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Global Goals for Tomorrow's Education, Today

19TH ~ 21ST JUNE 2018 KEELE UNIVERSITY

Gamification of Teaching and Learning Resources for Built Environment Education – Eco Material Trumps

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Context

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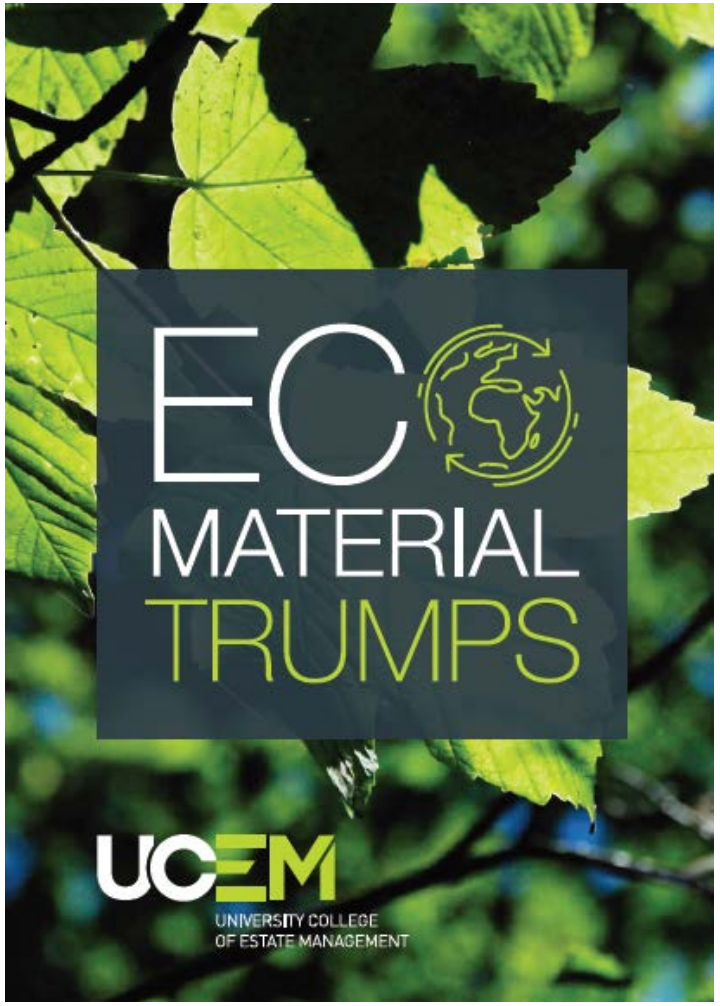

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THE GREEN APPLE AWARDS

GREEN WORLD AMBASSADOR 2017
HELPING OTHERS TO HELP THE ENVIRONMENT

Gamification of Teaching and Learning Resources for Built Environment Education– Eco Material Trumps

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- **Introduction** to theoretical principles and low environmental impact of construction materials
- **Definitions** of sustainability criteria and instructions how to play the game
- **Play Eco Material Trumps** in groups of 5 or 6
- Announce **Winners**
- **Feedback/Survey**
- **Q&A**

Questions to Consider - Feedback

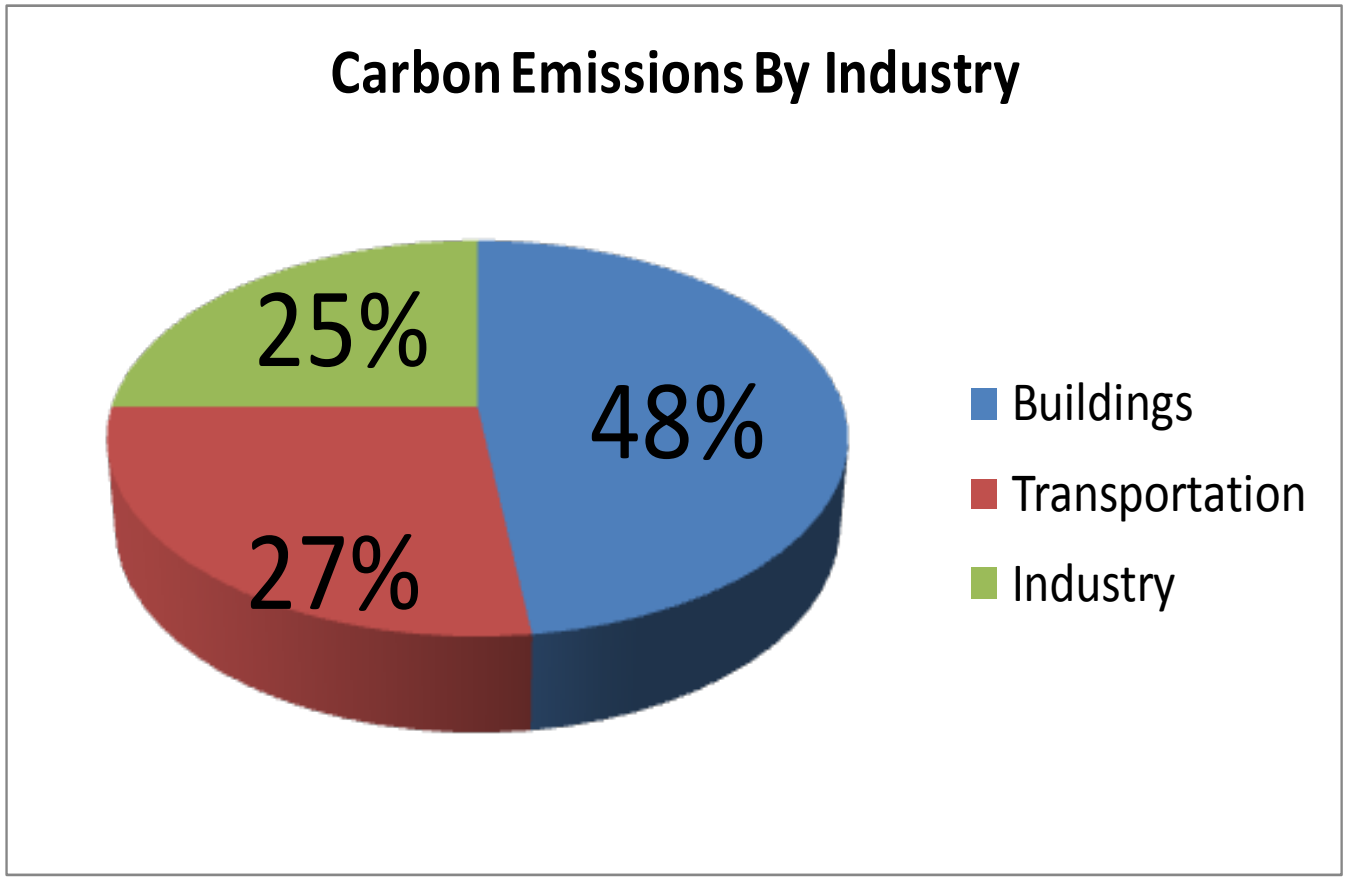
- How would you **use** Eco Material Trumps?
- What **benefits** do you think students/staff would get out of it?
- Any **improvements**?
- **Other** games?

Carbon Emissions UK Construction

84% - Operational Emissions

16% - Manufacture, Transportation & Construction of Materials

Carbon Emissions UK Construction



Carbon Emissions UK Construction

Buildings = 360 mt CO_2 pa

CarbonTrust 2008

UK Climate Change Risks:

- Warmer/drier summers (+2°C)
- Increase in winter rainfall (+16%)
- Decrease in summer rainfall (-22%)
- Rise in sea/river levels (up to 36cm)

EVENING STANDARD THURSDAY 26 JANUARY 2012

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The big heat: sun worshippers in Hyde Park – but experts warn of future dangers

London 'facing killer summers in climate peril'

Craig Woodhouse
Political Correspondent

LONDON is threatened by a future of long, hot summers which could kill thousands of people a year, a government report warned today.

Climate change will put the capital at risk of regular overheating and water shortages in the coming decades, causing heat-related illnesses and disruption to transport and business. Sea levels could rise by about six feet, with 1.25 million people at risk of flooding.

