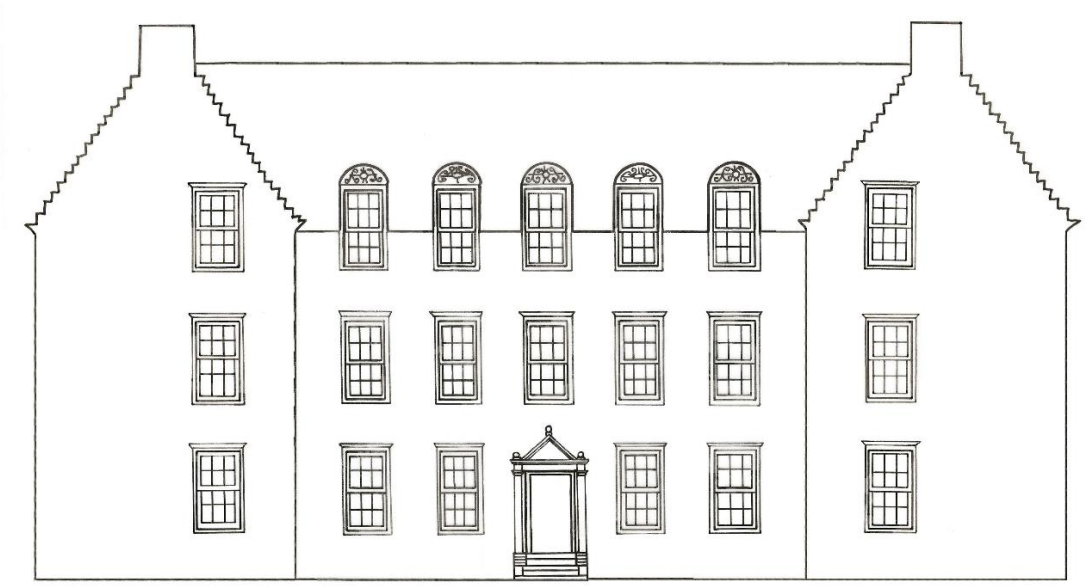

Measuring Scale Drawing

workshop ideas for

Bannockburn House volunteers

Bannockburn House
For the community

PF Charitable Trust

Introduction

This booklet contains three connected workshops which introduce basic concepts and hands-on activities of measuring buildings, understanding and using scale and drawing buildings freehand. The booklet accompanies and develops the content of the short videos introducing the workshops. The activities here complement the Bannockburn House modelmaking activity.

The workshops are intended to encourage participation, develop or refresh applied knowledge and practical skills and be enjoyable. The target audience is P5 to S2 pupils, e.g.: on average Curriculum for Excellence learning levels 2 and 3. Curriculum links at these two levels are contained in this booklet. The concepts and activities presented in each workshop provide a taster of real-life skills in a variety of work settings. The workshop ideas are also intended to be adaptable for adult learners as well as for children and young people at other learning levels.

Each workshop description begins with learning outcomes, suggestions for where to deliver the workshop and a list of equipment needed, and is followed by a series of thinking, talking and hands-on activities.

I hope this booklet proves to be helpful and useful for Bannockburn House volunteers' work with local young people, teachers and youth workers and provides a basis for adapting and creating your own workshops.
If you have any questions, suggestions or feedback about this booklet or would like to discuss delivery of in-person workshops, please contact Dr Nicky Imrie at nickyimriexl8@gmail.com

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Contents

1. Measuring

Getting started

In this workshop participants will be introduced to basic concepts and hands-on techniques for measuring buildings both outside and inside.

By the end of the workshop participants will have:

- thought and talked about locations and situations where measuring distance and height occur and what equipment and units to use
- tried out a variety of practical methods to measure distance
- measured accurately the footprint of part of Bannockburn House (or another familiar building)
- tried out practical methods and used trigonometry to calculate estimated heights

Workshop activities can take place either outdoors or in a large indoor space or both combined, depending on the time of year and weather conditions, current COVID safety regulations and numbers of participants.

