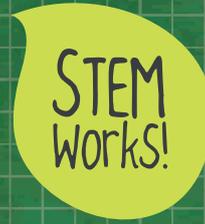


STEM FUTURES

Using Maths Tasks: Teacher's Notes



Northern Ireland
Curriculum

clean and green: Teacher's Notes

Acknowledgements

CCEA would like to acknowledge the support provided by Atkins Engineering and the Mathematics Departments of St Patrick's Grammar School (Downpatrick) and St Patrick's College (Magherafelt).



Overview

This task challenges pupils to work out solutions associated with building a school for the 21st century. They need to carry out a variety of calculations and take environmental issues into account.

We have provided data that you can use for the activities. However, you may wish to use the actual costs and figures for your school.

Prior Learning

To complete all aspects of the task successfully, pupils will need to have the knowledge, understanding and skills listed below.

In Mathematics:

- Applying mathematical concepts when working with money
- Making informed decisions based on calculations
- Calculating percentages of money
- Rounding to appropriate degrees of accuracy
- Using and manipulating formulae
- Calculating surface area and volume.

In Physics:

- Knowledge and understanding of sustainable development
- Knowledge and understanding of energy sources used to generate electricity and energy efficiency
- Knowledge and understanding of the units of measurement for energy consumption (kilowatt-hour, kWh)
- Knowledge and understanding that sound is a type of energy and that when a sound is transmitted it is absorbed and reflected as it travels
- Knowledge and understanding that different materials will absorb and reflect sounds by different amounts
- Understanding of what is meant by reverberation time.

General

These activities allow pupils to investigate the most efficient and cost-effective ways to power and light a school.

As well as the Key in this booklet, we have provided online spreadsheets that you can use to confirm the calculations for both tasks. These also allow you to change numbers, check and confirm pupil responses. The spreadsheets are for teachers' use only; however, pupils may choose to design and use their own.

ACTIVITY 1

The Cost of Electricity

In Activity 1, pupils explore the costs associated with different types of electricity that the school could use. See the Key in this booklet and/or the online spreadsheet for more details.

Together, Activities 1 and 2 challenge pupils' ability to interpret information and make decisions based on a wide range of requirements and outcomes. For some pupils, the mathematics involved may not seem difficult; however, identifying what approach to take and what maths to use may prove more demanding.

ACTIVITY 2

Light Options

In Activity 2, the focus is on different types of lighting and associated costs. Please note that the answers provided are based on calculations involving all 365 days in a year. As most school buildings do not open every day, pupils may choose to investigate the costs based on, for example, a five day week for 40 weeks of the year. This will affect their results and influence their decisions on cost and efficiency.

Once pupils have worked out the powering and lighting technology costs for the school, they will need to state which technologies they would choose for the school. But they need to be aware of the initial start-up costs for all three power and lighting technology options, as well as the yearly operating and maintenance costs for each technology option. This could affect their choice. They should also state how they could manage the budget accordingly.

ACTIVITY 3

Classroom Acoustics

In Activity 3, pupils investigate engineering concerns that relate to room design and acoustics. This includes the impact of reverberation time on their choice of materials for a school.

This activity challenges pupils' ability to combine their understanding of volume and surface area with their interpretation of given formulae to solve an unfamiliar problem. It includes terms that pupils may not be familiar with, such as absorption, coefficient, decibels, decibel meter, reverberation, sigma and summation. You may find it appropriate to discuss the meanings of these terms before and/or during the activity.

For example, you could explain (or encourage pupils to research) a definition for reverberation time: the time that it takes a sound made in a room to diminish to one millionth of its original intensity. However, pupils should have no difficulty using the formula provided (Sabine's formula) without additional information about it.

Pupils may have more difficulty with the formula to calculate the absorption of each surface. This involves sigma (Σ), so they need to work out the summation of a number of calculations. Explain that they need to add up each individual absorption calculation to get a total absorption value. (Please note that the absorption coefficients in this activity are given at a frequency of 500 Hz.)

Key

The methods shown here for working out and arriving at solutions are examples only. Pupils do not need to replicate them exactly. However, they will need to show how they worked out their answers.

Activity 1 Calculations

- 1.1 (a) $£15\,000 \times 50 = £750\,000$
 (b) $£750\,000 + £50\,000 = £800\,000$

1.2

	A		B		C		D	E
Technology	Purchase Cost (£)	Operating Cost (£/ year)	Operating Cost over 50 Years (£)	Maintenance Cost (£/ year)	Maintenance Cost over 50 Years (£)	Revenue (£/ year)	Revenue over 50 years (£)	Whole Life Cost (£) E = (A+B+C)-D
Option 1	£0.00	£3957.00	£197 850.00	£0.00	£0.00	£0.00	£0.00	£197 850.00
Option 2	£50 000	£2638.00	£131 900.00	£500.00	£25 000.00	£750.00	£37 500.00	£169 400.00
Option 3	£20 000	£1978.50	£98 925.00	£200.00	£10 000.00	£1500.00	£75 000.00	£53 925.00

Option 3 is the least expensive.

