

BarModelMaker User Manual

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1. Introduction

Bar modeling is an effective method that helps students to visualize and understand word problems in Math. Learning to draw bar models of word problems is a natural way to develop abstract thinking skills.

Drawing a clean and clear bar model is challenging, teaching a student to draw bar models is even more so. In most cases, students just see the final models without explanations about how the models were drawn step by step.

The BarModelMaker is specially designed to tackle these issues. You “draw” a bar model by writing script instead of drawing it directly. As you are writing the script, the tool calculates the size of the boxes and draws the model automatically. Once there are enough conditions specified, a precise model can be drawn. The script not only defines the final model but also explains how the model is drawn step by step and makes it possible to “replay” the model. Let’s look at an example:

There are a total of 200 apples and oranges. The number of apples is 50 more than that of oranges. How many oranges are there?

The following screen shot shows the script and the bar model of the word problem.

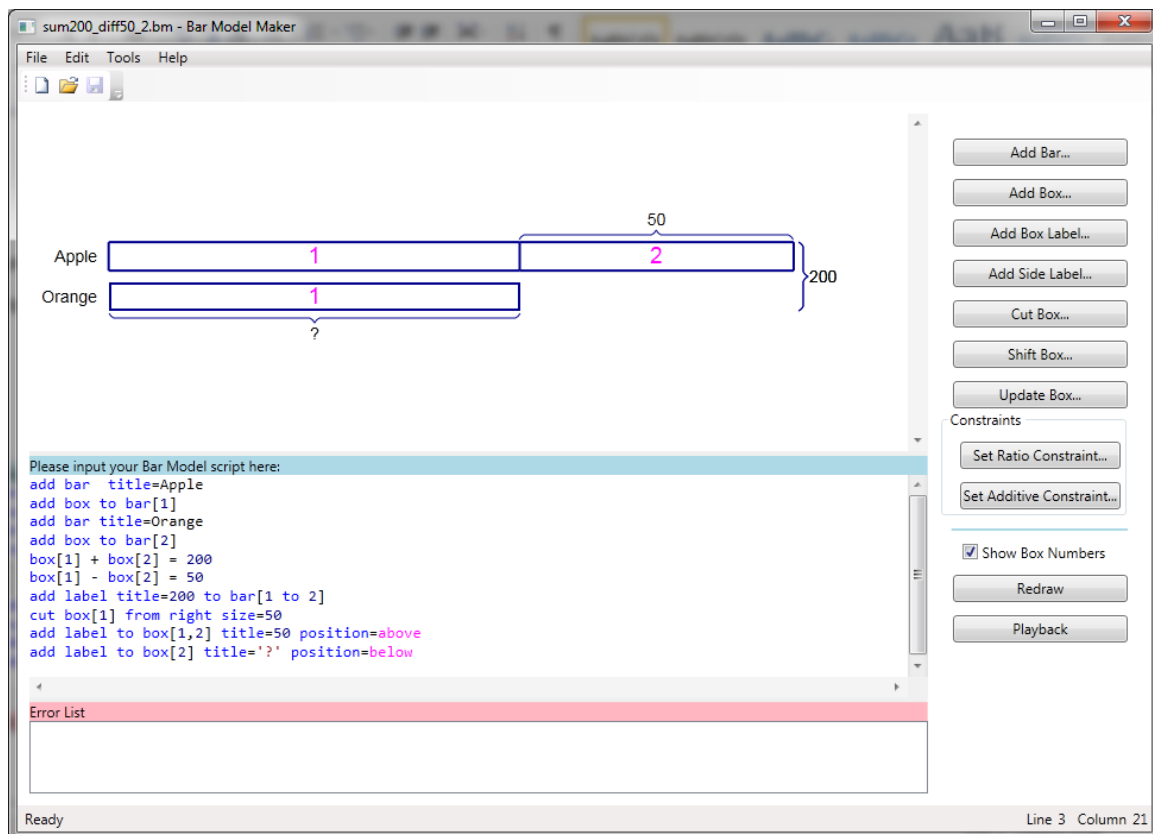


Figure 1 BarModelMaker Main Screen

By writing BarModel script, you can add a bar to a model, add a box to a bar, add a label to one or more boxes or bars, cut a box into smaller boxes, shift one or more boxes to another bar, or update the fill color or stroke style of one or more boxes.

This tool can be used by both students and teachers to draw bar models. It supports the saving of a bar model as an SVG file, which can be put in a Web page or a Word document.

2. Elements of Bar Model

A bar model consists of one or more bars. Each bar has one or more boxes and a title. The fill color and stroke style of a box can be specified. A box label can be assigned to one or more boxes and can be above or below the box(es). A side label can be assigned one or more bars. Figure 2 shows the elements of a bar model.

