Equipping the Next Generation for Active Engagement in Science

DELIVERABLE D3.5: RRI OER Annual reports

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EXECUTIVE SUMMARY

WP3 is a core production Work Package of ENGAGE, responsible for the production of Materials which will involve and excite teachers and students about teaching using RRI contexts, content and pedagogies, and for Online Courses and face-to-face Workshops which will go deeper, offering extended professional learning experiences.

The foundations for our work were laid by the WP1 Framework phase where pilot versions were tested and the concept validated across 4 countries, before the roll out phase began in September 2014.

The first phase of Materials, called 'Dilemma lessons' is well underway. We have produced 13 of the target number of 20 already and are on track to complete the rest by summer 2015. The Materials have been translated and are being actively disseminated in all partner countries, to attract large numbers of teachers into the project.

A sub-group of partners have collaborated on development of a strong conceptual underpinning for Online Courses, in the form of 'professional learning framework'. This began with a clear vision of 'RRI teaching' which has been translated into a number of practical classroom 'Tools', as the basis of the content teachers will learn in the Online Courses.

A draft version of both the ADOPT Workshop and Online Course has now been devised, which is being piloted in several countries in spring 2015, before a more polished version is rolled out in the summer term.

1. INTRODUCTION

Curriculum materials are one of the three Strategies of Engage and often overlooked as a component of CPD. Yet teachers spend a lot of time in their classrooms using them. Bruner in the 1960's suggested their 'educative' power for embedding new approaches. Krajcik and Davies (2005) argue that they "both effective and efficient" in the way they can communicate a rationale for new content and pedagogy, and help teachers deal with implementation problems. Materials in our 'teacher inquiry cycle' facilitate the first process of 'classroom experimentation'. They will be published as 'Open Educational Resources' (OER) on our Knowledge Hub (website), to encourage their free use, modification, and re-publishing by teachers, under a Creative Commons license. Acting through the Coordinator, we will make our best efforts to publish the Materials in other publicly available repositories. This will fulfil the terms of Special Clause 39 of the Grant Agreement, ensuring that there is free access to all the curriculum materials produced by ENGAGE. The Commission shall be authorised to publish any foreground disseminated by the consortium in whatever form and on or by whatever medium, in particular via a European level information provider on its behalf. To enhance the accessibility of this foreground for third parties, it may adapt such foreground in any manner, including by making translations thereof. Any third party shall be allowed to utilise this published foreground for free for non-commercial educational purposes. To ensure the above, the consortium, acting through the coordinator, shall upon dissemination of any foreground provide the Commission with an electronic copy thereof and shall ensure that any necessary authorisations have been obtained and that it has not accepted legal obligations which could conflict with this clause

The choice of Materials as a key Strategy is based on other criteria:

- ***to attract very large numbers of teachers.*** Research acknowledges the relative lack of suitable teaching materials to make RRI-teaching feasible and attractive (Eijkelhof & Kapteijn, 2000). Ours will be based on the recent 'Science upd8' project from partner SHU (and the Association for Science Education). Science upd8 brought the science behind the news into teachers' classrooms while it was still fresh. Almost every school in the UK, as well as 50,000 teachers worldwide, which downloaded them over 2 million times, used its materials. Evaluation showed that upd8 represented for teachers a way to engage students and prepare them with skills for everyday life. This brand image first with our objective for ENGAGE. Other high quality RRI materials have also been identified and in the 'preparation phase' we will conduct a wide analysis of best practice to build upon.
- ***easy to use exemplification with positive student outcomes.*** The stakeholder analysis identified this as a key constraint on teacher change. If teachers' first attempts at classroom experimentation produce positive student outcomes, this will more lead to the teacher continuing to use the strategy until it becomes practised. Thus Materials work as the springboard for the process of reflection - 'why did it work'? 'which is the next stage in the inquiry learning cycle'.
- ***replicable quality across partner countries***. Our partners carried out a detailed curriculum analysis which identified very strong overlaps in the knowledge and skills underlying 'the nature of science' and 'inquiry' in all curricular frameworks at 11-16. This means that we can develop a common set of curriculum resources, which can then be translated and localised. Doing so means we can concentrate our resources on achieving a very high quality. This is vital to achieve our quality criteria of student engagement, ease of teacher use, and successful embedding of RRI knowledge.

To make ENGAGE materials relevant to each country, there is a 'localisation' stage in production where specific details and cultural references can be changed. For instance, in the exemplar sketched below on using genetically modified mosquitoes to combat dengue fever, the context can be localised by imagining a future outbreak in each country, and using the details of the organisation that might make the decision (this is easy as the Materials use MS PowerPoint, for easy customizability). Learning objectives can be adapted to the national framework, and particular aspects of pedagogy can be emphasized locally.

ENGAGE is producing three different kinds of materials (I.Topicals, II.Sequences and III.Projects), to support teachers at each stage: adopt, adapt and transform. To make production efficient, one RRI context such as genetically modified mosquitoes can be differentiated into each kind.

2. ADOPT Materials

Adopt Materials - called Topicals - have to get teachers onto the path of RRI science when there is often little incentive for them to do so. Our partner's curriculum analysis revealed that the nature of science is present, but marginalised in their curricula.

Following the success of science upd8, topical contexts will be the unique element to make ENGAGE materials highly engaging for teachers and students. RRI issues, from applications of genetics, to human enhancement regularly appear in the news. Such relevant contexts also have a proven impact on achievement according to Schroeder (2007).

We know what areas of emerging technology students are likely to be interested in from research (e.g. Relevance of Science Education (ROSE) project), and this varies little across countries, but is quite different for boys and girls (see Gender). However sometimes the issues are more global and less personal, such as energy and climate. For these we use techniques taken from professional science communication, such as creating human stories, and highlighting 'extremes and limits'. We will consult our key stakeholders - teachers and students. We will search OER websites for source material related to socio-scientific issues, such as UNESCO (http://en.unesco.org)

We aim to cover areas common to all partners' 11-16 science curricula identified in the detailed analysis which takes place in the first, foundation phase of the project. Over the two years of the programme we will roll out a collection of 20 Topicals (every few weeks, 10 per year). In the process we will 'cover' all the main emerging technologies linked to the common areas of our partners' curricula. This will encourage the regular usage and word-of-mouth dissemination needed to achieve our ambitious targets, because teachers will start to think 'ENGAGE' and visit the Knowledge Hub, if they know that they will usually find a Material which covers the area they are teaching.

