RACE
RAw Communications and Engagement

RACE TRAINING GUIDE

HOME

RACE: CHANGING THE WAY WE LOOK AT SCIENCE COMMUNICATION

RAw Communications and Engagement (RACE) is an EIT funded program aimed at changing the way scientists and researchers connect with the public about the broad area of Raw Materials.

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INTRODUCTION

The RACE (RAw Communication and Engagement) programme, funded by the European Institute of Innovation & Technology (EIT) Raw Materials consortium, was initiated in 2015 as a joint project between universities and industrial partners across Europe in an attempt to address particular skill deficits in public outreach and communication among scientists, science students and industrial employees. The key focus of RACE is the development and implementation of adaptable training modules as a platform for the teaching and training of communication and public engagement, with a focus on raw materials, all the way from extraction to the final consumer products. The overall goal is to equip participants with the skills to conduct outreach and public engagement activities to a variety of audiences and stakeholders in society. In accordance, funding bodies and policy documents have recently elucidated the need for public engagement as a gatekeeper to impactful research, mediated by a 'bottom up' approach both locally and internationally. Moreover, Science, Technology, Engineering, Mathematics and Medicine (STEMM) disciplines are increasingly shaping the way we live. With this in mind, there is concern that skills shortages within STEMM could negatively influence national and global economies. Addressing challenges across these areas requires engaged and informed citizens with STEMM as a central asset to their lives. Within this remit, there are issues with how researchers 'responsibly' communicate to the public, with this communication being very much dependent on their ability to share and explain their knowledge in a meaningful fashion. In light of the above, RACE represents a nascent research venture providing much needed bespoke training modules guided by a modern focus on a variety of pedagogical modalities, thus placing RACE at the vanguard of advancements in STEMM communication and public engagement.

THROUGHOUT THE PROGRAMME TIMELINE, MULTIPLE EVENTS HAVE TAKEN PLACE IN 2017, INCLUDING A NUMBER OF TRAINING COURSES IN UPPSALA UNIVERSITY AND THE UNIVERSITY OF EASTERN FINLAND FOR BOTH MASTERS AND PHD STUDENTS, ALONG WITH A WEEK-LONG SUMMER SCHOOL (TRAINING WEEK) FOR PHD STUDENTS IN THE AREA OF RAW MATERIALS COMMUNICATION HELD IN THE UNIVERSITY OF LIMERICK.

RACE TRAINING

This document is designed to be practical and usable by any reader. The guide is non-prescriptive and gives illustrative examples to aid others in designing their own modules that can be grounded in their respective context. With this key focus, it is important to note that there are complementary handouts, slides and further reading for every section, covering the key components of effective public engagement including; Raw Materials and Ethics, Motivation and Challenges, Engagement Techniques and Methods, Relating to your Audience, Explaining your Ideas, Presenting demonstrations and workshops, Developing Public Engagement Activities, Planning and Logistics. By exploring these different areas, readers will get an insight into the training content taught over the entirety of the RACE project. This will then be fully illustrated by detailing the RACE summer school as a training event exemplar.

RAW MATERIALS AND ETHICS

The RACE program is built upon two pillars, one of scientific communication and the other of sustainability and ethics with regard to raw materials. Both can be coupled when working with students and researchers in the broad areas of pharmaceuticals, machinery, advanced materials, transport, energy, substitution and environmental sciences. The central focus is for researchers to convey key scientific messages with regard to sustainability and ethics in light of raw materials so that scientific research practice can be impactful at all levels of society. Indeed, the above falls under the umbrella of Responsible Research and Innovation (RRI), which represents a modern focus of the scientific process.

A raw material is defined as a material that needs to be 'fetched' and potentially converted either through physical or chemical means. They are then divided into two categories; primary materials taken directly from 'nature' and secondary materials are ones that are recycled from urban environments. Raw materials can also be subdivided into biological materials and geological materials. The crux of the issue is that raw materials are fundamental to the survival of modern society. The main question is not 'if' we should mine, but 'how?' Take a simple example of a tree. If you cut down the tree and plant another one, it seems on the surface that you have created a sustainable extraction or fetching method. However, this does not account for the lessened CO_2 intake from the new smaller tree. Moreover, it does not account for the new usage of the old tree. Is it being used for firewood? Hence, creating more of an environmental issue. Nutrient depletion and leaching are also problematic. Continual cutting and planting of trees can lead to a soil that requires fertiliser to be viable. Cutting trees

also radically changes the soil structure rendering it susceptible to nutrient leaching from rainfall. In addition, the larger tree could have been host to an ecosystem of animals that are now displaced. The key message is that the extraction and use of raw materials is not a simple issue, it is a complex and fluctuating field, especially since a portion of raw materials are finite, especially geological resources.