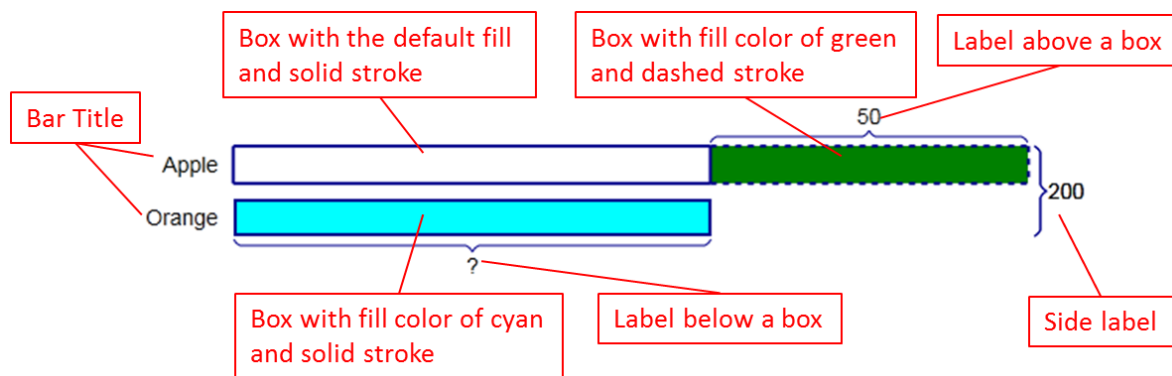


Figure 2 Elements of a Bar Model

3. Bar Model Script

Bar Model Script is a domain specific language specially designed for “drawing” bar models by writing script. A bar model script consists of statements. Each statement occupies a single line in the script. BarModel script is case-insensitive.

3.1. Basic Concepts

A statement is made up of keywords, properties, specifiers, and/or aliases.

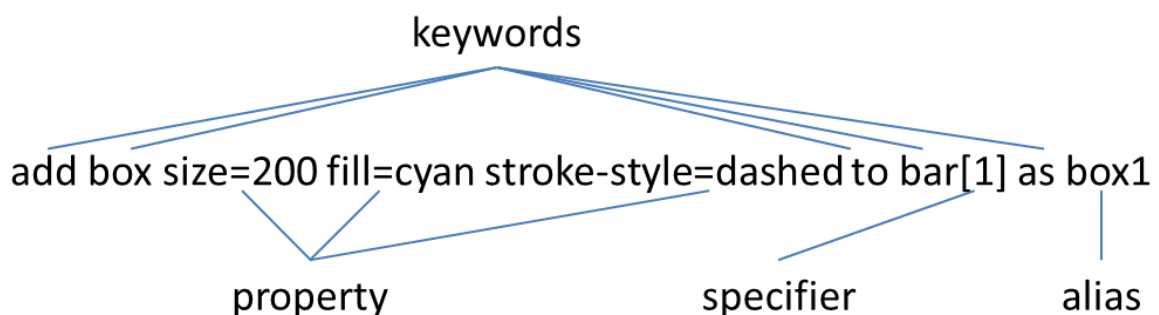


Figure 3 Elements of a Statement

3.1.1. Keywords

There are 4 categories of keywords: verbs, nouns, prepositions, and properties.

Category	Keyword
Verb	add cut shift update
Noun	bar box label
Preposition	as of
Property	title

	size fill stroke-style position
--	--

Table 1 Keywords

3.1.2. Properties

Bars, boxes, and labels have properties, as shown in the following table.

Element	Property	Description	Required/Optional	Example
Bar	title	The title of a bar	Required	Title="Books"
Box	size	The size of a box	Optional	Size=300 Size=part1
	fill	The fill color of a box	Optional	Fill=red
	stroke-style	The stroke style of a box, which can be either solid or dashed	Optional	Stroke-style=solid Stroke-style=dashed
Label	title	The title of a label	Required	Title="?"
	position	The position of a label relative to the box(es) the label is attached to, which can be either above or below.	Required	Position=above Position=below

Table 2 Properties

Syntax:

property_name=property_value

3.1.3. Specifiers

Specifiers are for identifying one or more bars or one or more boxes of a model.

3.1.3.1. Bar Specifiers

You can use bar specifiers to identify a bar or a range of bars, by specifying the orders of bars and/or boxes. Both bar orders and box orders start from 1. For instance, the order of the first bar of a model is 1; the order of the first box of a bar is 1.

Syntax 1, specifying one bar

bar[n]

n: the order of the bar of a model.

In the example below, bar[1] identifies the first bar, bar[2] the second bar, and bar[3] the third bar.