The stark vision of the future came in the first national assessment of climate change risks, highlighting the threats from global warming if no action is taken. Ministers said the £2.8 million "world class research" underlined the need for the UK to adapt.

By the 2050s, London temperatures could exceed the official definition of a heatwave – 32C by day, 18C by night – for more than a third of the summer.

And the thermometer is set to hit 26C on up to 92 days a year by the 2080s, compared with 18 days now. Premature deaths in the UK from hot weather are projected to soar from 1,100 a year to 7,000, with a third in London and the South-East. It means a worst-case scenario of about 2,300 deaths in the region, though cold-related deaths are likely to fall dramatically.

The Thames basin which supplies the capital's water faces a shortage of up to 2.6 billion litres a day, up from 59 million now. Flooding risks will also rise, threatening 83,000 properties.

The Tube will be hit particularly hard. The report warned: "Underground infrastructure is prone to rising water tables and pluvial flooding. Its lack of heating and ventilation means temperatures can exceed thermal comfort thresholds. All these issues are likely to be exacerbated as climate changes."

The Environment Secretary Caroline Spelman said the research provided "the most comprehensive case yet" for adapting to climate change. "It shows what life would be like if we stopped our preparations now," she said.

Lord Krebs, chairman of the group advising the Government on adapting to climate change, said: "Without an effective plan to prepare for the risks from climate change the country may sleepwalk into disaster."

Climate Change

Our response is strongest to threats that are:	Climate change is:
Visible	Invisible
With historical precedent	Unprecedented
Immediate	Drawn out
With simple causality	A result of complex causes
Caused by others	Caused by all of us
Have predictable and direct personal impacts	Unpredictable and has indirect personal impacts

Marshall (2001)

BREEAM Categories

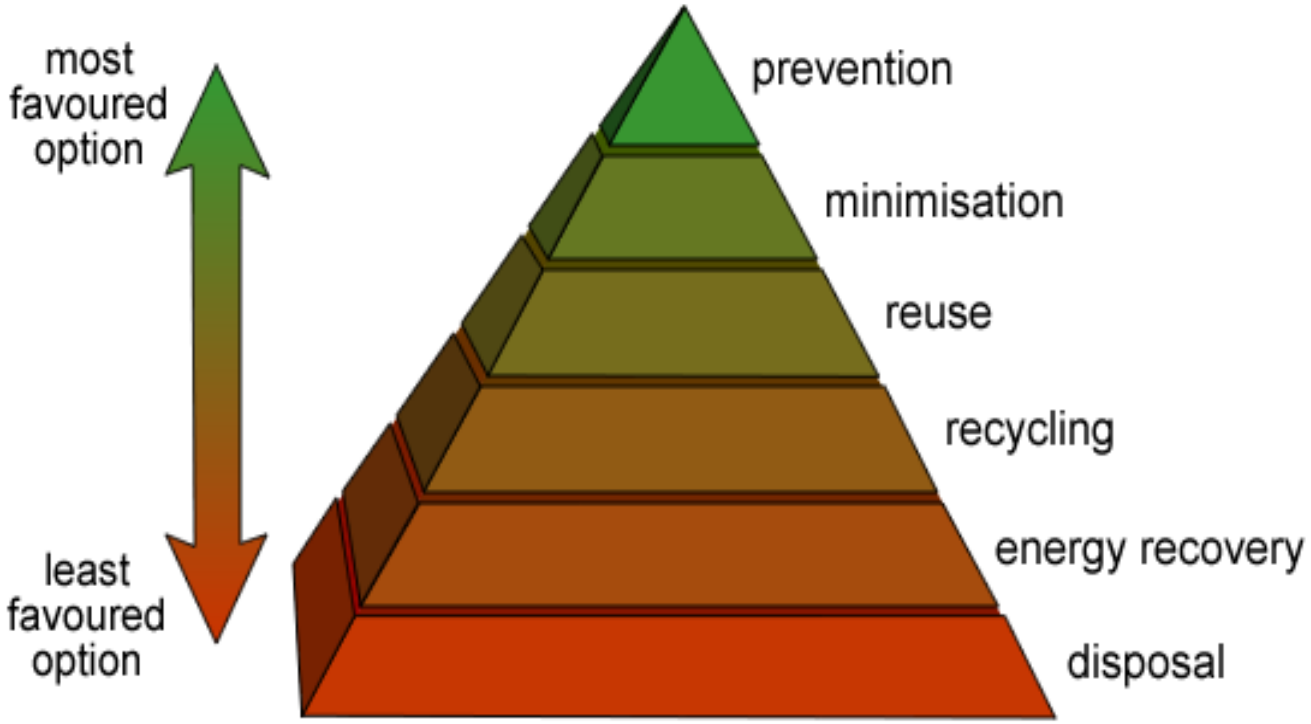
- Management
- Health & Wellbeing
- Energy
- Transport
- Water
- Materials
- Waste
- Land Use & Ecology
- Pollution

Construction Waste UK

- 420 million tonnes of materials used per year
- 120 million tonnes is ‘waste’
- 35 million tonnes goes to landfill
- 20 million tonnes are ‘unused’ materials

WRAP 2007

The Waste Hierarchy



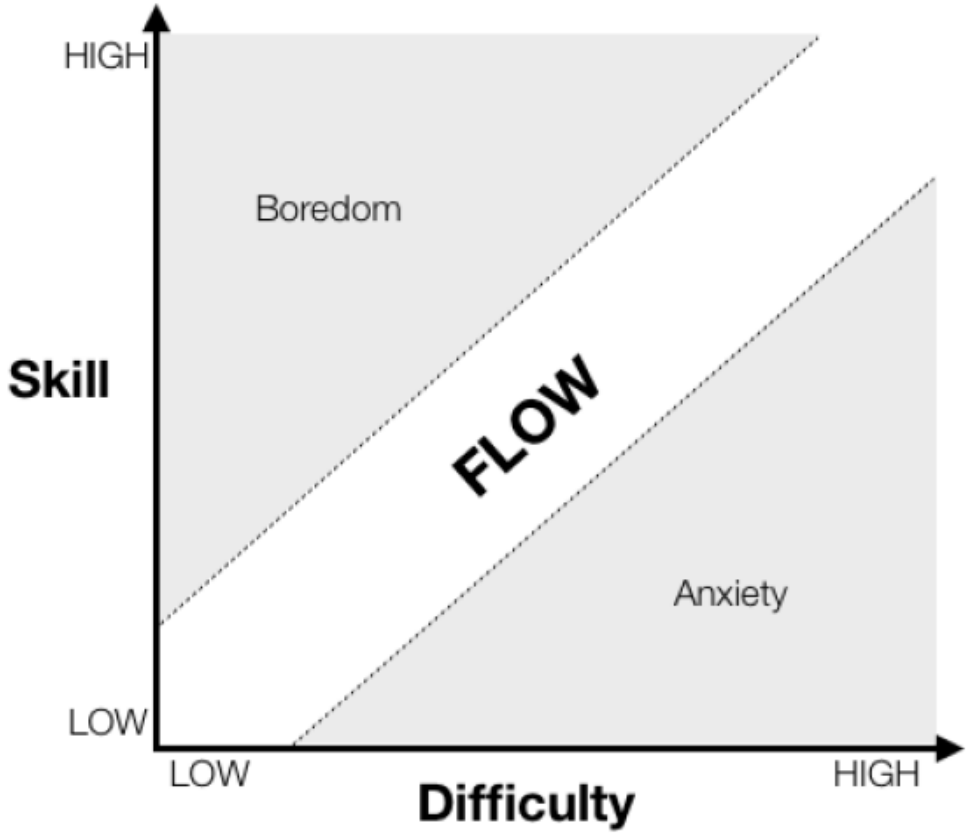
CO_2 can be reduced by up to 30% through the careful selection of materials alone.

