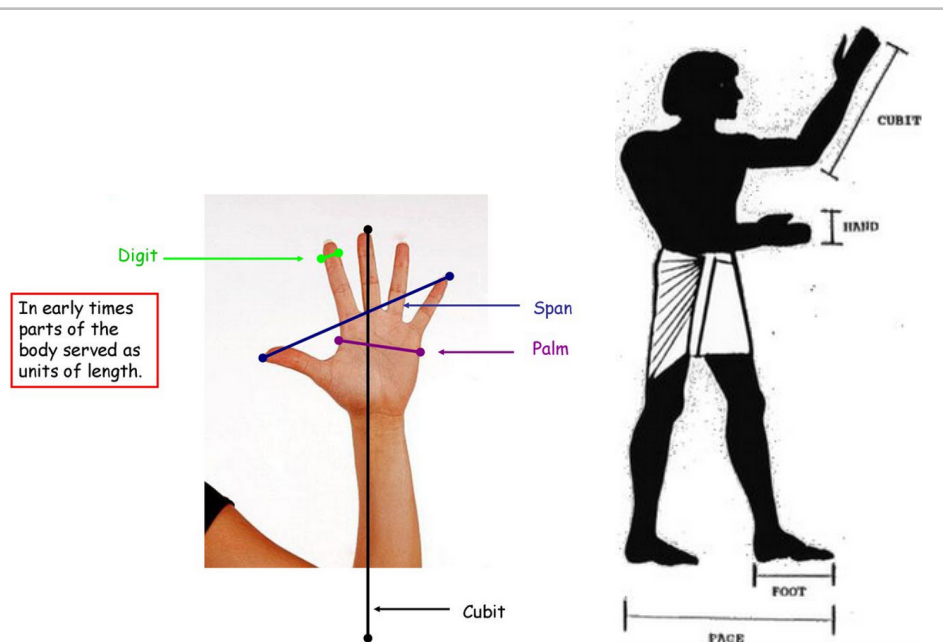# Draw and calculate like an architect (Level 3)

Description	Learners use body parts in scale drawing of floor plans and calculate area using simple counting methods
Leading Question	How can you draw floor plan sketches and calculate areas using your body parts as measuring tools?
Total Time Required	~6 hours over 4 days
Supplies Required	Paper and pencil a ruler (for smaller measures), a tape measure (for larger measures)
Learning Outcomes	1. Scale drawing using simple conversion of Foot to Digit 2. Find areas of rectangles by drawing unit squares and counting 3. Multiplication and its application to finding areas of rectangles 4. Dividing and applying division on word problems 5. Apply mathematical knowledge and skills in a real-life scenario
Previous Learning	- Counting and simple addition. - *It is preferred that learners do the "Beauty in Shapes and Measurements" project before this one.

Day 1

Today you will learn about creating your own house!

Suggested Duration	Activity and Description
20 minutes	● In this project, we will learn how an Architect draws floor plans, and what methods they use to calculate the size of rooms or houses. ● Let's start by measuring the floor dimensions of this room. ● As you may know from a previous project, in ancient times people used their body parts to measure lengths.

Digit

In early times parts of the body served as units of length.

Span

Palm

Cubit

CUBIT

HAND

FOOT

PACE

- Ancient people measured objects using different body parts. This is called non-standard measurements. Measurement is finding a number that shows the size or amount of something.

Examples of non-standard units used by ancient people to measure length included: the **Foot**, the **Hand**, the **Handspan**, the **Cubit**, the **Digit**, the **Pace** etc.

