always present excellent opportunities for the development of effective EPE programmes, led by scientists or by scientists and educators together. Projects with an exciting field component, in particular, easily capture the imagination of school students and engage them, as illustrated by the SEA-SEIS and a number of other EPE programmes (e.g., Kulhanek et al., 2014; IODP, 2019).

5.2 Team with diverse backgrounds

Our programme benefited greatly from its integration of practitioners from different disciplines. The team that developed ideas, produced digital content and conducted the EPE activities included Earth scientists, engineers and technicians, secondary school teachers, a journalist and a sound artist. Our teachers (CT and BOD) made key contributions to the development of classroom-activity ideas, from the early stages of the programme planning. Our journalist and media expert (DF) participated in the programme development since before the expedition and produced a popular blog that covered the expedition, also maintaining professionally the project's digital media presence, increasingly recognised as essential in science communication (Drake et al., 2014~~3~~). Together with our sound artist (DS), they shot and edited onboard the project-introduction and tour-of-the-ship videos. The sound artist, whose primary work using the sounds recorded on the ship will be presented in a month-long show as part of a major international festival, made sure we were all heard during the video links, even outside in strong winds. The engineers and technicians (AS, MS, LC) presented and explained with authority the technology aspect of the project. All the team members onboard the Celtic Explorer presented their perspectives on the project to the school students, conveying the importance of collaboration and the diversity of backgrounds and skills that is required by a major science project.

5.3 Students co-creating with scientists

School students were invited to help scientists and have made a real contribution to the project. Their names for the ocean-bottom stations (Fig. 1) have permanently replaced the tentative S01, S02, etc. After the data are collected, these names (abbreviated when required) will remain attached indefinitely to seismograms in international data repositories. In our two art competitions, the participants have produced pieces that are now themselves effective tools for education and public engagement.

~~I~~We found that inviting students to become co-creators gets them engaged with enthusiasm. They are, then, motivated to learn more on the project, the scientific hypotheses behind it, and what the scientists do in the course of the project. Even though the students do not perform any of the project's key technical tasks, co-creation does help to get across the excitement and creative nature of scientific research more effectively than a pure exchange of information would. This, in turn, is likely to contribute~~s~~ to increasing the students' interest in STEM and STEM careers.

5.4 Multi-faceted, "low-cost, high-gain" programme

We offered the teachers the flexibility of activities that could be fit into just one or two periods, or used in science and technology lessons and projects, or integrated into the Earth science part of the curriculum, according to their needs at the time. The different activities were inter-related but independent (the naming competition prior to the expedition, live video link-ups during the expedition, and the song and drawing competitions after the expedition). Some classes participated in only one of the activities, others—in two or three, with the teachers choosing what was the most suitable for them. The activities were "low-cost" in the sense of the minimum required classroom time commitment. Their impact was "high gain" when compared to the modest amount of the class-time investment required. The gain is in terms of encouraging the students' interest in STEM and STEM careers, which was achieved thanks to the captivating adventure aspect of the project's fieldwork, engagement of students through co-creation with scientists, and direct, live-video communications between students and scientists.

5.5~~4~~ What should be improved and perspectives

Our competitions were, in a sense, experiments. When announcing them, we could not predict the level of participation in either of them or their effectiveness in promoting STEM. The seismometer-naming competition was successful and got the students who participated in it engaged in the project. ~~(The participating classes who then took part in the ship-to-class video link-ups have shown an increase in the students' interest in STEM, according to the teacher survey after the live video events.)~~ The follow-up drawing and song-and-rap competitions produced some excellent entries, but the number of participating schools was lower than expected. A proportion of entries to the song-and-rap competition showed little evidence of the students researching either Earth science or the SEA-SEIS project's scientific goals.

While successful as a proof of concept, the competitions also highlighted what was missing: an effective network of teachers. We worked closely with a few teachers and attracted around 30 more from different schools through project announcements. But many other teachers did not respond to invitations to join our EPE activities, possibly not finding them sufficiently compelling or sufficiently informative. Our aim is to help the teachers to get their students more interested in STEM. In order to do this more effectively and develop our EPE programme further, we would need to grow an extensive, national-scale teacher network, offering the teachers continuing professional development, workshops and resources.

An expanded, sustainable EPE programme should also offer more activities. Video links can be performed not only from the ship but from the lab and from other fieldwork locations. The expanded programme can have joint activities with multiple research projects and a wider group of researchers associated with them. The programme can also broaden so as to target adult audiences, as well as school students. Generally, more engagement, co-creation, discussion and debate are needed in order to get people of all ages more interested, involved and comfortable with STEM subjects (SFI, 2015). Using the approaches, lessons and recipes from the present programme, this can be addressed through the work with schools supported by the development of an effective teacher network, through presenting science through arts, and through the use of a pervasive digital platform. Such expansion of the programme would, however, require dedicated funding—being sought at the moment.

6 Conclusions

A research project with an exciting field component presents a unique opportunity for broad public engagement. Educational activities with schools, in particular, can have a profound, lasting impact, showing the students how science works, encouraging them to study science, and broadening their career perspectives. Participation in a real research project and co-creation with scientists gets the students enthusiastically engaged.

