SUSTAIN

Everyday Objects

LINKING IBSE AND ESD

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Lifelong Learning Programme

The SUSTAIN network has been created to develop significant connections between Inquiry-Based Science Education (IBSE) and Education for Sustainable Development (ESD) in order to create classroom activities and professional development resources for teachers and teacher educators.

To reach this goal, the network uses and disseminates effective and well-tried methods of IBSE, that have been extensively developed throughout Europe in previous activities, especially in the Fibonacci project .

The network is composed of 11 European institutions actively involved in providing continuing professional development (CPD) to teachers and teacher educators in science in 10 European countries.

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Everyday Objects

Linking IBSE and ESD

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Introduction

Why address sustainable development through science education?

Climate change, loss of biodiversity, management of natural resources, pollution, are examples of global issues that are key for sustainable development which are related to science and technology and also have important implications for the socio-economical structure of a community. Consequently, they suggest a need for citizens and societies to engage in a deep behavioural change.

Education has a crucial role to play as a prerequisite for promoting change and providing all citizens with key competences needed to participate in the democratic debate. Citizens need better understanding of the scientific ideas that are inherent to these global issues in order to understand their causes and consequences, and the alternative choices that are proposed by the governments and also by the corporate world. They also need to look at those issues critically and be aware that in many areas there are several options and choices with different consequences.

This is why new skills, methods and connections are required among pupils and teachers in order to create better links between education for sustainable development, scientific literacy, and active citizenship.

The SUSTAIN network has developed this handbook with the aim of contributing to the development of the understanding of ESD topics in the context of science teaching.

What is Inquiry-Based Science Education?

"Inquiry is a term used both within education and in daily life to refer to seeking knowledge or information by asking questions. It is sometimes equated with research, investigation, or 'search for truth'. Within education, inquiry can take place in several subject domains, such as history, geography, the arts, as well as science, mathematics and technology, when questions are raised, evidence is gathered and possible explanations are considered. In each area different kinds of knowledge and understanding emerge. What distinguishes scientific inquiry is that it leads to knowledge and understanding of the natural and made world around through methods which depend on the collection and use of evidence."[1]

The process of IBSE begins by trying to make sense of a phenomenon, or answer a question, about why something behaves in a certain way or takes the form it does. Initial exploration reveals features that recall previous ideas leading to a possible explanation or hypothesis to be tried. Working scientifically, students then proceed to see how meaningful the existing idea is by making a prediction based on the hypothesis, because ideas are valid only if they have predictive power.

To test the prediction, new data about the phenomenon or problem are gathered, then analysed and the outcome used as evidence to compare with the predicted result. From these results a tentative conclusion can be drawn about the initial idea. If it gives a good explanation then the existing idea is not only confirmed, but becomes more powerful –'bigger'– because it then explains a wider range of phenomena. Even if it doesn't produce the expected result, and an alternative idea has to be tried, the experience has helped to refine the idea, so knowing that the existing idea does not fit is also useful.

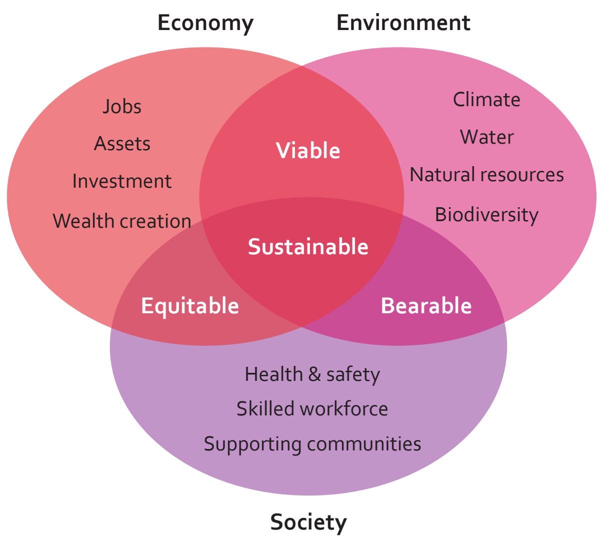
This process of building understanding through collecting evidence to test possible explanations and the ideas behind them in a scientific manner, we describe as learning through scientific inquiry.

What is Education for Sustainable Development?

Before defining ESD, it is important to consider what sustainable development is.

Sustainable development is commonly defined as 'development which meets the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development, Brundtland Report, 1987).

It is usually depicted through a model of three-interdependent-pillars environmental, social and economic, as illustrated in the diagram below.



The Three Pillars of Sustainable Development

1 From *Inquiry in science education*, Wynne HARLEN, 2013

Sustainable development is a holistic society project and as such it cannot be defined and implemented without science; indeed science plays a huge role in all the three pillars (the way we produce goods, the way we use natural resources, the way we care for people's health or we communicate…) and also forms part of our common culture, this being now often considered as a fourth pillar or rather a cross-cutting dimension of sustainable development. This is why cultural issues are addressed in this book, particularly within the Society pillar.

Because of this strong and crucial connection between science and the global ambition towards sustainable development, it is important to reinforce the links between Education for Sustainable Development and science education.

Education for Sustainable Development is defined by Unesco as "[education which] allows every human being to acquire the knowledge, skills, attitudes and values necessary to shape a sustainable future.

Education for Sustainable Development means including key sustainable development issues into teaching and learning; for example, climate change, disaster risk reduction, biodiversity, poverty reduction, and sustainable consumption. It also requires participatory teaching and learning methods that motivate and empower learners to change their behaviour and take action for sustainable development. Education for Sustainable Development consequently promotes competencies like critical thinking, imagining future scenarios and making decisions in a collaborative way."[2]

The educational responses to the challenge of sustainable development, however, cannot be reduced to a unique perspective. In fact, as Sterling (2001)[3] underlines, three approaches can be identified:

- **Education about sustainability**; the emphasis is on knowledge related to sustainability. It assumes that sustainability can be easily defined and so it can become a separate subject within school curriculum. This response supports a "conservative learning" and the current educational paradigm remains unquestioned;
- **Education for sustainability**; the emphasis is on "learning for change" (as in the UNESCO's approach). It includes knowledge but goes further to involve values, attitudes, skills and behavior. This response includes a critical and reflective thinking;
- **Education as sustainability**; the emphasis is on the process and on "the quality of learning". It includes all the above responses but emphasizes "learning", seen as "a creative, reflective and participative process". In this perspective, learning is considered "as change" and involves individuals and institutions. The current educational paradigms are put into discussion, supporting a transformative and creative response to sustainability.

Within this global framework, it is clear that ESD, supporting individual's engagement through quality learning, can lead to positive personal and community actions.

On these presuppositions, IBSE can contribute to ESD as they share common values: cooperation, creativity, innovation. It can particularly help building the knowledge, skills and attitude that support an objective reflection on environmental, social and economic phenomena which goes beyond opinion and anecdote.

Education for Sustainable Development and the place of inquiry: the contribution of SUSTAIN

Despite the fact that the three pillars of sustainable development are intertwined, educational disciplines tend to invest attention in just one of the three, thus perpetuating the compartmentalisation of traditional curriculum subjects.

Yet, ESD encourages more complex and multidimensional approaches. It includes a number of dimensions: scientific, geographical, economic, political, social, cultural.

Combining ESD with IBSE gives explicit attention to developing young people's awareness and ability to approach problems and imagine new scenarios through the active learning processes of conceptualising, planning, acting and reflecting. It provides the space for critical thinking to be combined with the creative act of interpreting images of the future.

This handbook explores the way IBSE can contribute to developing ESD: connecting more teachers and pupils with real life challenges and contemporary science; introducing topical issues related to science and technology, economy, culture, as they are debated in society; applying inquiry skills to issues related to

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2 Unesco website: http://www.unesco.org/new/en/education/themes/leading-the-international-agenda/education-for-sustainable-development/

3 Sterling, Stephen. *Sustainable Education – Re-visioning Learning and Change*, Schumacher Briefings, Green Books, Dartington, 2001.

sustainability in the wisest sense; connecting schools to the great diversity of sustainable development stakeholders within the different communities.

Some examples of the way IBSE can contribute to ESD

ESD is not only about environ-mental problems, it assumes a cross-dis-ciplinary approach encompassing economic social and cultural factors	←	IBSE is a method that develops the ability to approach complexity in a scientific way
ESD deals with complex issues, highly intertwined from personal to local to global levels	←	IBSE provides opportunities to develop deeper scientific concep-tual understanding and understanding about the nature of science that are needed to approach a complex world
ESD is oriented towards change of values, attitudes, behaviour and action patterns	←	IBSE develops a diversity of skills as well as knowledge; as such it engages children to seek answers and equips them to make informed decisions
ESD involves a wide range of subjects/ stakeholders	←	IBSE encourages an approach which develops strong links with econo-mists, scientists and local communities.
ESD often deals with controversial and debated issues	←	IBSE can help go beyond debate based on opinion by developing critical thinking and evidence-based arguments

Assessment within SUSTAIN

Assessment of students' learning can take many forms and serve many purposes:

- *formative assessment* can be done at any time to provide ongoing feedback and should influence your plans and practices in the classroom;
- *summative assessment* usually happens at the end of a sequence of lessons to determine the impact on student learning and the effectiveness of teaching.

SUSTAIN has a focus on integrating IBSE and ESD approaches, and so assessment needs to consider different types of learning outcomes. IBSE involves not only scientific knowledge, but also the ability to carry out and understand scientific inquiry. Learning outcomes in ESD include critical thinking and changes in attitudes and behaviour. Assessing this range of learning outcomes is challenging, and will involve a range of approaches, such as: looking at written reports about hands-on activity, science notebooks, posters or worksheets, listening to students' argu-ments and explanations, observing how students undertake inquiries and questioning them about their decisions and conclusions.

Below we offer some tools to support you in assessing your students' progress, which you can use within the context of your own National Curriculum. These may also provide a useful basis for evaluating your own planning and teaching by considering whether you have provided adequate opportunities for the diffe-rent kinds of learning activity. We also recommend more detailed information about assessment in IBSE which was developed by the Fibonacci Project, and which is available at http://www.fibonacci-project.eu[4].

For IBSE[5] These indicators are phrased in terms of student activity and could also be used to evaluate the learning opportunities provided.

Key elements	Example indicators	Yes	No
Students engage in answering scien-tifically oriented questions	A starting point is linked to a real situation		
	Students consider what they already know and what they want to find out		
	Productive questions are selected		
	Students make predictions and conjectures		

4 Tools for enhancing inquiry in science education (2012),

5 Adapted from: National Research Council (2000). *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning.* Washington, DC: National Academic Press

Students give priority to evidence	Students decide what data to collect		
	Students design the procedure for collecting data, and how to ensure accuracy		
	Students collect data		
Students formulate explanations from evidence	Students analyse data and identify evidence		
	Students formulate conclusions or explanations based on evidence		
	Students answer the inquiry question(s) using this evidence		
Students evaluate their explanations	Students check whether the evidence supports the explanations, and adequately answers inquiry question(s)		
	Students check for any biases or flaws in their reasoning		
	Students check their results with those of their classmates		
	Students consider alternative explanations and link their results to scientific knowledge		
Students communicate and justify explanations	Students share their results and explanations with each other through written, visual or oral reports		
	Students explain why evidence is important, and link this to specific concepts or assumptions		

For ESD[6] These indicators are phrased in terms of the design of learning opportunities and give some guidance about areas in which student learning could be assessed.

Key elements	Example indicators	Yes	No
The topic is developed in reference to the dimensions of sustainability	Its environmental implications are identified and analysed		
	Its social implications are identified and analysed		
	Its economic implications are identified and analysed		
	Local and global contexts and past/present/future perspectives are considered		
The topic is developed using an holistic approach	Connections between dimensions of ESD are sought and different disciplines are involved		
	The complexity of relationships between the natural environment and human activity are considered		
	There is awareness of uncertainty and its role in decision making		
The topic is developed using a participative approach	The activities support reflection on our (individual and collective) role as citizens and as consumers of goods and services		
	Different points of view and opinions, and the conflicts which may arise, are taken into account		
	Responsibility towards the environment and the 'common good' is highlighted		
The topic is developed using a transformative approach	The activities stimulate critical reflection on issues		
	The activities promote creativity and pro-active responses		
	Attention is focused not only on knowledge, but also on values, life styles and behaviours		
	Alternatives for change are explored		

6 Based on: UNESCO World Conference on Education for Sustainable Development (Bonn 2009), Bonn Declaration (http://www.esd-world-conference-2009.org/fileadmin/download/ESD2009_BonnDeclaration.pdf), Sterling, S. (2006) *EducazioneSostenibile,* Anna Mundi Editrice, Cesena, UNECE Strategy for Education for Sustainable Development (2005) (http://www.unece.org/fileadmin/DAM/env/documents/2005/cep/ac.13.2005.3rev.1.e.pdf)

Presentation of the set of three handbooks

This handbook dedicated to the issue of everyday objects is part of a set that includes two other handbooks on the issues of energy and food.

Together, these three handbooks form a large ESD-oriented science teaching resource that allows teachers to approach sustainable development issues on the basis of children's everyday life and experience. Such an approach considerably enriches the teaching content and relevance for the children of big ideas[7] and key competences of science.

Why those issues?

Food is a normal, but essential commodity in our daily lives. The handbook will enable teachers to examine different foods regarding their composition (nutrition), production (growth), distribution and consumption. In that way, children will not only increase their scientific knowledge and skills, but also their knowledge about the interconnectivity between environment, society and economy. Since the pupils will also reflect on their attitudes and values, they will be empowered to take action by making informed decisions and if wanted by changing their lifestyle.

Energy is essential to all our lives. However, global warming seems to be underway as a consequence of our pursuit to increase energy supply to meet the needs of development and population expansion. Concern about this has given risen to limitations on the use of fossil fuels, improving energy efficiency and the use of renewable energy systems. These initiatives have an important role to play in the debate about and for sustainability; as such understanding the issues involved (using non-renewable and renewable energy; energy usage and conservation) is an important part of scientific literacy for the future.

Everyday objects that we almost always take for granted can be a source of stimulating and accessible scientific inquiries for children. The handbook will explore how investigating the ways that familiar objects work can provide opportunities to develop both scientific understanding and inquiry skills. But objects also have life stories: investigating how they were made, and what will happen to them after we have finished using them engages children in perspective beyond their own needs and experiences, considering the environmental, social and economic issues relating to sustainable development, and gives interesting opportunities for cross-curricular activities.

7 *Principles and big ideas of science education*, Wynne Harlen Ed., Association for Science Education, 2010

Note

Please note that this handbook has been developed in the context of a European project gathering institutions from 10 different countries. As such, there may be no direct links between class activities proposed and the specific curricula applicable in each European country. Thus, the reader may wish to consult official documentation of his/her country for reference and appropriate adaptation.

A few resources

IBSE resources

Harlen W. (Ed.) *Principles and big ideas of science education*, Association for Science Education, 2010

Developed within the Fibonacci project, a FP7 European project:

http://www.fibonacci-project.eu

- Artigue M., Dillon J., Harlen W., Léna P. *Learning through inquiry*, 2013
- Harlen W. *Inquiry in science education,* 2013
- Borda Carulla S. (Ed.) *Tools for enhancing inquiry in science education,* 2013

Harlen W. *Assessment and Inquiry-Based Science Education: Issues in Policy and Practice*, Global Network of Science Academies (IAP) Science Education Programme, 2013

ESD resources

Education for Sustainable Development, Source book, Unesco, 2012, available at:
http://unesdoc.unesco.org/images/0021/002163/216383e.pdf
http://unesdoc.unesco.org/images/0021/002163/216383e.pdf

'Teaching and Learning for a Sustainable Future' - A multimedia teacher education programme of UNESCO, available at: http://www.unesco.org/education/tlsf/mods/theme_gs/modoa.html

Sterling, S. *Sustainable Education – Re-visioning Learning and Change*, Schumacher Briefings, Green Books, Dartington, 2001

Part 2: Inquiry with Everyday Objects

In this section we explain our rationale for choosing Everyday Objects as the focus for our work, and present the approach we have taken to planning the development of ESD through IBSE. We present tools for planning learning activities and outline the areas of scientific content that might be addressed to support you to plan lessons about Everyday Objects that are relevant for your students. We provide some suggestions about the kinds of resources that may be useful.

To show how this approach can be used with some specific objects, in Part 3 of this Handbook we offer a range of examples of lessons for students of different ages. You will find references to specific lessons to illustrate issues addressed in Part 2.

Rationale: why choose Everyday Objects as a topic?

In our daily lives we are surrounded by objects which have specific roles and functions. Some are relatively simple, like a drinking cup. Others are much more complex, like a mobile phone.

Take a moment to think about what is in your bag, or in your pockets.

We make choices about the objects we own or use which are influenced by many different factors. We choose objects that fulfill a purpose in relation to our needs, but also ones which are attractive in some way. I might choose a pair of gloves because they are warm, strong or waterproof, but my choice might also be influenced by their colour, their brand or their price.

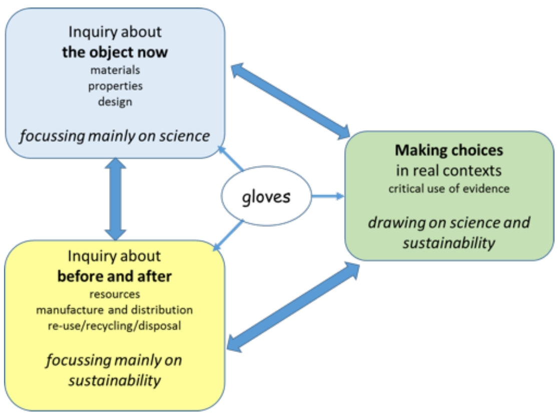
Because these objects and their uses are familiar to students, they can be good starting points for considering scientific explanations for aspects of their functionality. Most of the objects we carry around or use every day come in a variety of forms, often made from different materials. Think about gloves: thick, woolen gloves are good for keeping your hands warm, but may not keep them dry. Rubber gloves will keep you dry, but may tear easily. Leather gloves are tough and strong, but may be quite stiff and clumsy if you want to hold a small object. A collection of objects, such as different kinds of gloves, can be a starting point for students to explore the properties of some materials and develop inquiry skills which can be applied in many contexts.