- The **Cubit** is a measurement equal to the length from your elbow to the tip of your middle finger when your arm is extended. Egyptians mainly used their cobits to measure objects,
- The **Foot** is a measurement equal to the length of your foot from the toe to the heel. King Henry I of England standardized this measurement to measure his foot which was 12 inches long.
- The **Handspan** is a measurement equal to the length from the tip of the thumb to the tip of the last finger when your hand is stretched out.
- The **Digit** is a measurement equal to a finger's breadth. Four digits equal to a **Palm** and five digits equal to a **Hand**. Greeks mainly used their fingers to measure objects. The Hand is still used to measure the height of horses.
- The **Pace** is a measurement of the distance from one step to another. The Roman Army used the Pace to judge speed.
- The **Fathom** is a measurement equal to the length between both your base fingers when you outstretch both your arms. The Fathom was used to measure the depth of water

Activity 1: Personal Measures

In this activity learners will measure their Cubit, Foot, Handspan, Digit, Palm, Hand, Pace, Fathom and those of two of their family members/friends and enter their findings in the table below.

Learners will write down the measures in a table like the one below

Person	Personal Measure	Body part length (unit)
Learner	Cubit	
	Foot	
	Handspan	
	Digit	
	Palm	
	Hand	
	Pace	
	Fathom	
Family member 1	Cubit	
	Foot	
	Handspan	
	Digit	
	Palm	
	Hand	
	Pace	
	Fathom	
Family member 2		

- What do you notice from your findings?
- Is there any relation between the Handspan and the Cubit?

Among other, learners may notice from their findings that:

- Each person's body part unit is different from another's body part unit. This is the reason why measuring length using body parts units is referred to as measurement of length using non- standard units.
- The Handspan is about half the Cubit

15 minutes	**Activity 2: Comparing measurements made using Body Parts (Non-Standard Units) to those made using Standard Units**

In this activity, learners will use the Personal Measure (Body Parts) to measure different items and compare their results with those obtained using Standard Units

Learners will write down the measures in a table like the one below

Item	Personal Measure (Body part)	Estimate using a Personal Measure (cm or in)	Actual using a ruler or tape measure (cm or in)
Length of a pencil	Digit		
Length of a foot mat	Foot		
Length from table to door	Pace		
Length of room	Cubits		

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|	How close are the estimates obtained using Personal Measure to those obtained using a ruler or tape measure?
30 minutes	● For this activity you will use mainly the **Foot**, and the **Digit** which are non standard units. Of course, you know that your foot size is smaller than the actual Foot unit used on measuring tapes (as different people have different foot sizes!) - Pick one of the house rooms with a rectangular floor shape, preferably the smallest room in the house. - Stand on one corner of the room, and walk by the wall, step by step, to reach the other corner. - You must start with the back of your foot touching the wall behind, and then place the other foot right in front of and touching the other foot,and keep counting your steps until you reach the facing wall. - Repeat with the 4 sides of the room, and write down the measures in a table like the one below <table><tr><td>Room side 1</td><td></td></tr><tr><td>Room side 2</td><td></td></tr><tr><td>Room side 3</td><td></td></tr><tr><td>Room side 4</td><td></td></tr></table> - Is any of the sides equal in length to another side? Does this apply to all rectangles? - In a rectangle, usually the measure of the longer side is called length (L); and the measure of the shorter side is called width (W).
15 minutes	● On a piece of paper, you will draw a sketch of the room ● The room is much bigger than the sheet of paper, so architects usually draw a smaller sketch that looks like the actual room but smaller (something like a photograph of you compared to the real size of you). ● See below how to do it:

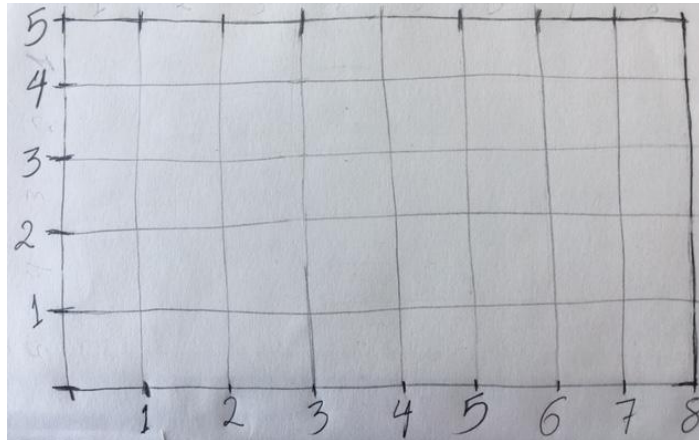- To do this, instead of using your Foot to draw the sides of the rectangle, you use your finger: Digit.
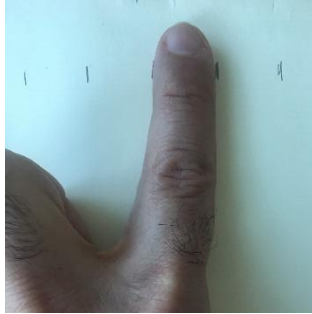
  - In the example below, see a sketch of a room whose Length L = 8 feet, and width W= 5 feet. The actual size of the sketch is 8 Digits by 5 Digits.
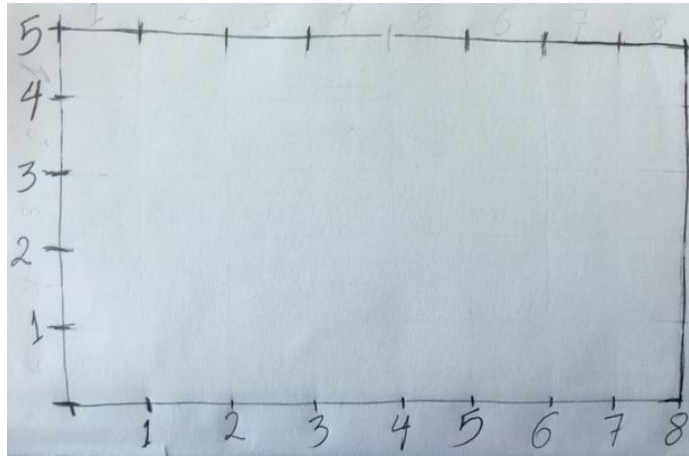
  - As you also notice, we do not need to write the sizes of the other sides, as in a rectangle opposite sides are equal in size.
- Now draw the sketch of the room on a sheet of paper.

15 minutes	● On your sketch, create a grid using the Digit marks, as shown below:

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- Count the number of squares in your diagram.
- **Notice** that the side length of the small square is 1 digit, so we call it a unit square.

15 minutes	- The number of squares inside the sketch is called the **Area** of the sketch. - The **area** is the size of the floor surface inside a certain shape, which is the count of unit squares enclosed within. - In the example above, we saw that the sketch has 40 unit squares within, so its area is 40 **squared Digits**, and we conclude that the area of the room is 40 **Squared Feet**. - What is the area of your sketch? (in squared Digits) - What is the area of your room? (in squared feet) *Foot measure used here is the Learner's foot size and not the universal Foot scale.
30 minutes	- In scale drawing, you can choose any scale you like and mention that on your drawing. For example, in some maps the scale can be 1:10'000, which is 1 centimetre representing 100 meters. - Try to answer the questions on the Day 1 Worksheet <u>without using a calculator</u>.
10 minutes	(Answer Key for Question 4: Area = 18.55 m^2, and Perimeter = 22.2 m; For Question 5: The Actual Area is 1500 m^2). Show your answers and discuss them with one of your parents based on the following questions:. What are the three most important things I have learned so far?

| | ● What have I found difficult? |
| | ● What additional support do I need from my family to complete this project? |

DAY 2

Today you will draw the sketch of your house floor map.