The EPE programme presented here as a case study comprised live video link-ups between scientists on a ship in the North Atlantic and students in classrooms and 3 school competitions, before and after the expedition. Survey responses from the teachers confirmed that the ~~engagement is not only enjoyable but has a lasting positive impact~~video links encouraged the students' interest in STEM. Researchers—both experienced and early-career—could~~an~~ see the real impact of the outreach and go~~e~~t involved with enthusiasm and commitment. The outcomes of an educational programme coupled with a research project can thus include both the school students getting more interested in STEM and STEM careers and researchers getting more experienced and proficient in the education and public engagement work.

This case study offers useful lessons and recipes for EPE programmes coupled with active research projects. First of all, it highlights how the research projects and the researchers working on them are a rich resource for EPE. Researchers can be effective EPE leaders, with the EPE programmes channelling their drive and creativity into the development of effective, novel EPE activities.

Secondly, it illustrates the importance of an EPE team with diverse backgrounds and complementary expertise and skill sets. In EPE with primary and secondary schools, the most essential partners are the school teachers and principals. The development of a network of actively engaged teachers is a pre-requisite of successful EPE with schools and should, if possible, be initiated at the earliest stages of the programme. Beyond that, our programme capitalized on contributions of not only scientists and teachers, but also engineers and technicians and a sound artist. Effective national media campaign around the start of the SEA-SEIS Expedition and EPE programme was orchestrated by our communication manager, working with a partner PR firm. Our digital media presence was maintained primarily by the team's digital journalist, his expertise increasing its effectiveness greatly.

Thirdly, the programme demonstrates the value of co-creation by the EPE team, teachers and school students. Close collaboration with the teachers was essential in planning and developing the programme activities. Getting the school students co-creating with scientists in the course of the school competitions got them engaged and genuinely interested.

Finally, our project can be seen as a template for a multi-faceted, "low-cost, high-gain" EPE programme. Recognising that the school curricular are already packed, so that teachers find it difficult to allocate a lot of time to extra material, we offered them the flexibility of activities that could be fit into just one or two periods or integrated into the Earth science part of the curriculum, according to their needs at the time. We offered a series of different, inter-related but independent activities (the naming competition prior to the expedition, live video events during the expedition, and the song and drawing competitions after the expedition). Some classes participated in only one of the activities, others—in two or three, with the teachers choosing what was the most suitable for them. In the sense of the minimum required classroom time commitment, the activities were low-cost. The high gain, relative to the amount of class-time investment and in terms of increasing the students' interest in STEM and STEM careers, is achieved thanks to the captivating adventure aspect of the project's fieldwork, engagement of students through co-creation with scientists, and direct, live-video communications between students and scientists.

Video supplements

In our three video supplements (*to be uploaded to the repository but for now available at the links given*), we present

1) an 8-minute introductory video created for our ship-to-classroom video link-ups (https://youtu.be/xb-idLyJWLI);
2) a light-hearted but informative account of instrument deployments in rough weather—an example of the presentation of an aspect of the project to a broad audience (https://youtu.be/i2lmBIpcgfI);
3) an entertaining compilation of selected images and sounds fro~~r~~m our competitions for the primary and secondary schools (https://youtu.be/KkDc4zqhG5c).

Data availability

~~No primary data sets were used in producing this article~~The evaluation survey data are provided in the Supplement.

Author contribution

SL prepared the manuscript with contributions from all co-authors. RB, DF and DS produced the project EPE videos. SL, BOD, CT, DF, SM, RB, CGG, JdL and LB developed and ran school competitions. SL and DF performed programme-evaluation surveying. SL, LB, RB, JdL, CGG, AS, DF, DS, LC and BC developed, managed and performed live video link-ups between the ship, classrooms and DIAS. CT and BOD contributed key ideas and co-created the competition and video-link activities.

Competing interests

The authors declare that they have no conflict of interest.

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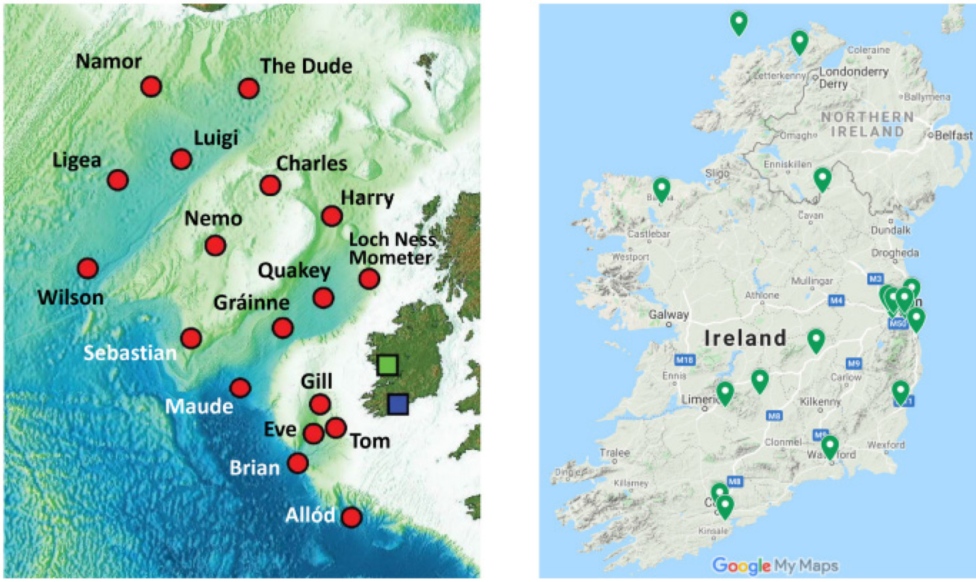