In our model, the Adopt stage focusses pedagogical strategies for RRI-teaching (see Concept), for instance small group discussion. These are embedded within the Materials, with clear instructions and all the presentation material and student sheets to help teachers to take 'baby steps'. There is also a short formative assessment built in, to check student learning (i.e. to show positive outcomes, and facilitates further experimentation). ‘Teachers' notes’ following the style of science upd8 have detailed commentary on managing the strategy and 'signs of success' teachers should look for.

At the Adopt stage, Materials focus on getting students to practice skills and knowledge already taught. This allows them to be short (from 20 minutes), and easy to fit into existing topics. Evaluation showed that this accessibility was a key factor in their widespread appeal.

The Materials will provide a broad, balanced of key areas of emerging technology in all scientific disciplines which are likely to affect students in their lifetimes, from nanotechnology and novel materials, to genomic medicine and genetic modification, to human enhancement, to geo-engineering.

We ensure the coverage and the delivery of the ‘RRI curriculum’ by pre-compiling the list of topics, and the issues within them, so that we are ready to react quickly to news stories relating to the topic.

2.1. Framework stage Pilot materials

Since Materials are a critical part of the ENGAGE output, we wanted to properly test their suitability during the first Framework stage. So between April and July 2014 the WP3 team developed a range of Materials in different styles, which we then disseminated and tested out in the classroom. The content of the Materials is summarised in the table below. The results of the dissemination and testing are published in Deliverable 1.2.

Lesson and objectives	Curriculum	Pedagogical Strategies
WHAT DOES THE FOX SAY Physics: Sound Society: Argument We use the viral video to raise a serious question: can we understand animal talk? 'Bowlingual' detects a dog's emotions by analysing a bark's sound waves. Students look at emerging research to decide what else the technology can do. Can we translate the sound waves into human speech? Learning objectives • Apply knowledge about sound waves • Construct and present an oral or written argument supported by empirical evidence and scientific reasoning to decide whether there is enough evidence to support the claim that a device can interpret dog barks	England National Curriculum KS3: •Working Scientifically: Analysis and evaluation – present reasoned explanations, including explaining data in relation to predictions and hypotheses. •Physics: Waves – frequencies of sound waves, measured in hertz (Hz). GCSE Combined Science subject content: •Working Scientifically: Analysis and evaluation – presenting reasoned explanations including relating data to hypotheses. •Physics: Waves in matter – describe wave motion in terms of amplitude, wavelength, frequency and period	Dilemma – can we use science to interpret animal sounds? Match dog barks to their visual representations. Discussion – does the evidence support Bow-lingual's claims? Study evidence to decide whether the Bow-lingual device does what it claims.
THREE PARENTS Biology: Genetics Society: Decisions Babies will soon be born which have two Mums and a Dad! A new procedure which creates babies with the DNA of three people has just been given the go ahead in Britain. In this activity, students learn how it can help women with a serious inherited condition to have a healthy baby and why it is deemed so controversial. They use ethical arguments to decide whether they would recommend it to help a couple in need. Learning objectives	England National Curriculum KS3: ▪ Working Scientifically: Using ethical thinking to reflect on modern developments in science ▪ Biology: Cells and organisation: the function of the mitochondria. ▪ Reproduction in humans: Heredity as the process by which genetic information is transmitted from one generation to the next. A simple model of chromosomes, genes and DNA in heredity GCSE Combined Science subject content: ▪ Working Scientifically: Development of scientific thinking: explain everyday and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments. ▪ Biology: Inheritance, variation and evolution: Inheritance.	Starter Initial reactions on the 3 Parents procedure. Core task Students do some research to find out if the procedure can help Jake and Maya have a healthy baby. Plenary Can the procedure be used to create 'designer babies'? Extension Students play a game to consider the arguments for and against the procedure. Plenary Students discuss what the game revealed about the decision and if they agree. For detailed running notes, download the teachers guide.

Describe how to create an embryo with three parents, and explain how this technique could be used. Make a decision about a new technology using ethical thinking.	▪ Cell biology: Prokaryotic and eukaryotic cells: explain how the main sub-cellular structures of eukaryotic cells are related to their functions, including the nucleus/genetic material, mitochondria.	
GROW YOUR OWN BODY Biology: Organs Society: Argument As people live longer the demand for new organs to replace failed ones increases. One possible solution is to build new organs in a dish from cells taken from the patient's own body. Students use evidence from case studies to work out if this is possible and then to decide whether this new technology offers a good alternative to transplants. Learning objectives Apply knowledge about cells, tissues and organs in a new context. Access, evaluate and synthesise relevant information to decide if a new technology will be possible in the next ten years.	England National Curriculum KS3: ▪ Working Scientifically: Recognise applications of specific scientific ideas. Access, evaluate and synthesise information in order to justify a decision based on new technology. ▪ Biology: Cells and organisation – the hierarchical organisation of multicellular organisms: from cells to tissues to organs to systems to organisms. GCSE Combined Science subject content: ▪ Working Scientifically: Development of scientific thinking – explain everyday and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments. ▪ Biology: Growth and development of cells – discuss potential benefits and risks associated with the use of stem cells in medicine.	Starter Will we be able to grow replacement organs in the lab within the next 10 years? Core task Explain how bladders are being grown in the lab. Use information to decide how likely it is we will be able to grow organs in the lab in the next 10 years Plenary Which organs will we be able to grow in the next 10 years? Why? Extension Should a friend get a lab-grown replacement trachea? Rank the argument cards and use them to write advice. Plenary Students carry out a class vote to show their decision. For detailed running notes, download the teachers guide.
Car Wars Earth: Atmosphere Society: Argument Imagine it is 2020 and students are about to get their first car. Increased carbon dioxide emissions have led to huge financial incentives to buy alternatives to petrol engines – but which car is best? In this activity students evaluate solutions and come to a decision on who wins the Car Wars. Learning objectives ▪ Apply knowledge about atmospheric carbon dioxide ▪ Evaluate solutions to the problem of increasing carbon dioxide emissions from cars	Curriculum link England National Curriculum KS3: ▪ Working Scientifically: Analysis and evaluation – evaluate data and present reasoned explanations. ▪ Chemistry: Earth and atmosphere – the production of carbon dioxide by human activity and the impact on climate. GCSE Combined Science subject content: ▪ Working Scientifically: Development of scientific thinking – explain everyday and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and argument. ▪ Chemistry: Earth and atmospheric science – carbon dioxide as a greenhouse gas.	Starter Consider which type of car to buy, and discover the percentage of carbon dioxide emissions that comes from cars. Core task Play a board game for an introduction to car selection criteria. Plenary Discuss whether there is enough evidence to make a decision. Extension Rank criteria and sort argument cards to decide which energy source for cars is best. Plenary Decide on the best energy source, and justify this choice. For detailed running notes, download the teachers guide.

