Putting the Jigsaw Together

Practical strategies for assisting apprentices with numeracy issues

Reading Technical Drawings

A trainer’s resource

Manufacturing a skilled Australia
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Guide for trainers

**It is recommended that you read the Trainer’s Guide for a full understanding of how to use this tool.**

*How to use this tool*

Each tool has been designed to support vocational trainers working with apprentices who desire to assist apprentices with numeracy skills and it focuses on a specific area of numeracy. Tools should be contextualised to match the workplace of the apprentice and the sample activities framed within a workplace context.

This tool focuses on reading technical drawings in the metals industry. An apprentice would begin to develop the numeracy skills to read technical drawings at Australian Core Skills Framework (ACSF) level 3 where they would be able to apply knowledge of the properties of 2-D and 3-D shapes to describe and draw everyday objects such as a box or cylinder. At ACSF level 3 an apprentice would be able to use distance, direction, coordinates, simple scales, labels and symbols and keys to read and use everyday maps and plans.

The use, calculation and interpretation of information using mathematical skills and knowledge in measurement and geometry is an ACSF numeracy level 4 skill. At this level, the apprentice should be able to use their knowledge about space and shape, including angle properties, symmetry and similarity to describe, draw or construct the relevant 2-D and 3-D shapes, such as compound shapes. They would be able to estimate, accurately measure and calculate quantities, including areas and volumes, using the relevant formulae, and to use, calculate and interpret information based on maps and plans.

This tool covers basic drawing conventions and the use of lines. The examples and activities within this tool can be easily contextualised to support apprentices with numeracy issues in other industries.

Topic content has been provided as background information for each numeracy task. This information can be worked through with the apprentice, or the trainer can go straight to the work examples and activities.

Apprentices may often question why they need to perform certain calculations manually rather than using a calculator. Some examples of times when it is useful to be able to perform manual calculations are:

- the battery in the calculator is flat
- the apprentice left the calculator at home
- the answer on the calculator looks ‘wrong’
• the apprentice may have entered the incorrect details/numbers
• the apprentice may be using an incorrect application on the calculator.

As a trainer, you may be able to provide other examples relevant to the apprentice’s workplace.

The numeracy examples for each task have been designed in small incremental steps to assist the apprentice to build up to the final answer. It is intended that there is no assumed knowledge. The tool may, where appropriate, point to foundation numeracy topics which can be found on the MSA website.

Sample activities are provided as practice for the numeracy task. These can be completed by the apprentice either with support from the trainer or alone. Worked answers are provided for each activity at the rear of the tool to assist the trainer to monitor the apprentice’s understanding and progress.

A word list has been provided to support the pre-teaching and/or review of specific numeracy terms. As the trainer you may want to provide your own definition of these words and/or add other words as required. You may also use the word list to encourage the apprentice to develop their own definitions which will assist in demonstrating their understanding of the numerical concepts being developed.

You may use additional activities or replace the sample activities with activities relevant to the apprentice. In some instances, you may want to focus on a particular area in which the apprentice is experiencing difficulty.

For the more advanced apprentice, this tool could be provided as a self-paced learning resource.
Functions are indicated by the following icons

- **Information (i)**: Information is provided that is relevant to the concepts, activities or workplace that the apprentice is engaged in.

- **Why we do this** (Why do we do this?): ‘Why we do this’ offers the apprentice an explanation regarding the relevance of the knowledge, skill or activity to the work they are engaged in.

- **Fact (FACT)**: A true statement.

- **Example (e.g.)**: An example of a function or calculation. Worked examples are given to assist the trainer to break down the steps involved in an activity.

- **Hint (HINT)**: A hint that can make things easier. Hints are an important part of the learning process for apprentices as they usually are based on the trainer’s own experiences.

- **Proposed theoretical activity (1)**: A proposed theoretical activity for apprentices. This activity is designed to embed the underpinning mathematical concepts needed to complete a task.

- **Use a calculator (Calculator)**: Use a calculator.

- **Do not use a calculator (No Calculator)**: Do not use a calculator.

- **Hands-on activity (Hands On)**: Hands-on activity for apprentices. This activity is designed to engage the apprentice in a practical activity that consolidates conceptual learning.
### Reading technical drawings

The word list below is designed to introduce or review the words/terms commonly used when working with shapes and calculating the perimeter.