Activity 2 Calculations

			A		B		C	D
Technology	Units Required	Purchase Cost (£)	Total Purchase Cost (£)	Operating Cost (£/ year)	Operating Cost over 50 Years (£)	Maintenance Cost (£/ year)	Maintenance Cost over 50 Years (£)	Whole Life Cost (£) D = A+B+C
Option 1	500	£1.00	£500.00	£11 554.44	£577 722.00	£50.00	£2500.00	£580 722.00
Option 2	500	£8.00	£4000.00	£2310.89	£115 544.40	£40.00	£2000.00	£121 544.40
Option 3	300	£100.00	£30 000.00	£0.00	£0.00	£30.00	£1500.00	£31 500.00

2.1 **Option 3:** Sun pipes/Skylights is the least expensive over the 50 years.

$£580\,722.00 - £31\,500.00 = £549\,222.00$ saving over standard light bulbs

$£121\,544.40 - £31\,500.00 = £90\,044.40$ saving over energy-saving light bulbs

2.2 Natural lighting means solar power for producing electricity and sun pipes/skylights to light the school.

Natural lighting would cost $£169\,400.00 + £31\,500.00 = £200\,900.00$

Total operational budget – natural light = $£800\,000.00 - £200\,900.00 = £599\,100.00$

2.3 Pupils provide their own choice, with reasons and justification for their choice, based on all their calculations, budget limit and factors which may affect power and lighting efficiency.

2.4 Pupils describe the advantages and disadvantages of using only natural light to power and light the school:

Advantages	Disadvantages
Environmentally friendly Free source of energy from sun Renewable Produced where it is consumed Equipment easy to install	Dependent on levels of natural light Dependent on climate Requires a large number of panels to generate electricity required Cost

3.1 Room dimensions:

- Width: 4 m
- Length: 6 m
- Height: 3 m
- Volume: 72 m³

	Surface Area	Absorption Coefficient	Absorption
Ceiling	24 m ²	0.12	2.88
Floor	24 m ²	0.15	3.6
Small Wall 1	12 m ²	0.18	2.16
Small Wall 2	12 m ²	0.18	2.16
Large Wall 1 (Plasterboard)	18 m ²	0.18	3.24
Large Wall 2 (Glass)	18 m ²	0.05	0.9
		Sum of	14.94

Reverberation time of classroom:

$$T = 0.161 \times (72 \div 14.94) \approx 0.78 \text{ seconds}$$

3.2 The time could be lower because the teacher, pupils and classroom furniture have absorbed some of the sound.

3.3 Room dimensions:

- Width: 4 m
- Length: 6 m
- Height: 3 m
- Volume: 72 m³

	Surface Area	Absorption Coefficient	Absorption
Ceiling	24 m ²	0.12	2.88
Floor	24 m ²	0.15	3.6
Small Wall 1 (Glass)	12 m ²	0.05	0.6
Small Wall 2 (Glass)	12 m ²	0.05	0.6
Large Wall 1 (Glass)	18 m ²	0.05	0.9
Large Wall 2 (Glass)	18 m ²	0.05	0.9
		Sum of	9.48

Reverberation time of classroom:

$$T = 0.161 \times (72 \div 9.48) \approx \mathbf{1.22 \text{ seconds}}$$

This reverberation time is too high for a classroom.

Clean and Green Assessment Grid

If you use Clean and Green to assess the Cross-Curricular Skill of Using Mathematics, the following assessment grid highlights the Requirements, Knowledge and Understanding that your pupils will cover in the task. It gives examples of how pupils might demonstrate these at Levels 6 and 7.