With a finite resource, issues of sustainability come to the fore. Europe utilises 20% of the world's primary metals but only produces 3%. Thus, Europe is reliant on others to maintain itself. This brings about the issue of conflict minerals. If mining based products, or any raw materials for that matter, are being produced in other countries and are imported, under what conditions are the materials generated? This is the mainstay ethical issue with regard to raw materials. Compounding this issue is a public who are left in the dark without knowledge of any scientific process or political agendas. This is why RACE provides a vital platform for the direct provision of impactful engagement with the public as their voice will lend itself to democratic change in the future.

PUBLIC ENGAGEMENT: MOTIVATIONS AND CHALLENGES

There are many differing motives for how and why scientific pursuits, specifically science education, are deemed valuable. Osborne et al. (2003 p. 1051) notes that "the nation's standards of achievement and competiveness are based on a highly educated, well trained and adaptable workforce." This has long been on the agenda for the European Union (Gago et al. 2004) and the United States (Augustine 2005) with a perceived need for scientists to contribute to the achievement of economic growth, and research stressed as a key priority for tackling societal challenges and delivering impact. More recently, investment into strategic applied research has been prioritised in Ireland as an aid towards economic recovery. With public money being put towards applied research in difficult economic times (Drudy 2011), the agenda turns towards the level of responsibility scientific researchers have in communicating to and engaging the public with their research.

In parallel to this effort, contemporary science education reforms (Duschl et al. 2007) place a significant emphasis on developing scientifically literate citizens. The importance of this is founded upon the notion of a socio-scientific citizen, one who understands the nature of science, and how it can impact upon their life, and who can also actively participate in debates and decision-making regarding scientific issues (Dillon 2016). This thinking has been picked up by policy makers and is now firmly embedded in national and international policy documents. This has led to the importance of communicating the impact of scientific research becoming even more pronounced. Policy documents

(European Commission 2008), Research Institutes and Funding bodies require outreach and public engagement as a pathway to research with impact. We are in a landscape where this is a 'widely entertained societal obligation' on the part of scientific institutions to offer 'the public' social impact an engagement in research policy (Bauer and Seurdem 2016). Both movements align in their drive towards a more informed and scientifically engaged and literate citizenship. Therefore, we can understand that, public engagement is frequently aimed at educating the public about current scientific developments, and potentially their ethical and moral implications (Bauer and Jensen 2011). These events may lead to the public learning more about the content of science, enhancing their views of science and scientists while, in the case of school students, also gain an insight into the broad range of career possibilities that science has to offer (Cleaves 2005). There are many challenges facing those who engage with the public, some of which are outlined in Table 1 below.

TABLE 1: CHALLENGES IN PUBLIC ENGAGEMENT WITH BACKGROUND INFORMATION

Challenge	Background information – See Public Engagement (PE) Motivation and Challenges PowerPoint
Attitudes	An attitude is a typically nebulous thing to define. Attitudes towards both school science (linked to a person's prior experience with school science) and real world science. Attitudes are typically positive towards science, however a typical theme of research into this area is that people are mostly positive about science but do not identify with it. Social, economic and educational background can have an effect and attitudes towards Science does not refer to just one homogeneous group, and cannot be treated as such.
Public Deficit Model	Researchers frequently presume a public deficit, which in turn influences how they will interact with the public. This means that researchers/scientists often presume that the public has a lack of 'knowledge', which needs to be fixed; poor attitudes or a lack of interest in STEM topics; or a lack of trust in STEM or scientific endeavours.

Language	Scientific language is by its nature complex and objective. Everyday language is colloquial, emotive and subjective. Additionally, there are many scientific words, which have dual meanings in all languages; further complicating understanding.
Context	This relates to linking topics being discussed to emotive issues, and issues that the audience group can relate to, e.g. topics that they encounter in their own lives, and thus may care more about them because they are 'real' and tangible.
Conceptual understanding	Many areas of scientific knowledge are conceptually challenging, particularly those that deal with abstract concepts, beyond concrete cognitive levels. This can lead to poor understanding, and information overload.