Ban Cola? ++++++++++++++++++ Now that scientists have discovered that sugar is like an addictive drug, pressure is building for action to reduce the amount of sugar that children and young people consume in sugary drinks. In this activity, students consider the evidence for causal links between sugar consumption, obesity and disease. They then weigh up arguments for and against banning sugary drink sales to under-18s Learning objectives ▪ Apply knowledge about food and health ▪ Use evidence to decide whether a correlation is causal	England National Curriculum KS3: ▪ Working Scientifically: Analysis and evaluation – interpret observations and data, including identifying patterns and using observations to draw conclusions. ▪ Biology: Nutrition and Digestion – the consequences of imbalances in the diet, including obesity. GCSE Combined Science subject content: ▪ Working Scientifically: Analysis and evaluation – interpreting observations and other data, including identifying patterns and trends, making inferences and drawing conclusions. ▪ Biology: Health, disease and the development of medicine – diseases influenced by nutrition.	Starter Sugar is addictive and causes obesity. Should we ban sugary drink sales to under-18s? Core task Sort strong and weak evidence that sugar causes obesity. Decide whether there is enough evidence to ban sugary drink sales to under-18s. Plenary Scientists can be more confident in a conclusion if there is a mechanism explaining a link between variables. Extension Sort argument cards to decide whether to ban sugar drink sales to under-18s. Plenary The decision on the ban cannot be based on science alone. For detailed running notes, download the teachers guide.
Attack of the giant viruses Biology: Disease Society: Technology Scientists have discovered a giant 30 000 year old virus still alive under the permafrost. As the world warms, others will be uncovered. Could such an ancient virus wipe out the human race? In this activity, learn how to interrogate sources to separate science fact from fiction. Learning objectives ▪ Apply knowledge of microorganisms to check the facts in a newspaper report. ▪ Evaluate how trustworthy scientific reports are in the media.	Curriculum link England National Curriculum KS3: ▪ Working Scientifically: Interrogate media reports to evaluate how trustworthy they are. ▪ Biology: Cells and organisation. GCSE Combined Science subject content: ▪ Working Scientifically: Development of scientific thinking: evaluate associated personal, social, economic and environmental implications. ▪ Biology: explain how communicable diseases (caused by viruses, bacteria, protists and fungi) are spread in animals and plants.	Starter Is the news story true? How could you find out? Core task Students read a newspaper article and decide how concerned they are. Plenary Why might you come to a different conclusion when reading different reports? Extension Students use a checklist to decide how trustworthy a report is. Plenary Students use a checklist to decide how trustworthy a report is. For detailed running notes, download the teachers guide

Take the test? Biology: Genetics Society: Decisions including what to do if they want children. In this activity students are placed in the role of a couple who are carriers of beta thalassaemia major. They are guided through how to make a difficult ethical decision and are introduced to IVF and the technology of pre-implantation genetic diagnosis Learning objectives ▪ Explain how IVF with PGD can be used to help a couple with an inherited condition to have a healthy child. ▪ Recognise ethical, social and economic arguments and use them to make an informed choice.	England National Curriculum KS3: ▪ Working Scientifically: Make decisions based on the evaluation of evidence and arguments. ▪ Biology: Inheritance, chromosomes, DNA and genes: heredity as the process by which genetic information is transmitted from one generation to the next. Reproduction: reproduction in humans (as an example of a mammal), including…gametes, fertilisation. GCSE Combined Science subject content: ▪ Working Scientifically: Development of scientific thinking: explain everyday and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments. ▪ Biology: Inheritance: explain single gene inheritance, predict the results of single gene crosses.	Running the activity Engage 1 Students get into role and learn about the options from a genetic counsellor Explore 1 Simulation on choosing an option using goal-based ethics Explore 2 Using duty-based ethics to explore the issues surrounding IVF with PGD Explore 3 Students use the decision making lifeline to explore the social and economic factors Explain Using discussion to make a personal decision Evaluate Students make their decision For detailed running notes, download the teachers guide.
Ban the beds Physics: Waves Society: Evidence In preparation for a summer holiday many people turn to sunbeds to top up their tan but could this habit be endangering their life? In this activity students are working as researchers on a TV show planning a report about the claim that sunbeds cause skin cancer. Learning objectives Use knowledge about UV light to explain the link between sunbeds and skin cancer. Understand how scientific evidence can support a claim.	Curriculum link England National Curriculum KS3: ▪ Working Scientifically: Analysis and evaluation: interpret observations and data, including identifying patterns and using observations, measurements and data to draw conclusions ▪ Physics: Waves GCSE Combined Science subject content: ▪ Working Scientifically: Analysis and evaluation: interpreting observations and other data (presented in verbal, diagrammatic, graphical, symbolic or numerical form), including identifying patterns and trends, making inferences and drawing conclusions ▪ Physics: Light and electromagnetic waves: give examples of some practical uses of electromagnetic waves in the … ultra-violet … regions and describe how ultra-violet waves…can have hazardous effects, notably on human bodily tissues	Starter Students study a graph that appears to show a link between sunbeds and skin cancer. Core task Students do some research into UV light and write the introduction to the report. Plenary There is a scientific reason why sunbeds could cause skin cancer. Extension Students study evidence presented as graphs and decide which best supports the claim. Plenary Discussion on if they now have enough evidence to prove the claim is correct. For detailed running notes, download the teachers guide