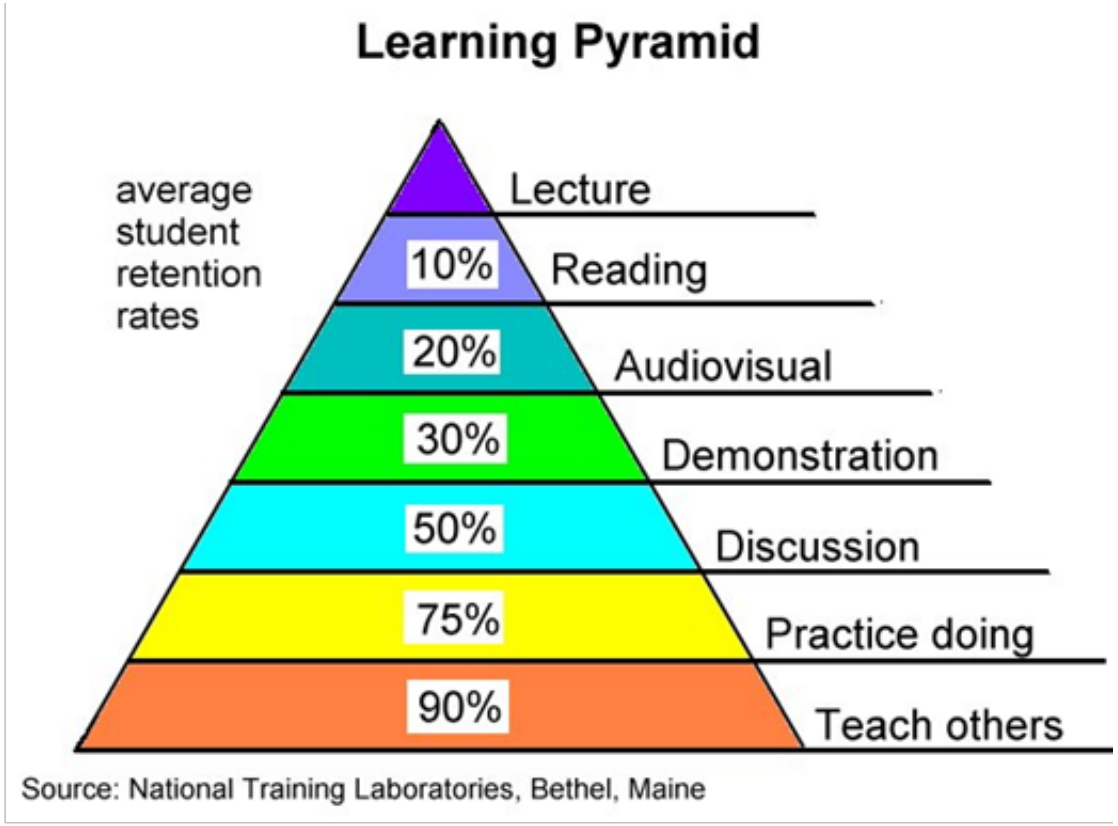
Serious Games Theoretical Perspective

- " a specific interaction of students with others (or individually) using specific game mechanics and dynamics, oriented towards specific outcomes" (Beetham, 2008)
- "the key challenge for effective learning with games is for the experience to be undertaken in relation to clear learning outcomes as well as being made relevant to real world contexts and practice" (De Freitas, 2005).
- "Experience with and affinity for games as learning tools is an increasingly universal characteristic among those entering higher education and the workforce" (New Horizon Report 2009).
- "The ability to absorb technical information can be daunting for built environment students and professionals alike and the value of games, used to support training and learning, has been widely recognised for many years" (Coleman, 1971)
- Lujan and Di Carlo (2005) argue that "the packed curriculum leaves little time for students to acquire a deep understanding of the subject or to develop life-long skills such as critical thinking, problem solving, and communication."
- "Lecturing merely exposes students to content, and exposure is not sufficient for learning. Active processing of information, not passive reception of information, leads to learning" (Bolles 1988).

Motivation

Flow is a state of *"deep concentration in which thoughts, intentions and feelings are focused on the same goal"* (Csikszentmihalyi, 1990)




Learning Pyramid
average student retention rates
Lecture
10%
Reading
20%
Audiovisual
30%
Demonstration
50%
Discussion
75%
Practice doing
90%
Teach others
Source: National Training Laboratories, Bethel, Maine

Eco-Material Trumps & Serious Games

- Enables processing of complex sets of data
- Brings together data from disparate sources
- Encourages interaction and discussion
- Visual and tangible presentation of data
- Simple, easy to use and fun learning
- Encourages ‘sustainable thinking’

UNIVERSITY COLLEGE OF ESTATE MANAGEMENT

Primary Data

Category→	Embodied Energy	Embodied Carbon	Landfill Decomposition	Recyclability	Toxicity	Durability	Density	Thermal Conductivity	Global Warming Potential
Unit of Measurement→	MJ/kg	kgC/kg	Years	%	L/M/H	Years	kg/m3	W/mK	g/CO2e/kg
Material↓									
Aerated Concrete Block	3.5	0.308	40	90	Low	65	625	0.24	270
Aggregates	0.083	0.0052	0	50	Low	200	2240	1.8	30
Aluminium (new)	224.1	12.79	300	90	Medium	60	2700	230	15000
Aluminium (recycled)	17.9	1.81	250	90	Medium	50	2700	230	3100
Bricks	3	0.24	0	80	Low	200	1900	0.72	190
Clay Honeycomb Block	3	0.2	5	70	Low	75	850	0.09	190
Clay Roof Tiles	6.5	0.48	4	60	Low	150	1900	0.85	185
Concrete (general)	0.99	0.13	50	70	Medium	80	2000	1.33	180
Concrete (reinforced)	2.88	0.306	200	50	Medium	150	2400	1.9	200
Damp Proof Course	134	4.2	75	40	Medium	60	1000	0.2	430
Earth (rammed)	0.45	0.023	0	100	Low	100	2000	1.28	20
Glass (recycled)	7	0.59	1000	50	Low	30	2400	0.96	600
Glass (toughened)	23.5	1.35	1500	70	Low	50	2500	1.05	1400
Glass (virgin/general)	15	0.91	1000	90	Low	40	2400	1.05	700
Insulation (fibreglass)	28	1.35	1000	60	High	30	30	0.038	1700
Insulation (polystyrene)	88.6	3.29	Never	50	High	40	20	0.035	3700
Insulation (sheep's wool)	29	?	1	80	Low	40	18	0.039	500
Lime (hydrated)	5.3	0.78	2	90	Medium	25	1700	0.675	190
Linoleum	25	1.21	5	40	Low	20	1200	0.19	1020
MDF	11.6	0.74	4	60	Low	15	600	0.098	1000
Paint (general)	70	2.91	500	30	High	10	700	0.5	2660
Paint (solvent-based)	97.46	3.76	700	10	High	20	800	0.4	5910
Paint (water-based)	59.01	2.54	10	25	Medium	10	500	0.6	650
Plaster (gypsum)	3.2	0.13	1	80	Medium	40	1120	0.51	190
Plasterboard	6.75	0.39	1	30	Medium	20	900	0.16	250
Plastic (HDPE)	76.7	1.93	Never	80	High	20	940	0.46	1600
Plastic (polypropylene)	115.1	4.49	Never	40	High	20	940	0.16	1650
Plastic (PVC)	77.2	3.1	Never	60	High	25	1380	0.19	3000
Plastic (uPVC)	69.4	3.16	Never	50	High	15	1380	0.16	2500
Portland Cement	5.5	0.95	25	30	High	60	1860	0.29	930
Roofing Felt	42.5	3.8	75	60	Low	20	1300	0.5	440
Slate	0.55	0.035	1	70	Low	85	1600	2.01	15
Steel (new)	35.4	2.71	100	95	Medium	85	7800	45	2200
Steel (recycled)	9.4	0.44	80	70	Medium	60	8000	45	1000
Stone (imported)	11	0.747	0	100	Low	500	2880	3.49	150
Stone (local)	1.26	0.079	0	100	Low	500	2700	3.49	10
Stone (recycled)	0.4	0.036	0	100	Low	400	2750	3.49	10
Strawbale	0.24	0.01	0.5	60	Low	50	90	0.06	5
Timber (sawn hardwood)	10.4	0.87	1.5	90	Low	50	680	0.05	550
Timber (sawn softwood)	7.4	0.59	0.5	50	Low	15	610	0.12	300
Timber Hardboard (recycled)	3.43	0.29	1.5	40	Low	20	880	0.12	750
Timber Hardboard (virgin)	37.42	1.72	2	70	Medium	25	880	0.15	1500
Timber Particle Board	12.25	0.86	5	40	Medium	15	750	0.098	1300
Vinyl Flooring	65.64	2.29	Never	30	Medium	15	1200	0.19	1600
New Materials									
New Categories									