The choices we make have implications for us as individuals, but also have wider social, economic and environmental implications. I may buy a fresh bottle of water, or re-fill an old one, or buy a special water bottle which can be used may times. Buying bottled water is expensive and buying small, easy to carry bottles is even more expensive than buying larger ones. Plastic bottles may be re-cycled, but many are also thrown away in landfill, or end up in rivers or the sea where they are a danger to wildlife. A specially designed water bottle may look stylish, and can be re-filled from the tap, but it is probably also made of plastic, and it needs to be washed, which uses hot water and detergent. Eventually it will probably be thrown away and end up in landfill.

Thinking about the choices we make about everyday objects can also provide a focus for students to consider issues of sustainability in contexts which relate to their immediate experience. Decisions about sustainability are often complex, and there is no simple 'best' solution. Focusing on choices about everyday objects is one way to help students to engage with that complexity, and to begin to develop critical inquiry skills.

Our approach: Everyday Objects and their Life Stories[1]

In this section we describe an approach to working with everyday objects, based around considering their life stories, and the life cycle of the materials from which they are made. Our approach has three elements. Focusing on the object now can be the starting point for scientific inquiry into its properties and how it functions. Taking a wider perspective to consider the object's life story, by exploring what happens to it before and after we use it, creates opportunities for inquiry into aspects of sustainable development. These experiences equip students to consider scenarios involving making choices about everyday objects.



Exploring objects now

This involves a collection of examples of a familiar object (such as cups, gloves, shopping bags, sneakers). The aim is for students to explore the design and properties of the objects. In doing this they can develop understanding of key scientific ideas as well as developing inquiry skills.

The first activity is for students to explore the collection of objects. This could be a set of different cups (or another object), provided by the teacher, or a collection of objects belonging to the students themselves, such as sneakers. By observing, students can identify similarities and differences. They might sort the objects in some way, or discuss which example they would choose for a particular purpose. This discussion may provoke questions and predictions about the properties of different objects. You can see examples of this kind of activity in lessons in Part 3 :'Which cup would you choose ?' and 'Sneakers for all seasons'.

Of course the students will be starting with some level of scientific understanding (e.g. about materials, hot objects cooling /cold objects warming up), and some inquiry skills, which are likely to depend on their age and their previous school and personal experiences. It is also likely that students will bring some sustainability perspectives into their discussion. For example, they might comment on differences between disposable and re-usable examples, or have some knowledge about materials that can be recycled.

From this discussion the teacher will need to direct the students' attention towards questions which can be explored through scientific inquiry.

Some examples when exploring gloves might be:

- Which gloves will be warmest in the winter?
- Are all of them waterproof?
- Are some gloves better for handling cold things like ice cubes?

Students select an inquiry question to explore. This is likely to require some discussion and guidance to identify both suitable questions, and appropriate methods of inquiry. The level of independence with which the students can work, and the support they will need, will vary according to their age and experience. Their inquiries might involve making predictions which can be tested, planning a practical investigation, gathering and interpreting evidence, and developing explanations.

Before and After

We widen the focus to think about the whole life story of the object, which introduces issues relevant to ESD.

- What happened before the object arrived in front of us?
- Who made it?
- What is it made from? Where did those resources come from?
- Where was it made? Why was it made there, and how did it get here?

We want to encourage the application of inquiry skills, particularly asking questions, interpreting data and making connections with scientific knowledge.

1 We refer to both 'life stories' and 'life cycles' in this Handbook. The two ideas are similar, but while the life story of an object is an accessible idea for younger students, it is also important to extend the thinking of older students to consider the life cycle of materials.

We also think about what will happen to the object after we have finished using it. The focus here might be immediate (what happens to the cup when I have finished my drink) or longer term (what happens when I grow out of my sneakers, or they wear out).

- Can it be used again? If so, what has to happen?
- Will it be 'thrown-away'? If so, what happens to it?
- Can it be re-used for some other purpose?
- Can it be re-cycled? What does that involve?
- What can be made from the recycled material?

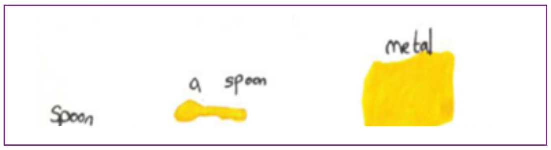
Imagining and investigating the whole life story of the object will employ an inquiry-based approach, even if it does not always involve hands-on activities. Therefore, we want to encourage the application of inquiry skills, particularly asking questions and identifying and using scientific data and evidence. This move from practical, hands-on activity to considering ideas which are less visible to students, and further removed from their experience, may be challenging, particularly for younger children.

Rather than focusing on a single object, comparing the life stories of two contrasting objects (e.g. a wool glove and a plastic glove, a ceramic cup and a paper cup) may be a powerful way of helping students to focus on the differences in the stories, and the reasons for these. (See the lesson 'Different Stories' page 31)

Young children may recognize objects but focus on their appearance, or use, rather than the material they are made from. Even if they are able to identify the material an object is made from they may have little understanding of how the object was made or of where the material originated. Some children may think of the object coming from a shop but find it more difficult to think beyond that.

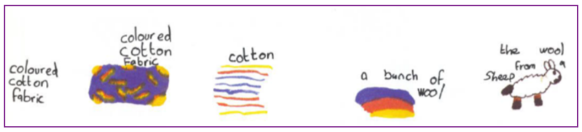
Older children may demonstrate awareness that an object has come from somewhere, and that some change or process has taken place, but only be able to articulate this as the object being 'made in a factory'.

Teachers may gain valuable insights about children's understanding from their drawings. In *Making a spoon* the child indicates that a spoon is made from a lump of metal but has not suggested the source of the metal or how the spoon is made.



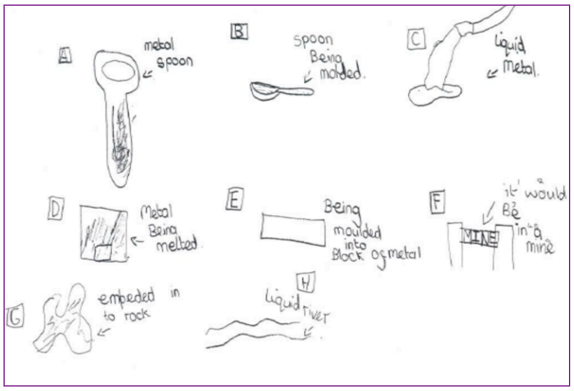
Making a spoon

In *Making fabric* the child shows some idea of the changes needed to make the cotton fabric but appears confused about the original source of the material, suggesting it came from a sheep.



Making fabric[2]

In *Another spoon* an older child recognises and describes changes needed to produce a metal spoon from metal ore.



Another spoon[3]

The diagram below[4] suggests how teachers might help young children to develop their ideas about changing materials

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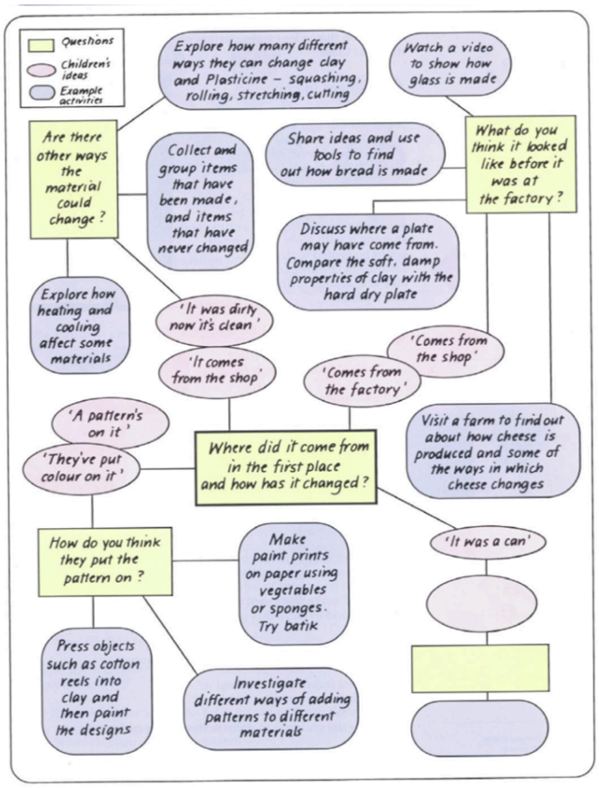
2 Illustrations from *Nuffield Primary Science SPACE project Materials (5-7) Teachers' Guide*, 1995 (2nd edition), ISBN:0 00 310247-5

3 Illustration from *Nuffield Primary Science SPACE project Materials (7-12) Teachers' Guide*, 1995 (2nd edition), ISBN:0 00 310259-9

4 Illustration from *Nuffield Primary Science SPACE project Materials (7-12) Teachers' Guide*, 1995 (2nd edition), ISBN:0 00 310259-9



Life cycle perspective

For older students it will be appropriate to introduce the idea of considering the life cycle of the materials from which the object is made. The term life cycle usually refers to the stages through which something (as an individual, a culture or an object) passes during its lifetime. Consequently it involves a global approach that puts the attention, in the case of an object, on the production, manufacture, distribution and disposal of raw materials, including all the necessary transportation steps.

A general Life Cycle

Starting from this idea, Life-cycle assessment (LCA, also known as life-cycle analysis, and cradle-to-grave analysis) is a method that considers the environmental impacts associated with all the stages of a product's life. The importance of LCA is mainly in its innovative approach, considering all the stages of a production process as linked and interrelated.

LCA can be useful for developing a global outlook on environmental concerns and effects related to products and services. It enables us to quantify all relevant emissions and resources consumed, together with the related environmental and health impacts and resource depletion issues (for instance water, energy, air) associated with any goods or services ("products"). In this sense, LCA provides a sound basis for informed decisions.

In order to get a 'whole picture' of a product, life cycle thinking must be extended to encompass all three pillars of sustainability: (a) environmental, (b) economic and (c) social. The life cycle of a product, in fact, involves not only flows of material and energy but also of money, so the picture is not complete unless impacts of the production and consumption on all actors along the 'value chain' (workers, local communities, consumers and society itself) are included. The interrelationships of the above aspects allow individuals and enterprises to assess the impacts of their purchasing decisions and production methods, giving form to an overarching idea of life cycle assessment, named life cycle sustainability assessment (LCSA).

Further detail about this can be found in the online resources on the SUSTAIN project website linked to this Handbook.

In this context, understanding, quantifying and communicating the sustainability of products is seen as part of the continuous reduction of impacts and increasing of benefits to society. Applying life cycle thinking to the pillars of sustainability, offers a way of incorporating sustainability in school within teaching and learning activities, going beyond the more narrow traditional and strictly disciplinary focus and approach. Starting from these considerations, this approach has been considered and used within the SUSTAIN project.

Making choices

In our approach we also focus explicitly on making choices, because reflection on individual behavior is one of the most important and ambitious goals of ESD. This stage could be developed in different ways; as a separate step of the learning sequence or as a focus point within different learning activities. Focusing on making choices involves combining ideas that students have explored in the other activities, together with their emotions, beliefs and values. People with the same knowledge, in fact, may display different and contrasting behaviors, if guided by different values or individual beliefs.

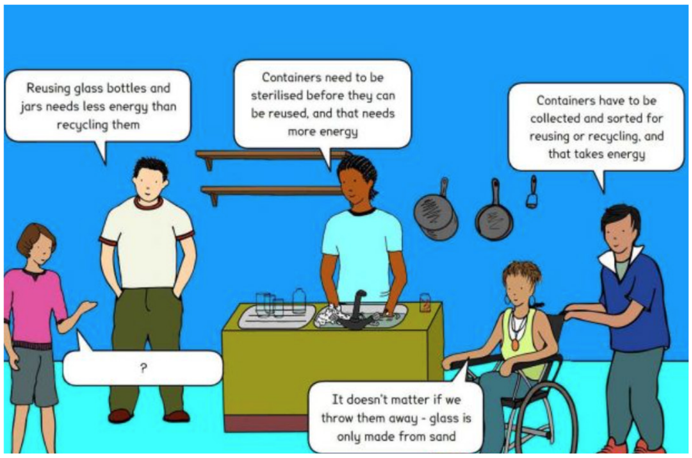
These activities are an opportunity to introduce the complexity of making sustainable choices in a way that is accessible to students and appropriate for their age and experience. The aim is not for students to discover the 'best' choice, but rather to develop the skills required to consider different kinds of evidence and construct arguments based on this. These are important skills because of the complexity of factors involved : the detail of the science involved may be too complex for students to understand and changes in technology may introduce new situations which affect these choices in the future.

Making choices activities can provide opportunities for the assessment of students, the learning activities and teaching approach (see the section on Assessment in Part 1).

A scenario is presented to students which involves making a choice about everyday objects. For example, this might involve a school deciding whether to use paper towels or electric hand dryers in their washrooms. The scenario needs to be sufficiently complex for students to take diff*erent points of view, and there should not be an obvious 'rig*ht' answer. It should encourage students to consider environmental issues (e.g. the impact of cutting down trees to make paper), but also consider economic factors (e.g. the cost of electricity) and social factors (e.g. what people prefer to use), which may be in conflict with these.

The scenario could be presented in a variety of formats that allow for the development of evidence-based arguments, for example:

- a role play, in which students take roles reflecting different perspectives (for example see 'Making choices in the Cafe' in Part 3)
- a concept cartoon, like the one shown below[5], in which students are invited to add their own comments to a discussion
- an authentic task, that is an assignment given to students designed to demonstrate their ability to apply knowledge and skills to real-world challenges[6] (for example see 'Salvatore's Story' in Part 3 on page 43)
- a debate, in which speakers support different points of view.



A suitable scenario should:

- make sense to the students involved, taking account of their age and experience
- link to work about the functionality and the life stories of objects
- encourage students to consider the implications of different choices that could be made
- provide opportunities for the use of evidence as well as personal opinions.

Useful background information to support making choices activities can be found on the internet. When making a search you will find websites created by organisations and individuals with different perspectives: manufacturers, retailers, environmental groups, journalists and others. The information that is emphasised, or the way in which it is presented, may differ between sources, and it is important to be aware of this. For younger students you may need to summarise information to make it accessible, as has been done in the cards included in the lesson 'Different Stories' in Part 3 on page 35 of this Handbook. Older students may be able to conduct their own searches, and consider the sources of the information they find.

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5 *Science Concept Cartoons Book 2*, (2015) Millgate House Education ISBN: 978-0-9562646-8-8 http://practicalaction.org/conceptcartoons

6 http://jfmueller.faculty.noctrl.edu/toolbox/tasks.htm

Inquiry

Planning Inquiry lessons

The inquiry process is driven by the students' curiosity and supported by their engagement in the learning process. Curiosity and engagement are important to support motivation and interest, but they are not enough to ensure effective and meaningful learning experiences that lead students to a deep understanding of scientific ideas and the development of inquiry skills. A well-planned structure for the learning process and expert guidance by a teacher are fundamental to build on curiosity and achieve the learning goals: science content, skills and attitudes [7].

INQUIRY STARTERS → FOCUSED INVESTIGATION → SHARING UNDERSTANDING

Inquiry starters introduce students to the inquiry topic in a way that stimulates curiosity and elicits questions that can be pursued during their *Focused Investigations*. Inquiry starters are activities designed to involve students in exploring materials, making observations and analysing evidence, videos, documents, case studies, etc. Photographs can also provide powerful starting points to stimulate discussion.

Students plan and carry out *focused investigations* to answer their research questions in small groups.

They are involved in:

- using materials and sources
- recalling previous knowledge
- proposing tentative explanations
- making predictions and testing them
- collecting data (direct and indirect)
- selecting evidence
- revisiting explanations in light of new observations
- recording and representing thinking through writing and drawing.

Students share understanding as they exchange investigation results with each other and examine and discuss their ideas to build their understanding of scientific concepts, supported by the teacher.

7 Adapted from: *Exploratorium, A professional Development Curriculum from the Institute for Inquiry*, National Science Foundation, San Francisco, 2006, workshop IV

This phase includes:

- giving students time to consolidate ideas and decide how to communicate what they have learned to others
- encouraging students to build upon each others' ideas, consider alternative explanations, make connections between their explanations and existing scientific knowledge to arrive at an understanding of key scientific concepts
- having the teacher, as facilitator, summarize key science concepts by drawing upon ideas presented by students.

Different Kinds of Inquiry

The rationale for our approach is that Inquiry is important in Science and in ESD, so the inquiry skills that children develop in one area can be applied in the other. We recognize that there are different kinds of inquiry that might be appropriate for exploring different kinds of questions [8].

Observing over time - *student observe or measure how one variable changes over time*

Identifying and classifying - *students identify features or tests that help them to distinguish similarities and differences between examples*

Pattern seeking - *students observe and record phenomena, carry out surveys or collect data from secondary sources, and then identify relationships between the data in their findings*

Research - *students use secondary sources of evidence to answer their questions*

Comparative and fair testing - *students identify the effect of changing one variable on another whilst attempting to keep other variables constant*

Within any particular activity or lesson the teacher may focus on the development of particular skills which are needed to carry out the inquiry. In the table over the page we list (horizontally) a range of skills and indicate with shading which are most likely to be appropriate within each of the types of inquiry listed above.