Sinking island Earth: Atmosphere Society: Evidence The Pacific island nation of Kiribati recently announced its purchase of land in mountainous Fiji for its population to move to when sea level rises make life on its own low-lying islands impossible. In this activity students use data to predict sea level rises, including uncertainties, and decide whether humans are to blame for climate change. If humans are to blame, then should the biggest polluters pay for land for vulnerable islanders to escape to? Learning objectives ▪ Apply knowledge about climate change to explain rising sea levels ▪ Make a prediction about rising sea levels and estimate the uncertainty in their prediction ▪ Evaluate evidence to decide whether humans are to blame for climate change	Curriculum link England National Curriculum KS3: Working Scientifically: Analysis and evaluation – evaluate data showing awareness of potential sources of random and systematic error. Chemistry: Earth and atmosphere – the production of carbon dioxide by human activity and the impact on climate. GCSE Combined Science subject content: Working Scientifically: Analysis and evaluation – representing distributions of results and make estimations of uncertainty. Chemistry: Earth and atmospheric science – carbon dioxide as a greenhouse gas. Timing This activity can be run in 30 minutes or be extended to 50 mins	Running the activity Starter Discover that Kiribati has bought land for its islanders to escape to. Explain rising sea levels. Core task Make predictions about rising sea levels in Kiribati. Plenary Discuss the impact of rising sea levels on the people of Kiribati. Extension Evaluate evidence to decide whether humans are to blame for climate change. Plenary Vote on whether climate culprits should buy land for vulnerable islanders to escape to. For detailed running notes, download the teachers guide.

2.2. ADOPT 'Dilemma lessons'

During Summer 2014 partners SHU and OU formalised the conceptual underpinning of our Materials into a 'Materials Framework'. This is fully described in Deliverable D3.6. We have named Adopt Materials as 'Dilemma Lessons', to fit with the ENGAGE CPD Framework (described in a later section), to encompass their essential nature, and make the Materials more memorable to teachers. The format of a Dilemma lesson is

- Dilemma - get students' attention set up a Dilemma question in students' minds
- Starter - review the essential science content, through a short activity
- Main - an involving activity for students to develop their views or a resolution of the Dilemma
- Plenary - teacher-led reflection on the learning

Each ADOPT Material is published with three components:

- Presentation slides – backbone of lesson, PowerPoint
- Student Sheets – PowerPoint
- Teachers Guide, with curriculum links and a lesson plan with commentary.

2.3. ADOPT Stage Materials

Since the formal launch of the ADOPT stage in September 2014, the WP3 team have started a regular development/publishing cycle to produce new Materials every 2 weeks. The table below summarised the Dilemma lessons produced up until the end of November 2014. For an up-to-date list of all published Materials, see the ENGAGE website: www.engagingscience.eu/en.

Making Decisions Biology: Genetics Society: Decisions Carriers of an inherited condition have to make many difficult decisions including what to do if they want children. In this activity students are placed in the role of a couple who are carriers of beta thalassaemia major. They are guided through how to make a difficult ethical decision and are introduced to IVF and the technology of pre-implantation genetic diagnosis Learning objectives Explain how IVF with PGD can be used to help a couple with an inherited condition to have a healthy child. Recognise ethical, social and economic arguments and use them to make an informed choice.	Curriculum link England National Curriculum KS3: ▪ Working Scientifically: Make decisions based on the evaluation of evidence and arguments. ▪ Biology: Inheritance, chromosomes, DNA and genes: heredity as the process by which genetic information is transmitted from one generation to the next. Reproduction: reproduction in humans (as an example of a mammal), including…gametes, fertilisation. GCSE Combined Science subject content: ▪ Working Scientifically: Development of scientific thinking: explain everyday and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments. ▪ Biology: Inheritance: explain single gene inheritance, predict the results of single gene crosses.	Running the activity Engage 1 Students get into role and learn about the options from a genetic counsellor Explore 1 Simulation on choosing an option using goal-based ethics Explore 2 Using duty-based ethics to explore the issues surrounding IVF with PGD Explore 3 Students use the decision making lifeline to explore the social and economic factors Explain Using discussion to make a personal decision Evaluate Students make their decision For detailed running notes, download the teachers guide.

Ebola Biology: Genetics Society: Decisions As Ebola continues its relentless progress across the world scientists are quickly developing drugs and vaccines to fight it. In this activity students are asked if they would trial a new Ebola vaccine. They gather information from different sources, weigh up risks and benefits and apply what they know about genes to decide if it is a risk worth taking. Learning objective ▪ Weigh up risks and benefits and make a decision, using scientific knowledge of the function of genes.	Curriculum link England National Curriculum KS3: ▪ Working Scientifically: Scientific attitudes: Evaluate risks ▪ Biology: Inheritance, chromosomes, DNA and genes: a simple model of chromosomes, genes and DNA in heredity GCSE Combined Science subject content: ▪ Working Scientifically: Development of scientific thinking: evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments; evaluate risks both in practical science and the wider societal context Biology: The genome and gene expression: explain the following terms:…chromosome, gene,	Dilemma Invitation to trial the vaccine Science Students use their knowledge of genes to explain how the vaccine works Decision Gathering information, weighing up risks and benefits and coming to a decision Plenary How did you make your decision? For detailed running notes, download the teachers guide
Solar Roadways Earth: Resources Society: Communicate These revolutionary roads, claim the developers, will remain snow-free, and, at the click of a switch, can be transformed into car parks or even sports pitches. In this activity students consider whether solar roadways are worth funding. They critique claims using reasoning and evidence, and apply what they know about generating electricity in solar cells, to make a decision. Learning objective ▪ Critique claims, using reasoning, evidence and scientific knowledge of how light	Curriculum link England National Curriculum KS3: ▪ Working Scientifically: Pay attention to objectivity… ▪ Physics: Light transferring energy from source to absorber leading to … electrical effects GCSE Combined Science subject content: ▪ Working Scientifically: Development of scientific thinking: make decisions based on the evaluation of evidence and arguments ▪ Physics: Energy: Renewable energy sources used on Earth; Wave motion: waves transferring energy	Dilemma View video on solar roadways. Are they worth funding? Science and Decision Students identify video claims and study evidence to decide whether each claim is supported by evidence Plenary Communicating the decision: are solar roadways worth funding? For detailed running notes, download the teachers guide.