Please ensure you have permission to work in your desired location(s) and have carried out a risk assessment of the workshop location.

For this workshop you will need:

- tables and chairs or clipboards
- plain and squared paper, pencils, pens, rulers, erasers
- long tape measures (30m or 50m), trundle wheels, metre sticks
- a scientific calculator; scientific functions are available in smart-phone calculators or the Google calculator
- cones
- chalk, wool or string

1.1 Thinking and talking about measuring distances

A general discussion or quiz altogether in one large group or in smaller groups. Answers to the questions could be discussed, written down or drawn. A set of flashcards displaying answers to each question could also be prepared.

Q: Where and when would you want to measure distance?

Q: Who would want or need to measure distances?

Suggested answers:

- in school subjects such as maths, technologies (craft and design and textiles), art, geography/social studies, P.E. (throws and jumps in athletics)
- setting out a football/hockey pitch, badminton/basketball/netball court, running track
- planning a journey by public transport, car, bike, on foot, wheeling, with dogs (or cats)
- doing DIY
- working as a builder, surveyor, architect, scaffolder, roofer, joiner, electrician, plumber, bricklayer, painter and decorator, carpetfitter, gardener, landscape designer, interior designer, estate agent, farmer, forester, civil engineer, transport planner, bridge, road or railway builder, archaeologist, photographer, modelmaker
- creating a building in Minecraft or other computer/video games
- what else?

Q: What equipment would you use to measure distance?

Suggested answers:

- ruler, metre stick, measuring tape, trundle wheel
- trundle wheel; bike wheel or wheelchair wheel with counter attached
- on my phone using Google Maps, SatNav, Strava, many other similar apps
- disto, theodolite, laser scanner
- radar, sonar, lidar, satellites/GPS

Q: What units would you use and where/when would you use them?

Suggested answers:

millimetres	architectural drawings, dimensions of objects in online shops, dimensions of objects in museum and archive, computer and electronics components
centimetres	a person's height and parts of the body, architectural drawings, dimensions of objects in online shops, dimensions of objects in museum and archive catalogues
metres	a person's height and parts of the body, building and room lengths and heights, hills and mountains, track and swimming races, how long or high a person can jump or throw, swimming pools and diving boards, DIY/contractors' materials, architectural drawings

yards	distances on streets, track and swimming races, how long or high a person can jump or throw (historically)
kilometres	journeys, bike rides, walks, road and cross-country races, parkrun
inches, feet	a person's height, building and room lengths and heights, hills and mountains, DIY/contractors' materials, architectural drawings up to 1950s (approx.)
miles	journeys, bike rides, walks, road and cross-country races
furlongs	horse races
fathoms, leagues	depth under the water/the sea
lightyears	space
what else?	

1.2 Trying out a range of methods to measure distances

This activity is best done in smaller groups and can take place indoors or outdoors.

1. set out a measured distance, i.e. 20 metres, using cones, chalk lines on tarmac/slabs or other means
2. groups are invited to try out 3 different ways of measuring the distance without measuring equipment, for example: using their own feet; their own strides; tip of middle finger to elbow; length of a wheelchair, any piece of equipment without measurements on it
3. each group writes down their different methods and their answers for each method
4. all the groups gather together, share their answers and discuss what worked best and what problems they encountered, such as reliability of results because of group members' different shoe sizes, stride or lower-arm lengths

1.3 Measuring part of your building

This activity is best done in smaller groups.

1. choose part of an outdoor elevation, a large indoor space, an outdoor path or an indoor corridor. If possible, have at least two groups working at each location so results can be shared, compared and discussed
2. groups are invited to measure, using measuring tapes or trundle wheels etc, the distance along the elevation, along the indoor wall, the path or corridor and to make a note of the distance doors, windows or other features appear
3. at Bannockburn House, participants could measure the footprint (dimensions at ground level) of the entrance porch
4. top tip: when measuring a longer distance along a straight wall, keep a running total of the distance rather than measuring each section independently. Why not invite participants to try comparing methods and compare the results?
5. each group writes down their different methods and their answers for each method
6. all the groups gather together, share their answers and discuss what worked well and what problems they encountered

1.4. What about measuring height?

This activity could begin in one large group or in smaller groups.