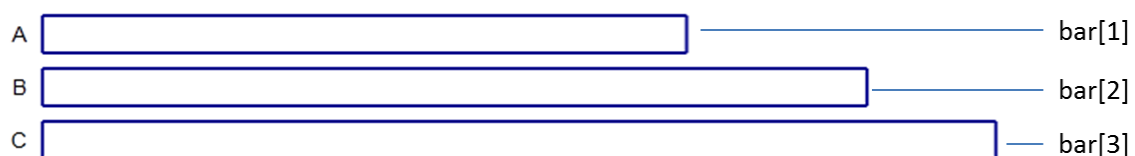


Figure 4 Bar Specifiers

Syntax 2, specifying a range of bars

`bar[m, n]`

m: the order of the bar that starts a range.

n: the order of the bar that ends a range.

In the example below, `bar[2,4]` identifies the 3 bars from the second one to the fourth one.



Figure 5 Specifying a Range of Bars

3.1.3.2. Box Specifiers

You can use box specifiers to identify a box or a range of boxes of a bar.

Syntax 1, specifying one box of a bar

`box[i, j]`

i: The order of the bar in the model.

j: The order of the box in the bar.

Syntax 2, specifying a range of boxes of a bar

`box[i, j to k]`

i: The order of the bar in the model.

j: The order of the box that starts the range.

k: The order of the box that ends the range.

In the example below, `box[1,1]` identifies the first box; `box[1, 1 to 3]` identifies a range of boxes from the first one to the third one.

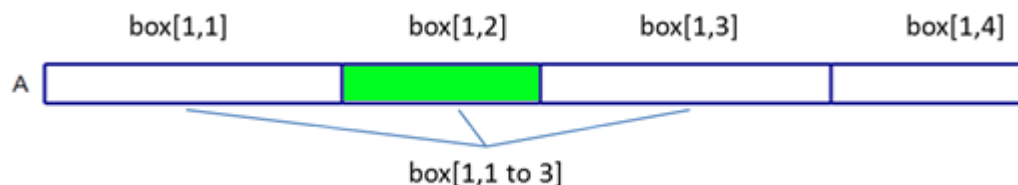


Figure 6 Specifying a Range of Boxes

Syntax 3, the overall box of a bar.

`Box[i]`

i: The order of the bar in the model.

Important Notes

The order of a box will change after one or more boxes in front of it are cut into smaller boxes. For instance, if box[1,1] in Figure 6 is cut into 2, the order of boxes from green box will increase by 1.

Always refer to a box based on the current order of box in the model, i.e. using box[1,2] to refer to the green box before box[1,1] is cut, and using box[1,3] to refer to the same green box after it is cut into 2.

3.1.4. Aliases

In addition to specifiers, you can give an alias to a bar or a box, and use the alias later to address the bar or the box later.

3.1.5. Comment

A comment is optional text that you type on a separate line in script. A comment starts with '#'.

3.2. Statements

There are two kinds of statements: action statements and constraint statements.

Syntax symbols used in the following sections:

Character	Description	Example
	The vertical-bar separates alternative items.	Solid dashed (The value can be either solid or dashed)
[]	Brackets enclose an optional item.	[as bar_alias] (A bar can optionally have an alias.)
<>	Angle brackets enclose a value to be specified.	<bar_title>

Table 3 Symbols Used in Syntax

3.2.1. Action Statements

You use action statements to add elements to a model and arrange them.

There are 6 kinds of action statements, all starting with one of the 4 verbs, including add, cut, shift, or update. With action statements, you can add a bar to model, add a box to a bar, add a label to one or more boxes, add a side label, cut a box into smaller boxes, shift one or more boxes to another bar, or update the fill color or stroke style of one or more boxes.

3.2.1.1. Add bar statement

Add a bar to the model. Figure 7 shows a model after a bar with the title of "B" is added.

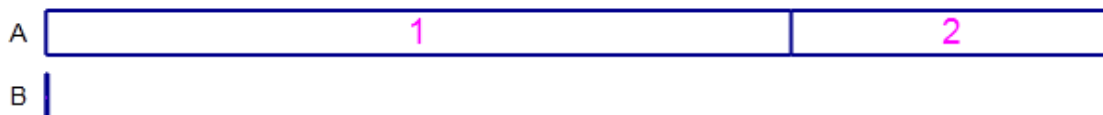


Figure 7 Add a bar with title of B

Syntax:

```
add bar title=<bar_title> [as <bar_alias>]
```

Parameters:

Parameter	Description	Example
bar_title	The title of the bar	title="Books"
bar_alias	An alias of the bar. The alias can be used to refer to the bar.	bar1

Table 4 Parameters of Add Bar Statement

Example 1, add a bar to the model without specifying an alias.

```
Add bar title=Apple
```

Example 2, add a bar with an alias to the model.

```
Add bar title=Apple as bar1
```

3.2.1.2. Add box statement

Add a box to a bar. You can optionally specify the size, the fill color, the stroke style, the label of the box, and/or an alias of the box.