Suggested Duration	Activity and Description
5 minutes	● Today you will draw a sketch of the house floor map using a Digit to represent 1 Foot. ● When doing this, Architects imagine that the roof of the house is transparent, and we draw the map as if we are looking at the house from the top like a flying bird. ● As an example, below is a simple floor map. **Source:** https://www.tuko.co.ke/276066-3-bedroom-house-plans-designs-kenya.html You may notice that: The walls are drawn on the map There are some arcs to represent doors The function of each room is marked (bedroom, kitchen, bathroom…)
30-40 minutes	● Draw a floor map of the house and then present it to the family. ● Try to ensure that: - The floor map is up to scale (each 1 Foot of actual measure is represented by 1 Digit) - The map accurately represents the actual rooms of the house

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	- The name of each room or space is written on the map (like bathroom, kitchen...etc.)
5 minutes	● Learners present the floor map to their parents. Parents will provide feedback to the learner: 　● What they love most about the floor plan 　● Suggested areas of improvement ● Use the feedback to revise the plan
10 minutes	● Add the areas of the various rooms and internal parts of the house to find out the total livable area of the house. *Pay attention that if your scale is <mark>5 feet : 1 digit</mark>, then each unit square on the sketch of dimensions 1 digit by 1 digit represents a square of 5 feet by 5 feet **1 squared digit on the sketch represents 25 squared feet in reality**. ● Learners will also calculate underline without using a calculator the Perimeter of the house.
5 minutes	● Present answers to one of the parents ● Parents will check to see if: - Learners followed the methods used in this activity, or logically deducted an own method - The answers are correct
10 minutes	● Do you think if you measured the dimensions of the house from the outside, there will be any difference from the measurements you made on the inside? ● Learners answer and explain. ● In fact, the overall house area includes the area occupied by walls, which is usually overlooked when just adding the inside areas of the rooms. ● Let's try to calculate or estimate how much area do internal walls actually take, which is the space they take off the floor map because of their thickness. ● Try to measure the thickness of one of the internal walls of the house by placing your foot next to the wall against the internal thickness part as shown in the photo below:

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- The wall thickness is around 4/5 or 0.8 Foot, so in the example below, you can see that there are 8 internal walls (we do not count the external walls if all our measurements were done inside the house). Let's say we measured the lengths of all internal walls and it was 50 feet. Hence, the area that the internal walls occupy is equal to 50 x 0.8 = 40 squared feet!
- Therefore, the actual internal Area of the house is: internal Area of rooms + Area of walls. In the example below, assume the sum of all room areas is 650 Sq. Ft, we must add to it 40 Sq. Ft to count the area of internal walls, hence the internal area of the house is 690 Sq. Ft, out of which the liveable area is 650 Sq. Ft.
- In this case the livable area is 94% of the total internal area:
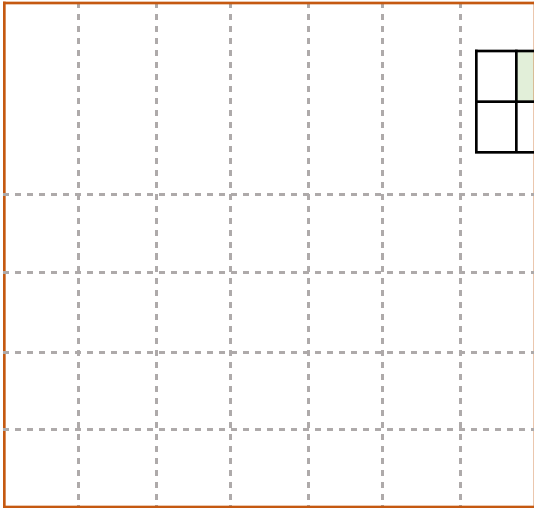
$$\frac{650}{(650+40)} \times 100$$

10 minutes	● Without using a calculator, do the following:
	- Calculate the areas of the internal walls of the house.
	- Add this to the livable are to find out the Total internal area of the house

	- What percentage is the Livable Area out of the Total Internal Area?
5 minutes	If we measure the house dimensions from outside, what do we need to subtract from it in order to find out the actual livable area?

DAY 3

Today you will practice division.