There may be other words/terms which the apprentice can add to this list.

#### Word list

<table>
<thead>
<tr>
<th>Word/term</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical drawing</td>
<td></td>
</tr>
<tr>
<td>Two-dimensional (2-D)</td>
<td></td>
</tr>
<tr>
<td>Three-dimensional (3-D)</td>
<td></td>
</tr>
<tr>
<td>Dimensioning</td>
<td></td>
</tr>
<tr>
<td>Projecting</td>
<td></td>
</tr>
<tr>
<td>Extending</td>
<td></td>
</tr>
<tr>
<td>Leaders</td>
<td></td>
</tr>
<tr>
<td>Redundant</td>
<td></td>
</tr>
<tr>
<td>Typograph</td>
<td></td>
</tr>
<tr>
<td>Conventions</td>
<td></td>
</tr>
</tbody>
</table>
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Technical drawing

While an apprentice may never have to draw a technical drawing, it is important that they are able to accurately read technical drawings. Understanding the purpose of and conventions used in technical drawings is essential to being able to read a technical drawing. The information and activities in this tool will assist you in providing the apprentice with these skills. As the trainer, you may want to give the apprentice a copy of the tables in this tool to use as a reference document.

The use of technical drawings is an example of how a picture is better than a thousand words.

If you just use words to share information and ideas it can be difficult to work out what is wanted, and so technical drawings can easily transfer information to make it more understandable. Technical drawings are common in many industries, including engineering, manufacturing, architecture, electronics, plumbing and just about any field where facts and figures are used.

Identification

Technical drawings use graphics to show details. In other words, they convert ideas into physical form. Technical drawing is also known as drafting. Technical drawing is done using a 2-D or 3-D depiction.
The drawing

This is a picture of a pen that is to be manufactured as a billboard. From this picture it cannot be manufactured because of the lack of information. The information needed is the addition of words and/or dimensions.

Figure 1

The dimensioned drawing

Figure 2

This drawing has enough dimensions to manufacture the shape. However, it is very hard to work out what the actual shape is.

Line styles and types

- A standard way to draw shapes is with different types of lines, some heavy and some light.
- A variety of line styles graphically represent physical objects.
- Lines can also be classified by a letter classification in which each line is given a letter.
Examples of different line styles can be seen in the chart below.

<table>
<thead>
<tr>
<th>Line type</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>The thickest lines on a drawing. They are only used to show an object’s outline. The diagram on the previous page uses only this line type.</td>
<td>________________________</td>
</tr>
<tr>
<td>B</td>
<td>A thin line that is used to show dimensions and also for projecting, extending, or leader lines.</td>
<td>________________________</td>
</tr>
<tr>
<td>C</td>
<td>A freehand line to demonstrate a short break.</td>
<td>________________________</td>
</tr>
<tr>
<td>D</td>
<td>The same purpose as a C line but to be used for longer breaks. This is used when long drawing objects with no change to dimensions (e.g. a long beam with work on either end).</td>
<td>___________ __________</td>
</tr>
<tr>
<td>E</td>
<td>Dotted lines are used to indicate internal hidden shapes. They are not used in 2-D drawings but for isometric (3-D) drawing it shows hidden details that cannot be seen from the particular viewing angle. An example is when drawing a cube to show the sides hidden from the viewer’s perspective or to show internal dimensions of an object.</td>
<td>________________________</td>
</tr>
<tr>
<td>G</td>
<td>Long and short lines used to indicate a centre line (see Figure 3 on the next page).</td>
<td>___________ - __________</td>
</tr>
</tbody>
</table>

Note: The chart includes examples of how each line type is used in technical drawings.
**Drawing convention**

By drawing Figure 3 with heavy and light lines we can show the difference between the shape of the billboard and what are dimension lines.