Syntax: (Note that all the code should be in a single line)

```
Add box [size=<box_size>] [fill=<fill_color>] [stroke-style=solid|dashed]  
to <bar_specifier>|<bar_alias> [with label title=<label_title>  
position=above|below] [as <box_alias>]
```

Parameters

Parameter	Description	Examples
Box_size	The size of the box.	Size=10.5 Size=parts
Fill_color	The fill color of the box. If the color is not specified, the default color will be used.	Fill=green
Bar_specifier	A bar specifier that identifies a bar.	Bar[2]
Bar_alias	A bar alias	Bar1
Label_title	The title of the label.	title=300
Box_alias	The alias of the box	box21

Table 5 Parameters of Add Box Statement

Example 1, add a box with size of 50, fill color of red, stroke style of dashed, and with a label to the first bar.

```
Add box size=50 fill=red stroke-style=dashed to bar[1] with label  
title=Apple position=below
```



Figure 8 Add a box with specified fill color, stroke style, and a label

Example 2, add a box with unknown size to a bar that has an alias.

```
Add box to bar1
```

Example 3, add a box with size of 100 to a bar and specify an alias of the box.

```
Add box size=100 to bar[2] as box21
```

3.2.1.3. Add label statement

Add a label to one or more box, or to one or more bar.

3.2.1.3.1. Add box label

Add a label to a box or a range of boxes.

Syntax:

Add label title=<label_title> position=above|below to
<box_specifier>|<box_alias>

Parameter	Description	Example
Label_title	The title of the label.	Title=450
Box_specifier	A box specifier that identifies one or more boxes.	Box[3,4] Box[3,2 to 5]
Box_alias	A box alias	Box21

Table 6 Parameters of Add Box Label Statement

Example 1, add a label with title “Fred” above the first box of the second bar:

Add label title=Fred position=above to box[2,1]



Figure 9 Add a label above a box

Example 2, add a label below the second and third boxes of the third bar:

Add label title=Mike position=below to box[2,2 to 3]



Figure 10 Add a label below 2 boxes

3.2.1.3.2. Add side label

Add a label to a bar or a range of bars.

Syntax:

Add label title=<label_title> to <bar_specifier>|<bar_alias>

Parameter	Description	Example
Label_title	The title of the label.	Title=450
Bar_specifier	A bar specifier that identifies one or more bars.	Bar[3] Bar[3 to 5]
Bar_alias	A bar alias	Bar1

Table 7 Parameters of Add Side Label Statement

Example

Add label title="?" to bar[1 to 2]

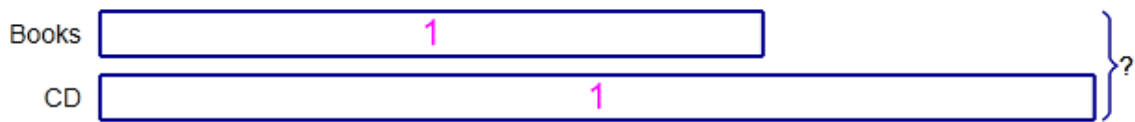


Figure 11 Add a side label

3.2.1.4. Cut box statement

You can cut one or more boxes into smaller boxes. There are 3 ways to cut a box or a range of boxes.

3.2.1.4.1. Cut into equal parts

Cut a box or a range of boxes into the given parts with equal size.

Syntax:

```
cut <box_specifier>|<box_alias> into <parts>
```

Example 1 Cut the first box of the second bar into 3

```
cut box[2,1] into 3
```



Figure 12 Cut a box into 3 equal parts.

Example 2 Cut the boxes from 2 to 4 of the third bar into 4

```
Cut box[4,2 to 3] into 4
```



Figure 13 Cut 2 boxes into 4 equal parts respectively

3.2.1.4.2. Cut by ratio

Cut a box or a range of boxes by a group of ratios

Syntax:

```
cut <box_specifier>|<box_alias> into <ratio_1> : <ratio_2> ... : <ratio_n>
```

Example, cut the first box of the third bar into 5 : 3 : 2

```
cut box[3,1] into 5:3:2
```



Figure 14 Cut a box by ratio

3.2.1.4.3. Cut from side

Cut a box from the left or the right side by a certain size.