1.4.1 Q: How could you measure the height of a building? Any answers at this stage regardless of safety…

Suggested answers:

- climbing scaffolding, ladders or onto the roof and dropping a tape measure down to the ground
- dropping a tape measure out of the highest window
- a drone fitted with a disto or tape measure
- a person in a hot-air balloon drops a tape measure
- acrobatics
- using architectural drawings

1.4.2 Q: But what about safety and if you don't have any of these options?

Try out these two variations of the practical 'line of sight' trigonometry experiment to calculate an estimated height of a building, 'h'. Source of the experiments: *Sciencing* website. Allocate different tasks to group members for the experiments. Be sure to measure using consistent units, i.e. metres/centimetres, throughout.

Variation A (see drawing A below)

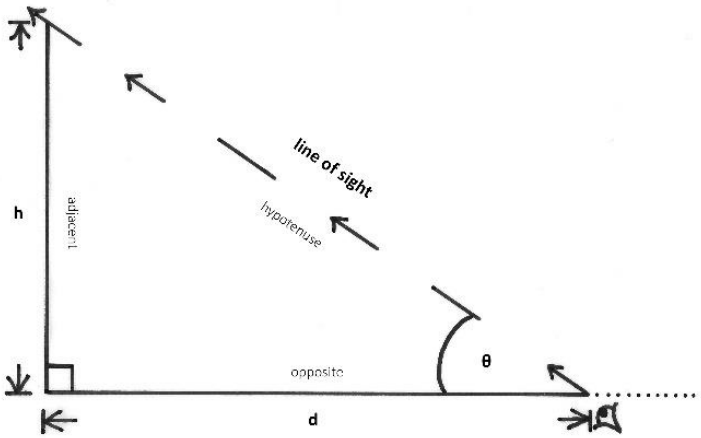
1. using a measuring tape, two people measure a distance away from the exterior elevation or interior wall of which you want to calculate the height, e.g,: 20m. Remember to hold the tape tight and at floor level. Write down this distance 'd' (in metres)
2. your chosen measurer lies down at the end of tape 20m away from the elevation/wall and looking at the building
3. the measurer holds a protractor on the ground and uses a 30cm ruler along their line of sight to determine the angle from the group to the top of the wall
4. another person confirms the angle (in maths notation 'θ', the Greek letter theta) and writes this down
5. now for some trigonometry: using a scientific calculator, find the 'tan' function. Then, make the following calculation: distance x tan of the angle, d x (tan θ). You can do this by first typing in distance 'd', followed by a multiplication sign, followed by pressing 'tan' and finally typing the angle 'θ'
6. the answer calculated is the estimated height of the building in metres, 'h'

Variation B (see drawing B below)

1. as Variation A
2. your chosen measurer stands at the end of tape 20m from the elevation/wall and looking at the building
3. measure the height of the measurer's sight line (eyes). Write down this height, 'p' (in metres)