ENGAGEMENT TECHNIQUES AND METHODS

A presenter has a limited time to engage. This is especially true for informal learning environments where audiences may 'judge' a presenter or topic very rapidly. Often you have to work from minute to minute attaining and maintaining attention. However, there are methods at hand that a presenter can employ to activate their audience and garner engagement for the smooth running of an event. The main technique in question is called a hook. Hooks represent an instructional method used to grab attention (Hunter 1994, Lemov 2010, McCauley et al. 2015, McHugh 2016) foster interest (Jewett Jr 2013, Marinchech 2013) and create engagement (McCrory 2011, Riendeau 2013). Hooks serve as an enticement for learning (Lemov 2010). Hooks have the potential to bring about behavioural benefits, combat boredom and augment learning (Lemov 2010). Indeed, engaging an audience from a passive to an active state is the first state towards active learning (Beeland 2002, Clifton and Mann 2011, Osborne and Dillon 2008, Patrick et al. 2000).

Expanding on the hook concept, McCrory (2011) articulates the difference between internal and external hooks. External hooks are any attention-provoking device, which is not directly related to the concept being taught. For example, playing music at the start of a presentation to simply get attention. Opposite this is the topic you are presenting, wave motion for example. This is a topic that the vast majority of audiences would not find engaging. However, if I present wave motion with links to modern music, I have created what McCrory (2011) has coined an internal hook. An internal hook combines or disguises the topic being presented with something that an audience

would find more interesting. Compounding this issue is that fact that educators all too often attempt to appeal to students outside the realm of the classroom. The students become more engaged, but not in the content of the lesson. This is something that formal educators must be aware of also. Your hook, as an engagement technique cannot act as a 'gimmick' (Mitchell 1993) that draws in attention, but will not hold it.

Being aware of the above, there are a number of tried and tested hook methods. These include well-organised and vivid texts (Schraw et al. 2001), discrepancy and conceptual change (Childs 2016). hands-on practical activities (Regan and Childs 2003), relevance (Roe 2011), puzzles (Chen and Darst 2002), teaching/presenting in a constructivist manner (Richardson 2003), active learning (Watkins and Mazur 2013), questioning (Bergin 1999) and the use of educational technologies (McCauley et al. 2015). In essence, a presenter must think about their audience and what techniques will engage and enthuse them over the course of a public outreach event while still getting the main messages across. The following will delineate how a presenter should think about their audience and explore a number key hooking strategies.

RELATING TO YOUR AUDIENCE

The best teachers, speakers and entertainers know how to prepare an audience (Riendeau 2013). In fact, today, most performers have warm up acts to engage the audience for the following entertainment. Unfortunately, the majority of people do not have such luxuries and rely on engagement techniques such as hooks! Often a hook is specifically designed or modified for a particular audience.

To create a hook, you need to develop an understanding of the audience. Why is your topic important to them? Why are they attending the event and what do they expect? A presenter needs to get across their goals, their personality and rapidly develop a strong impression of an audience to steer or guide the rest of the presentation. With this, you can see if the audience are starting to accept you as the presenter rather than spending their time asking 'so what?' or 'who cares'. Often, being interested in your audience is the best path to them being interested in you. People are very attached to their own ideas so asking an audience questions and eliciting their opinions can open the gateway to engagement, particularly if their input is valued and impactful. Four key areas, relevance, questioning, discrepancy and novelty are explored below in relation to the development of audience engagement. As such, they render themselves as excellent hooks.

Osborne et al. (2003) states that without relevance, sustaining interest is difficult, if not impossible. Perceived usefulness in content, creates an inherent interest (Palmer 2004) leading to attention (Jensen 2008) and engagement (WellcomeTrust 2011). Therefore, relevance within a presentation can provide a way of hooking an audience. According to Kember et al. (2008, p. 260), relevance can be established by showing how theory

can be applied in practice, establishing relevance to local cases, relating material to everyday applications, or finding applications in current newsworthy issues. Indeed, Chamany et al. (2008) advocate the benefits of social contexts as a basis for establishing relevance. However, what is relevant to one audience may not be relevant to another, rendering any relevance-based strategy a gamble.

Bergin (1999) states that the basic act of questioning facilitates attention. According to Aschner (1961), questioning is one of the best ways to stimulate thought. Questioning strategies are commonplace in teaching and Darby (2005) presents a coaxing questioning strategy to draw out interaction. The use of coaxing questions allow your audience to contribute their knowledge and build up a picture of a topic. In this way, the presenter does not dictate, rather directs contributions, placing more emphasis on certain information depending on their intended direction of the presentation. As an audience interacts, a representation of the subject is formed in their minds that is directly pertinent to them because they created it. As mentioned previously, people are attached to their own ideas. Hence, if their ideas form the perceived direction of a talk, they will rank it as being more enjoyable and interesting.