Syntax:

```
Cut <box_specifier>|<box_alias> from left|right size=<cut_size>
```

Example 1, cut from left with a known size

```
Cut box[2,2] from left size=10
```



Figure 15 Cut from the left side of a box

Example 2, cut from right with a unknown size

Cut box[3,4] from right size="p1"



Figure 16 Cut from the right side of a box

3.2.1.5. Shift box statement

Shift a box or a range of boxes to another bar. The end result is that new box(es) with exact properties will be added to the bar specified, and the stroke style of the original box(es) will be changed to dashed. Figure 17 and Figure 18 show the model before and after box[1,2] is shifted to bar[2].



Figure 17 The model before box[1,2] is shifted to bar[2]



Figure 18 The model after box[1,2] is shifted to bar[2]

Syntax:

Shift <box_specifier>|<box_alias> to <bar_specifier>

Example 1, shift the fourth box of the first bar to the second bar.

Shift box[1,4] to bar[2]

Example 1, shift the boxes from 2 to 5 of the third bar to the fourth bar.

Shift box[2,2 to 5] to bar[4]

2.1.1.1. Update box statement

Update the fill color or the stroke style of a box or a range of boxes

Syntax:

Update <box_specifier>|<box_alias> [fill=<fill_color>] [stroke-style=solid|dashed]

Example 1, change the stroke-style of the second box of the third bar to dashed

Update box[3,2] stroke-style=dashed

Example 2, change the color of the box whose alias is box45 to red

Update box45 fill=red

2.1.2. Constraint Statements

Constraint statements are used to specify the relationships of boxes. Bar Model Script supports two kinds of constraints: additive constraints and ratio constraints.

2.1.2.1. Additive Constraint

An additive constraint is basically an equation. Only addition and subtraction are allowed in an additive constraint. Box specifiers and constants can be in either side of an equation.

Syntax:

additive_expression = additive_expression

An additive expression is a set of box specifiers or constants combined together with plus or minus signs.

Example 1, the sum of the sizes of two boxes is 100

Box[2,1] + box[3,2] = 100

Example 2, the difference of the sizes of two boxes is 50

Box[1,3] - box[2,2] = 50

Example 3, a constraint involving multiple boxes

Box[1,1] + box[2,1] + 20 = box[3,1] - 300

2.1.2.2. Ratio Constraint

A ratio constraint defines ratio relationships between two or more boxes.

Syntax:

<box_specifier_1> : <box_specifier_2> : ... : <box_specifier_n> = <ratio_1> : <ratio_2> ... : <ratio_n>

Example

Box[2,1] : box[3,1] : box[4,1] = 8 : 5 : 6

4. BarModelMaker

BarModelMaker is a Windows desktop application that enables you to “draw” a bar model by writing script. BarModelMaker has two screens: the Model Editor and the Model Player. You use the model editor to write Bar Model script, and the model player to playback your model.

4.1 Bar Model Editor

The bar model editor has 4 parts: the script editor where you type your script; the model plotter where the bar model is drawn; the error list window where the errors are displayed, if any; and the buttons.