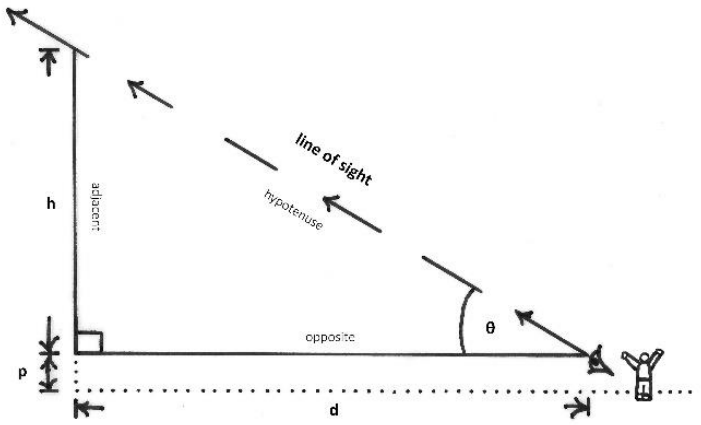
4. the measurer holds a protractor in front of their eye ensuring the protractor is parallel with the ground. Then, using a 30cm ruler along their sight line, they determine the angle to the top of the wall
5. another person confirms the angle (in maths notation ‘θ’, the Greek letter theta) and writes this down
6. now for some trigonometry: using a scientific calculator, find the ‘tan’ function. Then, make the following calculation: distance x tan of the angle, d x (tan θ). You can do this by first typing in distance ‘d’, followed by a multiplication sign, followed by pressing ‘tan’ and finally typing the angle ‘θ’
7. lastly, to the answer of this calculation, ‘h’, add the eye-line height of the measurer, ‘p’
8. the total of this final sum, ‘h’ + ‘p’, is the estimated height of the building in metres

Drawing A



Right-angle triangle ground/wall/line of sight
‘d’ is the distance measured from the building
‘θ’ is the angle measured using line of sight
‘h’ is the height of the building to be calculated

Drawing B



Right-angle triangle ground/wall/line of sight
‘d’ is the distance measured from the building
‘θ’: angle measured using line of sight
‘p’: height of the person’s eye line
‘θ’: angle measured using line of sight
‘h’: height of the building to calculate

Compare answers to Variation A and Variation B. Then, compare these estimated heights of the building with an accurate measurement from architectural drawings. What did you discover? How accurate are the estimates?

2. Scale

Getting started

In this workshop participants will be introduced to basic concepts and hands-on techniques for calculating and using scale.

By the end of the workshop participants will have:

- learned about situations where scale is used, scales used for different purposes and what large and small scale are
- made a series of scaled shapes
- learned about using multiplication, division, fractions, decimals and percentages to understand and calculate scale
- using the measurements taken in activity 1.3 (for example, the porch of Bannockburn House) and the scale of an existing, accurate architectural drawing of the building, calculated and then drawn the measured part of the building at the correct scale

Workshop activities can take place either outdoors or in a large indoor space or both combined, depending on the time of year and weather conditions, current COVID safety regulations and numbers of participants.

Please ensure you have permission to work in your desired location(s) and have carried out a risk assessment of the workshop location.

For this workshop you will need:

- tables and chairs
- plain and squared paper, pencils, pens, rulers, erasers, scissors, sticky tape, glue
- long tape measures (30m or 50m), trundle wheels, metre sticks
- cones
- chalk, wool or string

2.1 Talking about scale

A general discussion or quiz in large group or smaller groups using maps and drawings as prompts.

Q: What is 'scale' and why do we need it?

Suggested answers/discussion points:

- here, we are talking about the ratio (difference and relationship in proportion) between the size of a real object, building, landscape or town etc and how it is displayed on a paper or digital map, physical or digital model, paper or digital drawing or plan. It isn't possible to draw landscapes, towns, buildings at full size on paper or using drawing software; they wouldn't fit!
- we're not talking about weighing equipment, a series of musical notes, or fish and reptile skins or roof slate that look like them
- smaller scales are mostly used for maps and models of towns and landscapes, for example: 1:10,000, 1:5000, 1:2500, 1:1250. (These are known as smaller scales because the fraction of the original thing is small, i.e. 1/10,000th .)
- a range of larger scales are mostly used for drawings and models of buildings and their details, and designed objects: 1:200 - the scale of the Bannockburn House model - 1:100, 1:50, 1:10, 1:5, 1:2, even 1:1. (These are known as larger scales because the fraction of the original building or object etc is larger than for maps etc, i.e. 1/100th or 1/20th.)
- if you use map websites or apps, the scale changes when you zoom in or zoom out: zooming in/getting closer = larger scale; zooming out/moving further away = smaller scale.