In addition to this, a presenter needs to be aware of the type of questions they present. Petty (2009) demonstrates the schism between lower order (simple) and higher order (more complex) questions by using the human body as an example. Lower order questions are straightforward questions that require one to recall basic knowledge. For example, "how many bones are there in the human body?" (Petty 2009, p. 200). Higher order questions, however, force one to figure something out or establish their own opinions and views. For example, "what would happen if humans didn't have a skeleton?" (Petty 2009, p. 200). Thus, the phrasing and angle of questions can heavily impact upon their effectiveness.

Puzzles can also be regarded as a form of questioning. Puzzles are an effective tool as they form a type of cognitive stimulation that triggers interest (Rotgans and Schmidt 2011). They are deemed irregular and unusual questions that require divergent thinking. However, an audience must be primed and receptive to a puzzle and starting a presentation with one may fail if the audience is not receptive or the puzzle too complex.

Discrepant and conceptual based presenting methodologies are noted by a number of authors as ways to stimulate interest and attention (Bergin 1999, Cakir 2008). When employing this method, an issue is presented that has associated misunderstandings. Such discrepant events often only require intuitive knowledge so the vast majority of an audience can engage. This strategy can work well as people often hold misconceptions that are at odds with scientific explanations as we make sense of our world through observation. For example, the question 'Why is the sky blue?' is often used as an unanswerable question or something we have to accept. However, when explained to an audience that this question can be answered, you as the presenter, reveal a gap in

their knowledge, which they will want to fill. This leads to the development of interest.

Finally, your audience will be attracted to novelty in any capacity and this is something that is well established in the literature (Burke and James 2008). White (2010, p. 371) states, "communications in the age of information overload are more likely to be successful if they find new ways of getting and keeping attention". Hence, novelty can mediate and direct attention(Silvia 2008). Novel stimuli work in association with curiosity and challenge while substantially impacting the amount and depth of information processing in the brain (Burke and James 2008). Variety and novelty may result in greater attention, interest, recall and behavioural intentions (Silvia 2008) since new events act as a form of surprise (Itti and Baldi 2005). Curiosity driven behaviour through novelty is a well-defined human trait with possible associations to dopamine receptors (Itti and Baldi 2005). As such, unpredictable moments traverse all stages of neural processing indicating that novelty has the potential to be central to attention and engagement.

The scientific and psychological basis for novelty, relevance, questioning and the use of discrepancy are all well established. Indeed, the expert presenter will often combine methods so that they can attain and maintain the attention of the majority of the audience. Moreover, with any audience interaction, experimentation and practice is key. Timing, resources and the ability to react 'on the fly' are all key components of successfully engaging with a variety of audiences.

EXPLAINING YOUR IDEAS

Explaining is one of those skills, which seems easy until you try to do it. This is partly because, from your position of hard-won expertise and experience, concepts appear much more obvious than they are to a novice learner. Paradoxically, the more expert you are in a topic, the more difficult it is to truly appreciate what it is like to lack this understanding. Your key explanations need to be carefully worked out in advance.

You cannot force an audience to listen. As such, investing time into editing ideas is fundamental to communication. Statements need to be as concise as possible and set up in a logical sequence. Often in science, concepts are hierarchical and lend themselves to models. A model can be defined as a simplified view of a real phenomenon. Models and explanations designed for the public commonly only describe part of a topic or subject so the audience can take the first steps toward understanding. Certainly, this links back to relating with the audience. Any audience will have a set amount of knowledge and discovering this will aid in defining the course of a presentation. One popular model of learning suggests that knowledge is assimilated through cognitive schema by integrating new information with our existing understanding. However, people have a strong connection with their own ideas. Given this, a presenter must use cognitive conflict approaches that not only provide a gap in a viewer's knowledge, but

also fruitful knowledge or else they will not retain any new information. Learning is a slow, messy and incremental process, which requires patience and sensitivity.
Collating the above, one should start with the familiar and move to the unfamiliar, from the concrete to the abstract. Where possible, examples, analogies, metaphors and similes to should be used to bring ideas to life. Moreover, the language one implements is vital. 'Jargon' refers to the use of technical terms that the public will find off-putting. Language needs to be simple and convey a sense of the complex without bringing the audience down a rabbit hole.

PRESENTING DEMONSTRATIONS AND WORKSHOPS

There are many different live formats to engage the public with science. For example, formal presentations with questions at the end; interactive presentations; busking demonstrations; running a stand at an exhibition; demonstration shows; hands-on workshops; debate and dialogue events. The following are some important tips to consider when one is presenting two of the most popular formats – science demonstrations and workshops.