waves generate electricity in solar cells.		
<u>Eat insects</u> Physics: Waves Society: Evaluate claims As human population increases, our appetite for meat grows but very soon demand will outstrip supply. Farming large animals puts a strain on our natural resources and creates polluting waste. Scientists are proposing eating insects to help solve this problem. In this activity students are asked to plan a Christmas menu for the school canteen which contains tasty insect dishes alongside more familiar ones. Can they use persuasive communication, and their knowledge of natural resources, to get students to opt for the insect alternatives? Learning objective ▪ Communicate an opinion using evidence, persuasive writing and scientific knowledge of Earth's natural resources.	Curriculum link England National Curriculum KS3: ▪ Spoken language: articulating scientific concepts clearly and precisely ▪ Chemistry: Earth and atmosphere: Earth as a source of limited resources; the production of carbon dioxide by human activity GCSE Combined Science subject content: ▪ Scientific vocabulary, quantities, units, symbols and nomenclature: use scientific vocabulary, terminology and definitions ▪ Chemistry: Carbon dioxide and methane as greenhouse gases: evaluate the evidence for additional anthropogenic causes of climate change; The Earth's water resources	Running the activity Starter The news story is presented: Brussels University canteen sell dishes containing insects Main Students design their special Christmas dinner menus Plenary Peer assessment of persuasive writing. For detailed running notes, <u>download the teachers guide</u>

2.4. Ongoing Materials development

We expect to complete the target number of 20 Materials in the ADOPT style between April-June 2015, before moving on to develop the next, ADAPT stage Materials. During this time, we are continually improving and iterating the design of the Dilemma lessons, in response to feedback from partners on whether the published materials are meeting their needs - for instance, the use of video, and applicability of weblinks to different countries, and based on teacher feedback from website reviews.

3. ENGAGE Professional Learning Framework

3.1. The need for a Framework

The nature of the teacher change that ENGAGE is promoting is complex, and the challenge of our Face to Face Workshops and Online Courses is to simplify and make practical specific teaching practices which set teachers on the path towards RRI teaching. A further complication is that the Courses operate at each of the 3 project stages: Adopt, Adapt, Transform, and so the content is intended to be incremental.

Since we were not able to define the detail of the changes in teaches practice and how we would achieve this in detail in the DoW. Therefore we decided to create a 'Professional Learning Framework' to set forth the principles, objectives and how these will translate into the sessions of our Courses and Workshop.

A sub-group of partners was assembled to create this framework, including: FAU, WZ, OU, UNI, VUT and SHU.

3.2. Vision for expert RRI teaching

To create a CPD Framework coherent with our goals we need a clear definition of what ideal Engage teaching looks like in the classroom - i.e. a set of ideal 'practices' which describe expert RRI teaching. The starting point for this is the 5 dimensions of 'teacher impact' from the DoW.

DIMENSION	*EXPERT RRI TEACHER*
1. Teachers' knowledge of RRI	Confident that they have a sufficient understanding
2. Teachers' conception of their own role	Facilitator of learning (interpreted for ENGAGE as building on students' existing ideas)
3. Teachers' use of RRI pedagogies like discourse	Open and dialogic
4. Teachers' conception of learning goals	Includes the development of reasoning skills
5. The nature of classroom activities	Activities are authentic and owned by students

Dimension 1 represents knowledge teachers need to draw on, and Dimension 2 represents the overall change in identity that will accompany the change in practices. So the actual classroom practices are represented by just Dimensions 3, 4 and 5:

- Teachers' use of RRI pedagogies like discourse
- Teachers' conception of learning goals
- The nature of classroom activities

3.3. Engage Practices

These dimensions can be reworded to clarify 3 areas which distinguish the differences in practice between an expert RRI and novice RRI teacher.

1. Use authentic tasks to help students apply science learning to every-day life (dimension 5)

This practice should be a focus for Adopt, since the main challenge identified in the DoW is for teachers to introduce the teaching of socio-scientific issues using our Materials, and make the activities work in the classroom. Clearly the use of socio-scientific issues is fundamental to Engage. Authentic learning captures the shift away from setting abstract academic tasks towards real-life tasks, which we believe are needed if students are to see the connection and relevance of their knowledge. These tasks simulate but dramatically simplify the real issues to make them accessible to students, and use strategies which are manageable for teachers.

2. Explicitly teach 'RRI skills and knowledge' needed to deal with science issues (dimension 4):

This practice should be a focus for Adapt rather than Adopt for two reasons. First, the DoW identified Adapt with teaching students about RRI. Second, because the explicit teaching requires a commitment to spending more classroom time than is expected in Adopt. The shift involved in this practice is in two parts. First, to prioritise 'RRI goals' or scientific practices alongside the traditional content, and secondly a recognition that students will only master these if they are taught, using research-based methods. The ability to integrate component skills and knowledge also needs to be taught.

3. Use open dialogue to build students' reasoning and understanding (dimension 3)

This practice should also be a focus for Adapt rather than Adopt for two reasons. First because the practice relates to the longer Adapt Materials rather than the short tasks of Adopt. Second because it is probably the hardest practice to implement. Teacher-student interaction in science is typified by IRE questioning (initiation, response, evaluation) or 'guess what's in the teacher's head'. Inquiry and RRI are not about transmitting knowledge, but helping students build it for themselves. They need a more open form of interaction, where reflection, alternative ideas, and justifications. This indicates the importance of increasing the time allocated to student-student dialogue, and supporting teachers to deal with issues lacking correct answers.

3.4. 'Tools' to focus the practices

The research says that CPD works better when it is about well-defined skills or practices, and so the 3 general statements need to be made more specific to define the goals and content of our CPD programme. One approach taken by CPD projects, like the influential 'Ambitious Science Teaching' (Windschitl et al), and the EU SiS project 'TEMI' is to turn the practices into a small number of 'Tools' for teaching. A Tool here is something which makes it easier for teachers carry out part of the practice. It could be a new construct or methodology, like the 5E's for teaching inquiry, a new resource, like Engage curriculum materials, or some other form. The Tools approach works because it makes change easier to implement. It is backed up by the 'habits' literature: people find it much easier to change if they are given one or two concrete habits to adopt at a time. These then help to catalyse broader change.

The Tools will translate directly into the content of our CPD programme - i.e. a goal for the Workshops and Online Courses will be for teachers to become confident and competent using the Tools. The question is: *What Tools best crystallise Engage practices and help them to take root?*

A small number of Tools is best, because each one needs a significant time for us to teach and then for teachers to implement and refine, and because partners also need to become confident with them. So I have suggested 4 based on other CPD projects - 2 for each stage Adopt and Adapt, and given a justification for each. I am not sure whether we need further Tools for Transform or whether we just go into the RRI knowledge in depth. Maybe we need the experience of running Adopt/Adapt to know.