Secondary Data

Category→	Embodied Water	Unit Price
Unit of Measurement→	l/kg	£/m3, £/m2, £/m, £/1000, £/tonne, £/litre
Material↓		
Aerated Concrete Block	300	£11.36/m2
Aggregates		£185/tonne
Aluminium (new)	29000	£13.69/m2 (0.7 mm sheet)
Aluminium (recycled)		£9.52/m2 (0.7 sheet)
Bricks	520	£380/1000
Clay Honeycomb Block	190	£98.07/m2
Clay Roof Tiles	640	£771/1000 (365mm)
Concrete (general)		£79.98/m3
Concrete (reinforced)	170	£103.14/m3
Damp Proof Course		£0.11/m
Earth (rammed)		£19.33/m3
Glass (recycled)	680	£28/m2
Glass (toughened)		£75.04/m2
Glass (virgin/general)	680	£31.85m2
Insulation (fibreglass)	1360	£1.72/m2 (140mm thick)
Insulation (polystyrene)		£3.41/m2 (100mm thick)
Insulation (sheep's wool)		£8.59/m2 (140mm thick)
Lime (hydrated)		£155.80/tonne(91.64m3)
Linoleum	140	£17.21/m2
MDF	1000	£10.66/m2
Paint (general)		£4.29/litre
Paint (solvent-based)		£4.29/litre
Paint (water-based)		£1.37/litre
Plaster (gypsum)		£12.89/m2 (13mm)
Plasterboard	240	£10.52/m2
Plastic (HDPE)		£70/m2
Plastic (polypropylene)		£65/m2
Plastic (PVC)		£68/m2
Plastic (uPVC)		£63.72/m2
Portland Cement		£116.47/tonne
Roofing Felt		£15.71/m2
Slate	10	£22.57/m2
Steel (new)	3400	£650/tonne
Steel (recycled)		£565/tonne
Stone (imported)		£25.2/m2
Stone (local)		£13.97/m2
Stone (recycled)	5	£11.51/m2
Strawbale		£1500/1000
Timber (sawn hardwood)	330	£307.50/m3
Timber (sawn softwood)		£4.66/m (100x100)
Timber Hardboard (recycled)	2500	£6.5/m2
Timber Hardboard (virgin)		£7.1/m2
Timber Particle Board		£5.1/m2
Vinyl Flooring		£14.37/m2
New Materials		
New Categories		

Insulation (polystyrene)

SUSTAINABLE FEATURE	SCORE
Embodied Energy (MJ/kg)	88.6
Global Warming Potential (g/CO_2e/kg)	3700
Landfill Decomposition (yrs)	Never
Recyclability (%)	50
Durability (yrs)	40
Thermal Conductivity (W/mK)	0.035

Insulation (sheep's wool)

SUSTAINABLE FEATURE	SCORE
Embodied Energy (MJ/kg)	29
Global Warming Potential (g/CO_2e/kg)	500
Landfill Decomposition (yrs)	1
Recyclability (%)	80
Durability (yrs)	40
Thermal Conductivity (W/mK)	0.039

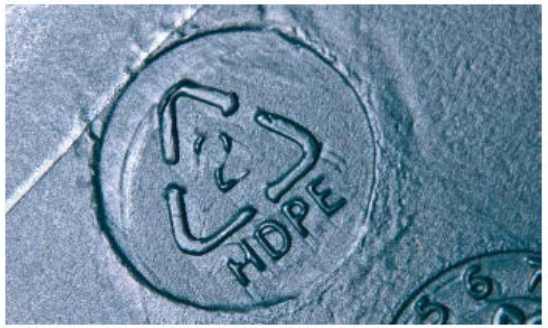
Insulation (fibreglass)

SUSTAINABLE FEATURE	SCORE
Embodied Energy (MJ/kg)	28
Global Warming Potential (g/CO_2e/kg)	1700
Landfill Decomposition (yrs)	1000
Recyclability (%)	60
Durability (yrs)	30
Thermal Conductivity (W/mK)	0.038

Plastic (PVC)
Polyvinyl Chloride

SUSTAINABLE FEATURE	SCORE
Embodied Energy (MJ/kg)	77.2
Global Warming Potential (g/CO_2e/kg)	3000
Landfill Decomposition (yrs)	Never
Recyclability (%)	60
Durability (yrs)	25
Thermal Conductivity (W/mK)	0.19

Plastic (HDPE)
High-density polyethylene

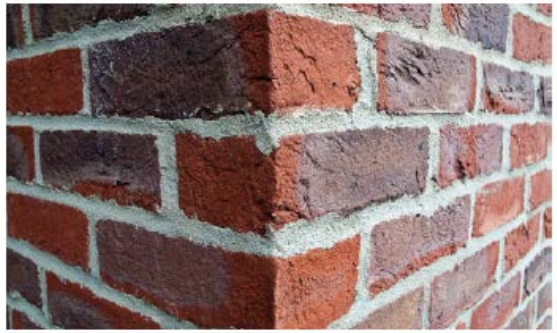


SUSTAINABLE FEATURE	SCORE
Embodied Energy (MJ/kg)	76.7
Global Warming Potential (g/CO_2e/kg)	1600
Landfill Decomposition (yrs)	Never
Recyclability (%)	80
Durability (yrs)	20
Thermal Conductivity (W/mK)	0.46

Plastic (polypropylene)

SUSTAINABLE FEATURE	SCORE
Embodied Energy (MJ/kg)	115.1
Global Warming Potential (g/CO_2e/kg)	1650
Landfill Decomposition (yrs)	Never
Recyclability (%)	40
Durability (yrs)	20
Thermal Conductivity (W/mK)	0.16

Bricks



SUSTAINABLE FEATURE	SCORE
Embodied Energy (MJ/kg)	3
Global Warming Potential (g/CO_2e/kg)	190
Landfill Decomposition (yrs)	0
Recyclability (%)	80
Durability (yrs)	200
Thermal Conductivity (W/mK)	0.72

Earth (rammed)

SUSTAINABLE FEATURE	SCORE
Embodied Energy (MJ/kg)	0.45
Global Warming Potential (g/CO_2e/kg)	20
Landfill Decomposition (yrs)	0
Recyclability (%)	100
Durability (yrs)	100
Thermal Conductivity (W/mK)	1.28

Concrete (reinforced)

SUSTAINABLE FEATURE	SCORE
Embodied Energy (MJ/kg)	2.88
Global Warming Potential (g/CO_2e/kg)	200
Landfill Decomposition (yrs)	200
Recyclability (%)	50
Durability (yrs)	150
Thermal Conductivity (W/mK)	1.9

How to play

Before beginning the game remove and read the 'Definition' and 'Material Facts' cards.

All the cards are shuffled and dealt face down among the players. Any remaining cards are placed in the middle of the table. Players hold their hand of cards so that they can see the uppermost card only.

The starting player (the player sitting on the dealer's left) selects a category from his or her uppermost card and reads out the name of the material, the category and its value and any knowledge they may have about that material. Each other player then reads out the name and value of their material for the same category and any knowledge they have about that material.

How to play (continued)

The most **'sustainable'** value (highest or lowest: see definitions) wins the **"trick"**, and the winner takes all the cards of the trick and places them at the bottom if his or her hand of cards. That player then looks at their new uppermost card and chooses the category for the next round.

In the event of a draw, the cards are placed in the centre and the same player chooses again from the next card. The winner of that round takes all the cards in the centre as well as the top card from each player.