DEMONSTRATION TIPS

- Practice, practice, practice - the better you know the demo, the more mental bandwidth you will have for improvising freely and interacting with your audience.
- React authentically to the demos as if you have never seen them before – create the "illusion of the first time" for your audience. Your emotions will infect them.
- Tease, do not spoil - generally, it is better to present a demo by getting the audience to predict what might happen, rather than saying what will happen and then demonstrating it.
- Demonstrations show phenomena rather than directly revealing principles. Your questions and explanations need to relate the phenomena to the underlying principles.
- When demos go wrong try to stay calm, maintain strong eye contact and remain visibly confident. If you do not show undue concern or embarrassment, the audience will not either.
- Ensure you stress the necessary safety precautions with every demonstration and that the audience understands which demos they should not try by themselves.

WORKSHOP TIPS

- Do not rob the audience of the joy of discovery – guide them, without taking over. Let them fail safely so that they can learn from their mistakes. Learn to ask the right questions rather than trying to answer all their questions. Provide lots of feedback and encouragement.
- Make sure you have everyone's attention before you give an instruction. Think about your instructions in advance – chunk them into small steps; use clear language and short sentences; repeat or rephrase the steps, as required; sequence the steps wisely; model the action for them, where possible; ask questions to check they understand.
- Establish ways of effectively moving the focus between you and the group work. Learn to "read the room" so you know the best time to move on. Manage groups, which finish early or late.
- Working with groups – quickly circulate around each group checking they understand the activity; be fair in the time you spend with each group; encourage all members to contribute; facilitate how they report back after the activity.
- Plan carefully how you are going to give out and collect in each piece of equipment – this is harder than it seems. Delegate so that each group clears up as much as possible before the end of the workshop.

DEVELOPING PUBLIC ENGAGEMENT ACTIVITIES

There is no single path to follow with any creative activity, but the following are some important guidelines to bear in mind when developing new activities to engage the public with research. The route to improving this skill is no different to the others in this guide – a constant cycle of training, experience and evaluation (including self-reflection).

Identify your purpose, audience, topic and constraints

A clear purpose must be set out before creating any public engagement event. A useful test at this early stage is to construct a one-sentence summary. This statement, if developed and analysed, will act as your 'north star' to navigate any decision or audience. The purpose(s) will inform second-level decision making with regard to the audience, the topic and engagement formats. For a successful event, all choices must be aligned. All of these choices necessarily generate certain constraints e.g. budget; time to develop; activity duration; venue; engagement experience of researchers involved; prior knowledge and interest of the audience. However, this provides a clear background to plan around in order to ensure success.

Mine and refine ideas separately

There are two main phases in any creative process and it is essential to keep them separate:

- Mining phase – research as widely as possible for material to combine in novel ways. This takes time and should involve the creation of as many ideas as possible.
- Refining phase – this is a more practical phase whereby ideas can be critically evaluated. Ideas must be balanced against time and constraints. Continual refinement is key. The majority of ideas will not work, but the best ideas will emerge and evolve with practice.

Interacting with an audience

Most of the engagement sessions developed are interactive. However, in truth, an interactive session must be acted out as opposed to written. Sessions evolve with constant questions, call outs, and reactions from the audience. One builds this feedback into the next iteration of the session, gradually improving it, one delivery at a time. First deliveries are generally poor. This is due to the inherent difficulty of predicting audience responses and, as is the case with any complex skill, practice makes perfect. Beta test activities early and often with small groups before you have to present to larger audiences.

PUBLIC ENGAGEMENT: PLANNING AND LOGISTICS

Planning and logistics are always one of the most important aspects of public engagement. When done well, the event should appear to run seamlessly for the audience, but if little planning and thought goes into an event it can have catastrophic results for both the audience and volunteer/researcher experience and put both groups off engaging with this type of activity again. The aim of this document is to provide a useful guide for the main aspects you need to consider when planning and running an event. It is by no means all-encompassing, and a group brainstorming session prior to the planning of the event is always useful, as each company, institution, group of researchers, country etc. will all have its/their own context which may need considerations not discussed here.

