

Mathematical Modelling Teaching Task Design Competition

Learning, Teaching and Assessment Activities Design

 Teaching Plan Title: Building a Power Consumption Equation Model for a Classroom

Teaching Plan Content:

Basic Information		
Grade:	Secondary 4	Duration: 80 minutes
Strand:	Number and Algebra	Number of Sessions: 2
Topic:	Variation (Partial variation)	
Class Mode:	☒ Whole-class Teaching ☐ Group Teaching ☐ Cooperative Teaching	
Teaching Objectives:	<ol style="list-style-type: none"> Understand the concept of partial variation and distinguish it from direct variation. Use real energy consumption data of a classroom to calculate power consumption and identify patterns between temperature and power consumption. Construct a power consumption model of the form: $\begin{cases} P = k_1T + k_2 & \text{for } T > T_{ref}^{\circ}\text{C} \\ P = K & \text{for } T \leq T_{ref}^{\circ}\text{C} \end{cases}$ where P is power, T is temperature, K is a constant term interpreted from the data, and T_{ref} is the reference temperature that depends on students' behaviour. Interpret and explain the meaning of the constant term and the coefficients in the model in a real-life context (e.g. what they imply about energy usage). Discuss assumptions, identify abnormal data, and suggest possible improvements and extensions of the model (e.g. including other factors like humidity, class size), thereby enhancing their awareness of energy saving and environmental protection. 	

Students' Difficulties:	<ol style="list-style-type: none"> 1. Conceptual difficulties in modelling: They just use “all data given” without checking whether the data is meaningful (e.g. when no one in the classroom or during PE lessons). 2. Algebraic and graphical difficulties: <ul style="list-style-type: none"> ■ Identifying linear patterns from a table of values and from a scatter plot. ■ Interpreting the slope and intercept in context (e.g. what does 0.94125 kW mean physically?). 3. Language and reasoning difficulties: <ul style="list-style-type: none"> ■ Expressing their findings and assumptions clearly in English. ■ Explaining in words why certain factors (e.g. humidity) may or may not be suitable to include in the model.
Prior Knowledge (if any):	<ol style="list-style-type: none"> 1. Understand the concepts of direct and inverse variation and solve simple related problems. 2. Be able to use simultaneous equations to find unknown parameters in a linear relationship. 3. Know basic ideas of linear functions, gradients, intercepts, and reading values from a table/graph.
Teaching Resources:	<ol style="list-style-type: none"> 1. iPad 2. EMSD SEMS platform 3. Printed worksheet

Teaching Plan		
Teaching Procedures and Time (minutes)	Teaching Activities/Procedures (please mark the parts related to mathematical modelling)	Required Resources
Pre-class Preparation		
Revision 10 minutes	<ol style="list-style-type: none"> 1. Application of direct and inverse variation. 2. Highlight that they will handle a more realistic situation where there is a constant term in the model. 	

	3. Review with students the 5 steps of the mathematical modelling cycle: scenario, assumptions, formulation, evaluation and review.	
Motivation 10 minutes	1. Log in to the EMSD SEMS platform to read the school's energy consumption dashboard and check the overall daily energy usage. 2. Ask: <ul style="list-style-type: none"> ■ “Which part of the school do you think consumes the most electricity during lesson time?” ■ “Which appliance inside a classroom uses the most power?” 3. Open the Excel files which show the daily energy data and maximum temperatures in Room 502. 4. Pose these guiding questions: <ul style="list-style-type: none"> ■ “What time of a school day should we focus on if we want to study power consumption in a classroom?” ■ “Why might data from 00:00–07:00 be ‘useless’ for our purpose?” ■ “How can we convert energy in kWh in a 4-hour period into power in kW?” 	
Development Stage 30 minutes	<u>Stating the assumptions</u> (5 minutes) 1. Discuss with students the assumptions of the mathematical model to simplify the real-world situation. <u>Calculating Power Consumption</u> (10 minutes)	