ADOPT Tool

1. Dilemma lesson
If we want teachers to use Materials effectively, and apply the approaches elsewhere, we need them to fully understand the rationale. So the main Tool for Adopt has to address the nature of the tasks. Adopt tasks focus around the use of a dilemma, which students have to resolve. The dilemma has specific features to make it effective, hence the notion of a 'productive' dilemma, which:

- clearly engages students interest, and raises a controversial question
- acts as a vehicle to apply curriculum science knowledge
- relates to emerging science/technology and practises RRI skills/knowledge

Our specification includes answers to what is a dilemma, why include dilemmas in science education and finally an example of how this can be made.

A Dilemma is a situation in which a difficult choice has to be made between two or more alternatives, especially equally undesirable ones. In ENGAGE we target dilemmas that each and every citizen may face. The ability to negotiate and resolve socioscientific issues has been posited as integral components of scientific literacy (Sadler & Zeidler , 2002) . The main reason is to improve individual decision-makers. Research revealed that moral considerations were significant influences on decision-making.

We target for engaging students moral, ethical and societal reasoning based on analyses the benefits, risks and possible sequences . We are also interested in supporting students' ability to use the scientific knowledge and principles that they learn in science lesson in their decision-making processes. This is especially important as research indicate that many students use emotion and intuition in the process. Sadler & Zeidler 2002 mapped a series of factors that are involved in socioscientific decision-making. These factors included personal experiences, family biases, background knowledge, and the impact of popular culture.

Not all real-life issues are equally effective for teaching curriculum science. We invent the notion of a 'Productive Dilemma' as a set of criteria with checklists to help teachers evaluate possible socio-scientific issues and craft an issue so that it meets the productive dilemma criteria. See Deliverable 3.6 for a full description of the 6 criteria.

2. Group discussions
The other key feature of Adopt tasks is that they focus on students working in groups to resolve the dilemmas. This Tool addresses the need to provide teachers with techniques to ensure that students do work together productively to manage the task, follow rules for discussions, contribute and problem solve (proper argumentation is covered in Adapt).

To help teachers use small group discussion to develop students' thinking, and argumentation. This content will take two parts. The first related to explaining the techniques which are effective for different purposes, and the second to the preparation for effective group work. The area of how teacher can intervene in the process is covered in Adapt.

2. Discussion Formats

In traditional classroom discussions, teachers ask the questions—which often have a single right answer, and students are told whether or not their responses are correct. The questions asked tend to focus on factual knowledge or experience (e.g., "What did we observe?" or "What did we do?"). These discussions are typically referred to as "IRE dialogues": The teacher initiates a question, a student responds, and the teacher immediately evaluates whether the answer is correct or incorrect. This type of discussion is useful, as it provides a quick, whole-class review before moving on to new activities.

However, a discussion involving socio-scientific issues, ethical aspects and decision-making is an interplay of meanings and ideas mainly from students. Students need opportunities to express their own ideas (even if they are not always correct or well-structured), listen to their peers ideas, evaluate and critique ideas, and revise and integrate them as well. Classroom talk should centre on engagement and thoughtfulness. Students should ask questions that arise from their own interests or confusion—and they should ask questions of each other as well as of the teacher. Teachers should pose questions that push students to think more deeply about what they have observed, experienced, or read.

To this end, we present three types of discussions that promote students' thinking: brainstorming, synthesizing, and sense-making discussions. Figure 1 displays the three types of discussions and some suggested prompts for each. In practice, classroom discussions are often not limited to just one type but include elements of more than one.

3. Types of discussion

Brainstorming discussions

A brainstorming discussion takes place usually at the beginning of the lesson. Its purpose is to allow students to share their experiences, and elicits their thinking.

Synthesizing discussions

A synthesizing discussion is a discussion in which students evaluate their ideas, suggestions and the evidence provided. A synthesizing discussion involves putting ideas together, or assembling multiple activities into a coherent whole. It also includes generalizing from specific activities to a broader conclusion. A synthesizing discussion helps students organize their knowledge and integrate their ideas about the topic discussed. It also helps students realize how their individual thinking is similar to or different from their peers' thinking about the same topic, and how ideas raised by others can be synthesized into a meaningful picture of the discussed dilemma . The inclusion of sense-making prompts by the teacher is necessary to remind students of their conclusions from previous activities and to support them in presenting their thinking to peers. The overall purpose of this discussion is to integrate ideas.

Consensus discussion

Usually in our activities we do not intend to reach a consensus but allow a variety of well-justified views. However, often students working in small groups are required to reach a consensus regarding various things: the validity of the data gathered; the way to represent the data; the meaning of the data. In cases a consensus is needed the teacher may ask: "Does everybody agree? Is everybody happy with that?" If one or

more students disagree, the teacher may ask the class: “What should we do in order to resolve this?” Sometimes it is wise to postpone the decision until they had more evidence to favour one decision. Reaching a consensus is one example of the necessity of discussions. The consensus discussion serves both to promote students’ learning and to construct a community of learners; it also models the discussions among practicing scientists.

Sense making discussions

A sense making discussion usually follows students’ reading, investigation, experiment, demonstration, or simulation. Its purpose is to get students thinking more deeply about their experiences and their answers.

4. Group preparation

Guiding discussions, in contrast to leading IRE dialogues, presents some challenges. Both the teacher and the students need to acknowledge the value of learning from peers. In such a learning environment, authority is shifted from the teacher to the students, and knowledge is built gradually by the whole class, instead of by the teacher simply providing facts. Developing norms of discussions—or accepted and polite ways in which the class discourse should be handled—is also a challenge. Norms should be developed for active participation (i.e., presenting, commenting, constructively critiquing, and persuading) as well as for passive participation (i.e., listening and respecting various opinions). The teacher should use strategies such as “wait-time” to give all students time to think and answer, ask students to support statements with evidence; and provide scaffolding when necessary. The teacher should remove himself or herself from the conversation and encourage students to talk to one another make sense of something together.