Figure 1: Left: the ocean-bottom seismic stations of the SEA-SEIS network (red circles), named by secondary school students in the seismometer-naming competition. Right: the schools across Ireland that suggested the winning names (for an interactive map, see https://sea-seis.ie/competitions/naming-competition).

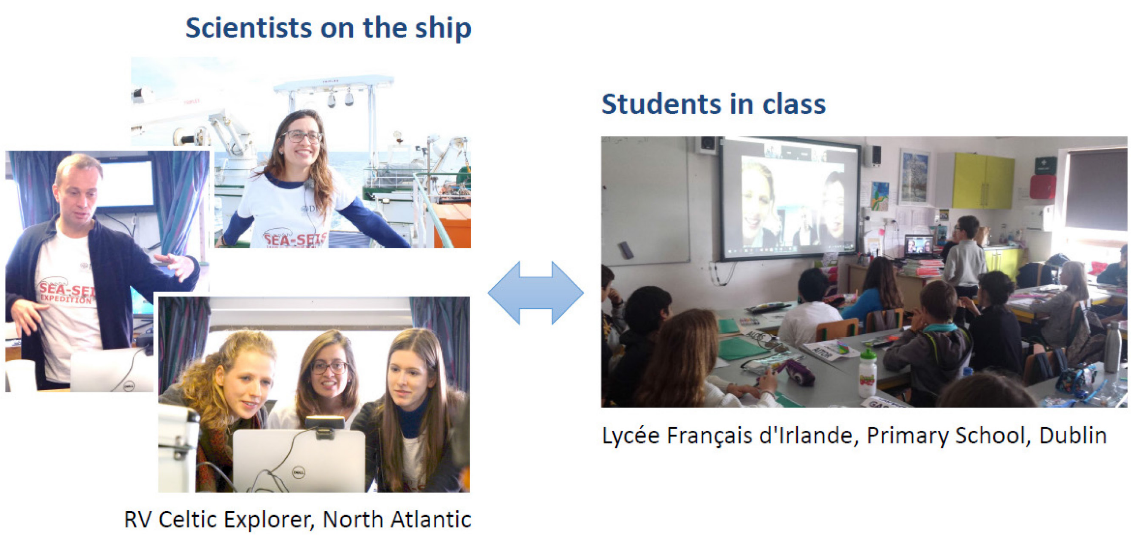

Figure 2: Live, ship-to-classroom video link-ups started with a brief introduction of the project and the team and continued with a 20-70 minute Q&A session.

Figure 3: Live, ship-to-classroom video link-ups with different schools in Ireland and Italy.

Figure 4: Participants of the Primary School Drawing Competition with their prizes, calendars featuring their art. Top left: the 2019-2020 calendar. Top right: students at Istituto Comprensivo Don Lorenzo Milani, Lamezia Terme, Italy. Bottom, left and right: students at Abbeyleix South National School, Abbeyleix, Co. Laois, Ireland.

Figure 5: Prizes and some of the winners of the geoscience song-and-rap competition for secondary schools. Left: Inspirational science books went to classes with winning and runner-up groups. Centre: one of the two Grand Prize winning groups (Lycée Français d'Irlande, Dublin). Right: SEA-SEIS branded, 16GB flash drives were awarded to every student in the winning groups and to their teachers.

Supplement of

Education and public engagement using an active research project: lessons and recipes from the SEA-SEIS North Atlantic Expedition's programme for Irish schools

Sergei Lebedev et al.

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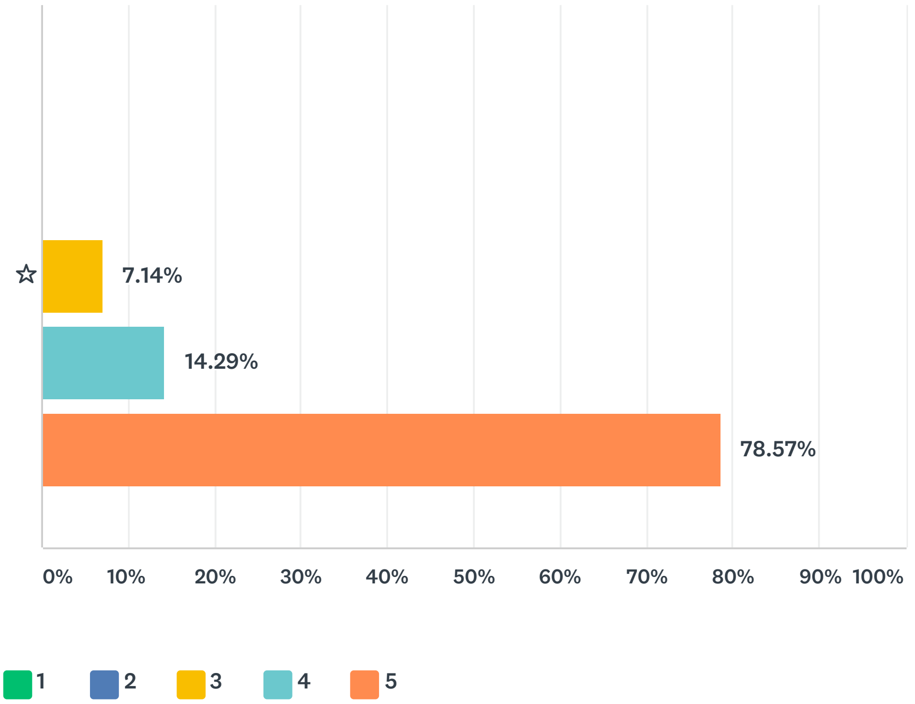
This file presents the data yielded by the evaluation survey of participating teachers in Ireland following our live, ship-to-classroom video link-ups. The survey was conducted via SurveyMonkey (surveymonkey.com).