8 Turner, Keogh, Naylor and Lawrence (2011) *'It's not fair or is it?'* Millgate House Education and Association for Science Education IBSN 978-9562646-0-2

	Observing: identifying similarities and differences, classifying, trying to make sense of a phenomenon or raising a question	Questioning and making predictions based on a possible explanation or hypothesis	Planning: designing an investigation to test predictions, determining what constitutes evidence	Gathering and recording data using appropriate tools ensuring accuracy	Analysing & interpreting data: comparing outcome to predicted result	Developing explanations: based on the evidence	Reporting and evaluating findings: justifying explanations, recognising why evidence is important	Making connections with scientific knowledge: thinking critically to link evidence and explanations, generalizing to a wider range of phenomena
Observing over time								
Identifying and classifying								
Pattern seeking								
Research								
Compa-rative and fair testing								

Maps: flexible planning tools

Maps are graphic representations of thoughts, knowledge and ideas about a specific topic and their relationships. The use of maps was suggested by the challenges of developing the topic of everyday objects through the life story/cycle approach and the perspective of ESD.

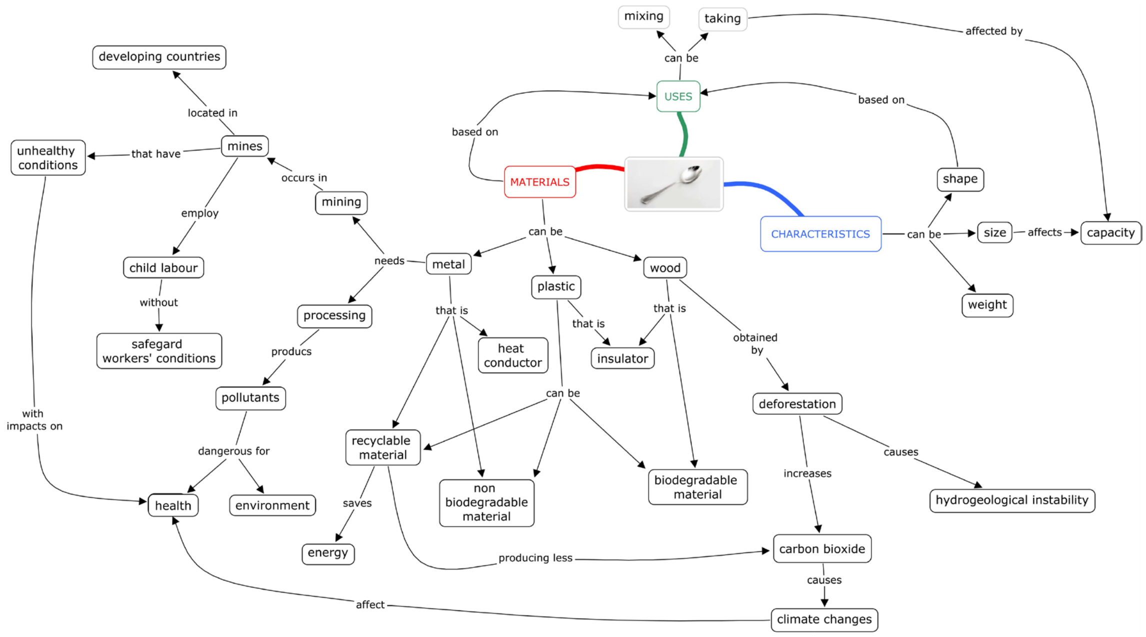
How can we deal with the complexity that emerges when the components of life cycle (past, present and future) are connected with the dimensions of sustainability (environmental, economical and social)? How can we hold on to the whole picture of all those elements together? These questions led to the use of concept and mind maps both during the design of the learning activities and for students' assessment.

One of the strengths of maps is that they are useful for cooperative work: drawing a map in a group is easier than writing a text in a group. Furthermore, they can be easily shared among different working groups, either as physical objects or through appropriate software that enables wide socialization on the Web[9]. The network of a map is the result of naive and structured knowledge, memories and emotions related to them. So different people might draw various maps on the same topic. In fact, the same issue can be seen from different points of view, also depending on the contexts; for this reason, there aren't 'right' or 'wrong' maps, but only different ones.

Concept maps are aimed at clarifying the knowledge, models of explanation and reasoning that an individual has in relation to a given topic. Their connected structure makes it possible to simultaneously highlight all the relationships between the different issues dealt with. In the case of the everyday object, these are the dimensions of sustainability and the phases of the life cycle. You can see examples of maps being used in planning activities about particular objects in Part 3 of the Handbook. In addition, concept maps fit well with the need to approach the complexity that is a feature of real situations and issues related to sustainability. Finally, they are open, dynamic and expanding representations which can incorporate new ideas or any changes in the initial scheme.

Mind maps are used to visualize a sequence of ideas. They are built through logical-associative relationships, emerging from the subjectivity and creativity of the author. They have a radiant structure which links ideas using a non linear, emotional and associational logic. Mind maps involve more different skills and cognitive styles than a verbal text. They stimulate individual's reflection on his/her thoughts and knowledge development in a personal and original way, avoiding rote memorization of ideas.

9 For example Cmap, http://cmap.ihmc.us/



An example of a map about spoons, that is a blend between a concept map and a mind map.

Science content

Students' understanding of everyday objects will be enhanced by developing knowledge and understanding of a number of key aspects of scientific knowledge and understanding. Teachers will be able to judge appropriateness depending on the students' age and local or national curriculum expectations.

Some key aspects of science needed to support work with everyday objects include the following.

1. Objects are made from different materials

Young children may:

- have difficulty distinguishing between objects and the materials they are made from (for example saying that a bicycle is 'made from' handlebars, seat, pedals and chain)
- focus on surface features and characteristics such as colour or texture, or on possible uses of the objects rather than the materials they are made from.

In some cases material composition may not be obvious as objects may be painted or coated with other substances.

They need to :

- develop awareness of different types of materials including metal, plastic, glass, wood, china, fabric, paper.

Older students need to:

- have some understanding that terms such as 'metal', 'plastic' or 'wood' describe groups of materials, rather than one particular material.

2. Properties of Materials

Young children need to:

- develop understanding that different materials have different properties such as flexibility, hardness and strength
- be able to classify objects and to describe them as being made from materials such as metal, plastic, glass, wood, china, or fabric.

Older students should:

- develop understanding that materials described by terms such as 'metal' (eg aluminum, and steel) may share particular properties or characteristics, but differ in other ways
- develop awareness that the selection of materials for making objects is often partly based on their particular properties.

3. Change in Materials

Younger children may experience difficulty recognizing materials which have been changed in some physical way such as by crushing or rolling and may consider them to be made of a different material.

They need to develop understanding that :

- materials can be changed into different forms such as powders or foils
- different forms of the same material may have some different and some common properties.

Older students need to have some understanding that:

- materials will have been changed to make objects

- some materials occur naturally and may be purified or processed before use and others are made by permanently changing the raw materials
- some materials can be changed permanently by heating but for other materials the changes can be reversed by cooling
- changes to materials may require water, other chemicals and heat or electrical energy
- changes to materials may produce by-products which might be useful or might pollute air or water.

Cross curricular links

A focus on Everyday Objects lends itself to links with other areas of the curriculum. Below are a few examples, based on cups: similar ideas could easily be developed with other objects.

History and geography: students might explore how people at different times in history, or in different parts of the world, have solved the problem of making containers for drinks using the raw materials and the technology available to them.

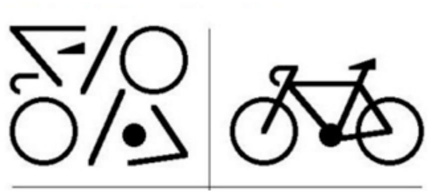
Design and technology: making their own cups from different materials will give students greater appreciation of the properties of those materials, and the processes that might be involved in commercial manufacture. Drinks containers made for particular purposes, such as folding cups and bottles for walkers and campers, or other cups designed to be used 'on the move', can provide further ideas about design.

Creative writing and drama: a specific cup can become the starting point for imagining and describing the person who owned and used it. Extending that idea by considering how two of the 'cup characters' students have described might meet is a starting point for a developing story.

Mathematics: the capacity of cups of different shapes can be difficult to judge, and so questioning which holds more can be the basis for an interesting investigation. The different sizes of drinks offered by coffee shops can also raise questions about value for money.

Working with complexity

Our aim is to help students to develop an holistic approach that encompasses knowledge of the science content, as well as understanding of the complexity of the environmental, social and economic dimensions. A complex system is not constituted merely by the sum of its components, but also by the intricate relationships between them. From these relationships new properties emerge.



A bicycle is something different from the sum of its parts

A common approach in IBSE is to design 'fair tests' by controlling variables to focus only on one aspect of a situation. For example, if we want to compare how waterproof different materials are we need to test them under the same conditions, using equal quantities of water. However, an important feature of inquiry in ESD is that it involves thinking about a range of different factors to make informed decisions. This is challenging for students (for example, see the lesson 'The cost of cups' in Part 3 on page 35). It is often tempting to simplify issues and reduce complexity in order to make them more accessible to students. This may lead to simplistic responses, and ultimately to behaviours which are ineffective. In our approach we are trying to support students to consider multiple dimensions of problems, in ways that are appropriate for them, so as to promote in-depth reflection on the links between science, economic, environmental and social factors. These can be seen as key skills for dealing with many of the problems of the future.

A simplified response to a complex problem

The statement below was seen on posters made by school students on display in washrooms in a US National Park.

> Using electric dryers instead of paper towels saves 17 trees per year.

Clearly the intention was to focus attention on the importance of trees in the environment, and the apparent wastefulness of cutting them down to provide towels to dry peoples' hands.

However, the statement raises a number of questions which might call into question whether electric dryers are the 'best' choice.

About paper towels	About electric dryers	About the choices
Does this mean 17 trees if dryers are used in this national park? Or in the USA? Or in the whole world?	How is the electricity produced? What resources does that use?	Which works best for drying your hands?
Can paper towels be made from recycled paper? Can they be recycled after they have been used?	What are the dryers made from? Can those materials be recycled?	Which is more hygienic?
Can new trees be planted to replace those that are cut down? How long would it take for them to grow?	What happens when they break down? How long do they last?	What are the relative economic costs of providing paper towels or electric dryers?

The 'best' choice may depend on whether the main concern is about economic cost, about environmental impact or about hygiene. Also, changes in technology may mean that the 'best' choice will be different in the future. This is why we emphasise the importance of developing the inquiry skills to approach decisions, rather than offering simplified answers.

Resources

Visitors and visits

Opportunities for developing students' perspectives beyond the classroom might involve the school and local communities by arranging opportunities for students to talk with visitors to the school, or to make appropriate visits.

Possible visitors

- People who make decisions about the choice and implications of the use of particular objects such as :
  - the manager of the school kitchen
  - school finance manager
  - owners / managers of small local businesses (cafes, leisure centres) which use the everyday objects.
- People who manufacture, distribute or sell the everyday objects who might explain, or answer questions about, how the objects are made.
- People who are involved in the collection and treatment of waste to explain what happens to everyday objects when they are placed in general waste bins or recycling bins. These might include:
  - local waste companies who deal with general waste
  - organisers of big events (fetes, fairs, concerts, sports events)
  - local community representatives who may have concerns about disposal of used everyday objects and the effects of litter in the community
  - local, regional or national parliamentary representatives with an interest in environmental issues, waste management, recycling.

Possible visits

- Small local businesses that use the particular objects eg cafes, leisure centres.

- Small manufacturers or craftspeople making the objects eg potters, small shoe makers, clothing manufacturers.
- Re-use or upcycling groups.
- Recycling centres.

Classroom resources

Here are some suggestions to help you locate appropriate resources to support work with Everyday Objects, based on general categories. The specific examples we have included are all in English but similar sources will exist in other languages. More specific examples are given within the 'Cups' and 'Sneakers' sections in Part 3.

Curriculum materials such as science texbooks at primary and secondary level may provide guidance establishing and developing students's understanding of materials and the reversible and irreversible changes undergone by materials when objects are made.

Concept Cartoons (either published by Millgate House Education (www.millgatehouse.co.uk) or home made) can be very useful for helping students to consider scientific content and choices about the use of objects.

National and international organisations which focus on developing innovative approaches to sustainability, may offer perspectives on the stories of where objects come from and what might happen to the objects or materials after use. Examples include

- **The Ellen McArthur Foundation** (www.ellenmacarthusfoundation.org) which is concerned with ideas for a 'circular economy'.
- **Practical Action** (http://practicalaction.org), a charity that focuses on sustainable technology, produces educational resources about their projects.
- Environmental campaign groups such as **Treehugger** (www.treehugger.com).
- Environmental organisations aimed specifically at children such as **Eco Friendly Kids** (www.ecofriendlykids.co.uk).

Manufacturers' websites may include some explanation and pictures or videos of their manufacturing processes which would be helpful to support student's understanding of how objects are made.

Videos on YouTube, particularly the series 'How it is made,' may provide insights to both hand -crafted and industrial manufacturing processes for everyday objects.

Newspaper and magazine articles often focus on uses of materials for particular objects in relation to sustainability.

Local and national waste management companies and organisations may have information on their websites about aspects of recycling and waste disposal, and may also produce educational materials.

National, regional or local events focussed on waste management and recycling may be organized to engage and involve children, families and communities.

Part 3: Taking Everyday Objects into the Classroom

How to work with these materials

In Part 2 of the Handbook we presented the rationale and planning framework that underpin our approach to using Everyday Objects as a starting point for IBSE and ESD. To support you in using this framework, Part 3 contains examples of the use of this approach, based around two objects: Cups and Sneakers. Some further examples of lessons based on Bags are available on the SUSTAIN project website, but we also stress that the framework could be applied to other objects that are appropriate for your students. There is an introduction for each object suggesting the kinds of ideas that might be developed when working with it, a planning map and then some example lessons. The lessons based on Cups are aimed at primary schools (age 5 – 11) and those about Sneakers are aimed at secondary students (age 11 – 14).

These examples are presented either as lesson plans, or as descriptions of lessons or CPD sessions. Generally we have not been too prescriptive because we recognize that the approach needs to be adapted to suit particular circumstances. The ideas in the example lessons are starting points, but we have tried to present ideas here so that they can be adapted to other objects which might suit your own situation. We hope that you will use ideas from the examples in this section, alongside the general principles, suggestions and tools in Part 2, to develop a specific plan for your own classroom, or a CPD session.

Following through all the activity stages for any particular object will take time. Although it is possible to work through them all in a 3-6 hour CPD workshop, in the classroom you may need to spread the work over several lessons, depending on your confidence with IBSE and ESD. If you are not confident with these approaches you could, for instance, explore the object now with an IBSE focus, and the life story with an ESD focus. So it may be natural to separate these focuses into different lessons.

Indeed, if you are unfamiliar with IBSE and ESD you might initially focus attention on only one of these stages until you and your students become more confident with an inquiry-based approach.Similarly, you may want to focus on particular inquiry skills, or types of inquiry, as discussed in Part 2.

Activities about making choices may require less time than the other stages, but it is important that these opportunities are included in the students' experience. In this way you will gradually improve your confidence and competences in IBSE and ESD that will help you to acquire an integrated approach.

Selecting objects

This handbook contains examples of work with two Everyday Objects. However, the principles we are using could be applied to many others which might fit appropriately into your curriculum. When choosing objects to work with, you will need to consider several questions, including:

- Are the objects familiar to your students and easily available?
- Can you easily collect a range of different examples of the object? Differences might be in shape, size, materials, methods of construction etc.
- What scientific understanding, appropriate for your students, might you focus on when exploring this object?
- What other equipment would you need for the practical investigations?
- What prior experiences might your students have that you can build on?
- What kinds of inquiry will be possible?
- What inquiry skills can be developed?
- How can the life story of the object, or the life cycle of the materials, be described?
- Can environmental, economic and social/political issues be highlighted in the life story or life cycle in ways that are accessible to your students?
- What competencies on ESD can be developed?
- How accessible is information about the whole life story of the object?

CUPS: Primary age group

What is the potential for working with cups?

Cups are common and familiar objects. They are also relatively simple both in their functions, and in their construction, which makes them an accessible object even for very young students. It is easy to make a collection which includes a number of variables:

- material (china, plastic, paper/card, metal)
- shape
- size (this is particularly interesting with disposable cups from coffee shops)
- cups designed for hot or cold drinks
- cups with or without handles
- cups designed to be re-used, or to be disposable
- cups made in different parts of the world (this information is often on the base of the cup!)
- different colours, patterns, textures
- cups (particularly take-away cups) with and without lids.

Exploring the object now might focus on:

- properties of the materials used – weight, rigidity, strength
- insulation and heat loss or gain
- capacity, related to different shapes
- stability
- aspects of design – how comfortable is it to hold? Does it have a particular purpose, such as a folding cup for hiking or camping?

Before and after might focus on:

- the resources used in making different kinds of cups, and where those come from
- how and where cups are made
- how different cups can be re-used or re-cycled
- the relative economic and environmental costs of different kinds of reusable and disposable cups.

Making choices might focus on:

- litter caused by disposable cups, and the impact on the environment
- 'take away' cups as advertising materials
- the relative costs of washing and storing re-usable cups, compared to the costs of disposable cups
- how fashion and life-style choices affect our use of different cups.

Planning for lessons based on cups

Because there are so many variations available, it is not difficult to make a large collection of different cups. It is worth thinking about how you want to focus the activity in the classroom in order to decide how to choose which cups to present to the students.

The first decision is whether you want each group of students to work with a similar collection of cups, so that it is easier to bring the whole class together to compare what they are doing, or to have different groups working with different collections and so potentially exploring a wider range of inquiry questions.

The second decision is about how to put together the set of cups for each group of students. It is best to have more examples than there are students in each group, and enough to offer contrasts. For a group of 4 students, 7 – 10 examples would work well.