ADAPT: Proposed Tools

3. Gradual Release of Responsibility

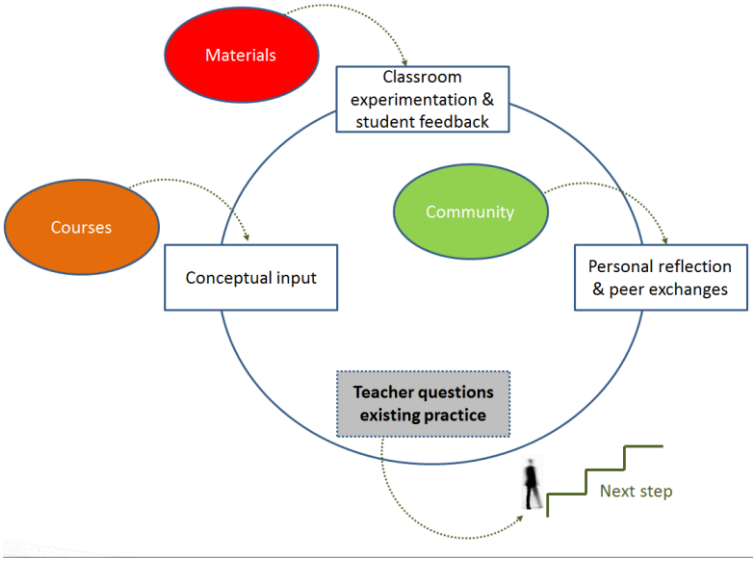
In science, skills are often left to develop, and not explicitly taught, or are not given the right type of quantity of practice. The GRR model is a research-based approach which sets out a plan for how RRI skills, which have now been defined in our ‘Materials Framework’ can be developed to mastery.
Effective skills teaching means first breaking down complex RRI skills into small parts. For instance, a task such as ‘evaluating a media article’ can be decomposed into: identifying the claim, finding the evidence, checking the source. Each can be further broken down - until your reach a set of thinking steps which an inexperienced students can follow. This is a ‘cognitive strategy’, and such strategies have been proven highly effective in teaching reading, writing, and problem solving. Teachers start by modelling the cognitive strategy, which students then practice, with scaffolding to support them and enable success. This is followed by gradual integration, and application to a range of contexts.

4. Question patterns

A modern research-based view of how questions can develop thinking is to think in terms of question sequences, not individual questions. Basing a Tool on this will help overcome prevalent misconceptions, such as that Bloom’s taxonomy can be used to generate questions at different levels, and that ‘higher order questions’ are better than ‘lower order’ ones. Our Tool is based on several innovations which have dissected how to build thinking through dialogue, including our partner Weizmann’s work on discussion types (brainstorm, synthesise, press), the argumentation framework claim/idea, evidence and argument/reasoning frameworks (Krajcik), and Questioning Sequences from our project advisor Robert Marzano. The Tool will model a sequence which starts at the level of details, moves to concepts, and then to elaboration, providing evidence, and building or challenging ideas.

3.5. Our CPD Model - teacher inquiry

The next area to clarify is the theory of action for our CPD programme. The latest view of teacher learning is like a complex system, where multiple interrelated conditions need to work together over a long period to create change. Classroom experimentation and feedback, reflection, peer discussion and input of new ideas are all vital elements. The theory of action is that our Strategies represent these multiple interrelated conditions. The diagram indicates the primary CPD function of each Strategy:



- Materials -> experimentation
- Community -> reflection with peers
- Courses -> conceptual input

In the DoW we described the teacher' learning process as active inquiry, and formulated inquiry questions to which teachers will discover answers as they use Materials and get positive student responses, as they reflect with others in the Community, and as they learn the rationale and theory in our Courses/Workshops:

- Adopt: 'What teaching techniques are best suited to exploring socio-scientific issues? How to allow students more self-expression, and deal with a diversity of opinions, while still keeping the class under control?
- Adapt: 'How can you best teach difficult concepts like evidence or skills like ethical thinking? How can you take account of students' existing knowledge and misconceptions?
- Transform: 'How does science work, and how are decisions about technology made?' 'What makes trustworthy evidence, and how do you interrogate sources in the media?'

3.6. Draft professional learning outcomes by stage

Now we have clarified the innovations we want to see, and the theory of change to make them happen, we can define learning outcomes for teachers on the programme. The draft proposals below are taken from an earlier set of outcomes, which have been aligned with the practices/tools/inquiry questions outlined above. For each stage, the outcomes are intended to show some progression from 1-3, to allow for different teacher starting points and rates of progress. 1 focuses on usage, 2 is about integration, and 3 is the ultimate goal of applying and innovating.

Adopt outcomes

1. Teachers understand the rationale for the Tools Dilemma lesson and Group Discussion and their implications for classroom practice.

2. Teachers use the Tools competently so that student are engaged, achieve their learning outcomes, giving teachers positive experiences which they reflect on

3. Teachers can apply the Tools to lessons beyond the Materials, or to other areas of practice

4. ENGAGE Workshops

The Workshop is conceived as a 1-day event for teachers to gain more understanding and expertise in using Adopt Materials, as well as learning more about the whole programme. The justification for a face-to-face event is to:

- learn directly from 'experts' in the practices they are learning
- practice using the Tools, with guidance and feedback
- building relationships with other teachers who share similar interests

Workshops are best for addressing discrete goals, such as learning to use a particular strategy (Loucks-Horsley et al 1998). As a result of our CPD Framework, we will specify goals for each session in the ENGAGE Workshop. The goals will be based on the need for teachers and their schools to get maximum practical value from time out of school if they are to get permission to attend.

It is important that each country has its own strategy to customise the message to local teachers' needs about why they should attend. It is difficult to get teachers to come out of school for a workshop in most partner countries.

4.1. Workshop programme overview

The main part of the Workshop is the presentation, and teacher practice of using the Tools for the Adopt stage. Optionally, the Workshops will also have a theme – of teachers creating a new Dilemma lesson to maximise their motivation, and involvement. A draft outline of the Workshop programme is below. The design will be tested in a number of pilots in Spring Term 2015 before being rolled out in the Summer Term 2015.