![Figure 3](image)

**Lines styles and conventions used in Figure 3**

<table>
<thead>
<tr>
<th><strong>Outline</strong> - These lines show the outline of the feature of an object. They are the thickest lines on a drawing.</th>
<th><img src="image" alt="Outline example" /></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension lines should be fine full lines broken where measurements are inserted.</td>
<td><img src="image" alt="Dimension lines example" /></td>
</tr>
<tr>
<td>Measurements are known as dimensions. They are normally placed in broken sections of a dimension line or above or below the line or between narrow dimension projection lines.</td>
<td><img src="image" alt="Dimension example" /></td>
</tr>
<tr>
<td>Dimension lines are drawn between projection lines.</td>
<td><img src="image" alt="Dimension lines between projection lines example" /></td>
</tr>
</tbody>
</table>
Projection lines should be fine full lines drawn at right angles to the specific shape and start 1–2 mm from the shape and are used to indicate the end of a dimension.

<table>
<thead>
<tr>
<th><img src="image" alt="Projection lines example" /></th>
</tr>
</thead>
<tbody>
<tr>
<td>Each dimension line has an arrowhead that can be open or closed.</td>
</tr>
<tr>
<td><img src="image" alt="Arrowhead example" /></td>
</tr>
<tr>
<td>Arrowheads touch (but don’t cross) projection lines.</td>
</tr>
<tr>
<td><img src="image" alt="Arrowhead touching projection line" /></td>
</tr>
<tr>
<td>Arrowheads are usually three times longer than they are wide if manually drawn.</td>
</tr>
<tr>
<td><img src="image" alt="Arrowhead example" /></td>
</tr>
<tr>
<td>A dimension indicating the diameter of a circle can be indicated by a dimension line using the circumference of the circle as projection lines.</td>
</tr>
<tr>
<td><img src="image" alt="Diameter symbol example" /></td>
</tr>
<tr>
<td>The diameter can be indicated by a symbol (Ø) and the measurement or the dimension as 300 mm if it is obvious that it is a diameter. It is normal to use an extension line to move the measurement away from the shape.</td>
</tr>
<tr>
<td><img src="image" alt="Diameter example" /></td>
</tr>
<tr>
<td>An extension or leader line should be a fine full line used to lengthen the projection line to move the measurement away from the specific dimension.</td>
</tr>
<tr>
<td><img src="image" alt="Extension line example" /></td>
</tr>
<tr>
<td>There is no gap as is used for projection lines.</td>
</tr>
<tr>
<td>A centre line is used to indicate symmetry to eliminate the need for additional dimensioning and measurements.</td>
</tr>
<tr>
<td><img src="image" alt="Centre line example" /></td>
</tr>
</tbody>
</table>
Deciding where to place dimensions

- Place dimension numbers so that they can be read from the bottom or right side.
- Consider where measurements are easily found and read.
- Where possible, place outside the drawn shape.
- Consider placement next to the shape.
- Don’t repeat a dimension as this is ‘over dimensioning’ or ‘double dimensioning’.

In the example below, the red line is redundant in that it will mean that the overall dimensioning is done twice. Technical drawing convention details that this is wrong. It does mean that some calculations are necessary to read a drawing.

Example – defining a diameter
(1) with a dimension line (2) an extension line

- Draw the number characters very clearly to prevent misinterpretation. 1 and 7. The numbers 3, 5, 8 need to be carefully drawn for the same reason.

Using a workplace technical drawing that the apprentice has access to, have the apprentice demonstrate/identify the drawing conventions that are being used in the drawing.

Does the apprentice agree that there is sufficient information in the drawing for its use?
The job – Scenario 1

Fabulous Fabrications has been asked to quote on a galvanised sign for a local pen manufacturer who has just moved into new premises.

On the drawing below, identify the different lines used and the reason for use.

In Activity 1 the Fabulous Fabrications design for the local pen manufacturer drawing can be broken down into four distinct shapes of their own. Draw and dimension the four shapes using the conventions that have been discussed in this tool.
Answer to activities

On the drawing below, identify the different lines used and the reason for use.

Outline (Type A) – These lines show the outline of the feature of an object.

Dimension (Type B) – Dimension lines are used for dimensioning, projecting, extending, or leaders.

Projection (Type B) – Projection lines should be fine full lines drawn at right angles to the specific shape and start 1–2 mm from the shape and are used to indicate the end of a dimension.

An extension or leader (Type B) line should be a fine full line used to lengthen the projection line to move the measurement away from the specific dimension.

Centre line (Type G) is used to indicate symmetry to eliminate the need for additional dimensioning and measurements.