The choice of examples that you put together is a way of 'controlling variables' and can focus the kinds of questions that the students might be encouraged to explore (see 'Which cup would you choose ?' on page 26)

Here are some possibilities:

- if you want to focus on comparing and classifying, then a mixture of cups is best
- cups for cold drinks might lead to a focus on heat gain rather than heat loss
- cups of similar size, but made from different materials, might focus attention on the properties of those materials
- cups of different shapes could raise questions about capacity and about heat loss
- cups of similar shape but different sizes might also raise questions about capacity, and about value for money if they are cups in which drinks are sold
- choosing just one material will reduce the variation and help to focus attention on other aspects of design and construction.

Resources you might need

For before and after and making choices:

These online resources are from websites in English : similar sites can probably be found in other languages.

These **potters and cup manufacturing companies** have some explanation and pictures of their manufacturing processes on their websites.

Dunoon

http://www.dunoonmugs.co.uk/Manufacturing.html

Aston pottery

http://www.astonpottery.co.uk/content/manufacture

Emerson Creek pottery

http://www.emersoncreekpottery.com/ceramic-mugprocess.shtml

Lakeside pottery

http://www.lakesidepottery.com/Pages/Pottery-tips/throwing-custom-made-mug.htm

'How it's made' videos on YouTube

Paper cups

(https://www.youtube.com/watch?v=dtnp9KwvCnI)

Plastic cups

(https://www.youtube.com/watch?v=Ynz76a34sKs)

Ceramic cups

(https://www.youtube.com/watch?v=roPYlpdM6sU_

Alternatives to ceramic, plastic or paper :

Products made from bagasse

http://www.vegware.com/index.php?act=viewCat&-catId=4

Bamboo cups

http://www.boobalou.co.uk/product/ecoffee-cup-organic-bamboo-fibre/#.V1A-wkoUW70

Recycling and waste

Simply cups is a recycling company for paper cups

http://www.simplycups.co.uk/the-process/

Save a cup recycles both paper and plastic cups

http://www.save-a-cup.co.uk/index.php

Cups: Summary Information (adult level)

Here we summarise some background information that may be useful for teachers when planning lessons based on cups.

Cups can be made from a variety of different materials (and sometimes a combination of materials). They are generally designed either to be reused, or to be disposable.

Reusable cups

To be reused, cups must be washed, using hot water and detergent, which has economic and environmental consequences.

Ceramic cups are made from a combination of clay and glaze. They must be fired at high temperatures in a kiln during manufacture, so a lot of energy is used. Ceramic cups can be microwaved and refrigerated, however they are fragile and need to be handled carefully to ensure a long life. They are relatively heavy and bulky to transport. The ceramic shards do not decompose readily and do not produce significant greenhouse gas emissions when put into landfill.

Rigid plastic cups are durable and can be reused many times. They are made from oil, are non-biodegradable and will remain intact in landfills for hundreds of years.

Bamboo cups can, the manufacturers claim, be reused for about 2 years. They are made in China (where bamboo grows) but are light and compact to transport. When they do break they can be composted.

Disposable cups

These are generally light in weight and take up little room when packaged, so the distribution costs are much less than for ceramic, glass or metal cups.

Paper cups generally are manufactured using 100% bleached virgin paperboard because recycled paper isn't strong enough to hold a liquid. Manufacturing paper cups is extremely resource intensive; it requires harvesting trees and using machines to turn the wood into wood chips. The chips are heavily washed to remove any dirt, and then mixed with more water and processed. The resulting paper pulp is dried and the fibers are pressed together to make paper. The entire process requires a substantial amount of water, energy and a lot of trees. Paper is recyclable; however paper cups must be coated with a polyethylene plastic to prevent damage to the cups from hot beverages. Separating the polyethylene shell from the paper is complex, and uses more energy, and so often these cups end up in landfills where they eventually decompose, releasing carbon dioxide and methane.

Single use plastic cups are made from oil. They can be re-cycled, but often end in landfill, where they can remain intact for hundreds of years.

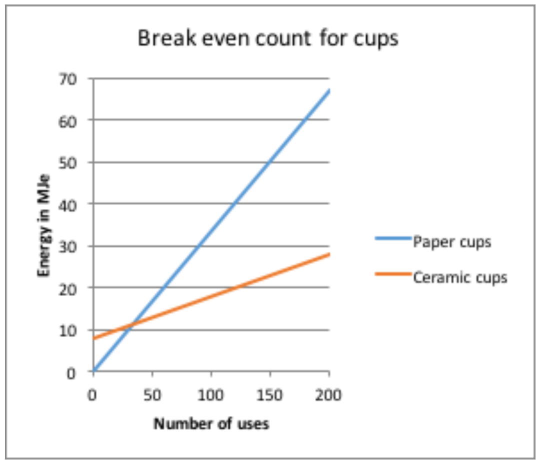
Polystyrene foam cups can be washed and reused but are seldom reused in practice. They can be recycled but this is generally not done due to lack of incentives to invest in compactors and the logistical systems required for recycling polystyrene economically. Unlike paper cups, polystyrene foam cups are non-biodegradable and will remain intact in landfills for hundreds of years.

Cups made from vegetable matter called bagasse, which is a by-product of sugar cane, are becoming available. These can be composted with food waste.

Comparing environmental and economic impact

Making a ceramic cup uses a lot more energy than making a disposable cup, mainly because of the very high temperatures that are needed when it is fired in the kiln. However, making a comparison between individual cups is misleading, as ceramic cups are re-used while disposable cups are only used once. One source suggests that on average a ceramic cup is used 2,000 times before it breaks. So to make a fair comparison we need to look at the energy needed to make 2000 disposable cups compared to the energy used to make one ceramic cup. A similar comparison can be made for the cost of different types of cups.

The graph below shows the energy required for different numbers of drinks using three kinds of cups. For small numbers of drinks ceramic cups use a lot more energy, but at 31 drinks the energy used to make paper cups and ceramic cups is the same. This is called a 'break even count'. For more drinks, papers cups use much more energy. The graph also compares polystyrene cups. The 'break even count' for paper and polystyrene cups is very close to zero because of the relatively small amounts of energy needed to make individual cups.



- Reusable plastic cups need to be reused 10 times to be more sustainable than single use plastic, 14 times to be more sustainable than bagasse, or 17 times to be more sustainable than paper.
- To break-even with paper cups in energy use, ceramic cups have to be used 118 times, glass 15 times, reusable plastic 17 times, and stainless steel 24 times.
- Research concluded you'd need to use your ceramic mug 1,006 times for it to break even (in energy terms) with its polystyrene competitor. This is largely because kilns used to make ceramic cups are very energy intensive, because using a dishwasher to wash the cup also uses energy, and because cups get broken.

You can see an example of how children might be introduced to considering the relative cost of disposable and reusable cups in the lesson 'The cost of cups').

Young children's ideas about cups

The following ideas were provided by groups of 6-year old children discussing a collection of cups which included ceramic cups of different sizes, plastic cups with and without handles, glass cups and paper cups, one of which had a lid. Their comments reflect their familiarity with a variety of cups, and with the language of 'recycling', but also suggest that we should not make assumptions about their understanding of things that are beyond their immediate experiences.

The children were quick to recognise aspects of the appearance of the cups (size, handles, colours and patterns) and also commented on the materials the cups were made from. However they claimed that the ceramic cups were made of 'white glass', and some of them thought that the paper cups were made from plastic.

They were able to make suggestions about which cups might be best for hot drinks:

- *the one with a lid*
- *the ones that come from cafes (i.e. the paper cups)*
- *not the ones that are 'see through' glass*

They also had suggestions about which would be best to take a drink outside:

- *the one with the lid because of would not spill*
- *the plastic ones would not break if you drop them, but the glass ones would*
- *ones with a handle are safer to carry*

One of the cups had a recycling symbol on it, and the children noticed this. They were familiar with hearing adults talk about recycling, and seeing recycling bins at school and at home. However they had some different ideas about what recycling means:

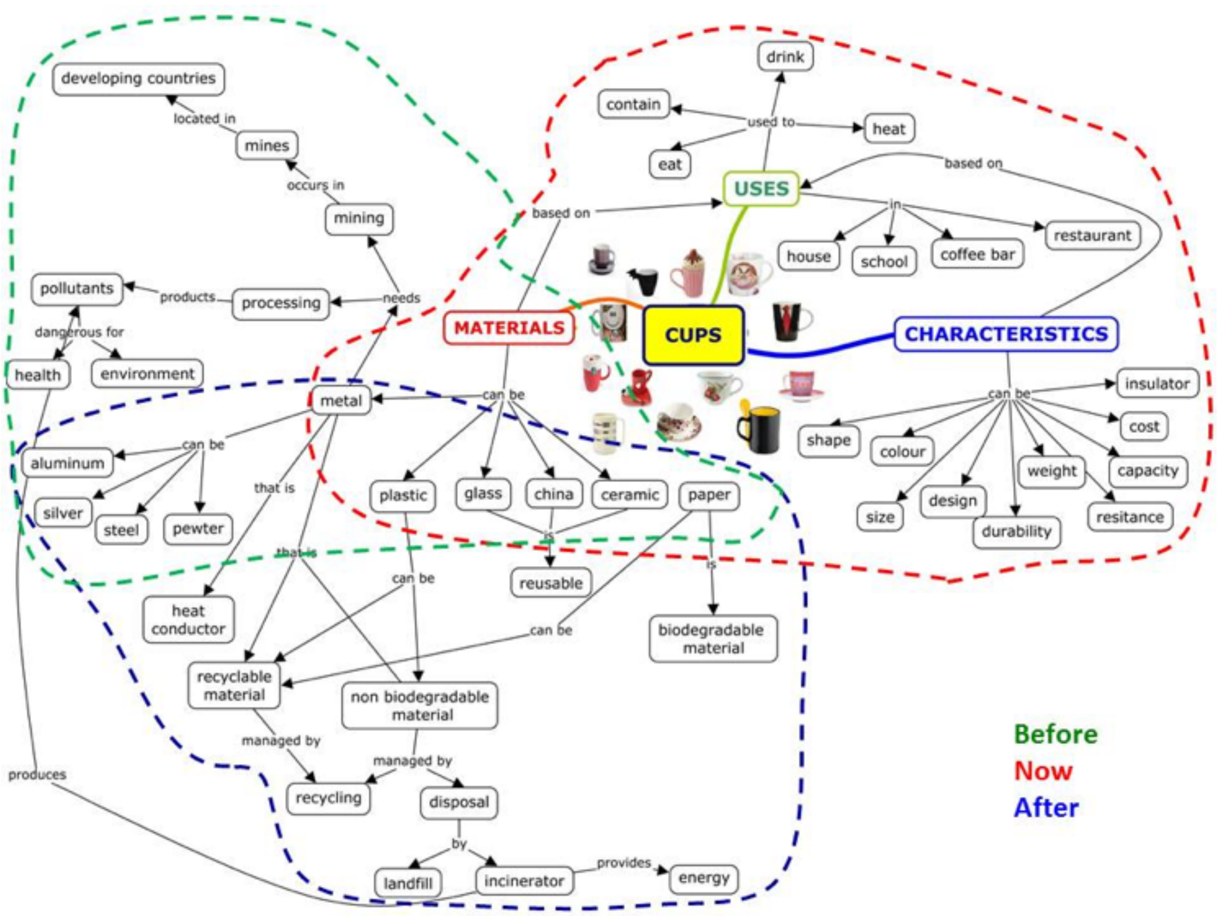
- *it means when you don't want it anymore you can recycle it, and someone else can use it to build something*
- *the recycling people make it into something else in a machine*
- *recycle means you can use it again lots of times, but you have to wash it in between because of germs*

Planning Map for Cups

This is an example of a map which has been used as a tool for thinking about cups. This includes:

- considering aspects of their present form and use
- the materials they are made from
- where the material might have come from
- what might happen to the cups (and the materials they are made from) after use.

In this example there is an indication that cups may be made of different materials. However the 'before' and 'after' sections have only been completed for metal cups.



Example lessons

In the following sections there are some examples of lessons based on cups.

Lesson title	Age range	Life story phase
Which cup would you choose ?	CPD for primary teachers	exploring the object now
Cups – what's the story ?	CPD for primary teachers	before and after
Making choices at the cafe	CPD for primary teachers	making choices
Sorting cups	7-8 yearss	exploring the object now
Different stories	8-9 years	before and after, making choices
The cost of cups	8-9 years (or older)	making choices

Which cup would you choose?

Age range: CPD session for Primary teachers

Life story phase: *exploring the object now*

Inquiry skills:

Observing: *identifying similarities and differences, classifying, trying to make sense of a phenomenon or raising a question*

Questioning and making predictions: *based on a possible explanation or hypothesis*

Planning: *designing an investigation to test predictions, determining what constitutes evidence*

Gathering and recording data: *using appropriate tools, ensuring accuracy*

Analysing and interpreting data: *comparing outcome to predicted result*

Developing explanations: *based on the evidence*

Reporting and evaluating findings: *justifying explanations, recognising why evidence is important*

Making connections with scientific knowledge: *thinking critically to link evidence and explanations, generalizing to a wider range of phenomena*

Scientific content:

properties of materials

insulation and heat loss/gain

capacity, surface area and volume

Estimated time: 90 minutes

Resources:

- a collection of cups of different kinds, particularly made from different materials
- water, kettles and ice
- thermometers and data loggers
- measuring jugs and cylinders

Activity 1: Starter (10 minutes)

Initially the teachers worked in groups of four. The session started with a discussion of the 'everyday objects' that everyone had in their bags or pockets. Each participant was asked to show one object and to say why they had chosen to own it. Reasons included colour, design, size, efficiency, cost, convenience and sentimental reasons (given as a gift). The workshop leaders used this discussion to introduce the idea of the kinds of choices we make about everyday objects, and the idea that such choices may have wider consequences.

Activity 2: Observing similarities and differences, raising questions (20 minutes)

Each group was given a different set of cups, chosen to suggest a particular focus:

- A set of china cups of similar size but different shapes
- A set of cups designed for cold drinks
- A set of similar sized cups made from different materials
- A set of small cups
- A set of take-away coffee cups of different sizes

The teachers were asked to look carefully at their collection of cups, noticing similarities and differences. Some did this by sorting them into sets and then describing what each set had in common.

While they were looking at the cups, they were encouraged to think of questions that they, or their pupils, might ask and to record these on Post-its. All the questions were collected on a board so that they could be shared. Similar questions were grouped together.

Questions might arise spontaneously (which one holds most?) or be prompted by an intervention (which would you choose if you wanted a really big drink?). It may be tempting to provide pupils with suitable questions, but it is important that they have opportunities to develop skills both in asking questions and deciding which are appropriate to explore.

In this workshop teachers raised many different kinds of questions:

- About properties of the cups (What is it made from? Which holds most? Which is the heaviest? Is it flexible? Would it break easily?)
- About aspects of design (Why do some have handles? Why do some paper cups have ridges? Why are the cups different shapes?)
- About how the cup functions (Which will keep the drink hottest (or coldest)? Which is most comfortable to carry?)
- About the manufacturing process (Where was it made? How are the handles attached?)

Activity 3: Investigating questions (60 minutes)

Each group was asked to choose one question to investigate. A range of resources was provided and the teachers were given a free choice of which to use in their investigations.

For teachers and pupils who were less familiar with IBSE it would have been important to spend time discussing which were suitable inquiry questions, and also how practical investigations could be designed. It is also important to encourage children to make predictions, and to give the reasons for these, before the investigations begin.

The activities of some of the groups are described below.

A set of china cups of similar size but different shapes: which one holds most?

The teachers found it hard to predict which of this set of cups held the most and so decided to measure the capacity of each carefully using a large jug of water and a measuring cylinder. They collected the measurements by recording them on Post-its and used a display of the cups themselves to record their findings. They were surprised that two of the cups had the same capacity, and thought that it would make a good challenge for the pupils to predict and test which two cups from a collection held the same amount.

A set of similar sized cups made from different materials: which is the best insulator?

Although the cups in their collection were designed for hot drinks, this group decided to test them for insulation using ice cubes. They added the same number of ice cubes to each cup, and then measured how much water was in each cup after a period of time. They found that they needed to use narrow measuring cylinders, as the quantities of water were small, and also to add a drop of food colouring to the water to make is easier to read the height.

Testing insulation by melting ice

A set of take-away coffee cups of different sizes: why do some cups have ridges?

This group made the prediction that having ridges on the outside of the cup improved insulation (by trapping air) and so would keep the outside of the cup cooler and more comfortable to hold. They put the same amount of water at the same temperature into two different cups and used dataloggers to measure how the temperature of the outside of the cup changed. This was more difficult to do than they had expected, and they did not get a clear result.

A set of small cups: which will keep the drink hottest?

This group decided to test four small cups of different shapes made from different materials. They filled each with warm water, and used thermometers to measure the temperature at regular intervals over a period of time.

Checking the temperature at regular intervals

The teachers were anxious to design a fair test, and came across several issues for discussion which illustrate the potential complexity in even a fairly simple experiment. Should they fill each cup, or put the same volume of water into each? The material the cup was made from was not the only variable, as the cups were also different in size. In particular the area of the top of the cups varied, and they realized that the surface area of the liquid would affect how it cooled. This made it difficult to predict which would be the most effective insulator.

Cups – what's the story?