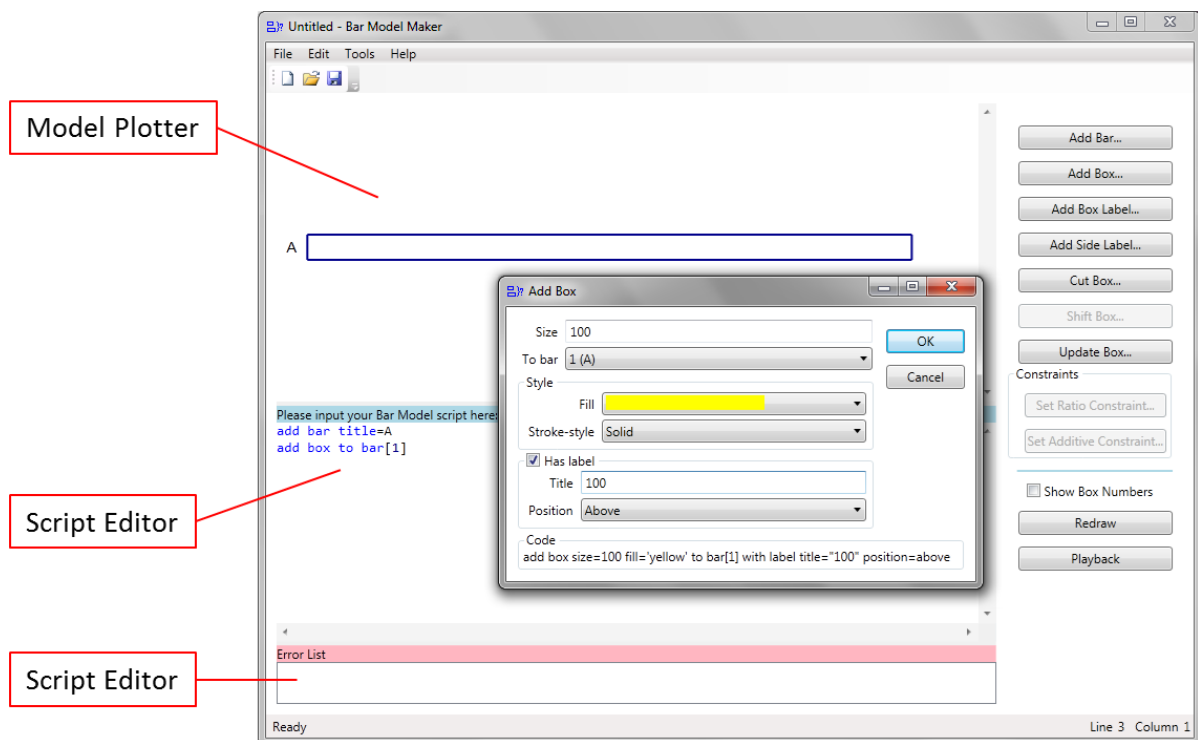


Figure 19 The Model Editor

You can type a statement directly into the script editor or use the 9 dialog boxes to add different statements.

BarModelMaker animates all shift box statements by “moving” the box(es) from the source location to the target location.

4.2. Dialog Boxes

BarModelMaker provides some dialog boxes that help you to write statements. At the bottom of each dialog box, you will see the statement that is to be added to the script. The dialog boxes are a good aid for learning Bar Model script.

In the dialog boxes, you will see a repeating pattern as illustrated in Figure 20 for selecting a box or a range of boxes. First, select a bar from the dropdown list, and the following 2 dropdown lists will be updated automatically. To select a box, make sure the From Box and the To Box are the same. To select a range of boxes, make sure the From box is smaller than the To Box.

Bar	1 (R1)
From Box	1
To Box	2

Figure 20 Selecting a box or a range of boxes

4.2.1. Add Bar Dialog Box

The first thing you do when you draw a bar model is to add a bar to the model. Type the title of the bar and click on the OK button, a new bar will be added to the model.

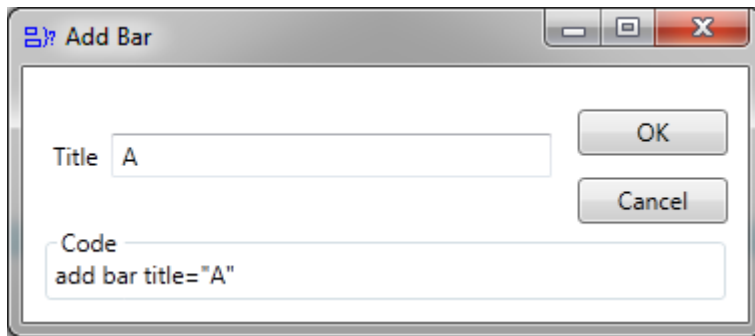


Figure 21 Add Bar Dialog Box

4.2.2. Add Box Dialog Box

To add a box, you must select a bar for the box to be added. You can also specify the fill color, the stroke-style, and the label of the box. To add a label to the box, tick the Has Label check box and input the title of the label.

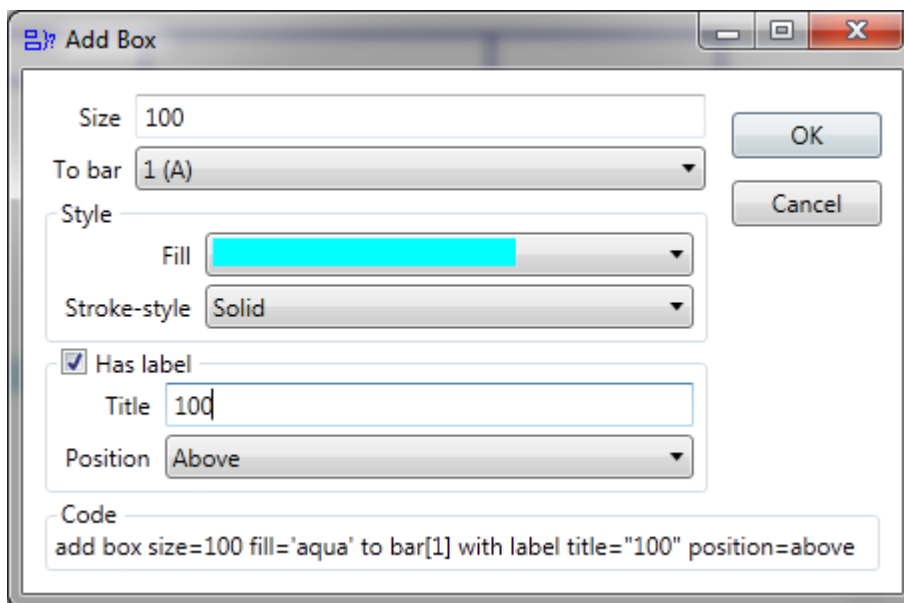


Figure 22 Add Box Dialog Box

4.2.3. Add Box Label Dialog Box

To add a label to one or more boxes, input the title of the label, select the position of the label, and select box(es) to which the label is attached.