The survey included 10 questions. The first 5 were multiple-choice and the last 5 were free-form questions. In the following, we first give a graphical summary and basic statistics for the 5 multiple-choice questions. After that, we give complete responses by the respondents to all the questions, apart from the last one.

The survey was anonymous by default. The last, 10th question gave the participants an opportunity to give their name and information on their school and class, if they wished. Here, we omit the answers to this last question.

Q1 How many stars (1 is worst, 5 is best), would you give your SEA-SEIS video link overall?

Answered: 14 Skipped: 0

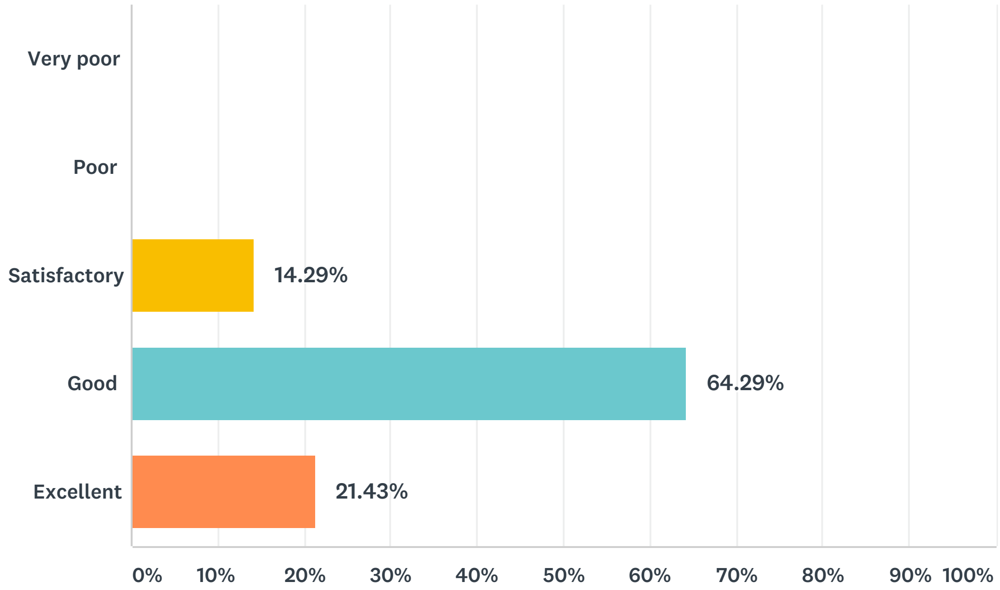


	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	TOTAL	WEIGHTED AVERAGE
☆	0.00% 0	0.00% 0	7.14% 1	14.29% 2	78.57% 11	14	4.71

BASIC STATISTICS				
Minimum 3.00	Maximum 5.00	Median 5.00	Mean 4.71	Standard Deviation 0.59

Q2 How was the audio and video quality?