Age range: CPD session for Primary teachers

Life story phase: *the object's past and future*

Inquiry skills:

Questioning and making predictions: *based on a possible explanation or hypothesis*

Gathering and recording data: *using appropriate tools, ensuring accuracy*

Analysing and interpreting data: *comparing outcome to predicted result*

Making connections with scientific knowledge: *thinking critically to link evidence and explanations, generalizing to a wider range of phenomena*

Scientific content:

properties of materials

changes to materials

Dimensions of sustainability:

Economic

Environmental

Estimated time: 30 minutes

Resources:

a variety of cups, as in previous session

large sheets of paper, coloured pens

text and video resources related to the manufacture and re-cycling of different kinds of cups

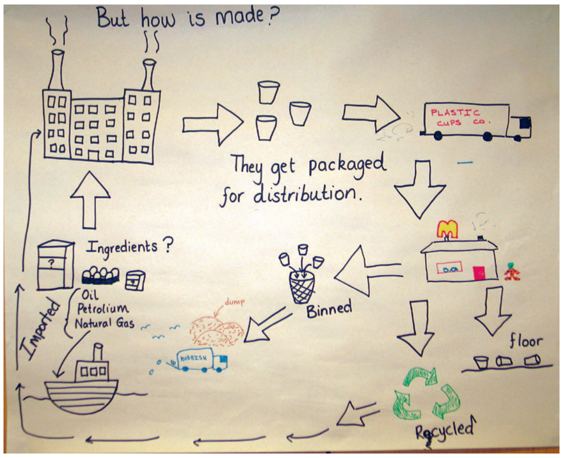
Activity 1: Starter (10 minutes)

In their groups, the teachers were asked to choose one cup from the collection on their table that they particularly liked, and discuss the reasons for their choice. A slide with stimulus questions was then used to encourage them to think about the life story of that that cup.

Before	After
▪ Where did the cup come from? ▪ What is it made from? ▪ Where did the materials come from? ▪ How were they changed in the manufacturing process? ▪ Who made it? ▪ Where was it made? ▪ Why was it made there?	▪ What will happen after you finish your drink? ▪ Will it be used again? ▪ If so, how will it be cleaned? ▪ What resources will that use? ▪ If not, what will happen? ▪ If it can be recycled, what does that involve? ▪ How else might it be disposed of?

Activity 2: Telling a life story (20 minutes)

As a way of recording their discussion, they were asked to produce a poster showing the life story of their cup, including any information that they knew or could find from the available resources, and also questions that they might want to explore further.



Life story for a disposable cup from Macdonalds

Making choices at the cafe

Age range: CPD session for Primary teachers

Life story phase: *Making choices*

Inquiry skills:

Questioning and making predictions: *based on a possible explanation or hypothesis*

Analysing and interpreting data: *comparing outcome to predicted result*

Developing explanations: *based on the evidence*

Reporting and evaluating findings: *justifying explanations, recognising why evidence is important*

Making connections with scientific knowledge: *thinking critically to link evid*ence and explanations, generalizing to a wider range of phenomena

Scientific content:

properties of materials

changes to materials

Dimensions of sustainability:

Economic
Environmental
Social

Estimated time: 30 minutes

Resources:

- Scenario descriptions for each role (café owner, disposable cup supplier, ceramic cup supplier)
- Text and video resources (from internet) relating to arguments about the implication of using different kinds of cups

Activity 1: Preparing roles (20 minutes)

For this activity the teachers worked in groups of 6 or 7. They were given the scenario shown below, and asked to divide up into small groups to take each of three roles: the café owners, a company selling ceramic cups, a company selling disposable cups.

<table>
<tr><td colspan="3">City Café is preparing to open. It is a small, stylish café on a busy high street. It will serve a limited range of drinks, all of which will be 'Fairtrade' brands. Because the space is small, the owners aim to have a rapid turnover of customers.</td></tr>
<tr><td>Your role: café owners</td><td>Your role: supplier of disposable cups</td><td>Your role: supplier of ceramic cups</td></tr>
<tr><td>You are the owners of the City Café. You need to make a choice about the equipment for your café. You are concerned about environmental issues, and want to run your café in a sustainable way.

But it is a business, and you are also concerned about costs, and about convenience and efficiency. In order to attract customers, you also need to make your café look attractive and stylish.

You need to consider all the arguments made by the suppliers before making your choices.</td><td>You want to persuade the City Café owners that disposable cups are the best option for their business.

You need to make your arguments in terms of cost, convenience and efficiency, but also consider environmental and social factors which might influence their choices.</td><td>You want to persuade the City Café owners that ceramic cups are the best option for their business.

You need to make your arguments in terms of cost, convenience and efficiency, but also consider environmental and social factors which might influence their choices.</td></tr>
</table>

Using the materials provided, those taking the roles of the sales companies prepared the case they would make to the owners, and the owners discussed their priorities and constraints, and planned the questions they might ask.

The resources provided came from a variety of sources, including manufacturers, environmental campaigners and news media, and presented a range of views and arguments. This ensured that there was no obvious 'right answer', and meant that there was a need for critical questioning about the evidence presented, including the date when each was published. For children these sources would need editing to make them more accessible: see the examples of information cards on page 35.

Activity 2: The role play (10 minutes)

Within each group, those representing the two companies were allowed a short time to make their sales pitch, and the owners posed their questions. The teachers enjoyed the activity, and became quite involved in their different roles. The discussions covered a number of different environmental, economic and social aspects:

- the initial costs of buying cups
- the need for storage space, and for facilities to wash ceramic cups
- the staffing implications, and how this might affect prices in the cafe
- the possibility of litter from disposable cups, and arrangements for collecting them for re-cycling
- the overall environmental impact of either choice
- the style of the café, and the types of customers they hoped to attract (ceramic cups could be more stylish)
- the need for a rapid turn-over of customers, and how efficiently they could be served
- the advertising value of customers taking branded disposable cups out into the shopping centre
- the overall 'costs' to the café owner, the consumer and the environment.

In the end the café owners in all three role-play groups decided that both kinds of cups had advantages and disadvantages, and that their best option was to offer both in order to maximize their potential sales to different kinds of customers.

School students would probably not address all of these issues in their discussions. It might be helpful to have a brain-storming session before beginning the role play to make a collection of possible issues to consider. For example, students may not be aware of all the different jobs that have to be done in a café, such as clearing tables and keeping the café clean and tidy. You might need to have some discussion of this before the role play begins.

For adults and older students, providing detail in the scenario can add to the challenges. Younger students may need less detailed descriptions to help them focus on key issues. Some alternative café scenarios are given below.

Coffee Bean is opening in the centre of a busy village, close to the square where there is a weekly market. The building is old but quite spacious, with three different areas inside. As well as drinks, it will serve light meals throughout the day. It aims to attract the whole range of people who come to the village, including retired people and families with young children.

College Cup is about to open an outlets on a College campus on one of the main walk-ways between teaching blocks. it will sell drinks and snacks. The College has a strong 'green' policy. However, there is already a problem on campus about litter from several nearby 'fast food' outlets.

In a school the headteacher has to make a choice between using reusable plastic cups or disposable paper ones in the dining room for water and other cold drinks. Sales people are trying to sell the school different cups.The staff who serve the drinks and tidy up, parents and students all have opinions about which is best.

Sorting cups

Age range: 7-8 year olds

Life story phase: *exploring the object now*

Inquiry skills:

Observing: *identifying similarities and differences, classifying, trying to make sense of a phenomenon or raising a question*

Questioning and making predictions: *based on a possible explanation or hypothesis*

Scientific content:

properties of materials

capacity, surface area and volume

Estimated time: 60 minutes

Resources:

- a collection of cups of different kinds, particularly made from different materials
- large sheets of paper and coloured pens

Activity 1: Starter (15 minutes)

Maria chose to focus on observing, sorting and classifying in this lesson. The class were organized in small groups of 2-4 children, and each had a collection of about 6 different cups. Each group had a fairly similar mix of different kinds of cups.

The lesson began with the children exploring the cups on their table, and initially Maria moved around the groups to listen to their discussion. After a few minutes she drew the class together and asked them for examples of things they had noticed about the cups. Their comments covered a variety of features:

- *Some are heavier than others*
- *Some have writing on the bottom, which shows different information on different cups (where it was made, the name of the manufacturer)*
- *The cups are made from different materials (plastic, china)*
- *Only one of ours has a handle*
- *There is one you can squeeze (made from flexible plastic)*
- *They are different sizes*
- *One is a cylinder, but others are different shapes*
- *One has a lid*

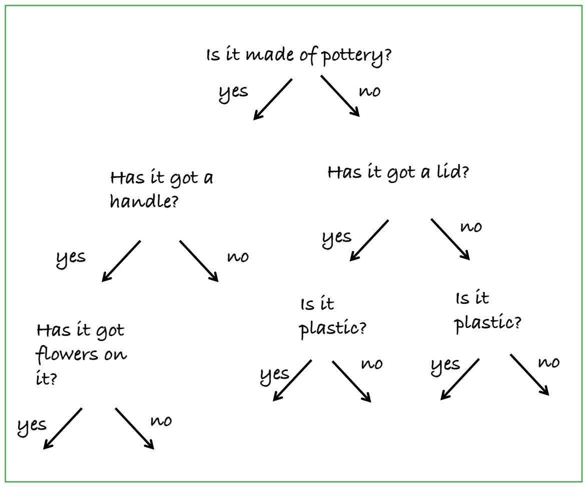
Maria then asked the students to think about what the cups might be used for. First she asked which they thought would be best for a hot drink, to stop it going cold. Some students chose a paper cup with a lid. Others thought that one of the ceramic cups would be good because it was thick. Maria then asked which would be good if you wanted to take a drink outside. Suggestions included:

- *One with a lid so that it won't spill*
- *A plastic one, so that if you drop it, it won't break*
- *One with a big handle so that you can hold it easily*
- *One made from card which won't break – though it might tip over*

Activity 2: Sorting the cups (30 minutes)

Maria now introduced the idea of sorting trees, and challenged the children to ask questions which would divide their collection of cups into separate groups. Each group of children was given a large sheet of paper to record the questions they asked to sort the cups. For the groups that needed more support, Maria had put a starting question onto their sheets: Is it made from pottery?

At each stage the children had to add a question which could be answered 'yes' or 'no', which would split the remaining cups into two groups, until each cup was separated.



The idea of sorting trees was fairly new to the students, and this was the first time they had tried to create one for themselves. Some students found it difficult to frame all their questions so that they could be answered 'yes' or 'no'. Some groups realized that they needed to ask the same question in two places, as in the example above.

As students become more familiar with sorting trees it will be important to introduce the idea that it is more efficient to consider the order in which questions are asked to avoid the need for repetitions. In this case, focussing on questions about the material the cup is made from before introducing other attributes would have simplified the tree.

Activity 3: Identifying cups (15 minutes)

In the last part of the lesson Maria gathered the students around one table where the group had made a clear sorting tree. She pointed to the end of one of the arrows and asked: which cup could go here? The students had to look at the set of cups on the table and try to identify one that would fit the description. For example: it is not made from pottery, it has a lid, it is not plastic.

The students then went back to their own tables and played the same game, with appropriate support from Maria.

Different stories

Age range: 8-9 years (variations are suggested for other age groups)

Life story phase: *the object's past and future, making choices*

Inquiry skills:

Questioning and making predictions: *based on a possible explanation or hypothesis*

Analysing and interpreting data: *comparing outcome to predicted result*

Developing explanations: based on the evidence

Reporting and evaluating findings: *justifying explanations, recognising why evidence is important*

Making connections with scientific knowledge: *thinking critically to link evidence and explanations, generalizing to a wider range of phenomena*

Scientific content:

properties of materials

changes to materials

Dimensions of sustainability

environmental

social

Estimated time: 90 minutes (the description below is of a single lesson, but this set of activities could be divided into two or three separate lessons)

Resources:

- Summary information sheet (Pages 23-24 in the introduction to the CUPS section) from different sources (for the teacher)
- Information cards (for students) – examples included at the end of the lesson
- Ready-made signs saying 'shop', 'factory', 'truck' etc
- a collection of cups of different kinds, particularly made from different materials. It is worth making careful choices: some cups will carry information about where they were made, whether they can be re-cycled etc.

Ideally this lesson would follow an inquiry lesson in which children have explored the properties of the object. The aim is to move beyond students' everyday experience and imagination, and engage them in inquiry and researching evidence.

Activity 1: Starting the story (10 minutes)

Freya introduced the idea of telling the life story of an object, using a plastic cup as an example. She asked the students where they thought this cup came from.

As expected, the first response was from a shop. Adam immediately asked 'But where did the shop get it from?' and other students suggested that it was made in a factory. Freya next asked how the cup got from the factory to the shop, and Luke suggested it was put in a box, and then in a truck.

Using some ready-made cards, Freya began to build up an image of the life story on a large sheet of paper, adding lines to show the sequence.

The students found it quite hard to describe how they thought that the cup might have been made in the factory. It would have been useful at this point to show a video clip of plastic cups being made.

Freya then went on to explore the student's ideas about the material from which the cup was made. They were confident that it was plastic because even though it looked a bit like a ceramic cup, it was very light. Dani's first suggestion was that the plastic might come from plastic things that were put into the re-cycling bin. She had a sense that plastic things could somehow be broken up, and then made into something new.

Other students suggested places where plastic items might be found, such as in the sea or on the beach. However, their comments seemed to show some confusion between existing plastic items that had been thrown away as rubbish, and imagining that there might be natural sources of plastic in the ground or under the sea. Adam suggested that there might be 'plastic ore' in rocks, like metal.

Freya allowed the students to make suggestions, and then told them that plastic is made from oil, which is found under the ground, and sometimes under the sea. For these young students it was not appropriate to go into more detail.

Discussion like this will reveal some of the things that students already know, but also raise questions to which they (and the teacher) may not know the answers. This is an opportunity to introduce ideas about possible sources of information the students might research, and follow up in other lessons.

Activity 2: Developing a life story (20 minutes)

The students then worked in small groups. Freya chose to use just two different kinds of cups, so each group had either a ceramic cup or a paper cup. Their task was to make the life story of their cup, using some ready-made cards and adding their own comments. They also had information cards available, like those shown on page 35. They were encouraged to think about the materials from which the cups were made, and where those came from.

For older students it would have been appropriate to have some other text or video resources available so that they could research stages of the story. They might consider other resources, such as water, which might be needed in the manufacturing process, and the use of energy at different stages. If the information is available, students might think about where the cup was made, why it might have been made there, and how it has been transported.

Older students might also work with a wider range of cups.

The students who were looking at the story of ceramic cups already had some ideas about how pottery could be made by shaping clay on potter's wheel, and also that the clay had to be dried out to make it hard. They related the idea of a kiln to an oven in which the clay was 'cooked'. Some students also knew that clay is dug out of the ground.

Companies that manufacture ceramic cups, such as those listed in the Resources section above, may have useful information on their websites.

The groups working on the story of paper cups found telling that story more challenging. Although they knew that paper was made from trees, it was not easy for them to think about the different stages of the process; first how logs are made into paper and then how the paper is shaped to make cups. Freya planned to spend some time in a future lesson looking at these two different stages of manufacturing, alongside some input on how paper can be recycled.

The 'How it's made' videos on YouTube could be a useful resource.

Activity 3: comparing life stories (10 minutes)

Freya brought the class back together to compare the stories they had made about ceramic and paper cups. Because these young students had not been able to look at the manufacturing processes in much detail, the main difference was in the raw materials used.

Older students might begin to consider further questions:

Are the raw materials used renewable?

What is the impact of the manufacturing process – e.g. the use of water, pollution?

Where the cups are made and why: is that where the raw materials are? Is it because labour in that country is cheaper? How are they transported? (The lesson 'How far have my sneakers travelled?' in the section on sneakers page 44, gives an example of how these issues could be explored.)

If students have access to a range of sources of information it may also emerge that different sources say different things. Indeed, you might want to ensure that examples of this are included in the resources made available. This might lead students to think about the reliability of the information, and the different perspectives from which it might have been written. For example, information from an environmental campaign group might have a different emphasis from that provided by a manufacturer.

Activity 4: What happens next? (20 minutes)

Freya now returned to the plastic cup in her original example and asked the question; 'if I have finished my drink, what will happen next to this cup?' The students agreed that it could be cleaned and used again. She then asked them to think about what might happen if the cup got old, or broken so that it could not be used any more. Some students suggested that it could be put into the plastic recycling bin, or just thrown away, though it became clear that they had only limited ideas about what happened after things were put into a rubbish bin. Luke suggested that if it was not broken, she might give it to someone else who needed it.

The students then returned to their groups to continue the 'after' life stories of their cups. Freya encouraged them to try to think about the details of the different possibilities.

The students working with ceramic cups recognized that the cups could be used again, and would have to be washed with water and detergent. However they were less sure about how hot water for washing up is provided, beyond saying from the hot tap. They had several suggestions about how water could be heated (leave it in the sun, put it in the microwave, in a kettle) but had not yet made a connection with the need to use a source of energy to create heat, or that this would cost money. Freya planned to focus on energy in some science lessons in the future.

The students had some interesting thoughts about what might happen when the cup became broken. Heally suggested that it could be mended with glue, but Dani argued that if it broke into lots of pieces you might not be able to put all of them back together, and there would be holes. Some of the students thought that the cup could be recycled, but Adam said that because the cup was hard it would just break into small pieces, and could not be made into anything.

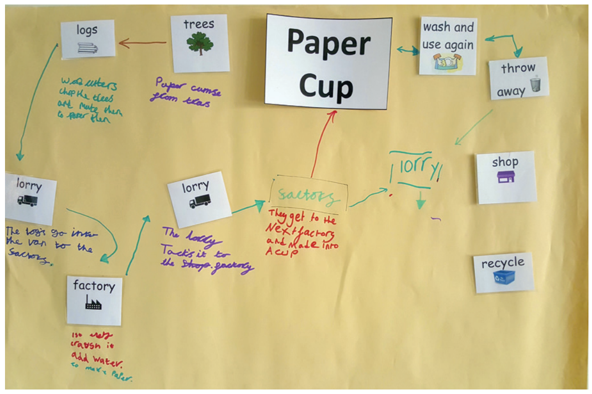
The groups working with paper cups were confident that these could be put into the recycle bins; indeed some of the examples of paper cups had the recycle symbol on them. They also knew that these bins were collected in a truck, but beyond this had little idea about what recycling involved.