	<ol style="list-style-type: none"> Work through one full example with the class (e.g. 2/10/2025) <ul style="list-style-type: none"> Add the four energy readings for the relevant time slots to get the total energy for the 4-hour period. Divide by 4 to get the average power in kW. Emphasize the formula $P = \frac{E}{t}$ and specify E in kWh and $t = 4$ hours. Ask students to compute power consumption for the other days in the list using suitable computational tools. After a few minutes, show the answers to students so they can check their own calculations. <p><u>Relationship between Temperature and Power</u></p> <p>(10 minutes)</p> <ol style="list-style-type: none"> Using the updated table (dates with their max T and corrected P), ask: <ul style="list-style-type: none"> “In general, what happens to power consumption when temperature increases?” Guide students to notice by creating a scatter plot: <ul style="list-style-type: none"> At higher temperatures, power tends to be higher because air-conditioners work harder to maintain a set indoor temperature (e.g. 23°C). Ask students to observe the distribution of pattern of the data points, namely that they are scattered in two clusters. Highlight the data when $T \leq 23.1$ °C and show that the power consumption there is close to a constant. 	
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	<p>4. Ask:</p> <ul style="list-style-type: none"> ■ “Why is there a constant power consumption even when the temperature is low, and the air-conditioners are off?” <p>5. Guide them to the idea: other appliances (lighting, computers, projectors) still consume power; this gives the constant term K as the background power consumption.</p> <p>6. Discuss with students a few low-temperature days (e.g. 22/10, 23/10, 15/12 and 16/12) to obtain an estimate of K (around 0.94125 kW).</p> <p><u>Identifying Abnormal Data</u> (5 minutes)</p> <ol style="list-style-type: none"> 1. Ask students to examine the energy readings by time slot for certain dates (e.g. 3/10 and 24/10). 2. Guide them with questions: <ul style="list-style-type: none"> ■ “On 3/10, why is the energy consumption unusually low during 09:00–10:00?” ■ “What happened during that time?” 3. Explain the context: There were PE lessons, so the classroom was empty. 4. Show how to re-evaluate the power consumption by normalizing that abnormal time slot. 5. Ask students to identify other abnormal time slots (24/10, 09:00–11:00) and calculate the normalized power. 	
Evaluation Stage 15 minutes	<ol style="list-style-type: none"> 1. Guide students to formulate the mathematical model and use the software Excel to plot the graph and generate the equation using their data. 2. Ask students: 	

	<ul style="list-style-type: none"> ▪ “How does the mathematical model reflect, and what are the assumptions?” ▪ “What is the physical meaning of the temperature condition?” <p>3. Use the mathematical model to calculate the total energy consumed for 6 hours at a maximum temperature of 30°C, and let students get a sense of how much energy is needed through a real-life example.</p>	
<p>Application Stage</p> <p>10 minutes</p>	<p>1. Introduce other possible factors: humidity, classroom size, number of students, window orientation, ratio of boys to girls, etc.</p> <p>2. Ask students:</p> <ul style="list-style-type: none"> ■ “If we include humidity as a factor, what do you expect theoretically?” ■ “Why might it still not be a good factor for Room 502 based on our actual data for 9/10, 13/10, 15/10?” <p>3. Guide them through the comparison: On 13/10, humidity is higher than on 9/10 and 15/10, but power consumption is lower, so humidity does not behave as expected here. Also, as there are not sufficient data, no conclusion on the effect of humidity can be drawn in the model.</p> <p>4. Let students guess the new equation model if they want to reduce power consumption.</p>	
<p>Summary</p> <p>5 minutes</p>	<p>1. Recap the modelling cycle using this task:</p> <ul style="list-style-type: none"> ■ Identify the problem (estimate the power consumption of a classroom). 	

	<ul style="list-style-type: none">■ Collect and clean data (select relevant times, remove abnormal readings).■ Build a mathematical model (piecewise linear equations – partial variation).■ Interpret and test the model (check against the data, consider other factors).■ Reflect and improve (add assumptions, consider extensions to home and gas/water usage). <p>2. Highlight how this model can help:</p> <ul style="list-style-type: none">■ Plan energy-saving actions (e.g. adjusting air-con settings).	
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