Take a look at a selection of drawings and maps of Bannockburn House and its surroundings. Explore the size of area covered and the level of detail shown in each drawing/map and compare between. Participants could write down their answers or simply talk and share their answers. Suggested drawings and maps:

G. D. Hay, ground + first-floor plans, north elevation, 1956 https://canmore.org.uk/collection/464237

HES ground-floor plan, 2017, 1:100 scale https://canmore.org.uk/collection/1578040

Ordnance Survey map, 3rd edition, Stirlingshire nXVII.SE, 1913/1922, 6 inches to the mile https://maps.nls.uk/view/75676209

Ordnance Survey map, 3rd edition, Stirlingshire nXVII.15, 1913/1918, 25 inches to the mile https://maps.nls.uk/view/82906659

You may download for free low-resolution copies of drawings from *Canmore* or extracts of maps from the *National Library of Scotland Maps website* for personal-research and educational purposes.

2.2 Exploring and understanding scale practically

These activities are best suited to smaller groups. Gather all participants together following each activity to share and compare their experiences.

Proportional paper shapes

1. use squared paper, pens/pencils, rulers, scissors and sticky tape or glue to create a series of simple shapes which are in proportion with each other
2. begin by drawing, cutting out and sticking together when needed a 5x5 square, then a 10x10 square, 20x20 square, continuing to 50x50 or 100x100 square and beyond. Write the size of each square on it
3. then, the scale of each square can be worked out in relation to the others using times-tables and simple division. Taking the 5x5 square as the starting point, the 10x10 square would be 1:2 scale in relation to it, the 20x20 would be 1:4, 50x50 would be 1:10, 100x100 would be 1:20 etc
4. the relationships between the different-sized squares could also be explored in terms of fractions, decimals and percentages. For example, the 5x5 square is $1/10^{th}$ or 0.1 or 10% of the 50x50 square
5. explore different, simple shapes such as rectangles and right-angled triangles, and the 'H-shaped' plan of Bannockburn House, and using a selection of different scales

Drawing or marking out proportional shapes

1. use a metre stick or tape measures, chalk or string/wool
2. following steps 2 and 3 above, except shapes are drawn on the ground outdoors in chalk or marked out using string wool or other material to hand either outdoors or indoors (NB: string/wool won't provide perfect straight lines unless metal tent pegs or similar or heavy cones are used.)
3. participants could also use their own feet as a unit of measurement instead of using a metre stick or tape measure. (Ensure the same person's feet are used through out the activity!)

2.3 Making a scale drawing

1. use the measurements gathered in measuring activity 1.3, for example the footprint of the Bannockburn House porch and adjacent walls, and an existing scale drawing of your building, to create your own scale drawing. You could use the plan of the Bannockburn House paper model which does not include the porch. The scale of the model drawings is 1:200
2. before you begin drawing, take time to work out all the dimensions you measured in activity 1.3 at the chosen scale before beginning to draw using simple division. If you are adding the Bannockburn House porch to the plan drawing of the model, divide each of your measurements by 200
3. use squared paper, a scale ruler, a regular ruler and a set square to help you with your drawing

3. Drawing a building

Getting started

In this workshop participants will be introduced to hands-on techniques for drawing buildings freehand.

By the end of the workshop participants will have:

- taken time to look carefully at a building they know well to understand its basic shapes and proportions and the arrangement of features and details
- tried out drawing freehand the basic shapes, proportions, features and details of the building
- learned a step-by-step approach to putting a freehand drawing together
- felt encouraged to practise freehand drawing regularly and record their own development and achievements. Practice makes progress!
- felt encouraged towards the belief that everyone really can draw!

Workshop activities can take place either outdoors or in a large indoor space or both combined, depending on the time of year and weather conditions, current COVID safety regulations and numbers of participants.

Please ensure you have permission to work in your desired location(s) and have carried out a risk assessment of the workshop location.

For this workshop you will need:

- tables and chairs or clipboards
- plain paper, pencils, erasers, coloured pencils, felt pens, crayons, chalk etc
- the building or interior in front of you as well as photos
- plenty of time!