TABLE 2: KEY PLANNING AND LOGISTICS QUESTIONS

Main Question	Supplementary Question
Purpose of event	What are you hoping your audience will get from this event? What is the primary purpose?
Desired outcomes for audience	Are there any other additional outcomes you would like?
Desired outcomes for those delivering /volunteers:	What type of an experience would you like this to be for those volunteering/helping? Do you want them to partake in this type of activity again?
Venue	Where will the venue be? At your typical location, e.g. laboratory or off-site at a school, shopping centre, community hall? What is the rationale for this venue? Is it easy for your audience to access? How will the venue be laid out? Do you need to adapt the layout?
Type of event	Is it a show, workshop (scheduled or drop in), science fair, tour etc.?
Any logistical issues	Numbers anticipated. Is the event ticketed/not ticketed? Can we track the numbers in attendance? How? Will this require additional volunteers? Do you have a budget? Do you want a photographer? Is there going to be catering? Any dietary considerations?
No of volunteers required	How many? What will each specific person be doing? Have breaks for volunteers been scheduled, should they be there early for set-up, how long will they need to stay after the event to aid with take down? Do you need to organise shifts, police vetting (for working with young people), health and safety training, manual handling training? Do you need name badges for volunteers? Do you need t-shirts for them?
Background information for volunteers	Do you need to develop a pack for volunteers? Is this specific to the subject area being covered? Specific to the location e.g. venue, map, parking, public transport, directions, guidance
Information for audience	Parking. How to get there? Is there a website? Are you broadcasting over radio/newspaper? What are the venue contact details?

Health and Safety	Have you conducted a risk assessment and/or chemical agent risk assessment for the following: transport of anything off site, activities at venue, set-up and take-down?
Additional health & safety	Are there any child protection issues you should consider, particularly if you are working with young people under the age of 18 or vulnerable people? Are you aware of your organisation's child protection policy? Is your event compliant with this? Do you need a photo release form to take pictures at the event?

RACE TRAINING DELIVERY MODEL

The philosophy underpinning the RACE public engagement training programme is based on researchers following a cycle of:

- Interactive training;
- Opportunities to gain experience, with support;
- Evaluation and self-reflection.

Each institution that wants to implement its own training programme is encouraged to design a delivery model, which suits that university, its research and unique context. Additionally, consultation with potential trainees is advisable during the planning stages in order to set out their needs. The trainees also need to have a clear understanding of the benefits of the course (including any academic recognition) and what will be required of them in terms of their initial and ongoing commitment. Common models to deliver the training stage of the course include - a seminar series over one semester; individual training days; or an intensive week-long course. Regardless of the training model selected, the crux of any model is that researchers are provided with a range of supported opportunities to put the skills they have learnt in these sessions into practice as soon as possible. Ideally, these should be authentic contexts in which researchers can interact with members of the public. Considerable thought also needs to be given, when planning the training, to develop systems and tools to help structure the process of evaluation and self-reflection for the researchers. As a caveat, it should be noted that this guide does not make recommendations about the depth of the training provided or the rigor of the related assessments. Both will heavily vary based on each institution and their academic requirements.

THE RACE SUMMER SCHOOL

The following will demarcate the RACE Summer School. In this context, the summer school represents a week-long training module. The week will be illuminated presently with a simple design and implementation approach to demonstrate as a prototypical example of work conducted within the RACE programme. It should also be adaptable to those planning on utilising similar frameworks.

The RACE Summer School involved cross coordination from all project partners. Taking place in August 2017, the summer school targeted PhD students whose projects transected with raw materials, albeit in a diversity of capacities. The summer school covered a range of topics linked to societal engagement concomitant with enabling the PhD researchers to skillfully create and delivery public engagement and outreach activities with a diversity of audiences. The course content, designed by senior RACE partners along with experts in science communication, reflected the aforementioned aim of the course and covered topics such as challenges in public engagement, how to be engaging, relevant and understood, the organisation of public events, and the delivery of multiple types of events, ethics and audience management. Preceding this, upon acceptance to the summer school, participants took part in seminars that provided context in terms of scientific content, mainly grounded upon fitting links to raw materials. Participants were also directed toward pertinent reading for the course. In terms of assessment, this took place after the summer school as a way for participants to actualise their learning in a real world environment. For all participating third level institutions, PhD students were required to design, implement and evaluate their own public engagement activities. Students then reported on these events and submitted relevant documents on a pass/fail grading criteria. Examples of projects carried out are included on the RACE website.

DESIGN

The first stage of the project involved the design of a training module that had to be adaptable. This requirement was paramount for transferability and usefulness across academic and industrial contexts and their respective professionals. Moreover, a goal from the outset was to train higher education staff in the delivery of the module to ensure sustainability and growth in the long term. The first steps required the identification of key features with regard to both subject content and themes, along with skills that should be central to the course. Two broad realms were set out, including skills pertinent to effective STEMM communication and the broad range of topics that included research, applications and products of 'raw materials'. This was bolstered by considerations with regard to Responsible Research and Innovation (RRI), underpinned by modern ethical practice and

sustainable development.