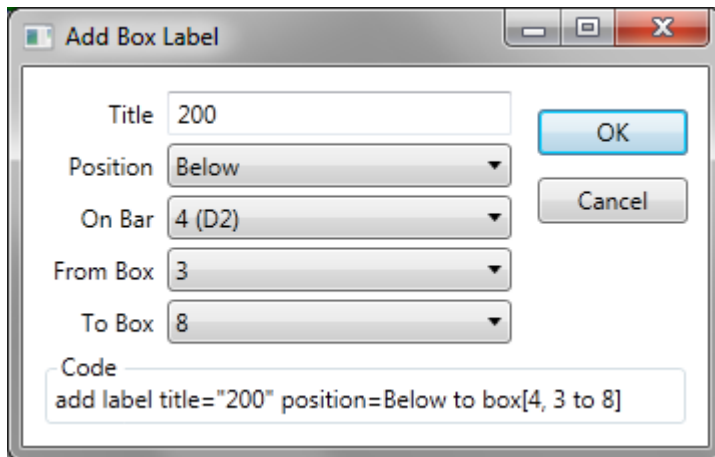


Figure 23 Add Box Label Dialog Box

4.2.4. Add Side Label Dialog Box

To add a side label, input the title of the label and select the bars that the label will be assigned to.



Figure 24 Add Side Label Dialog Box

4.2.5. Cut Box Dialog Box

There are 3 ways that you can cut a box or a range of boxes:

4. Cut one or more boxes into some equal parts,
5. Cut one or more boxes according to a ratio,
6. Cut from the left or the right side of a box.

The following 4 screen shots show the different ways of cutting one or more boxes.