3.1 Getting to know the building

Start with an elevation (side) of a building you know well.

1. take time to look carefully and thoroughly at your building in person and/or at photos of it
2. take your own photos of the building
3. when looking and photographing, start with the big picture, the overall shapes and their proportions, how they fit together, how features are arranged and then work down to the small details

3.2 Looking and sketching

On separate sheets of paper or in a sketchbook, put pencil to paper.

1. begin with the basic shapes of the elevation, for example squares, rectangles and triangles
2. then, the smaller shapes such as doors, windows, chimneys etc and how they are arranged in relation to each other – you can use your fingers, thumbs and pencil/pen to work out the spacing of features
3. finally, the smaller details individually

"Practice makes progress"

Top tip: practise sketching out the shapes and details regularly at different sizes, using different pencils and pens, to build up your own confidence and proficiency. If you like, keep a sketchbook and date your drawings so that you can keep a record of your own progress.

3.3 Putting a drawing together

When you feel ready, move on to drawing a complete elevation. Use light lines at first and then firm in the lines when you are happy with your drawing.

1. as before, start with the basic shapes of the elevation
2. then, the smaller shapes such as doors, windows, chimneys
3. finally, the smaller details

Take time regularly, perhaps with others, to draw out the shapes and details that make up the elevation as well as the complete elevation.

To represent the textures of building materials you could add colour and a variety of lines, dots etc, and add shading to represent shadows cast by different parts of the building.

Keep practising and enjoy drawing! 😊

4. Curriculum for Excellence links

The Measuring, Scale and Drawing workshop and Bannockburn House modelmaking activities can fulfil *Curriculum for Excellence Experiences and Outcomes at* learning levels 2 and 3, i.e. P5 to P7 and S1 and S2. The following information should prove useful when planning workshops with teachers and youth workers. Please consult the linked documents for Early Years, level 1 (P1 to P3) and level 4 (S3 and S4) Experiences and Outcomes.

Maths and Numeracy Experiences and Outcomes

https://education.gov.scot/Documents/numeracy-maths-eo.pdf

Number, money, measure

Fractions, decimal fractions and percentages, including ratio and proportion

MNU 2-07a	I have investigated the everyday contexts in which simple fractions, percentages or decimal fractions are used and can carry out the necessary calculations to solve related problems.
MNU 2-07b	I can show the equivalent forms of simple fractions, decimal fractions and percentages and can choose my preferred form when solving a problem, explaining my choice of method.
MTH 2-07c	I have investigated how a set of equivalent fractions can be created, understanding the meaning of simplest form, and can apply my knowledge to compare and order the most commonly used fractions.
MNU 3-07a	I can solve problems by carrying out calculations with a wide range of fractions, decimal fractions and percentages, using my answers to make comparisons and informed choices for real-life situations.
MTH 3-07b	By applying my knowledge of equivalent fractions and common multiples, I can add and subtract commonly used fractions.
MTH 3-07c	Having used practical, pictorial and written methods to develop my understanding, I can convert between whole or mixed numbers and fractions.

Number, money, measure

Measurement

MNU 2-11a	I can use my knowledge of the sizes of familiar objects or places to assist me when making an estimate of measure.
MNU 2-11b	I can use the common units of measure, convert between related units of the metric system and carry out calculations when solving problems.

MNU 2-11c	I can explain how different methods can be used to find the perimeter and area of a simple 2D shape or volume of a simple 3D object.
MNU 3-11a	I can solve practical problems by applying my knowledge of measure, choosing the appropriate units and degree of accuracy for the task and using a formula to calculate area or volume when required.
MTH 3-11b	Having investigated different routes to a solution, I can find the area of compound 2D shapes and the volume of compound 3D objects, applying my knowledge to solve practical problems.