Suggested Duration	Activity and Description
10 minutes	● Architects use the different measurements of the house to calculate the material needed to complete the house construction. For example: using the area, they can calculate how many tiles they need to cover the floor. ● For example: A room of L 7m and W 5m, is to be covered by square tiles of S= 0.5; how many tiles are required? - If you notice on the sketch above, each unit square will take 4 tiles of side 0.5. - So, the number of tiles can be calculated in 2 steps: First calculating the room Area = 7 x 5 = 35 squared m. Then multiplying the area by 4, 35 x 4 = 140 tiles. - Another Method First calculating the room Area = 7 x 5 = 35 squared m. Then calculating the tile area = 0.5 x 0.5 = 0.25 Then dividing the Area of the room by the area of the tile: 35 ÷ 0.25 - As you know 0.25 is $\frac{25}{100}$

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$35 \div 0.25 = 35 \div \frac{25}{100} = 35 \times \frac{100}{25} = 35 \times 4 = 140$ tiles.

- As you see above, we solved a division problem using multiplication.
- For the cost of tiles, it is usually sold per square meter, for example if the tiles are sold for 3$ per m^2, then the tiles to cover the room in this example would cost:

$35 \times 3 = \$105$.

15 minutes	● Now it is your turn to calculate <u>without using a calculator</u>: if you were to change the tiles in your house with square tiles of 0.5 foot, how many tiles would you need? ● And how much would that cost, if the tiles are sold at $0.3 per sq. foot?
30 minutes	● Solve the Day 3 Worksheet and show your work and answers to one of your parents.

5 minutes	● If we were to estimate the amount of paint required for the walls and ceiling of the room, in the previous example, we need:
	- The dimensions of the room: Length, Width and Height.
	- The dimensions of any doors or windows
	- We estimate that 1 L of wall paint covers 10 m^2, or 100 Sq feet.
	● Let's assume that we have a room of dimensions Length 7m, Width 5m, & Height 2.5 m. The room has 1 door and 1 window whose area adds up to 4 m^2. Find out how many L of paint it requires, if we apply 2 coats of paint, and what would that cost if the paint is for $3.5 per L.
	● To solve this problem, we follow the below steps:
	- To solve this problem, we follow the below steps:
	- The total area that requires painting:
	- Ceiling: is same as floor L x W = 7 x 5 = 35 m^2
	- Area of walls, after taking out the areas of doors and windows:
	    o Wall 1: 7 m x 2.5 m
	    o Wall 2: 5 m x 2.5 m
	    o Wall 3: same as Wall 1
	    o Wall 4: same as Wall 2
	    o Area of walls = 2x(7x2.5) + 2x(5x2.5) – Area of doors and windows
	        • = 35 + 25 – 4 = 56 m^2
	- To calculate the amount of paint required, we divide this area by the estimate of 10 m^2/L :
	    o 56 $m^2 \div$ 10 m^2/L = 5.6 L of paint for one Coat
	    o For 2 coats we need 2 x 5.6 L = 11.2 L
	- The cost of that is 11.2 L x 3.5 $/L = 39.2 $

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30 minutes	• Now it is your turn to calculate **without using a calculator**: if you were to paint all the walls and ceiling of your house from the inside, how many liters of paint are required (for 2 coats)? And how much would that cost? • Assuming that 1 L of paint covers 100 Sq Ft for a single coat, and costs $3.5 per L.
5 minutes	• Show your answers to one of your parents • Criteria: - The method is correct with logical steps - The answer is correct or reasonable

DAY 4

Today you will do a treasure hunt!

Suggested Duration	Activity and Description
30 minutes	• Learners will hide 3 items around the house and will mark where they hid them on the floor map. They will ask 3 family members to find one of the hidden items each. • If that was too easy, they can make it harder by hiding smaller items, and giving an approximate location.