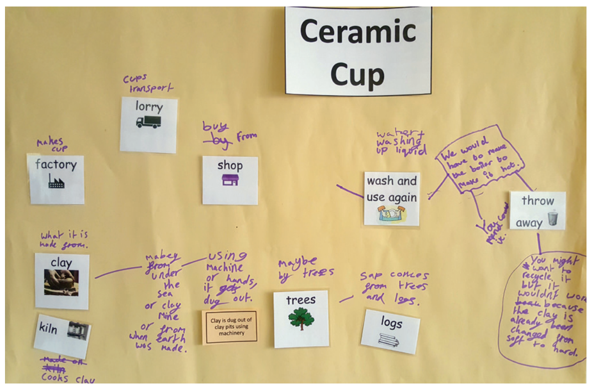
Using videos, or making an appropriate visit would be good ways to extend the children's experiences.

Discussions about recycling are an opportunity to move the focus from the life-story of the object, to the life-cycle of the materials.

Activity 5: comparing life stories (10 minutes)

Freya ended the lesson by asking some groups to share the life story they had made. Some elements of all the stories were similar, so Freya tried to draw attention to differences, such as whether cups could be re-used, and which materials could be recycled.





Activity 6: Making choices role play (15 minutes)

Freya decided to end with a role play based on a simplified version of the café scenario described in 'Making choices at the Cafe'. She chose to base it on a café in a supermarket, which was a familiar context for the students. The group acting as the café owners had a short list of the jobs they had to do:

- prepare and serve food and drinks
- clear the tables and keep the café clean and tidy
- wash up, and make sure there are clean cups, plates and cutlery ready for the customers

Paper Cups

Paper comes from trees which are a natural source
New trees can be grown to replace used ones
Paper cups:

- Can be used for any occasion indoors and outdoors
- Light, easy to carry and easy to store
- Cheap compared to other types of cups.
- Can be decorated in any style
- Coated in plastic so can be used for hot or cold drinks
- Often just used once
- No washing up so no hot water or washing-up liquid needed

Paper and plastic in the cups may be separated
Paper
- can be recycled to make new products
- biodegradable and will break down in landfill

Plastic
- may be recycled to make new products
- may go to landfill and may cause pollution

Information from a company that sells paper cups

Plastic Cups

Plastic cups
- are made from oil
- are very convenient
- can come in many colours
- can be used for any occasion indoors or outdoors
- are light and easy to carry
- stack so it is easy to store a large number
- are cheap compared to other types of cups
- are difficult to break
- can be washed and reused if needed

- Most light plastic cups are only used once. No washing up needed
- Some plastic may be recycled to make new objects
- Plastic cups are put into rubbish and may end up on landfill sites or being burned. This may cause pollution

Described by an organisation of plastic cup manufacturers

Ceramic Cups

Ceramic cups are made from types of clay.
They are made in different shapes and sizes and decorated with patterns or names
Ceramic cups
- look and feel good
- can be used for many occasions
- last a long time
- can be washed and re-used hundreds of time

Each cup only needs a little hot water for washing
They are cheap for each use compared to other types of cups

Broken cups are thrown away and taken to landfill.
The waste is not harmful.
It may be separated from other waste and re-used in road building materials

Described by a company that sells ceramic cups

Glass Cups

Glass cups
- are made from sand
- can be different shapes, sizes and colours
- look good and feel good
- can be washed and reused many times . Each cup only need a little hot water for washing
- some glass cups can be used for hot and cold drinks

Glass cups last a long time
Glass cups might break but some glass is strong and doesn't break easily

Broken glass cups are thrown away
Glass can be recycled to make new products
Glass cups might go to landfill but don't break down to cause any pollution

Information from a company that sells paper cups

The owners and the sales teams also had some suggestions of things they might need to consider:

- what customers like
- how the cups are made
- the cost of the cups
- litter
- what happens after they have been used?
- how nice do the cups look and feel?
- do they keep drinks hot?

The students were enthusiastic about the role play, but did not find it easy to think about several different factors at once. The cost of the cups drew their attention, and when they realized that paper cups would be much cheaper than ceramic ones, the café owners thought this was the most important factor in making their decision. Some students argued that although the ceramic cups cost more, they could be reused, but others found it hard to think about this in relation to the relative prices.

The cost of cups (a planned lesson)

Age range: 8-9 years

Life story phase: *making choices*

Inquiry skills:

Analysing and interpreting data: *comparing outcome to predicted result*

Reporting and evaluating findings: *justifying explanations, recognising why evidence is important*

Dimension of sustainability

economic

Estimated time: 30 minutes

Resources:

Calculators (possibly spreadsheets)

Activity 1: Starter (10 minutes)

Freya decided to spend some time in a mathematics lesson helping the students to think about the idea of the cost-per-drink. Here is her plan for a lesson.

Thinking about the café in a supermarket, ask the students what things need to be paid for that would affect the cost of a hot drink. The aim here is to help the students to think about the cost of the cup as only one factor in a more complex situation. This will probably need quite a lot of prompting, but should produce a brainstorm something like this.

Activity 2: Calculating costs (10 minutes)

Suggest some approximate costs for different kinds of cups:

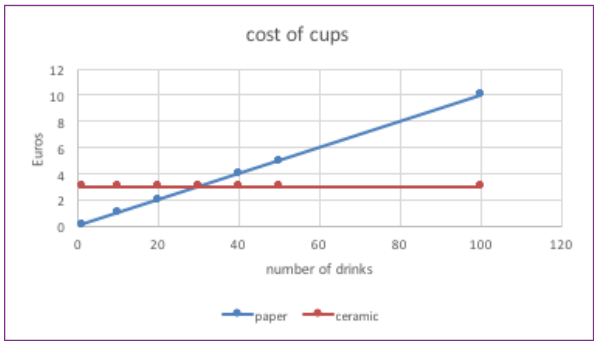
Ceramic cups	3 Euros
Paper cups with lids	10 cents (0.1 Euro)

Show the table below, and ask students to explain what they think it means; they may need to be reminded that a ceramic cup can be used over and over again. Either individually, or in groups, ask students to fill in the table to work out the cost for different numbers of drinks.

Cost of cups		
	paper	ceramic
1 drink	10 cents	3 Euros
10 drinks	1 Euros	3 Euros
20 drinks		3 Euros
30 drinks		
40 drinks		
50 drinks		
100 drinks		

Once the table is complete, introduce the idea of a 'break-even' point, where the cost of using paper and ceramic cups is the same.

If students have access to spreadsheets they could use these to create a dynamic table to explore further, and also present the information as a graph in which the 'break-even' point can be easily seen where the lines cross.

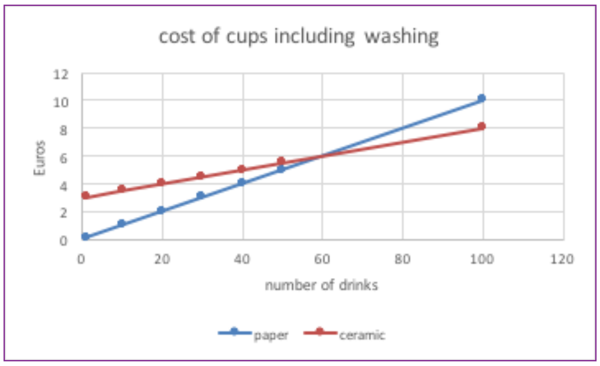


Activity 3: Adding another element (10 minutes)

Go back to the brainstorm, and ask students whether they think that the comparison they have made is fair. Someone may suggest that the cost of washing up should be considered (if not, this may need some prompting). It is hard to get an accurate idea of the cost for washing one cup, but you might estimate that it is about 5 cents, in order to make the calculations easy.

The students can then add more rows to the table. The break-even point will now be higher, but ceramic cups still become cheaper to use for a large number of drinks.

Cost of cups				
	paper	ceramic	washing	ceramic + washing
1 drink	10 cents	3 Euros		3 Euros
10 drinks	1 Euros	3 Euros	50 cents	3 .5 Euros
20 drinks		3 Euros	1 Euros	4 Euros
30 drinks				
40 drinks				
50 drinks				
100 drinks				



Older students could extend this activity to

- *include different kinds of cups (plastic, glass, bamboo, bagasse),*
- *include other factors, such as costs for additional staffing needed for washing cups, for collecting and disposing of rubbish, etc.,*
- *look at other comparisons such as the energy used to manufacture different kinds of cups (as shown in the Summary Information sheet)*

SNEAKERS: secondary age group

What is the potential for working with sneakers?

Sneakers are common and familiar objects, which are important for teenagers. They are relatively complex both in their functions, and in their construction (they are made from multiple materials), which offers some challenges for older students. It is easy to make a collection which includes a number of variables:

- material (plastic, leather, wool, cotton, metal, etc.)
- use/shape (sneakers for tennis, basketball, running, walking, etc.)
- sneakers for summer or for winter
- sneakers with or without laces.

Exploring the object now might focus on:

- properties of the materials used – weight, rigidity, strength
- insulation
- waterproofing
- breathability.

Before and after might focus on:

- the resources/materials used in making sneakers
- how and where sneakers are made
- the relative socio-economic and environmental costs
- how fashion and life-style affect our choices when we are buying sneakers
- waste caused by the disposal of sneakers, their degradability and their impact on the environment
- how they might be recycled, by individuals, families, communities.

Choosing sneakers as an object to study

When preparing these materials, initially a lot of time was spent on selecting the everyday object to work with, following a bottom-up approach to answer questions such as: What are the favorite objects of students? What object could stimulate their interest and motivation?

Students from a sample of 5 different classes of secondary school level were asked to think about their most important/favorite everyday objects, to choose 2 of them and to write each of the selected objects on a Post-it. Following the students' suggestions, the object was then selected according to some criteria. In particular, we wanted to choose an object which:

- was among the highest rated
- has a clear function and purpose
- is of daily use
- is desirable
- is 'multi-material' (as almost all the objects in daily use are).

Here is what happened in the classes.

This approach had both positive effects and challenges. As a strength, the students' engagement in the choice supported their motivation. In fact, students were involved in a learning path about something that they considered interesting. A resulting challenge for the teacher was the move from teacher-directed to student-centered learning activities.

Planning lessons based on sneakers

Because there are so many variations available, it is not difficult to make a large collection of different sneakers. It is worth thinking about how you want to focus the activity in the classroom in order to decide how to choose which sneakers to present to the students.

An important decision is whether you want each group of students to work with a similar collection of sneakers, so that it is easier to bring the whole class together to compare what they are doing, or to have different groups working with different collections and so potentially exploring a wider range of inquiry questions.

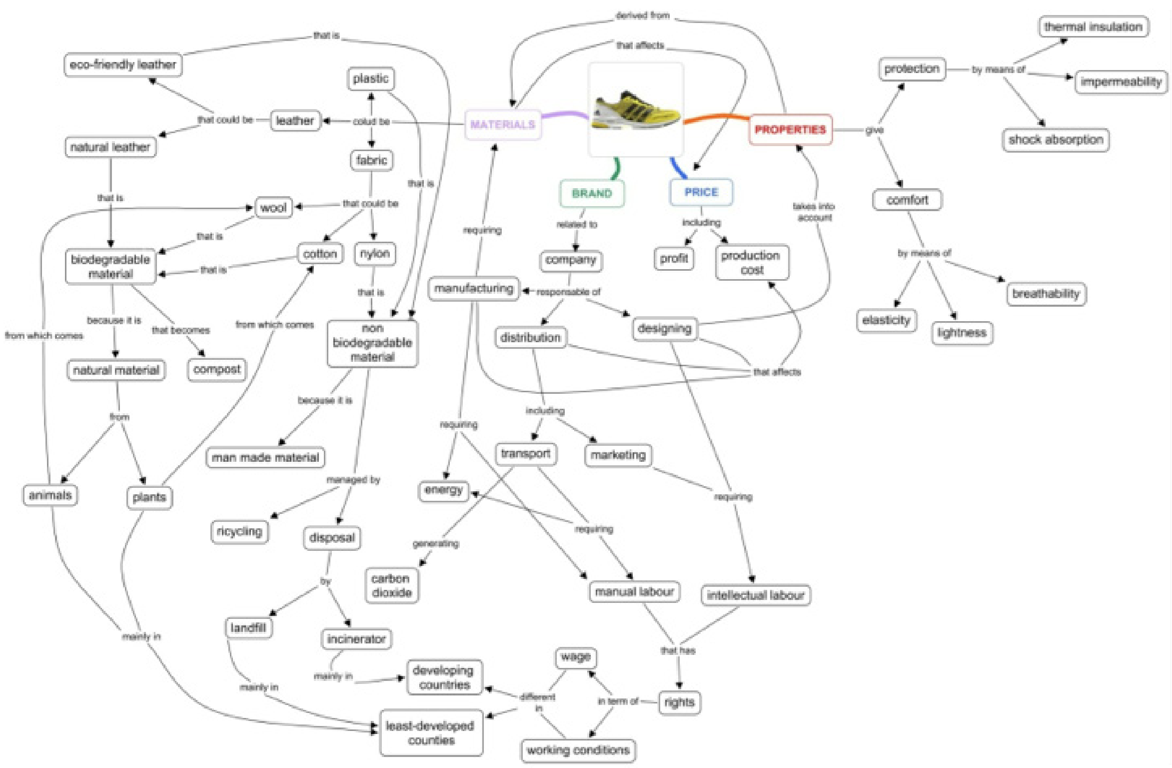
Planning with maps

The lesson sequences on sneakers were planned by drawing the following map. According to what is described in Part 2 (see, "Maps: flexible planning tools") this can be considered as a blend between a concept map and a mind map. The coloured part is based on the associative logic of *mind maps* and was drawn with the engagement of the students. The further development (in black) was carried out using the structure of concept maps. The whole path, consequently, was designed starting from the students' ideas.

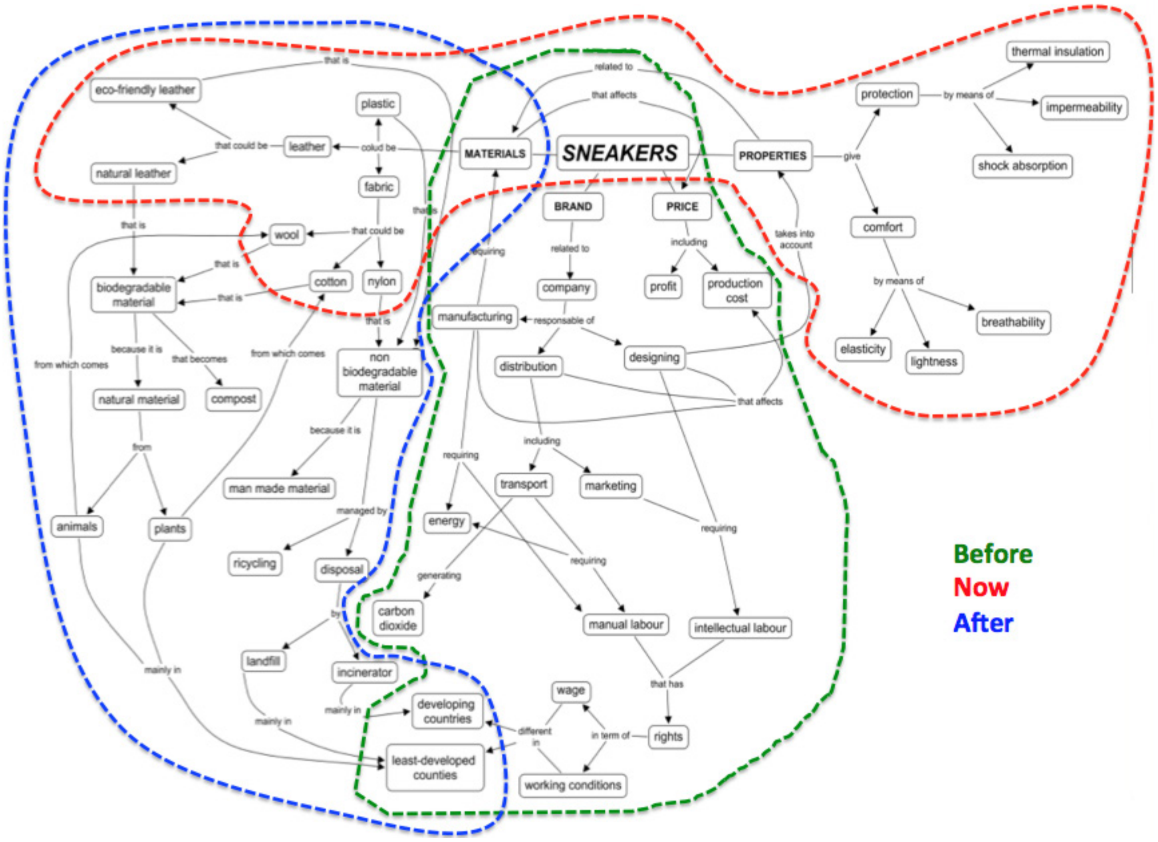
Despite some challenges for teachers (such as longer time devoted to planning activities, difficulties in managing a participative process, uncertainty of the results) this bottom-up approach involves students in planning their own learning. In this way they feel more empowered and their learning becomes more focused on their interests.

Students were first asked to think about sneakers and write what this object evoked in their minds. Then students shared the keywords that summarized their thoughts and grouped them into categories, with the support of the teacher as facilitator. After that each category was labeled and considered as the starting concepts of the map (materials, brand, price, properties).