Considerations involving the pillar of STEMM communication were informed by research indicating that there are issues with how researchers communicate to the 'public', with this communication being very much dependent on their abilities to present, explain and engage. This issue belies that fact that many researchers presume a deficit model of public scientific knowledge and assume public 'trust' in science, something that is more salient among chemistry professionals. The former defines how a scientist may or may not create a narrative outside of their specialist area. Engaging in dialogue with others is fundamental to scientific research at all levels, however, modern practice pulls scientists toward professional and career-based communication, primarily conferences and publications. Breaking the 'seal' of such trends requires a shift in mind-set at all levels. Presently, this has been achieved at a policy level and the trickle-down effect has resulted in projects such as RACE.

Pertaining to raw materials, public perception and knowledge is generally poor with typecast images of mining being prevalent. As such, the training module aimed to arm PhD students in the area of raw materials to spread their research messages in areas such as advanced materials, medical and electronic devices, pharmaceuticals, jewellery, information technology and machinery in addition to material development and material substitution.

With this grounding, the focus of the summer school then turned to pedagogical implementation. A core facet of RACE is that is has been developed by experienced educational professionals. The delivery as such is informed by state of the art teaching and learning practices. Fundamental to the course are the concepts of modelling effective communication, the flipped classroom, active learning, demonstrations, experiments, peer feedback and assessment along with reflection being essential to the course. The following will demarcate the implementation of the course through the examination of the week-long timetable on a day-by-day basis and theoretically linking aspects of various days.

IMPLEMENTATION

The summer school represented a week-long residential PhD course at the University of Limerick in August 2017 with participation from PhD students from the University of Limerick (10), the University of Eastern Finland (4) and Uppsala University (10). The week was designed in such a manner that certain days and activities linked into each other to reinforce learning. Day 1 is presented below.

DAY 1

Time	Day 1
09.30 10.30	Ice-breaker activities Raw Materials Why Communicate & Engage?
10.30 11.00	11.15-10.45 Coffee break
11.15 13.15	Thesis in 3 presentations Introduction to Communication & Engagement Reflection
13.15 14.15	Lunch
14.15 15.45	How to be engaging
15.45 16.00	Tea & Coffee
16.00 16.45	How to be understood
20.00	Screening of 'The Farthest' (121 mins) followed by panel discussion with Director Emer Reynolds

The start of day 1 involved the introduction of the various participants and ice-breaker activities so that participants could get to know each other in a new environment. This was followed by an introductory lecture on the motivations behind impactful communication and engagement, asking participants, the why, when, how, where and what behind public outreach.

During the first day, participants were asked to present a pre-prepared Thesis in 3 presentation. This is a presentation format in which PhD students are asked to present their research in three minutes with three slides. This is to actively engage students with the course and establish a baseline in relation to the communication and presentation abilities. With this established, the remainder of time is used as an introduction to some key facets of communication and an introduction to reflection. This is specifically timed as students have just completed their first presentation in the course and can apply their learning in relation to reflection at this point in time.

Following this, the participants receive three interactive lectures on how to be engaging, understood and relevant. This establishes some of the course content and the aim is for participants to explore the new subject areas by also reflecting on their own practice and potential improvements they can make to their Thesis in 3 presentations, which are repeated later on in the week.

Finally, the evening is capped off with a social event. The social programme is not only designed as a form of bonding between participants, but as an example of science communication. The screening of 'The Farthest' was followed by a panel discussion with the director. This was selected as a way to demonstrate impactful communication through collaboration with scientists and a range of artists in the area of cinematography.

DAY 2

Time	Day 2
09.30 10.30	FAQ's & How to develop creative direct public engagement events
10.30 11.00	Tea & Coffee
11.15 13.15	Presenting demonstrations & Workshops
13.15 14.15	Lunch
14.15 15.45	Organising direct public engagement events
15.45 16.00	Tea & Coffee
16.00 16.45	OPCW Presenting to Policy makers (*45 mins) Seminar & Deconstruction activity
16.45 17.30	
	Free time

Day 2 begins with a question and answer session. The key to this is interactivity, as participants should have questions from the previous day, especially in relation to their own practice and how to improve. This is followed by a lecture based on various techniques and methodologies employed in the development of public engagement events.

The next lecture examines various formats of public engagement. These included presenting, demonstrations and workshops. This lecture covered the logistics and planning of successful events that deal directly with the public. It reveals multiple challenges that participants will often encounter in the real world environment. With their learning in hand, this part of the week involved a skype presentation and interview with a member of the Organisation for the Prohibition of Chemical Weapons (OPCW) whose job is to interact with policy makers and politicians. Hence, the role of this seminar to allow students to view the usefulness of their learning in a real world context. This is followed by a deconstruction activity in which the day's learning is 'signposted' and directly linked back to the interview with the OPCW member.