Answered: 14 Skipped: 0

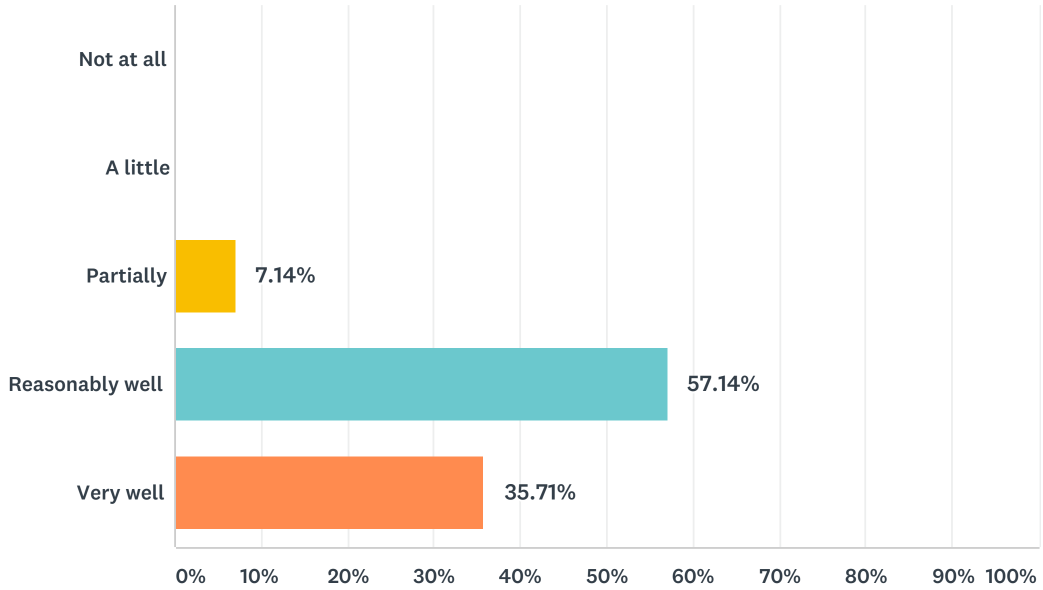


ANSWER CHOICES	RESPONSES	
Very poor (1)	0.00%	0
Poor (2)	0.00%	0
Satisfactory (3)	14.29%	2
Good (4)	64.29%	9
Excellent (5)	21.43%	3
TOTAL		14

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
3.00	5.00	4.00	4.07	0.59

Q3 How well did the students understand why the scientists went on the expedition?

Answered: 14 Skipped: 0

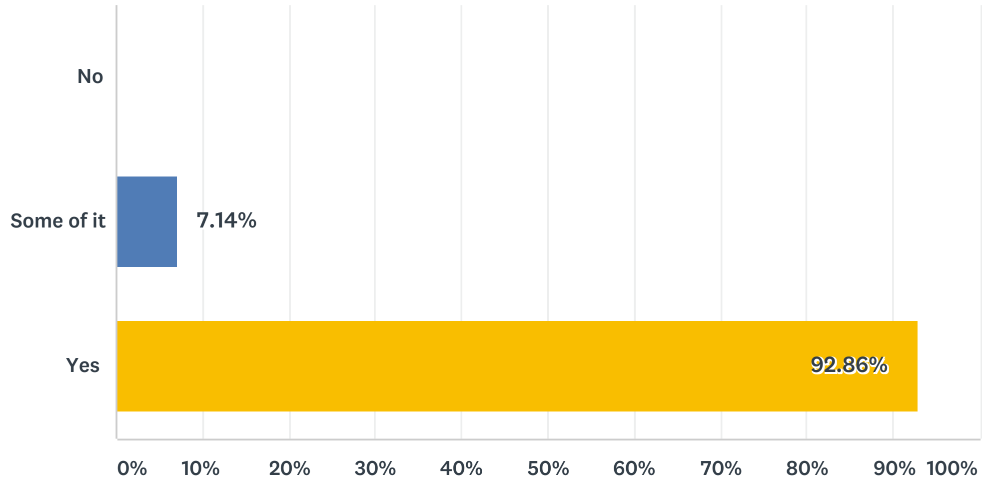


ANSWER CHOICES	RESPONSES	
Not at all (1)	0.00%	0
A little (2)	0.00%	0
Partially (3)	7.14%	1
Reasonably well (4)	57.14%	8
Very well (5)	35.71%	5
TOTAL		14

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
3.00	5.00	4.00	4.29	0.59

Q4 Was the information presented on the appropriate level for your audience?

Answered: 14 Skipped: 0

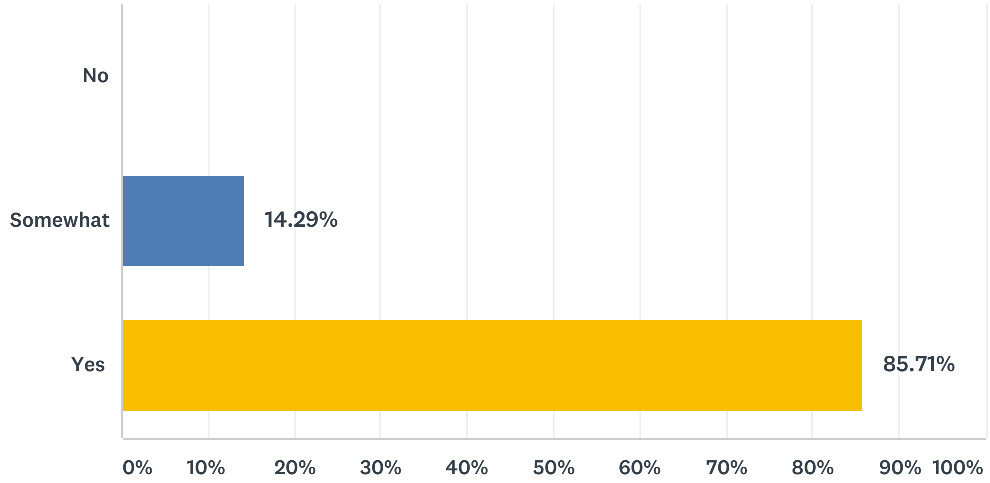


ANSWER CHOICES	RESPONSES	
No (1)	0.00%	0
Some of it (2)	7.14%	1
Yes (3)	92.86%	13
TOTAL		14

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
2.00	3.00	3.00	2.93	0.26

Q5 Did the video link encourage the students' interest in science?