Pupils should be enabled to:	Level 6	Level 7
Context	Through discussion, solving routine and non-routine problems with increasing independence in a wide range of familiar and unfamiliar contexts and situations, pupils can:	Through discussion, solving routine and non-routine problems with increasing independence in a wide range of familiar and unfamiliar contexts and situations, pupils can:
<ul style="list-style-type: none"> choose the appropriate materials, equipment and mathematics to use in a particular situation; 	<ul style="list-style-type: none"> plan for an activity by identifying and sequencing component steps; Pupils identify how the information provided in Activity 1 and 2 should be used to calculate the total costs for the electricity and lighting technologies. They recognise that they need to calculate the yearly and 50-year operational costs for the options. Pupils identify that they need to calculate the volume and surface area of the classroom for Activity 3. consider and identify a range of materials/equipment, mathematical techniques and problem-solving strategies required to meet the purpose of activities; Pupils use the four operations when calculating the costs for Activity 1 and 2. Pupils use the formula for the volume of a cuboid for Activity 3. They also calculate the area of the ceiling, floor and each wall of the room when finding the surface area. They draw a net of the room to help calculate surface area. 	<ul style="list-style-type: none"> plan an activity, explaining their reasons for their chosen structure and approach; Pupils identify that the information provided for each option for the electricity technology requires them to calculate the total operating, maintenance and revenue costs in order to work out the total costs (Activity 1). They also identify that for the lighting technology they need to calculate the purchase, operating and maintenance costs in order to work out the total costs. They use a table to present their costs and explain why (Activity 2). Pupils explain that they need to work out the area of each surface of the room and multiply it by the associated absorption coefficient. They explain that they also need to add up the absorption value for each surface to get the total absorption to help find the reverberation time. consider and identify, with some justification, the materials/equipment, mathematical techniques and problem-solving strategies required; Pupils give some justification for how they present their information and how their approach has aided them in solving both activities.

<ul style="list-style-type: none"> • use mathematical knowledge and concepts accurately; • work systematically and check their work; 	<ul style="list-style-type: none"> • use a range of appropriate mathematical techniques and notation; Pupils show their working out throughout all three activities, systematically working out the options. They include money and measure notation. • work systematically and efficiently to a given degree of accuracy; Pupils work through the options for Activity 1 and 2, clearly showing their working out, and clearly present their answers. They calculate in pence and convert the answers to pounds. They compare their answers when deciding on the most cost-effective option. Pupils calculate the volume of the room and show evidence of working out the surface area, too. • review their work, using appropriate checking procedures and evaluating their effectiveness at each stage; Pupils show evidence of reviewing their calculated costs in line with the associated costs of the options and the operating budget for each year and for the 50-year period and identifying if they feel they have been successful or not for Activity 1 and 2. Pupils identify the dimensions for each wall before calculating the surface area of the room in Activity 3. 	<ul style="list-style-type: none"> • use a range of appropriate mathematical techniques and notation; Pupils present their information for Activity 1 and 2 efficiently, so it can be compared, in order to make decisions. Pupils clearly show how they calculate the reverberation times for Activity 3 and use rounding when presenting their answers. • critically review to what extent they succeeded in carrying out activities, checking if the level of accuracy and their findings are appropriate and making an assessment of any limitations; Pupils relate all their calculated costs with reference to the expectations for Activity 1 and 2. They explain effectively how they have provided a solution for the client. Pupils decide and explain if the reverberation times are acceptable for the rooms in Activity 3.
<ul style="list-style-type: none"> • use mathematical understanding and language to ask and answer questions, talk about and discuss ideas and explain ways of working; 	<ul style="list-style-type: none"> • use appropriate mathematical language/notation to communicate and explain their work for a wider audience; Pupils describe their steps and use all of their calculated totals to explain which option they would choose for both the electricity and lighting technologies. Pupils explain why they need to calculate the surface area of the room. 	<ul style="list-style-type: none"> • use appropriate mathematical language/notation to explain and justify their findings or solutions; Pupils present their work clearly and explain their chosen approach at each step. They communicate their findings and their conclusions effectively, relating them directly to the problems at hand, and explain whether they have been successful or not.

Knowledge and Understanding		
Number and Algebra	<ul style="list-style-type: none"> • carry out calculations with whole numbers of any size; Pupils calculate the total budget and the costs for each option using whole numbers and decimal numbers. Pupils calculate the volume and surface area of the room using whole numbers. • use appropriate formulae; Pupils recall and use formulae for calculating the volume and surface area of the room in Activity 3. • apply mathematical concepts to a range of financial situations; Pupils use the information provided to calculate operational and total costs in Activity 1 and 2. 	<ul style="list-style-type: none"> • round to an appropriate number of decimal places and significant figures; Pupils round the reverberation times in Activity 3 to an appropriate number of decimal places of their choosing. • manipulate simple algebraic expressions, equations and formulae; Pupils calculate the absorption for each individual surface and use Sabine's formula to calculate reverberation time. • make informed decisions involving money; Pupils use their solutions to respond to the questions in Activity 1 and 2 with regard to costs and budgets.
Shape, Space and Measures	<ul style="list-style-type: none"> • calculate surface area and composite volumes of cubes and cuboids. Pupils calculate the surface area of the room in Activity 3. 	<ul style="list-style-type: none"> • solve complex problems involving perimeter, surface area and volume. Pupils calculate the absorption of each surface of the room by multiplying the area of the surface by the absorption coefficient.