The player with all the cards at the end is the winner.

There are a number of variations of how to use the cards. **Can you think of any alternative ways?**

Definitions

Embodied Energy (MJ/kg)

Measured in megajoules per kilogram, embodied energy accounts for all the energy consumed over a defined lifecycle of a product – in this case from "cradle-to-gate" which is the extraction of raw materials, through manufacture, then transportation to site. (Lowest score wins).

Global Warming Potential ($g/CO_2e/kg$)

Measured in grams of carbon dioxide (equivalent) per kilogram. It is a measure of the adverse impact different greenhouse gases might have upon the atmosphere. Greenhouse gases such as carbon dioxide, nitrogen oxide, methane and hydrofluorocarbons are released into the atmosphere by human activities. Greenhouse gases remain within the atmosphere for many years until natural depletion occurs. (Lowest score wins).

Landfill Decomposition (yrs)

A landfill site is basically a disposal facility where waste is permanently buried. Different materials decompose, or biodegrade, at different rates (measured in years) and have different environmental impacts depending on their chemical composition. (Lowest score wins).

Definitions

Recyclability (%)

Measured as the percentage (by mass) of material capable of being recycled or reused at the end of life of the product. It is the capacity of a material to be captured, separated from a waste stream and processed for conversion or reuse. In a circular economy, virtually all materials are capable of being recycled. (Highest score wins).

Durability (yrs)

The number of years the product will last before needing to be replaced. The more durable a material is the better the component performs from a sustainability perspective. (Highest score wins).

Thermal Conductivity (W/mK)

This is the rate at which heat flows through a particular material. It is measured in Watts (heat flow) per metre (depth of material) per degree difference (inside to outside), so the unit is W/mK.

The lower the value, the better the material's ability to insulate. (Lowest score wins). Thermal conductivity can be used to calculate thermal transmittance, commonly known as the U-value, measured in W/m^2K.

Material Facts

➜ Metals

Energy consumption is a key source of environmental impact from metals production. Recycling metals is a far less energy-intensive process requiring up to 95% less energy. Toxicity from the release of chemicals during the mining process and in the metal manufacturing process can also be a key environmental impact. For many metals, the minerals extraction and waste associated with extraction of ores is a significant issue. The disposal of such waste is a key consideration in the environmental impact assessment of metal products.

➜ Stone

Stone needs relatively little treatment before it is used, which is advantageous, mainly in terms of the climate change impact. The mining and finishing of stone is increasingly mechanised, therefore is energy intensive, and the density of the material means that its transport is also energy intensive. Other environmental impacts associated with quarrying of stone include dust emissions, loss of habitat for native flora and fauna and changes in ground water conditions. The stone industry reduces its environmental impact by turning old quarry sites into nature reserves.

Questions to Consider - Feedback

- How would you **use** Eco Material Trumps?
- What **benefits** do you think students/staff would get out of it?
- Any **improvements**?
- **Other** games?


Useful
Orange
Trumps
Competition
Fun
Nostalgic
Easy
Conversation
Learning
Inspiring
Retro
Knowledge
Original
Thought provoking
Building
Enjoyable
Alternative
Challenge
Engaging
Game
Accessible
Clever
Well done
Extensive
Inventive
Informative
Impact
Kids
Cheerful
Team
Nice
Friendship
Resources
Evaluation
Recycle
Interactive
Interesting
Simple
Education
Play
Materials

Critical Feedback

- Non-traditional teaching method
- Too simplistic
- Updatability
- Too generic
- Reliability & validity of data
- Conflicting sources of data

References

www.ucem.ac.uk/ecomaterials

Any Questions? j.clarke@ucem.ac.uk

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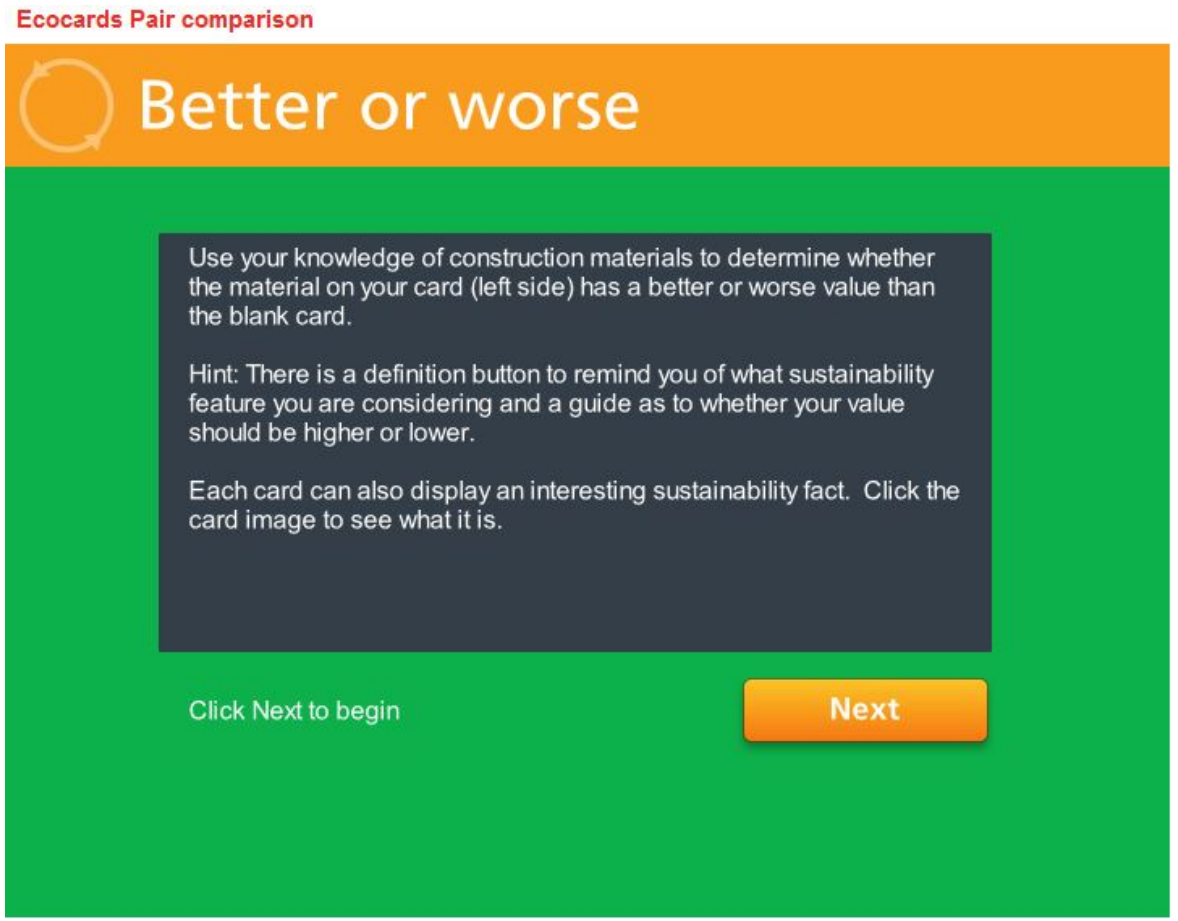
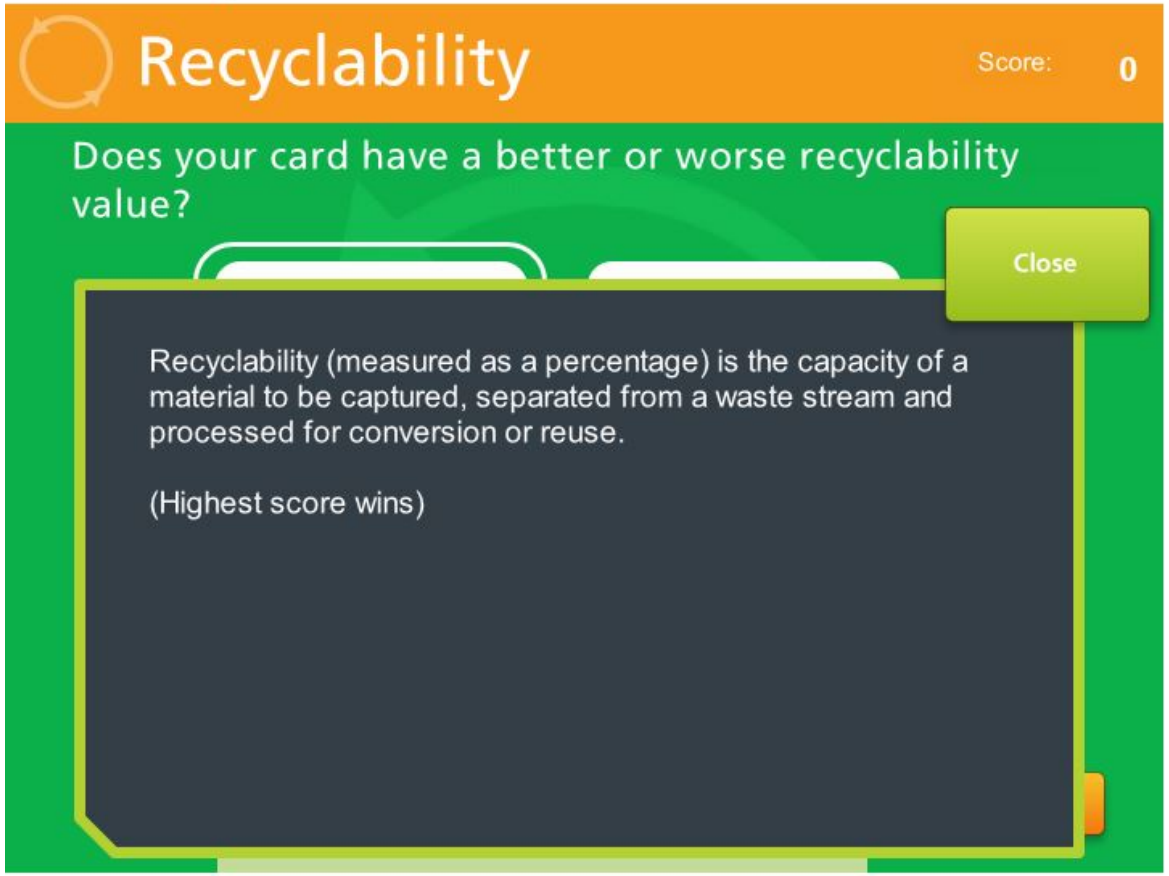
Eco-Materials Interactive