Answered: 14 Skipped: 0



ANSWER CHOICES	RESPONSES	
No (1)	0.00%	0
Somewhat (2)	14.29%	2
Yes (3)	85.71%	12
TOTAL		14

BASIC STATISTICS

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	3.00	3.00	2.86	0.35

#1

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Wednesday, September 26, 2018 9:29:06 PM
Last Modified: Wednesday, September 26, 2018 9:33:57 PM
Time Spent: 00:04:50
IP Address:

Page 1

Q1 How many stars (1 is worst, 5 is best), would you give your SEA-SEIS video link overall?

☆ **5**

Q2 How was the audio and video quality? **Excellent**

Q3 How well did the students understand why the scientists went on the expedition? **Very well**

Q4 Has the information presented on the appropriate level for your audience? **Yes**

Q5 Did the video link encourage the students' interest in science? **Yes**

Q6 Did the students enjoy the video link? Did it spark their imagination?

They were telling their other teachers about it afterwards so it was definitely enjoyed. They were asking could they keep an eye on how you were getting on in class !

Q7 What did you like most about your video link?

The crew were very good with the students and obviously loved their jobs which came across very well

Q8 Approximately how many people were in attendance at your event?

16 plus teacher

Q9 Do you have any general comments or suggestions for our video links?

Keep up the good work !!

#2

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Wednesday, September 26, 2018 9:37:37 PM
Last Modified: Wednesday, September 26, 2018 9:41:19 PM
Time Spent: 00:03:42
IP Address:

Page 1

Q1 How many stars (1 is worst, 5 is best), would you give your SEA-SEIS video link overall?

☆ **5**

Q2 How was the audio and video quality? **Good**

Q3 How well did the students understand why the scientists went on the expedition? **Reasonably well**

Q4 Has the information presented on the appropriate level for your audience? **Yes**

Q5 Did the video link encourage the students' interest in science? **Yes**

Q6 Did the students enjoy the video link? Did it spark their imagination?

They enjoyed it and continue to talk about it. Some wants to participate to the competition!

Q7 What did you like most about your video link?

the questions with the team!

Q8 Approximately how many people were in attendance at your event?

30

Q9 Do you have any general comments or suggestions for our video links?

no, it was nice

#3

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Wednesday, September 26, 2018 9:47:50 PM
Last Modified: Wednesday, September 26, 2018 9:50:47 PM
Time Spent: 00:02:56
IP Address:

Page 1

Q1 How many stars (1 is worst, 5 is best), would you give your SEA-SEIS video link overall?

☆ **5**

Q2 How was the audio and video quality? **Excellent**

Q3 How well did the students understand why the scientists went on the expedition? **Very well**

Q4 Has the information presented on the appropriate level for your audience? **Yes**

Q5 Did the video link encourage the students' interest in science? **Yes**

Q6 Did the students enjoy the video link? Did it spark their imagination?

Yes, they loved it. They enjoyed seeing scientists from different strands and backgrounds working on the same project.

Q7 What did you like most about your video link?

Great atmosphere from scientists, very friendly and engaging towards students.

Q8 Approximately how many people were in attendance at your event?

17

Q9 Do you have any general comments or suggestions for our video links?

Excellent idea. Really sparked and interest in the students

#4

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Wednesday, September 26, 2018 9:44:05 PM
Last Modified: Wednesday, September 26, 2018 9:51:55 PM
Time Spent: 00:07:49
IP Address:

Page 1

Q1 How many stars (1 is worst, 5 is best), would you give your SEA-SEIS video link overall?

☆ **4**

Q2 How was the audio and video quality? **Satisfactory**

Q3 How well did the students understand why the scientists went on the expedition? **Reasonably well**

Q4 Has the information presented on the appropriate level for your audience? **Yes**

Q5 Did the video link encourage the students' interest in science? **Yes**

Q6 Did the students enjoy the video link? Did it spark their imagination?

Yes they really enjoyed it and other classes were asking them all about it - think they felt very privileged that it was just them getting this special lesson

Q7 What did you like most about your video link?

The very friendly nature - smiling faces of all the scientists who spoke to and answered the students questions - this allowed usually very shy students to come forward to the camera.

Q8 Approximately how many people were in attendance at your event?

28

Q9 Do you have any general comments or suggestions for our video links?

The audio was difficult to hear for the pre recorded parts of scientists explaining their roles but got much better for questions and answers inside

#5

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Wednesday, September 26, 2018 10:06:12 PM
Last Modified: Wednesday, September 26, 2018 10:11:59 PM
Time Spent: 00:05:46
IP Address:

Page 1

Q1 How many stars (1 is worst, 5 is best), would you give your SEA-SEIS video link overall?

☆ **5**

Q2 How was the audio and video quality? **Good**

Q3 How well did the students understand why the scientists went on the expedition? **Very well**

Q4 Has the information presented on the appropriate level for your audience? **Yes**

Q5 Did the video link encourage the students' interest in science? **Yes**

Q6 Did the students enjoy the video link? Did it spark their imagination?

yes! it showed them that science is part of real life and they are very pleased that the project is so close to their homes. One student is preparing work for another project and has decided to concentrate on Plate tectonics!