Timing	Session	Description of activity
15	Experience a dilemma	Warm up: teachers are presented with a socio-scientific dilemma and challenged to make a joint decision in 15-20 minutes, through discussion.
15	Why teach socioscientific issues?	Reflection on the experience, and benefits for understanding science, inquiry, attitude and ability to use science in their lives.
15	Goals and overview	Communicate our aims, the Model for Engage and its components, Goals for Adopt Stage. Describe how Workshop sessions contribute to these. Introduce the Tools that are the focus of the day: Dilemmas, Discussions

60	Productive Dilemma Criteria (Dilemma 1)	Show and discuss the criteria and checklists, and then get teachers in groups to use them to evaluate the Summaries teachers brought along from the Pre-Course Task, as candidates for 'This week's Dilemma' Challenge teachers to 'craft' the issue to meet all the criteria and checklist items, and complete a 'Dilemma outline' template. Engage examples available for comparison.
60	Dilemma Lesson Model (Dilemma 2)	Introduce the 3 stage lesson model, step by step. Stage 1: Dilemma - stimulus - dilemma question Stage 2: Student task - review science - consider options/issues Stage 3: Plenary - revisit dilemma question - assessment for learning At each stage, set teachers the challenge of developing the content for 'This Week's Dilemma', working out what will happen in that stage of the lesson.

5. ADOPT Online courses

Aims

The aim of Online Course is to extend the workshop experience as well as provide an introduction for those who could not participated in the workshop. ENGAGE online courses will support teachers by:

- Providing simulated practice for teachers, in a supported atmosphere of experimentation learning directly from 'experts'.
- Focussing on successful use of curriculum materials with feedback, which will be given by the course facilitators .
- Practicing using the strategies through simple tasks based on teachers needs, interests and efficient time.

ENGAGE Open On-line Courses will be set up in the EDX MOOC platform. They focus on addressing discrete goals, such as learning to use a particular strategy. Course participants will use a wide range of media and interactive online tools to engage with other colleagues and learn alongside them. These tools include video lectures, videoclips, online discussion boards, blogs, wikis and social networking sites such as Twitter.

Program

Learning objectives

- Teachers are aware and understand the rationale for the Tools and their implications for classroom practice.
- Teachers use and share their practices on the Tools to engage students and achieve lesson outcomes, resulting in positive experiences which teachers have reflected upon.
- Teachers can apply the Tools to areas of practice beyond the Materials and discuss their practices

Content is in development. Its design considers the following components:

- TEACHING TOOLS teaching strategies illustrated with resources (Materials and Video Library)
- ACTIVITIES based on the overall outcomes for Adopt, which includes teachers' tasks.
- ASSESSMENT procedures for assessing teachers' learning

Guidelines in development will include information for pilot-partners related to:

- LOCALISATION/TRANSLATION: information for partners to translate and localise their online courses
- FACILITATOR'S ROLE: support and feedback provided by online course experts who will be facilitators

Available languages

All pilot-partners language

Timetable

1. January 2015: Completion based on WP1 CPD framework and WP2 EDX specifications. WP4 will lead the dissemination and WP2 will open the registration
2. February/March 2015: Pilots and final improvements
3. April 2015: Online Courses will be ready to start based on pilot-partners country calendar

ONLINE COURSE Outline (draft)
The outline below will be refined by testing of pilot courses by a number of partners, during the period January-March 2015.

Units / time / week	**Session Titles**	**Description of activity/ suggested activities**	**CPD Activity (see Appendix 1)**	**Focus of CPD Activity (see Appendix 2)**	**Resources**
Introducing engage /	Welcome to engage /	What is Engage?	1		. Video / presentation on Engage

2h / 1st week	Knowing Engage/	What is new / different in Engage How can you profit from Engage? How does Engage work?			. Open discussion either synchronous (webseminar) or asynchronous (forum)
Productive dilemmas / 2h / 2nd week	Introduce productive dilemmas Set up criteria for choosing productive dilemmas Assess examples of productive dilemmas	Introduce Discussion – Do you use already productive dilemmas in your teaching? (Forum) Debriefing of the Discussion (Tutor lead / Scripted) Discussion – Criteria for productive dilemmas in your teaching? (Forum) Debriefing of the Discussion (Tutor lead / Scripted) Conclusions and follow –ups (by tutor and discussed in the forum)	2	1	Presentation with uncommented good and bad dilemmas Presentation (after debriefing) with the engage Criteria for productive dilemmas Guidelines and ideas for the tutor
Group discussion / 2h / 3rd week	Introduce group discussion / Identify group discussion methods and their pro and cons in the	Introduce: Text and Pictures Discussion on Methods pros and cons (synchronous or asynchronous) Debriefing of the Discussion (Tutor lead / Scripted)	2, 5		Presentation / video on methods for group discussions Presentation (after debriefing) on ideas for promoting and

	classroom situation Learn methods for setting - up and moderating a group discussion fo r productive dilemmas	Presentation: Methods Discussion on Criteria for good group discussions in the context of productive dilemmas Debriefing of the Discussion (Tutor lead / Scripted) Presentation: Promoting and moderating Conclusions and follow –ups			moderating group discussions
ENGAGE Materials for your teaching / 4h / 4th and 5th week	Know the Engage Materials How to download an d give feedback Know the concepts Know possible approaches for using Engage materials in the classroom situation Experience the Engage materials in the classroom	Introduce: Text Presentation: on the Engage Materials Discussion: open Tutorial: How to download and upload Discussion: open, technical support Download two materials and outline the different aspects of the activity Discussion: Tutor should animate the discussion by bringing in facts and interesting issues related to the Engage materials	2,3 and 6		. Video / presentation on Engage . Open discussion either synchrono us (webseminar) or asynchronous (forum)

	Developing your ENGAGE Lesson	Transfer task : Adopt one of the materials for a certain grade Discussion: Upload your concept and request feedback (facultative) Transfer task: perform the activity Reflection and Evaluation Evaluation in the classroom, self-report (à send to tutor) Discussion: how did it work and why (Forum)	4, 5 and 6		Guidelines for adoption (if necessary) Concept template Evaluation questionnaires, self-report template
Summary and feedback / 2h / 6th week	Feedback and Further engaging in Engage	Discussion: What did you like and what you would like to improve? (forum) Debriefing: A short list of good aspects and aspects to improve Discussion: What did you miss and would like to get in a next course? (forum) Debriefing: A short list of missing aspects and wishes for the future Presentation: Further activities of the project and opportunities to contribute Questionnaire on the Online Training			Template for lists Presentation on the further activities Questionnaire for online course evaluation (Activity, presentation, technology, support)

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