30 minutes	• Learners will explore how we could help people navigate using verbal instructions.
	• Learners will imagine how they would help a blind person who could not see the map. They will blindfold one of their family members and give them directions to go from one location to another in the house using the following verbal directions only:
	   o Move (a number of) steps forward
	   o Turn to the left
	   o Turn to the right

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10 minutes	● Questions for discussion with family members after the treasure hunt game: - How good were your directions to guide the blindfolded member? - Did you have to correct any of the directions you gave? Why? - How do you think boats navigate their way in the sea without using technology? - Imagine ways to help sailors navigate in the oceans when they are unable to see land. Hint: Learners can be prompted to look out into the sky and imagine the north star (the brightest star in the sky) and the direction that the sun rises (east) and sets (west).
10 minutes	● Reflection questions - What did you like the most about this project? - Using what you have learned in this project, what floor maps would you like to draw? (probing: playground, your school, another house, …etc) - If you were the architect to design this house, what would you change while keeping the same total area of the house?
	Literacy Extension and Final Reflection Write 2 or 3 paragraphs about their key learning points about measurements, body parts (Non-standard units), how architects work, and/or how they intend to use the knowledge acquired in the project and share these with their family.

ASSESSMENT CRITERIA

● The house floor map is accurate and clear
● Worksheet questions are answered correctly using methods and skills introduced in earlier activities
● Learners are engaged and show grit while working on project tasks
● All calculations are done without using a calculator. (A parent may use a calculator to verify answers)

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ADDITIONAL ENRICHMENT ACTIVITIES

Draw the floor map of another space (School, playground…) and calculate how many tiles and litres of paint it will require.

MODIFICATIONS TO SIMPLIFY

Simpler version of this project can be to learn how to sketch floor maps of a rectangular space using simple conversion of Foot to Digit, and then using the sketches to calculate Areas and Perimeters.

DAY 1 WORKSHEET

Answer the below questions without using a calculator

1. Draw a floor map of a room whose Length is 14 Feet, and Width is 12 Feet, using the scale 2 Foot is represented by 1 Digit

   Then find the area of this room in Squared Feet.

2. A rectangle has an area of 20 Squared Feet. Its Length is 5 Feet. What is its width?
   Hint: use the formula A = L x W,
   20 = 5 x ?

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3. A rectangle has an area of 35 m². One of its sides measures 5 m, can you find the measure of the other side?

4. Find the Area and Perimeter of the shape in the sketch below. Each unit on the sketch represents 1 meter. All lines intersect at 90 degree angles. (The shape is not drawn to scale, so don't use measurements to identify missing lengths, but calculate them using opposite side lengths).
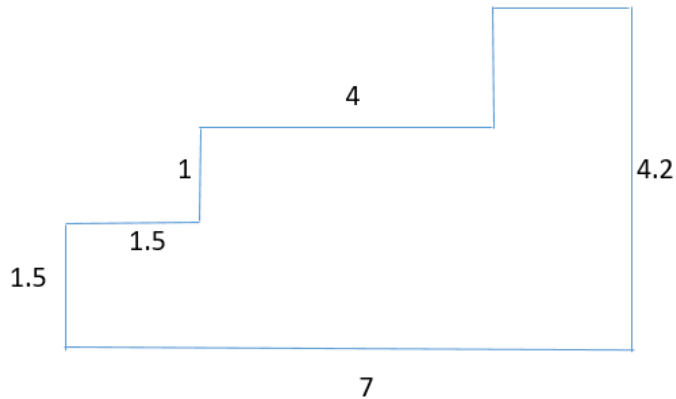
5. On a drawing of scale 1 :1000, the area of a rectangular piece of land if 15 cm². What is the actual area of this land in m² ?

DAY 3 WORKSHEET

Answer the below questions without using a calculator

1. A rectangular room is 12m by 7m. How many square tiles of side 0.5 m are required to cover the floor?

2. a. The perimeter of a rectangular hall is 36 m. Its Width is 6 m, what is its Length?

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b. How many square tiles of 0.3 m are required to cover the floor of the room?

c. What will be the cost of the tiles if they are for $4.5 per m² ?

3. A square room has an internal perimeter of 26 m. Find out how many square tiles of side 0.25 m are required for its floor, and the cost if you were to use tiles sold at $5 per m² ? (Hint: first identify the side length, then the area of the room, and last calculate the number of tiles).