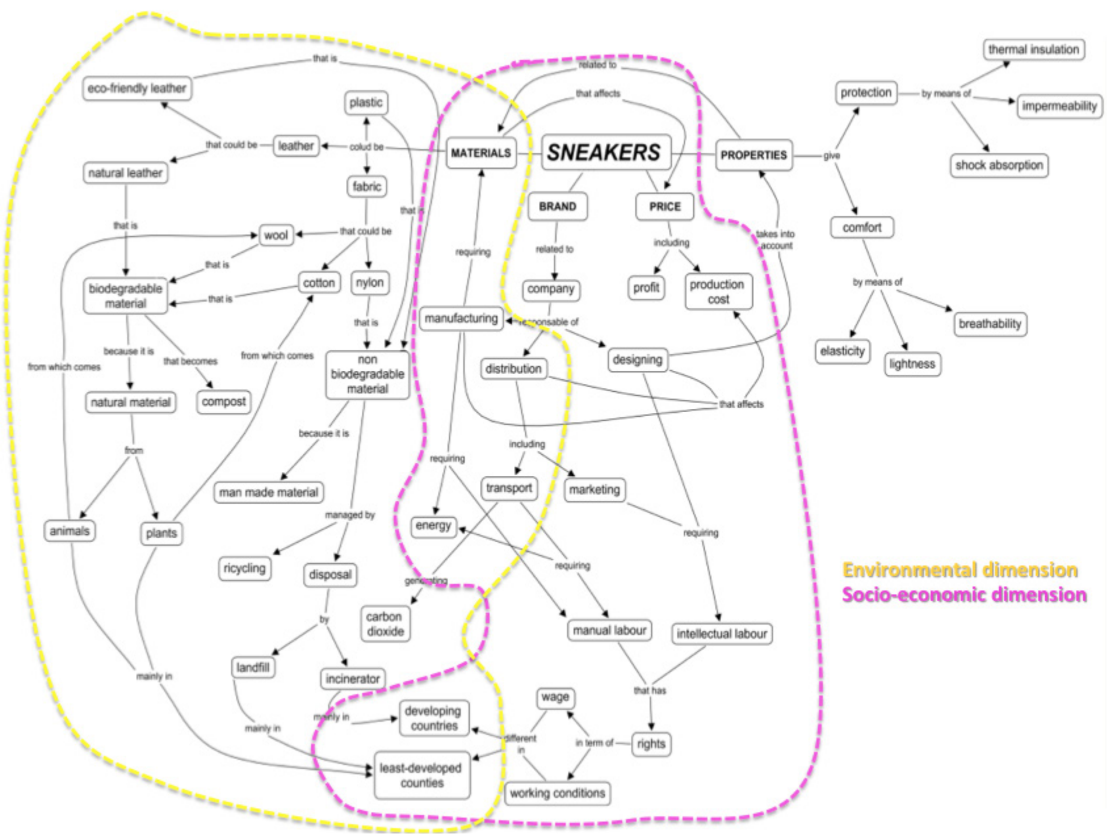
The further development of the map was based on the rules of building concept maps, even if the selection of the concepts was not guided by a focal question, which defines the topic and its limits, and guides its development. The direction and the perspective that oriented the map drawing were suggested by the life cycle approach which guided the identification of concepts and their relationships. The dynamic nature of the map enabled its revision during its development. Sustainability represented a new perspective for reconsidering the initial draft of the map, suggesting removals and integrations, especially in terms of new cross-links between concepts related to different domains.



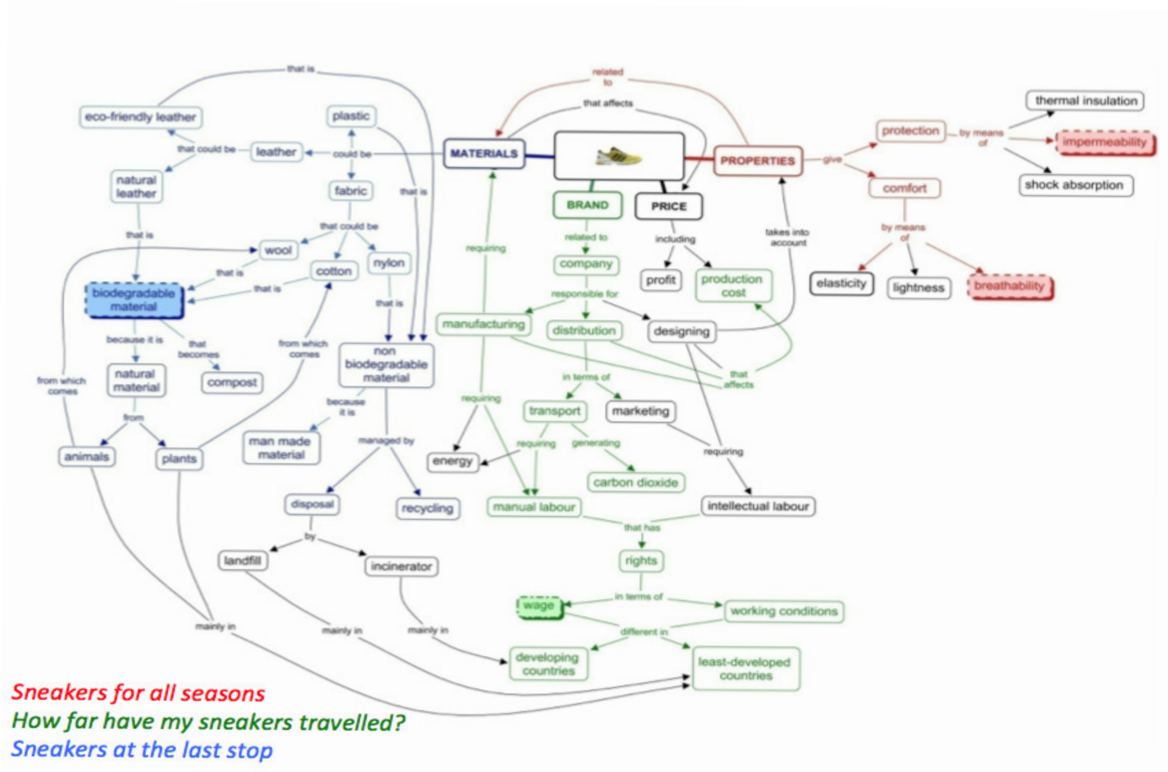
Map of the lesson sequences on sneakers



The map showing the components of life cycle



The map showing the dimensions of sustainability



The map showing the learning activities

In the last planning phase, some branches of the map, the most suitable to be approached with inquiry based teaching and learning, have been translated into learning activities.

The map can be analysed as a whole as well as in the light of each of the two perspectives that guided its development (life cycle and sustainability). In the next two illustrations the components of the life cycle are highlighted and the dimensions of sustainability are shown. The possibility of making these perspectives visible made it possible to check the internal coherence of the whole path while it developed. These two versions should also facilitate the reading of the map by those not involved in its development and might promote the understanding of the full meaning of the map that can only emerge by considering the interconnection between the different dimensions.

The final version shows (in red, blue and green) the branches of the map which have been transformed into learning activities. There are several paths that can be explored and provide inspiration for new activities. Therefore, the map is not only a planning tool but also a useful support for the learning activity itself. For this purpose, the teacher can start his/her learning activity in class, by showing the map that represents it.

It's very likely that at first students may find the map too difficult to understand but, if the map is exhibited in the classroom, students will gradually discover its meaning. In this way, they will be aware of the global framework in which the different activities are included.

In a similar way, the map can be used by teacher educators in CPD courses for teachers who will carry out the learning activities shown in the map in their classrooms.

Example lessons

In the following sections there is some detailed discussion of the planning process used, and then examples of lessons planned for students 11-14 years old.

Lesson title	Age range	Life story phase
Sneakers for all seasons	11-14 years	*exploring the object now*
How far have my sneakers travelled?	11-14years	*before, making choices*
Sneakers... at the last stop	11-14 years	*after, making choices*

Resources you might need will be listed at the beginning of each lesson sequence. They include worksheets and some materials easy to collect and generally available in the school's science laboratory, as well as some online resources.

Sneakers for all seasons

Age range: 11-14 years

Life story phase: *exploring the object now*

Inquiry skills:

Observing: *identifying similarities and differences, classifying, trying to make sense of a phenomenon or raising a question*

Planning: *designing an investigation to test predictions, determining what constitutes evidence*

Gathering and recording data: *using appropriate tools, ensuring accuracy*

Analysing and interpreting data: *comparing outcome to predicted result*

Developing explanations: *based on the evidence*

Reporting and evaluating findings: *justifying explanations, recognizing why evidence is important*

Scientific content: properties of materials

Estimated time: 6 hours

Resources:

- PC and a video projector
- Introductory presentation including an image of a sneaker and "Salvatore's story";
- A collection of sneakers of different kinds (or a collection of pictures) particularly made from different materials
- Hotplate
- Conical flask
- Drinking straws/small rubber tube (to put into the side of the conical flask)
- Pump to blow air (it has to be connected to the rubber tube)
- Pipettes
- Beaker (250 ml) /little transparent glass jars
- Measuring jugs and cylinders
- Container with water / squirt bottle with water
- Small rectangles pieces of different materials (20 cm x 20 cm):
    - o nylon pantyhose
    - o leather
    - o cotton
    - o wool
    - o Gore-Tex
    - o Terry towelling
    - o canvas for umbrellas
- Ammonia solution
- pH indicator paper
- Tweezers
- Scissors
- Large elastic bands
- Rulers

Lesson sequence

INQUIRY STARTERS	→	FOCUSED INVESTIGATION	→	SHARING UNDERSTANDING
Activity 1		Activity 2 Activity 4		Activity 3 Activity 5

Activity 1: Starter (1 hour)

The teacher divides the class into groups, gives them a collection of sneakers (or pictures) and asks students to compare their different characteristics. The aim of this exploration is to look for similarities and differences. The teacher then focuses the students' attention on the different materials that the sneakers are made from, introduces the terms used to name the various parts of a sneaker, and finally asks the students to list the materials observed.

It is a good idea to have an image of a sneaker on a display, so that its parts can be labelled with the different materials.

The teacher asks each student to choose the sneaker they prefer and write the reasons on a sheet of paper (to be kept for further activities). The choices expressed within each group are then discussed and compared, so as to identify the sneaker preferred by the whole group. Finally, the selected sneaker is presented to the class, along with the reasons for the choice.

The teacher should focus attention on the different criteria that have guided the choices of the groups (aesthetics, comfort, price, brand, etc.) highlighting the connected needs (to be fashionable, to receive protection from cold, to spend little money, etc.).

The possible relationships between needs, selection criteria, properties and materials should be identified and written on a poster, to give the basis for a map or a diagram.

Some slides about "Salvatore's story" are then used, making sure that the problem of this boy will be shared by all the students.

The teacher engages different students to highlight the properties of the sneakers Salvatore liked and his needs.

The properties of impermeability and breathability should emerge, linked to the need for comfortable and suitable sneakers to protect against cold and water.

A larger version of these four cards is available on pages 53 and 54

The teacher introduces the research question: "**How can you test the impermeability and how can you test the breathability of a material?**"

Activity 2: Investigating waterproofing and breathability (2hours)

The students are divided into groups to plan how to test impermeability and breathability using the materials provided by the teacher. The teacher points out that the students have to test only one property.

The students might already know the meaning of impermeability and breathability. In any case, from the interaction within the working group these concepts should emerge. They will be checked and evaluated in the next stage of the lesson.

The term impermeability refers to the property of a material of not allowing a fluid (liquid or gas) to pass through it. In this activity only water-impermeability (waterproofing) is considered because it is relevant for the case studied.

The waterproofing test should not highlight particular difficulties but it requires the introduction of the variables "amount of spilled water over the material" and "length of time before the spilled water passes through the tested material".

The test of breathability poses the problem of how to detect the flow of water vapour through a selected material. You can find one suggestion for a method for testing breathability in the materials on the SUSTAIN project website.

The teacher reminds the students that each group will perform the tests designed and finally will communicate the results to the class. He/she provides students with a worksheet to use during their investigation.

Research question	**How can you test the water permeability of a material?**
Planning	
Materials needed for investigation:	
Method:	
Finding:	

Activity 3: Sharing (1 hour)

Each group communicates to the class the test they have performed and their results. The proposals are then compared and evaluated. The teacher guides the identification of criteria for the evaluation of the tests, noting that it is important first to know the exact definition of the properties tested.

The communications of different groups may not include the definitions of waterproofing and breathability used and, if so, the teacher should ask for clarifications.

The evaluation stage should include a comparison between the ideas expressed by the groups and the scientific definition of the concepts examined, directly supplied by the teacher or obtained from research carried out by the students.

The evaluation of the test presented is done by linking the procedures proposed with the properties to be tested. For the waterproofing test, the procedures should consider the variables 'amount of water poured on the material' and 'time necessary for water to cross it'.

The groups can choose different materials for testing: in this case, the two variables should emerge. The leather, for example, is waterproof only with a reduced amount of water; the terry towel may initially retain water, but begin to drip off after a certain time, while Gore-Tex is constantly waterproof, even with large amounts of water.

The comparison and discussion should suggest possible changes to the tests. At the end of this activity, the teacher recalls the research question by noting that there isn't only one right answer.

From the group activities different tests might emerge. A plurality of answers is not only desirable but should be emphasized by the teacher.

Activity 4: Investigating Salvatore's choice (1 hour)

The teacher recalls Salvatore's story focusing on his statements and on his father's doubts that seem to suggest the impossibility of finding materials that are both waterproof and breathable. The teacher engages the students in Salvatore's problem, challenging them to find evidence supporting his ideas. The new research question is introduced: **"How can I prove whether a material is both waterproof and breathable?"**

The teacher divides the class into groups and provides the materials used during the previous investigation (Activity 2).

The groups may design a unique test to check waterproofness and breathability at the same time. Alternatively, they may perform the tests used in the previous investigation and then answer the research question by combining their results.

The teacher should encourage students' creativity and should analyze and evaluate any new tests proposed.

Activity 5: Sharing (1 hour)

The groups communicate their results which are then compared and discussed. The teacher draws attention to any evidence which refuted the concerns of Salvatore's father. Therefore he/she suggests a focus on the microscopic structure of materials that are both waterproof and breathable. He/she recalls the definitions of the two properties, focusing on the physical status of the substances that "cross" or "do not cross" through waterproof and breathable materials. The particulate matter model is introduced, to explain the physical states (in particular, liquid and vapour), together with the microscopic structure of water.

The key idea at the basis of the coexistence of the two properties concerns the larger size of the aggregates of molecules in the drops of water, compared to the molecules in the water vapour. The microscopic structure of a waterproof and breathable material should present some pores; their size needs to be sufficiently small to block the drops of water, but sufficiently large to allow the flow of water vapour.

The students might search for information on new materials such as Gore-tex, published by companies producing sneakers and sports equipment. They might also read the labels inside the clothing considered "techno" (Gore-tex, microfiber, for instance) that they own or are available in the shops.

The teacher asks students to imagine, describe and draw the structure of a material that is both waterproof and breathable.

How far have my sneakers travelled?

Age range: 11 - 14 years

Life story phase: *exploring the object's past, making choices*

Dimension of sustainability: socio-economical

Inquiry skills:

Analysing and interpreting data: *comparing outcome to predicted result*

Developing explanations: *based on the evidence*

Reporting and evaluating findings: *justifying explanations, recognizing why evidence is important*

Making connections with scientific knowledge: *thinking critically to link evidence and explanations, generalizing to a wider range of phenomena*

Estimated time: 5 hours

Resources:

- a map of the world
- flags of different colours / pins / stickers
- PC and a video projector
- the video "What is there behind my sneakers" (available within the online resources)
- a display board for the "Dominoes of the ideas"
- coloured Post-its for the "Dominoes of the ideas"

For each group:

- a map of the world
- a picture of sneakers for each group with the label on the back indicating the registered office, the manufacturing and selling places
- coloured markers
- geographical atlas
- a selection of documents related to some socio-economical issues on labour rights (cost of living/salary, workers' rights, etc.)
- working sheets (Wages of workers in different countries, Break down the price of a pair of basketball shoes).

Lesson sequence

INQUIRY STARTERS (Activity 1) → FOCUSED INVESTIGATION (Activity 2) → SHARING UNDERSTANDING (Activity 3, Activity 4)

Activity 1: Starter (1 hour)

The teacher introduces the activity by telling the students that all everyday objects have a story and they can discover it. Before each object arrived in front of us, it was in faraway places and met different people. The teacher then introduces the aim of the activity: to tell the story of the sneakers outlining the journey they have made.

The teacher points out that when people tell their own story, they usually start from the place where they were born, where they lived, etc. Therefore, the teacher asks students to identify what are the most important places in the story of their sneakers.

The discussion should focus on where the sneakers are manufactured and sold. If the registered office is not mentioned, the teacher can point out that before manufacturing any object must be designed, advertised and so on.

The teacher asks students to predict where the registered office, the places of manufacture and sale are located, adding the question: are they in the same country? After this, she/he sets up the work, giving to each group of students: a political map of the world, a geographical atlas, coloured markers and a picture of a sneaker with some information on the back (the registered office, the manufacturing and selling places) to discover the sneaker's story.

This information can be easily obtained from the sneaker's label and from an internet search (for instance, look at the website of the shoes' brand).

The teacher asks students to show these three places on their map of the world. A student from each group, then, marks the three places of its sneaker on the class map. The teacher recalls the students' predictions and asks them to compare those to what is marked on the map.

The teacher introduces the research question: **"Why are the registered office, the manufacturing and the sales of the sneakers located in different countries?"** and asks each group to formulate hypotheses and then to share them to the class.

The students' hypotheses could be the following:

- *Hypothesis 1: manufacturing occurs where there are the raw materials*
- *Hypothesis 2: manufacturing takes place where wages of workers are cheaper.*

If these hypotheses do not arise spontaneously, they can be prompted by the teacher posing questions as: «What does the manufacturing require?» This should help students to focus on raw materials and the wages of workers.

The teacher asks students what evidence supports each hypothesis.