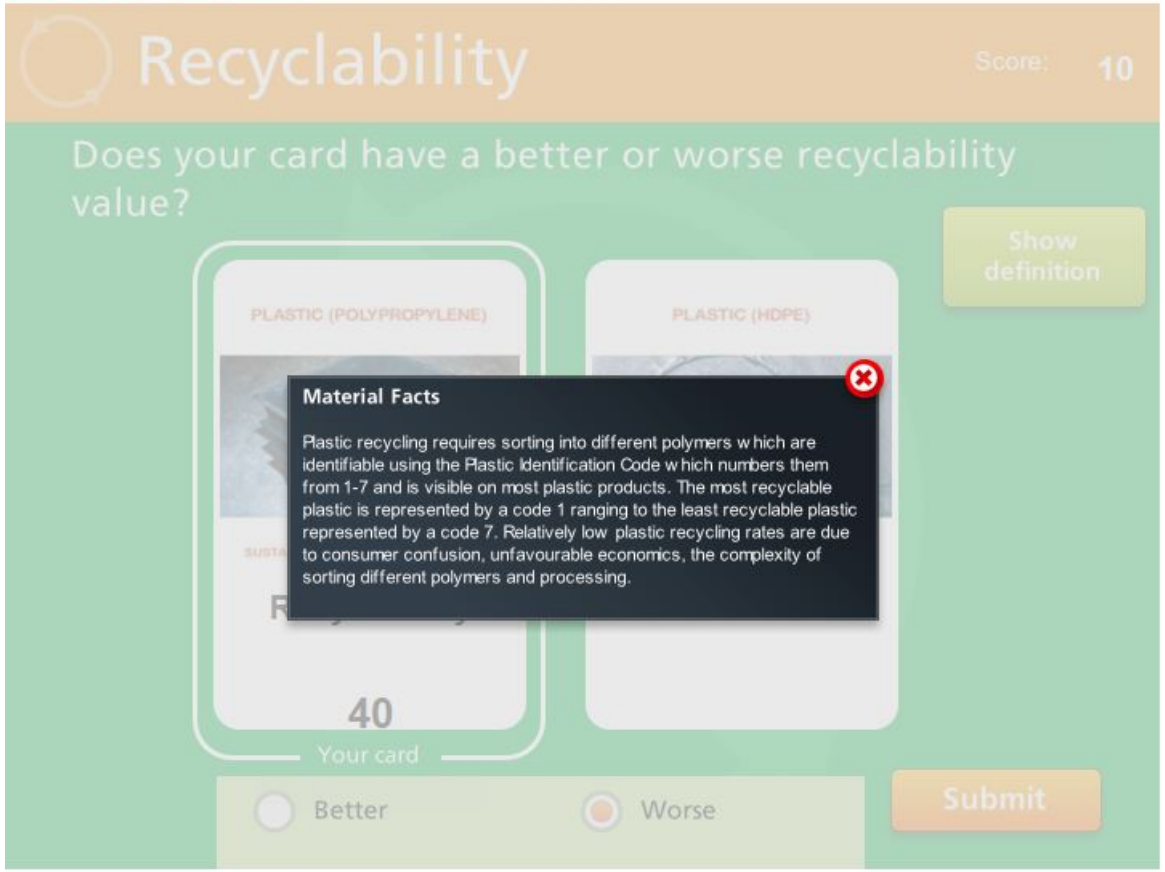
Ecocards Pair comparison

Ecocards Pair comparison

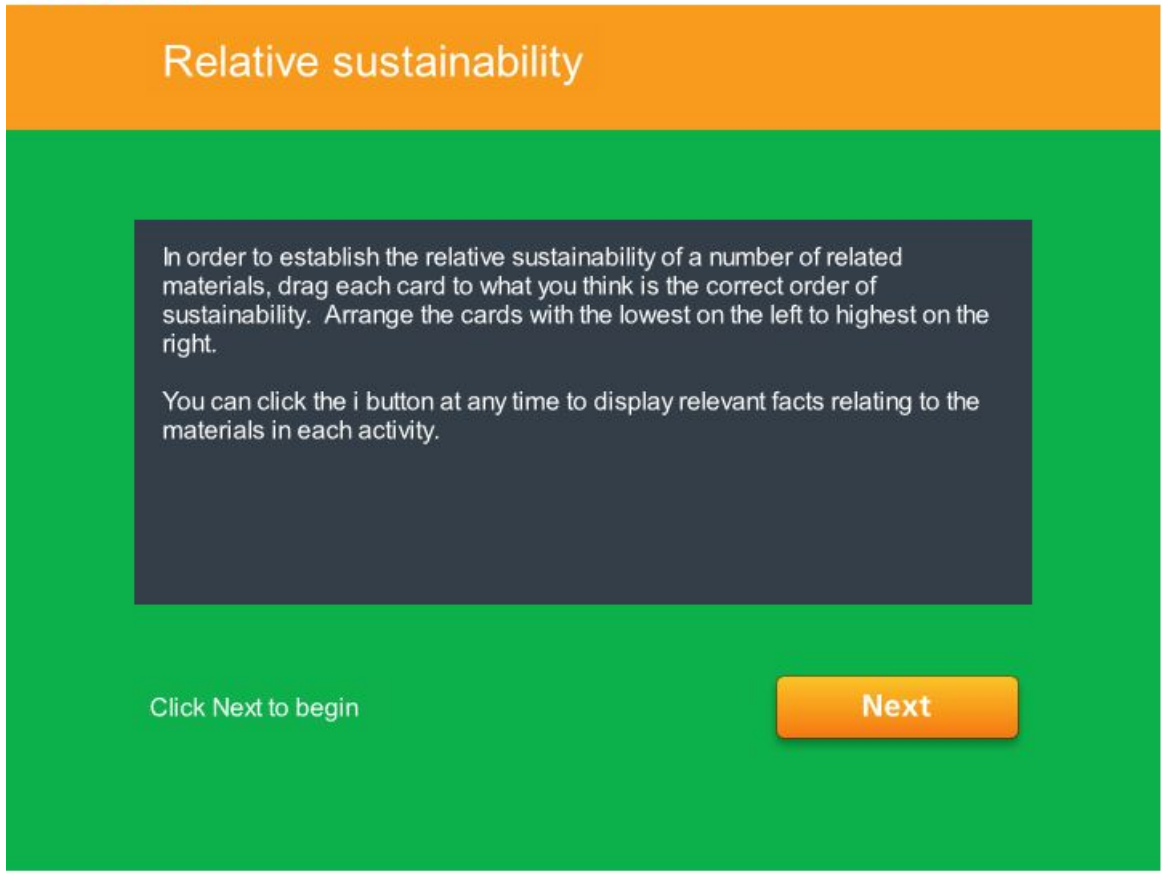
Ecocards Pair comparison



Ecocards Pair comparison



Ecocard sorting



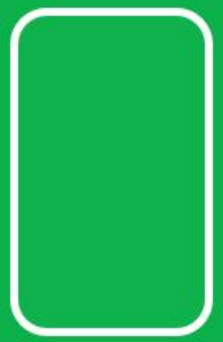
Ecocard sorting

Arrange the materials from lowest to highest recyclability (%).

Low		High
INSULATION (FIBREGLASS)	INSULATION (POLYSTYRENE)	INSULATION (SHEEP'S WOOL)
		