Q7 What did you like most about your video link?

The fact that the 'scientists' who are normally perceived as a remote group of people removed from ordinary society were willing to talk to our students.
And the fact that the team seemed very happy to be on the ship and excited by the project

Q8 Approximately how many people were in attendance at your event?

5 students (total pupil population); principal and three other teachers and the school administrator.

Q9 Do you have any general comments or suggestions for our video links?

try and do more of them.
I appreciate the difficulties involved but it will encourage students when they see science in action.

#6

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Thursday, September 27, 2018 4:42:56 PM
Last Modified: Thursday, September 27, 2018 4:45:47 PM
Time Spent: 00:02:50
IP Address:

Page 1

Q1 How many stars (1 is worst, 5 is best), would you give your SEA-SEIS video link overall?

☆ **5**

Q2 How was the audio and video quality? **Excellent**

Q3 How well did the students understand why the scientists went on the expedition? **Reasonably well**

Q4 Has the information presented on the appropriate level for your audience? **Yes**

Q5 Did the video link encourage the students' interest in science? **Yes**

Q6 Did the students enjoy the video link? Did it spark their imagination?

Yes! The students very much enjoyed the video link! They can't believe how lucky they were to experience that and to see the seismometer being deployed!

Q7 What did you like most about your video link?

The whole experience was fantastic! From the excitement waiting for the call to the questions and answers it was a great morning!

Q8 Approximately how many people were in attendance at your event?

50

Q9 Do you have any general comments or suggestions for our video links?

Keep up the good work!

Q10 Optional: This survey is anonymous, but if you do not mind sharing this information, please give your name, the name of the school, and the class that participated.

Jessica Lynch. Kingswood Community College. 2nd & 3rd Year Geography classes.

#7

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Thursday, September 27, 2018 5:34:53 PM
Last Modified: Thursday, September 27, 2018 5:40:25 PM
Time Spent: 00:05:31
IP Address:

Page 1

Q1 How many stars (1 is worst, 5 is best), would you give your SEA-SEIS video link overall?

☆ **5**

Q2 How was the audio and video quality? **Good**

Q3 How well did the students understand why the scientists went on the expedition? **Reasonably well**

Q4 Has the information presented on the appropriate level for your audience? **Yes**

Q5 Did the video link encourage the students' interest in science? **Somewhat**

Q6 Did the students enjoy the video link? Did it spark their imagination?

The students were full of energy after the video and were still coming up with questions they should have asked at the end of the day. This showed that they were thinking about the information they learnt and about the answers to other peoples questions.

Q7 What did you like most about your video link?

Getting to meet all the staff, and the variety of different expertises that are on the both. I think it showed the importance of collaborating, and the different sides there are to a real life functioning scientific team.

Q8 Approximately how many people were in attendance at your event?

30

Q9 Do you have any general comments or suggestions for our video links?

I only booked the room for single class 40min but I think the students would have kept going for longer had there been time to do so. I thought that would be sufficient time. Had I known it might run over I would have organised an extended period.

#8

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Thursday, September 27, 2018 5:54:17 PM
Last Modified: Thursday, September 27, 2018 5:58:57 PM
Time Spent: 00:04:40
IP Address:

Page 1

Q1 How many stars (1 is worst, 5 is best), would you give your SEA-SEIS video link overall?

☆ **5**

Q2 How was the audio and video quality? **Good**

Q3 How well did the students understand why the scientists went on the expedition? **Reasonably well**

Q4 Has the information presented on the appropriate level for your audience? **Yes**

Q5 Did the video link encourage the students' interest in science? **Yes**

Q6 Did the students enjoy the video link? Did it spark their imagination?

I would say that they loved it.

Q7 What did you like most about your video link?

I loved it all.
The crew introductions and information at the start was very well done. The question and answer session was very enjoyable and interesting. Your crew were very friendly.

Q8 Approximately how many people were in attendance at your event?

28

Q9 Do you have any general comments or suggestions for our video links?

It was very well planned - well done!
The slight technical problems were our end and didn't last long.
My only suggestion would be to show us a bit more of the ship.

#9

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Thursday, September 27, 2018 6:25:36 PM
Last Modified: Thursday, September 27, 2018 6:29:49 PM
Time Spent: 00:04:13
IP Address:

Page 1

Q1 How many stars (1 is worst, 5 is best), would you give your SEA-SEIS video link overall?

☆ **5**

Q2 How was the audio and video quality?

Good

Q3 How well did the students understand why the scientists went on the expedition?

Reasonably well

Q4 Has the information presented on the appropriate level for your audience?

Yes

Q5 Did the video link encourage the students' interest in science?

Yes

Q6 Did the students enjoy the video link? Did it spark their imagination?

Yes they enjoyed it very much. They were amazed that they were going to part of a research project collecting data that had never been collected before.

Q7 What did you like most about your video link?

The question and answer session was excellent and really informative. That was the mine and the students highlight

Q8 Approximately how many people were in attendance at your event?

22

Q9 Do you have any general comments or suggestions for our video links?

No. Excellent quality and delivered in a very efficient and interesting manner.