Activity 2: Investigating data (2 hours)

The teacher gives the students the sheet with the raw data to analyse (Wages of workers in different countries).

Wages of workers in different countries						
Countries (local currencies)	Hourly wage (2013)[a], local curren-cies	Average annual wage (2013)[b], US Dollars	Average hourly wage (1995)[c], US Dollars	Average hourly wage (2010)[d], US Dollars	Gross average monthly wage (2009)[e], US Dollars	Net average monthly wage (2014)[f], local curren-cies
Brazil (Real)				5.41		
China (Yuan)			0.14		656	4498.22
Philippines (Peso)	65.82		0.48	1.41	279	
France (Euro)	15.95	40242		21.06	2886	
Germany (Euro)	20.57	43682		25.80	2 720	2070.71
Japan (Yen)	1605.50	35405		18.32	2 522	266665.71
India (Rupee)					295	28425.95
Indonesia (Rupiah)			0.35			3614758.13
Italy (Euro)	15.02	34561		18.96	2445	1547.55
Turkey (Lira)					1731	1679.67
USA (Dollars)	23.93	56340		23.32	3263	2941.92
Singapore (Singapore Dollars)	19.62			12.68	2616	
Slovakia (Koruna)		20307		6.03	1638	744.43
Switzerland (Swiss Franc)		54236		34.29		
Vietnam (Dong)			0.12			5488077.60

Notes

a Source of data: US Bureau of Labor Statistics, International Labor Comparisons http://www.bls.gov/home.htm
b Source of data: http://data.oecd.org/earnwage/average-wages.htm
c Source of data: Sweatshop watch, 1996 in: Gesualdi, F. 1999. Manuale per un consumo responsabile, Universale Economica Felrinelli, pag.24.
d Source of data: http://www.ilo.org/wcmsp5/groups/public/@dgreports/@dcomm/@publ/documents/publication/wcms_194843.pdf
e Source of data: https://en.wikipedia.org/wiki/List_of_countries_by_average_wage
f Source of data: http://www.numbeo.com/cost-of-living/

Then, the teacher asks students to find information about raw materials from some selected resources available on the internet (for instance: http://www.icis.com/resources/news/2010/08/30/9388327/china-strengthens-position-in-nylon-fibers; World Statistical Compendium for Raw Hides and Skins, Leathers and Leather Foot wear, FAO, 2010; http://www.nasdaq.com/markets/ipos/filing.ashx?filingid=7115902) which show processed data and diagrams.

Students could discover that different sources provide different information. This may lead them to reflect on the reliability of the information and the different perspectives from which it may have been written. For example, the perspective of an NGO may be different from the perspective of a company which makes or sells sneakers.

The teacher reminds students that each group will communicate the results of its investigation.

About hypothesis 1: the distribution of raw materials in the world should show that in the manufacturing countries there are not all the raw materials needed to produce the sneakers. The places where raw materials and manufacturing are located should appear delocalized in one case and concentrated in specific areas in the other.

About hypothesis 2: when the students analyse the data provided (Salaries of workers) they should:

- *make a comparison between pairs of countries (those where the registered office and manufacturing are located);*
- *use data of the same column (if possible), as they come from the same source;*
- *prefer the most recent data and those from the most reliable sources;*
- *pay attention to the currencies in which the different data are expressed*
- *distinguish the gross from the net salary*

These suggestions might be provided and explained to the students before the activity; in any case they have to be underlined during the class discussion.

Activity 3: Sharing group investigation (1hours)

The groups communicate the results of their investigations, which will be discussed and evaluated in the whole class.

The students should confirm Hypothesis 2: companies that own the brand get high profit from placing manufacturing in countries where the wages of workers are very low, compared to those where the registered office is located.

The teacher should also point out that the same conclusion (confirmation of the hypothesis 2) can be formulated using different arguments (more or less effective).

The teacher challenges the students suggesting that brand owners might choose to produce in countries where wages paid to the workers are very low, to limit the sneakers' prices. In this way it is assumed that the manufacturing cost has a significant impact on sneakers' prices.

The teacher poses the following question: **"How important is the the wage of workers in relation to the cost of the sneakers?"**

To guide the answers, the teacher gives students the sheet "Break down of the price of a pair of basketball shoes" with reference to a kind of sneakers made in China (Fujian) and sold in Belgium. He/She asks students to make a prediction.

Break down of the price of a pair of basketball shoes

According to the research carried out as part of a campaign called "Clean Clothes" (promoted by a network of non-governmental organisations in 16 European countries) the price of a pair of basketball shoes (115 Euros) can be divided into different components as shown in Table 1. The costs of the components are listed in ascending order in Table 2.

Table 1

Components	Expected costs	Real costs
Design		
Raw materials		
Workers' wages		
Additional manufacturing costs		
Profit to the factory's owner		
Transportation and taxes		
Advertising and sponsorship		
Distribution		
Profit to brand's owner		
National taxes (shoes were bought in Belgium)		

Table 2

Cost in Euros
0.46
1.84
2.31
5.57
9.20
9.77
12.65
15.52
20.01
37.49

Complete the first column of Table 1 (expected costs) connecting each of the components with their cost, choosing from those listed in table 2.

After some minutes, the teacher brings the class together and asks students to share their expected costs. After this, she/he provides the real costs encouraging students to compare them with the expected ones.

Components	Real Costs (Euro)	%
Design	12.65	11
Raw materials	9.20	8
Workers' wages	0.46	0.4
Additional manufacturing costs	1.84	1.6
Profit of the factory's owner	2.31	2
Transportation and taxes	5.75	5
Advertising and sponsorship	9.77	8.5
Distribution	37.49	32.6
Profit of brand's owner	15.52	13.5
National taxes (V.A.T.) *	20.01	1.,4
Total	115.00	100

It will emerge that because the wages of workers, and other costs of production, in this case are low, they have very little impact on the price of sneakers. If students show interest and motivation towards these issues, the activity can be extended by presenting the FairTrade movement, which aims for 'better prices, decent working conditions and fair terms of trade for farmers and workers' (http://www.fairtrade.org.uk/en/what-is-fairtrade/what-fairtrade-does).

To add new suggestions, the teacher poses the question: **"Are there other reasons, besides workers' wages inducing companies to locate manufacturing in some particular countries?"** The teacher provides students with a selection of documents related to some socio-economical issues on labour rights (cost of living/salary, workers' rights, etc.). (These are some useful links for this purpose:

http://www.cleanclothes.org/about/principles;

http://policy-practice.oxfam.org.uk/publications/offside-labour-rights-and-sportswear-production-in-asia-112448;

http://www.cleanclothes.org/;

http://www.engaged-pfc.org/). The students' assignment is to read the given documents at home selecting the most interesting and relevant information.

This activity should extend the results of the investigation, in order to promote the students' awareness about the complexity of the problems faced. Social and environmental conditions should emerge in addition to the economic issues.

Activity 4: Sharing ideas (1 hour)

This activity starts with a discussion on the ideas of each student coming from the reading of the documents provided by the teacher.

Strong social inequalities at all levels (eg. quality of work, individual chances) between different countries should emerge.

If the documents provided include information about the cost of living as well as the level of wages, the teacher should ensure that this is understood. This means that wage levels do not necessarily indicate the relative quality of life in the different countries. For this purpose, Numbeo (http://www.numbeo.com/cost-of-living/), the world's largest database, provides current and timely information on world living conditions including cost of living, housing indicators, health care, etc.

One important issue which may emerge is that in countries where the wages of workers are low, other manufacturing costs are also low, and this may mean that workers' rights (such as the right to a safe and healthy workplace, the right to associate in trade unions etc.) are not given high priority.

The video "*What is there behind my sneakers*"~ (https://www.youtube.com/watch?v=QqF7YJKuEc8&feature=youtu.be) is shown to the class. It should stimulate the students to connect what they learned through the activity (the sneakers' past) with their experience (as they have chosen and bought their sneakers!), and reflect on their behaviour (making choices).

To conclude the activity the teacher engages the class in the "Dominoes of ideas", asking each student to summarise (in a short sentence) what they learned, and record this on Post-its. The first student attaches his/her sentence in the middle of a display board. The student who wrote a sentence that is similar or connected to the first, goes to attach her/his Post-it near the previous one, like a game of dominoes. The activity continues until all the students have attached their Post-its. The Post-its of the whole class will form something like a snake or a tree with several branches. Finally, the teacher could draw circles on the board to display the most important issues highlighted by the activity.

Sneakers...at the last stop

Age range: 11-14 years

Life story phase: exploring the object's future, making choices

Dimension of sustainability: environmental

Inquiry skills:

Planning: designing an investigation to test predictions, determining what constitutes evidence

Gathering and recording data: using appropriate tools, ensuring accuracy

Analysing and interpreting data: comparing outcome to predicted result

Developing explanations: based on the evidence

Reporting and evaluating findings: justifying explanations, recognising why evidence is important

Scientific contents:

- properties of materials
- changes to materials

Estimated time: 6 hours

Resources:

- Video or collection of pictures of sneakers
- Video or selection of images highlighting the consumerist lifestyle and the high production of waste
- Picture or table showing the degradation time of different materials
- Display board
- Post-its
- A collection of biodegradable and non-biodegradable materials
- Weighing scales
- Scissors and cutter

Lesson sequence

INQUIRY STARTERS
Activity 1 → FOCUSED INVESTIGATION
Activity 2 → SHARING UNDERSTANDING
Activity 3
Activity 4

Activity 1: Starter (1 hour)

Initially each student is asked to identify three reasons that explain why, when buying a pair of sneakers, it is important to know the materials that they are made of, and record these on Post-its.

All the reasons are collected on a display board so that they can be shared. Similar reasons are grouped together.

Students might link the materials only to their needs (i.e. comfort, protection) and so only the perspective of 'now' may be considered. In this case, the teacher has to engage students in focusing also on what happens to sneakers 'after' they finished using them (object's future).

Students watch a video or alternatively look at a selection of images (for instance, our cupboards full of clothes and shoes, fridge full of food, open dumps), highlighting that a consumerist lifestyle causes high production and accumulation of non-biodegradable waste[10]. The teacher uses this inquiry starter to stimulate a reflection on the environmental and social effects of waste accumulation.

This introduces the idea of the kinds of choices we make about sneakers, and the idea that such choices may have wider consequences.

A discussion is used to encourage students to think about the life-story of the sneakers focusing on the sneakers' future and verify if they have previously considered this phase. Then, the teacher introduces the research question: **"What happens when things become waste?"**

The inquiry starter should be extended if students need more stimuli to understand the significance of this research question.

10 Some suitable images are available from Practical Action (http://practicalaction.org/image-galleries)

Activity 2: Investigating the end of materials (1 hour + time to gather data about the degradation of materials)

Students are divided into groups to plan an investigation to answer the research question. The teacher provides them with a selection of materials (e.g.. apple, plastic bag, paper, aluminum foil).

As gathering data on degradation of materials needs a long time (a minimum of one month), the collection of materials provided has to be carefully selected.

The focused investigation should enable students to actively develop the understanding of the degradation of materials. The students could already know this concept; in this case the investigation should help them to formulate explanations based on evidence.

During the group work, the teacher helps students to identify the experimental conditions and the time required for gathering data. She/he points out that the planning of the investigation should include a table to record data and a timetable to set up their collection.

One of the critical points is performing a fair test, especially if students don't have experience in carrying out the inquiry. Then students need to be guided and supported by the teacher. Even if the groups planned different timetables, sharing a common length for the investigation is suggested.

Activity 3: Sharing (2 hour)

Each group communicates the tests performed and their results that are then discussed in the whole class.

The discussion should focus on:

- *the appropriate length of time and the experimental conditions (i.e. materials under the sunlight/in the dark, at a high/low temperature, wet/dry environments) for the investigation;*
- *the amount of data collected;*
- *the possibility of comparing the results.*

It might emerge that some materials are changed, some are not changed (so that over time the material would accumulate) and some others disappeared.

The teacher points out the connection between results and both the experimental conditions and the length for the investigation. This discussion could also suggest possible changes to improve the tests planned.

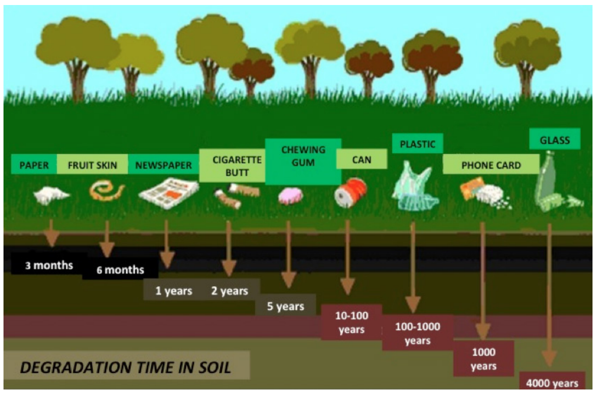
The teacher challenges students with a new question: **"What transforms the materials?"**

After collecting the students' ideas, she/he makes the connection between the answers and the exiting scientific knowledge, as a way to introduce the role of organisms in degradation and gradually develop the concept of "biodegradable" and "non-biodegradable" materials.

It is too difficult for this school level to answer the new question through an investigation.

Also scientists, in their work are used to searching for data and information from the existing scientific knowledge.

To ensure a good understanding of the concept of biodegradable and non-biodegradable materials, the teacher gives students a table with different types of common materials and their degradation times [11].



Students need to understand that time is a relevant variable linked to the concept of biodegradability. Some materials are degraded by microorganisms but they require a very long time (hundreds or thousands years) much longer than human life.

Therefore, the time of degradation is fundamental to reflect on the environmental impact of a material.

The teacher could also point out that «degradation» of materials means «transformation» and not «disappearance».

This concept could be a useful introduction to biogeochemical cycles, as a way to understand the role of decomposer organisms within ecosystems.

11 http://www.comune.san-giorgio-di-piano.bo.it/Main/037052bis/Contenuti/tempo_decomposizione_rifiuti.jpg modified by the authors

Activity 4: Applying the concepts learned (2 hours)

This last activity provides an experience where the students demonstrate their understanding by applying what they have learned in a new situation.

Students are divided into groups and a sneaker and some equipment are given to them to complete the following tasks:

1. to identify the biodegradable and non-biodegradable materials in the given sneaker;
2. to calculate the total amount of biodegradable and non-biodegradable materials in the given sneaker;
3. to count the pairs of sneakers they bought in the last 5 years;
4. to calculate the total amount of biodegradable and non-biodegradable materials produced by each student in the last 5 years.

Students should cut the sneaker, sort the different parts obtained into biodegradable and non-biodegradable materials and finally weigh them. The teacher should inform the students about the safety rules for the activity.

Starting from the results of the groups, the teacher asks students to calculate the amount of non-biodegradable materials produced by the whole class in the last 5 years.

The amount of the non-biodegradable materials produced by the class will -probably be very high.

The teacher could use these results to stimulate reflection on individual behavior and lifestyles and on their environmental, social and economical impacts. In this way the most ambitious goals of ESD can be approached.

The teacher guides students to think about the effects of their choices posing a new question: **"What can we do to reduce the production of non-biodegradable materials?"**

Two different types of actions should emerge: one related to good practices in waste disposal (separate waste collection, recycling, etc.) and one other involving individual lifestyles (to become an aware consumer, to reduce consumptions, etc).

The teacher could also encourage students to search for information about "eco products".

Making choices

At the end of the whole learning sequence on sneakers, some tasks could be proposed that give students opportunities to draw on what they have learned about the properties, the life story of the sneakers and its multifaceted impacts (environmental, social and economical) to make a choice.

- Authentic task

Students have to imagine that they are working for an advertising agency and they have to design the campaign to launch a new model of sneakers. They can use one of the following tools: flyer, poster or video. The students have to choose the information that they want to provide to consumers to achieve their objectives (the growth in sneakers' sale).The campaign should highlight the product's quality in an effective and convincing way.

- Criteria for buying sneakers

Students are asked to list the criteria they might use to buy a new pair of sneakers. The criteria selected are compared with those listed at the beginning of the learning paths (inquiry starter "Sneakers for all seasons") in order to find and analyse any changes.

The above tasks can be used to approach the evaluation of some of the ESD learning outcomes: critical thinking, change in values, attitudes and behaviour.

Note that these are only some proposals to approach the complexity of student assessment.

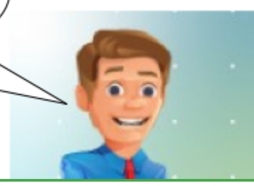
Salvatore's story

Winter is coming and Salvatore needs new shoes

Dear daddy, can you buy me the Blazer sneakers?

Salvatore's father doesn't agree with his son

Those shoes are not good in winter! On rainy days, you'll find yourself with wet feet. Suede leather will certainly let in water!



Salvatore's story

Salvatore tries to convince his father

It is not so! I can show you that these shoes are waterproof ...

Salvatore's father is not convinced

If the Blazer are waterproof, they will not let your feet breathe. They are not good, as you sweat a lot. What a smell!

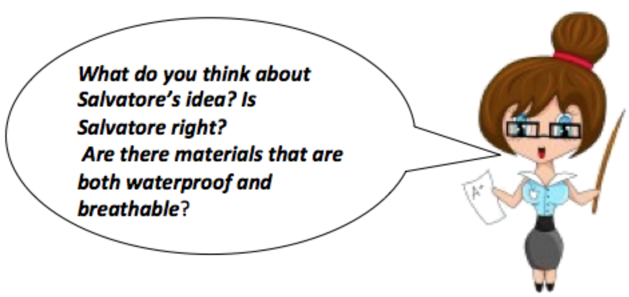
Salvatore’s story

Salvatore doesn’t change his opinion…

Salvatore’s story

The next day at school Salvatore tell his classmates what happened

then the teacher, Miss Pascucci, asked



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