SUSTAINABLE FEATURE SCORE	SUSTAINABLE FEATURE SCORE	SUSTAINABLE FEATURE SCORE

Ecocard sorting

Arrange the materials from lowest to highest recyclability (%).



Ecocard sorting

Arrange the materials from lowest to highest recyclability (%).

INSULATION (FIBREGLASS)

SUSTAINABLE FEATURE SCORE

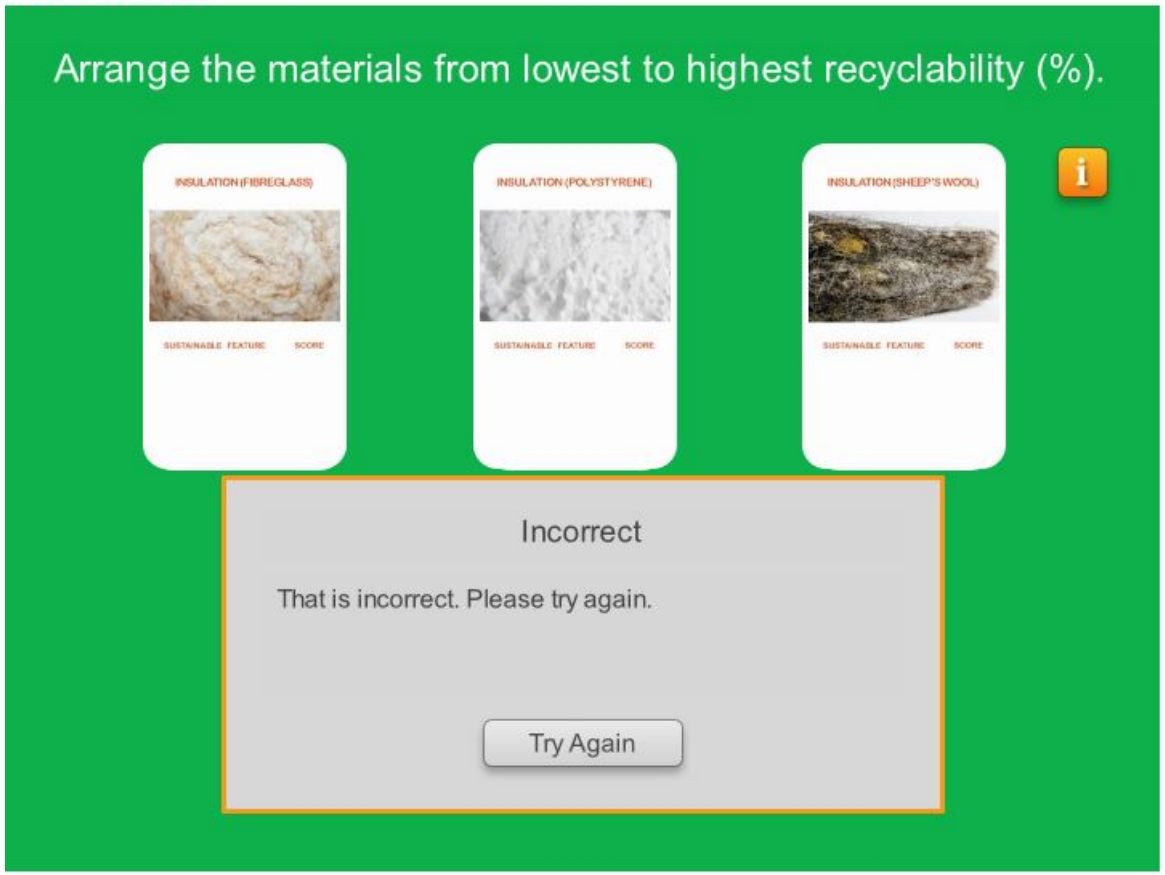
INSULATION (SHEEP'S WOOL)

SUSTAINABLE FEATURE SCORE

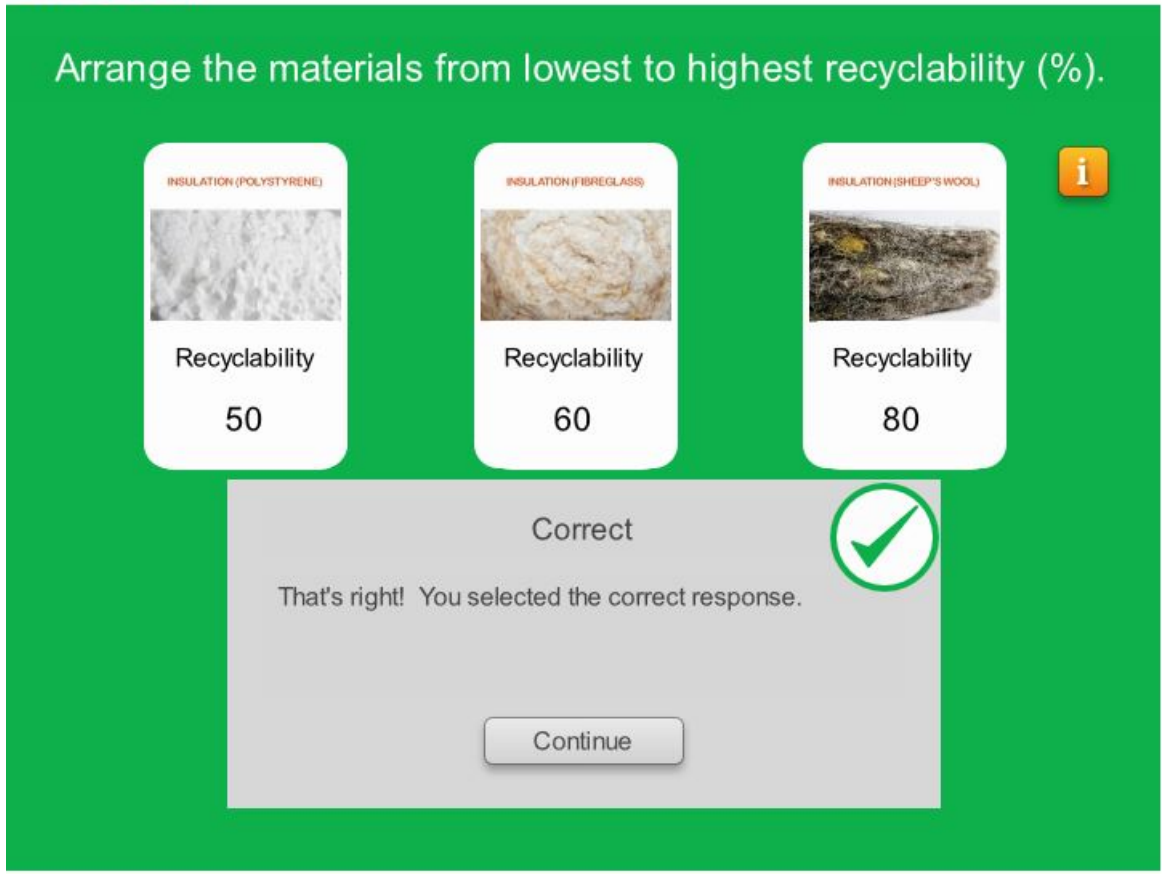
INSULATION (POLYSTYRENE)