#10

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Thursday, September 27, 2018 6:34:43 PM
Last Modified: Thursday, September 27, 2018 6:41:56 PM
Time Spent: 00:07:13
IP Address:

Page 1

Q1 How many stars (1 is worst, 5 is best), would you give your SEA-SEIS video link overall?

☆ **4**

Q2 How was the audio and video quality? **Good**

Q3 How well did the students understand why the scientists went on the expedition? **Partially**

Q4 Has the information presented on the appropriate level for your audience? **Some of it**

Q5 Did the video link encourage the students' interest in science? **Somewhat**

Q6 Did the students enjoy the video link? Did it spark their imagination?

It was very exciting for the class (1st year students aged 12/13) and tied in well with the the topic on plate tectonics which we had recently covered.
The students really enjoyed the experience and I have no doubt that it broadened many of their career ideas!

Q7 What did you like most about your video link?

The fact that we were communicating with people far away in the middle of the ocean in real time!

Q8 Approximately how many people were in attendance at your event?

30

Q9 Do you have any general comments or suggestions for our video links?

No, it was all went very well.

#11

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Monday, October 01, 2018 3:54:59 PM
Last Modified: Monday, October 01, 2018 4:00:41 PM
Time Spent: 00:05:41
IP Address:

Page 1

Q1 How many stars (1 is worst, 5 is best), would you give your SEA-SEIS video link overall?

☆ **5**

Q2 How was the audio and video quality? **Good**

Q3 How well did the students understand why the scientists went on the expedition? **Reasonably well**

Q4 Has the information presented on the appropriate level for your audience? **Yes**

Q5 Did the video link encourage the students' interest in science? **Yes**

Q6 Did the students enjoy the video link? Did it spark their imagination?

Definitely yes, it triggered their curiosity greatly. They were asking more questions after the link.

Q7 What did you like most about your video link?

Photos of the named seismometer. Asking questions. Idea of gaining information about tsunamis etc.

Q8 Approximately how many people were in attendance at your event?

26

Q9 Do you have any general comments or suggestions for our video links?

Maybe some video footage of where the scientists sleep, eat and work.

#12

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Tuesday, October 02, 2018 9:17:53 PM
Last Modified: Tuesday, October 02, 2018 9:29:35 PM
Time Spent: 00:11:42
IP Address:

Page 1

Q1 How many stars (1 is worst, 5 is best), would you give your SEA-SEIS video link overall?

☆ **5**

Q2 How was the audio and video quality? **Good**

Q3 How well did the students understand why the scientists went on the expedition? **Very well**

Q4 Has the information presented on the appropriate level for your audience? **Yes**

Q5 Did the video link encourage the students' interest in science? **Yes**

Q6 Did the students enjoy the video link? Did it spark their imagination?

Yes the students enjoyed the video link and they learned a lot through discussion with the Scientists .

Q7 What did you like most about your video link?

The video where the seismometer was dipping into the water .

Q8 Approximately how many people were in attendance at your event?

19

Q9 Do you have any general comments or suggestions for our video links?

Everything was very good .

#13

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Wednesday, October 03, 2018 4:42:10 PM
Last Modified: Wednesday, October 03, 2018 4:48:16 PM
Time Spent: 00:06:06
IP Address:

Page 1

Q1 How many stars (1 is worst, 5 is best), would you give your SEA-SEIS video link overall?

☆ **5**

Q2 How was the audio and video quality? **Good**

Q3 How well did the students understand why the scientists went on the expedition? **Very well**

Q4 Has the information presented on the appropriate level for your audience? **Yes**

Q5 Did the video link encourage the students' interest in science? **Yes**

Q6 Did the students enjoy the video link? Did it spark their imagination?

Yes, absolutely

Q7 What did you like most about your video link?

The link with the real. The time spent by the team to answer our questions. Friendly but serious spirit

Q8 Approximately how many people were in attendance at your event?

25 students and 3 adults

Q9 Do you have any general comments or suggestions for our video links?

No, it was really interesting because it will introduce my lesson on volcanism.

#14

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Wednesday, October 03, 2018 5:28:07 PM
Last Modified: Wednesday, October 03, 2018 5:42:46 PM
Time Spent: 00:14:38
IP Address:

Page 1

Q1 How many stars (1 is worst, 5 is best), would you give your SEA-SEIS video link overall?

☆ **3**

Q2 How was the audio and video quality? **Satisfactory**

Q3 How well did the students understand why the scientists went on the expedition? **Reasonably well**

Q4 Has the information presented on the appropriate level for your audience? **Yes**

Q5 Did the video link encourage the students' interest in science? **Yes**

Q6 Did the students enjoy the video link? Did it spark their imagination?

Those students made sure to go and tell others in their year about their experience and interests. They would have liked to be doing something like this every day.

Q7 What did you like most about your video link?

The actual witnessing of the seismometer as it entered the waters off the North Atlantic Ocean.
The interaction between students and scientists and how open and friendly you were.

Q8 Approximately how many people were in attendance at your event?

20 students

Q9 Do you have any general comments or suggestions for our video links?

There was a bit of time lag in some of the recordings between what someone was saying and when it was said. It was confusing.