Shape, position and movement

Properties of 2D shapes and 3D objects

MTH 2-16a	Having explored a range of 3D objects and 2D shapes, I can use mathematical language to describe their properties, and through investigation can discuss where and why particular shapes are used in the environment.
MTH 2-16b	Through practical activities, I can show my understanding of the relationship between 3D objects and their nets.
MTH 2-16c	I can draw 2D shapes and make representations of 3D objects using an appropriate range of methods and efficient use of resources.
MTH 3-16a	Having investigated a range of methods, I can accurately draw 2D shapes using appropriate mathematical instruments and methods.

Shape, position and movement

Angle, symmetry and transformation

MTH 2-17b	I can accurately measure and draw angles using appropriate equipment, applying my skills to problems in context.
MTH 2-17d	Having investigated where, why and how scale is used and expressed, I can apply my understanding to interpret simple models, maps and plans.
MTH 3-17b	Having investigated navigation in the world, I can apply my understanding of bearings and scale to interpret maps and plans and create accurate plans, and scale drawings of routes and journeys.
MTH 3-17c	I can apply my understanding of scale when enlarging or reducing pictures and shapes, using different methods, including technology.
MTH 2-18a & MTH 3-18a	I can use my knowledge of the coordinate system to plot and describe the location of a point on a grid.
MTH 2-19a & MTH 3-19a	I can illustrate the lines of symmetry for a range of 2D shapes symmetrical pictures and and patterns.

Expressive Arts (Art) Experiences and Outcomes

https://education.gov.scot/Documents/expressive-arts-eo.pdf

EXA 2-04a	Through observing and recording from my experiences across the curriculum, I can create images and objects which show my awareness and recognition of detail.
EXA 3-04a	Through observing and recording, I can create material that shows accuracy of representation.

Technologies (Craft, Design, Engineering and Graphics) Experiences and Outcomes

https://education.gov.scot/Documents/Technologies-es-os.pdf

Design and construct models/product

TCH 2-09a	I can extend and enhance my design skills to solve problems and can construct models.
TCH 3-09a	I can create solutions in 3D and 2D and can justify the construction/graphic methods and the design features.

Representing ideas, concepts and products through a variety of graphic media

TCH 2-11a	I can use a range of graphic techniques, manually and digitally, to communicate ideas, concepts or products, experimenting with the use of shape, colour and texture to enhance my work.
TCH 3-11a	I can apply a range of graphic techniques and standards when producing images using sketching, drawing and software.

Social Studies Experiences and Outcomes

https://education.gov.scot/Documents/social-studies-eo.pdf

People, past events and societies

SOC 2-02a	I can interpret historical evidence from a range of periods to help to build a picture of Scotland's heritage and my sense of chronology.
SOC 3-02a	I can make links between my current and previous studies and show my understanding of how people and events have contributed to the development of the Scottish nation.

People, place, environment

SOC 2-14a	To extend my mental map and sense of place, I can interpret information from different types of maps and am beginning to locate key features within Scotland, UK, Europe or the wider world.
SOC 3-14a	I can use a range of maps and geographical information systems to gather, interpret and present conclusions and can locate a range of features within Scotland, UK, Europe and the wider world.

5. Resources

Scotland's Urban Past (Historic Environment Scotland, 2014–19) How to: Record Buildings skill-building guides

Historic Environment Scotland *Canmore* online buildings and archaeology archive

Contact the Historic Environment Scotland archives team: archives@hes.scot

National Library of Scotland *Maps* website

Maps FAQs and enquiries

Contact the National Library of Scotland maps team: maps@nls.uk

Dictionary of Scottish Building

Daniel McCannell, *How to Read Scottish Buildings*, Birlinn: Edinburgh, 2015 (£9.99 RRP)

Historic Environment Scotland (HES) Learning Resources

Archaeology Scotland Heritage Resources Portal

Royal Institute of British Architects (RIBA) learning resources for schools (linked to the English, Welsh and Northern Irish curriculum key stages)

Open City London Architecture in Schools programme

Archischools

Planning Aid Scotland (PAS) projects and skills training including *Young People and Placemaking* resources

Outdoor and Woodland Learning (OWL) Scotland resources library

Introduction to Trigonometry, *Skills You Need* website