SUSTAINABLE FEATURE SCORE

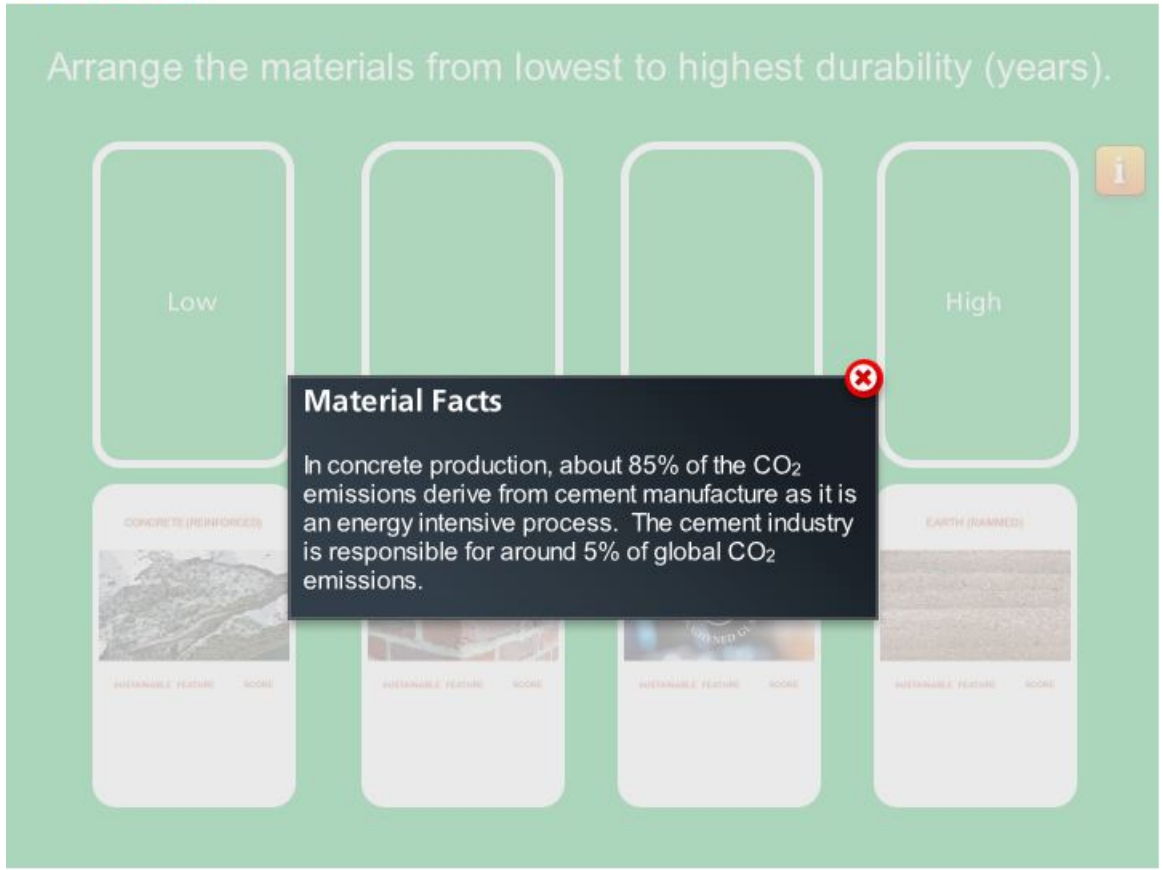
Ecocard sorting



Ecocard sorting



Ecocard sorting



Ecocard sorting

Material Facts

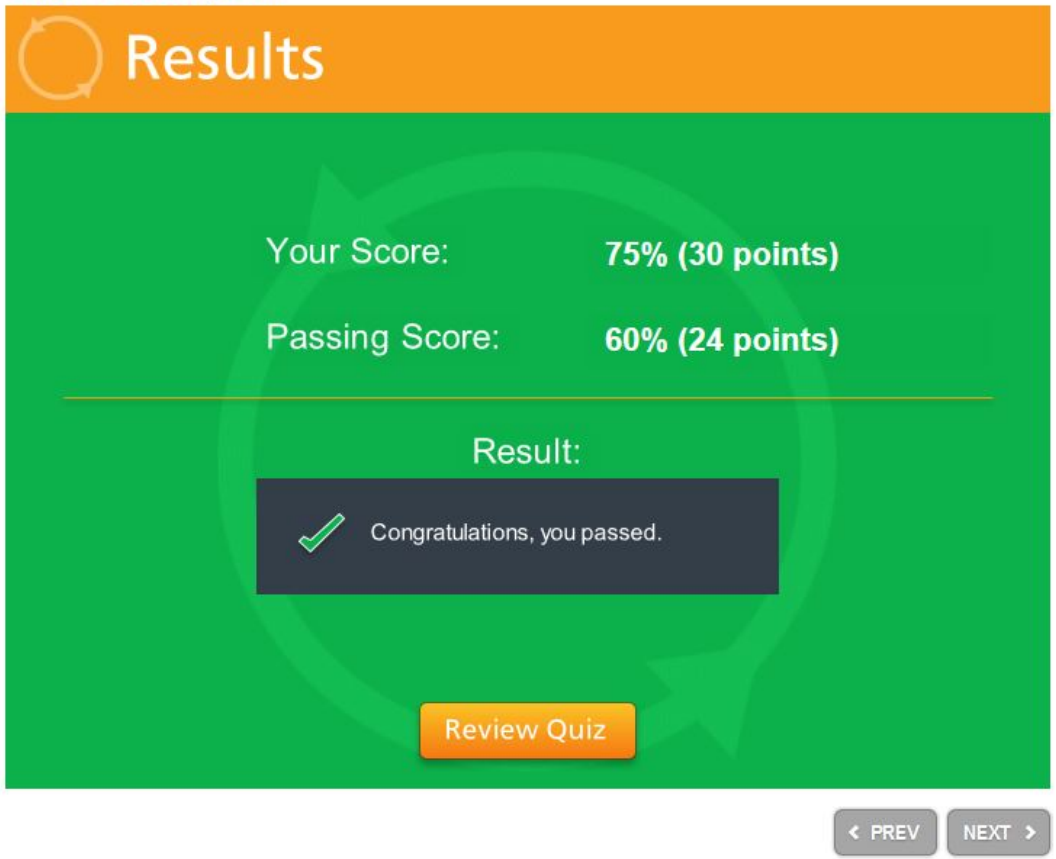
During the building design and construction phases alone CO_2 emissions can be reduced by as much as 30% through the careful selection of low environmental impact construction materials.

Ecocard sorting

Material Facts

Waste can originate from the source of the original materials, during manufacture or during installation. If not reused or recycled waste construction material is likely to be landfilled or incinerated for which climate changing green house gas emissions can occur. In a landfill site, waste is permanently buried. The process of material decomposition results in the release of methane, a greenhouse gas with 4 time the Global Warming Potential (Amount of heat trapped by greenhouse gases) of CO_2.

Ecocards Pair comparison



As the world transforms in its efforts to avert dangerous climate change, ecological literacy will become a vital part of all education. We cannot expect future generations to value what they are being taught, unless they also experience and live it in their learning environments…students will come to think of sustainability as being as obvious and essential to a building as doors and windows.'

(Mazria in Taylor 2009 p.1)