DAY 3

Time	Day 1
09.30 10.30	Circus of demonstrations
10.30 11.00	Tea & Coffee
11.15 13.15	Presenting your demonstration & Group reflection
13.15 14.15	Lunch
14.15 15.45	Brainstorming & Planning your own demonstration Group feedback & Tutor feedback
15.45 16.00	Tea & Coffee
16.00 16.45	Lecture on Raw Materials
16.45 17.30	Raw Materials Debate
19.00	BBQ at the Locke Bar followed by traditional music

Day 3 began with a circus of demonstrations. This took place in a teaching laboratory and approximately 20 prepared demonstrations were set out on benches for the participants to try out. The overarching goal was to inspire the students and model effective communication of scientific concepts through simple and innovative ideas.

The former session is a precursor to the students having to select one of the demos in the room and present it in an interesting manner to the rest of the group in pairs. As such, the students are taking their learning from the previous days and applying it in a peer-learning environment.

Based on the last reflective activity, the students are asked with the use of the internet and other resources, to revise their demonstration and make it as engaging as possible based on their learning and practice to date. Group and tutor feedback is provided in creating an iterative and reflective design process with the overall aim of cyclical improvement.

The afternoon starts off with a lecture on raw materials and invites students to determine their own research-based links to raw materials and how to communicate them effectively. To elicit a variety of viewpoints that may be expressed by the public, a Raw Materials debate was held around the controversial topic of conflict minerals along with mining and technology R & D methodologies.

DAY 4

Time	Day 1
09.30 10.30	Types of presentations: - Thesis in 3 - PINT of Science - Funding agency - School audience
10.30 11.00	Tea & Coffee
11.15 13.15	Coaching Thesis in 3 presentations Group reflection and feedback
13.15 14.15	Lunch
14.15 15.45	Engaged Research & where it can lead How to be engaged in your own research
15.45 16.00	15.30-15.00 Bus to BOI Workbench
16.00- 16.45	Presenting to innovators: Entrepreneurship & Elevator Pitches
16.45 17.30	
17.00 17.30	Tapas at the Buttery

On the start of day 4, students get to observe a number of presentation formats including Thesis in 3, PINT of Science, presenting to a school audience (career talk) and a presentation to a funding agency. Each of the presentation formats allowed time for questioning and signposting of why certain methodologies were employed within particular types of presentations.

After break, students then received individual coaching on their Thesis in 3presentations, which they were asked to present again, while reflecting on the learning of the week. The goal is improvement and application of knowledge in a real world setting. Improvements in performance and technique are noted and anonymous group feedback on paper is given to each individual.

This lecture revolves around the question 'How to be engaged in your own research?' The process elucidated gives students a variety of techniques and methods to truly engage with their community of practice from professional scientists in their field to lay people.

This was followed by a trip to the Bank of Ireland (BOI) workbench, an innovators hub focussed on entrepreneurial pursuits. A presentation by a local business owner and someone who had pitching experience in the development of a business was used to again model perceived usefulness of the knowledge acquired throughout the week.

DAY 5

Time	Day 5
09.30 10.30	Group works & discussion: Putting actions into practice
10.30 11.00	Tea & Coffee
11.15 13.15	Visit from local school. Circus of Demonstrations Final discussion Close
13.15 14.15	Lunch

Day 5 was a half day that began with a reflective group work session covering the week. It also discussed the assessment students would have to complete as part of the course and how to put their learning in practice.

In keeping with many of the pedagogical themes embedded within the course, the last session involved a visit from a local school. Approximately 25 students (aged 10 - 11) took part in the circus of demonstrations from earlier in the week, however, this time, the RACE participants were in charge of presenting the demos and engaging the audience. This was in the vein of reflection and having an active learning based ending to the week, which was closed off with a final discussion and question session.

SUMMARY

If one is to examine the week in totality, it follows a pedagogical learning model based on theory, learning, practice, implementation and reflection. This is a closed learning loop in which participants can fluidly move between various stages of knowledge acquisition. The rationale is the utilisation of versatile and variable learning modalities with the overarching goal of cyclical improvement through 'learning by doing'. The assessment component of the course caps off the learning by placing the student in the real world. A variety of public engagement and outreach events were conducted, a number of which are included on the RACE website to aid the reader in visualising not only the course content, but also its impact.

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