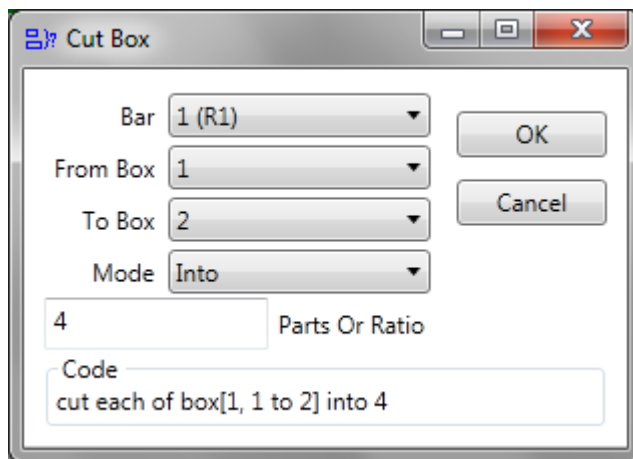


Figure 25 Cut each of the 2 boxes into 4 equal parts

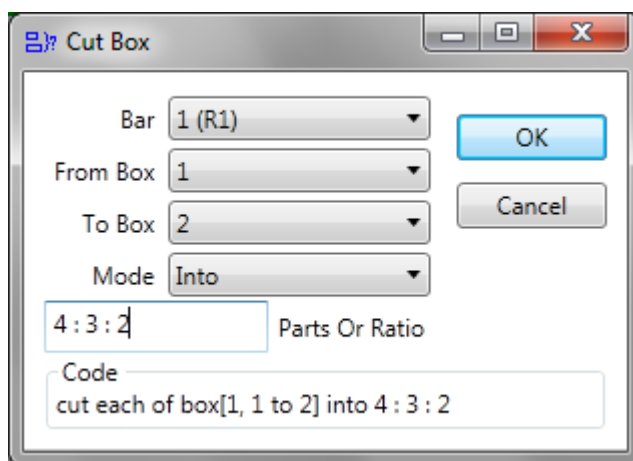


Figure 26 Cut 2 boxes according to a ratio

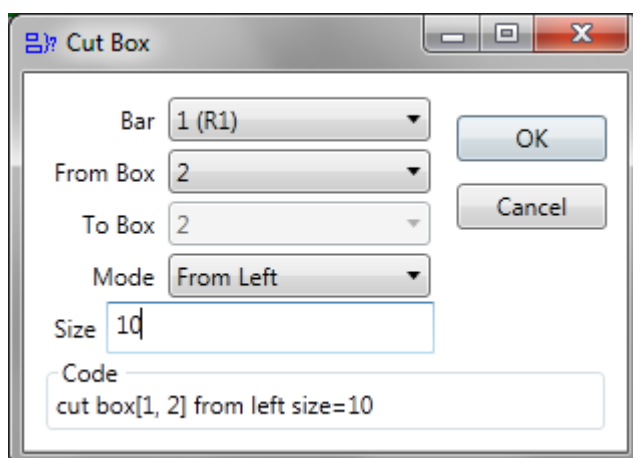


Figure 27 Cut 10 units from the left side of a box

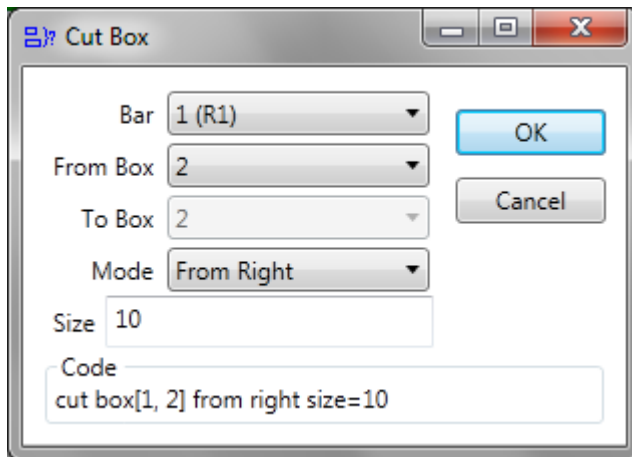


Figure 28 Cut 10 units from the right side of a box

4.2.6. Shift Box Dialog Box

To shift one or more boxes to another bar with the Shift Box Dialog Box, select the source box(es) and the target bar.

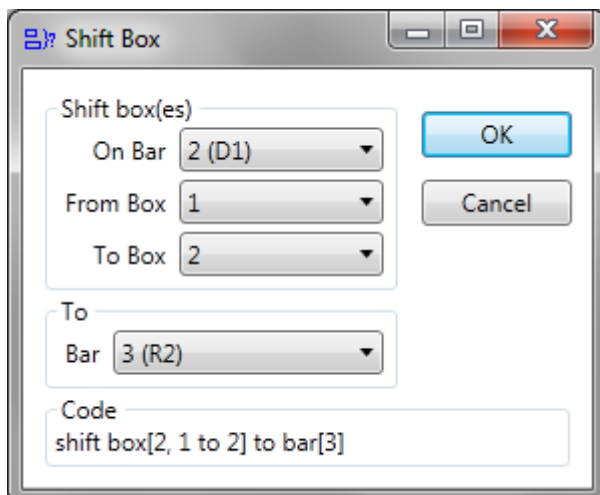


Figure 29 Shift Box Dialog Box

4.2.7. Update Box Dialog Box

To change the fill color and/or stroke style of a box or a range of boxes, select the box(es), then select the new fill color or stroke style.

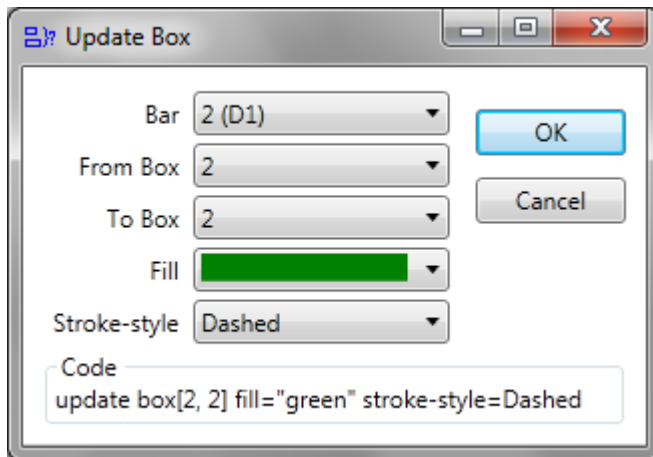


Figure 30 Update Box Dialog Box

4.3. Bar Model Player

You can “play” a bar model by clicking on the Playback button on the Bar Model Editor. The Bar Model Player has 3 components: the control bar to control the play, the model plotter to show the model, and the script view to show the script that has been executed.

Once the bar model player screen appears, the bar model will be played step by step automatically. You can pause, jump to the next step, the previous step, the first step, or the last step. To go back to the model editor screen, click on the Close button.

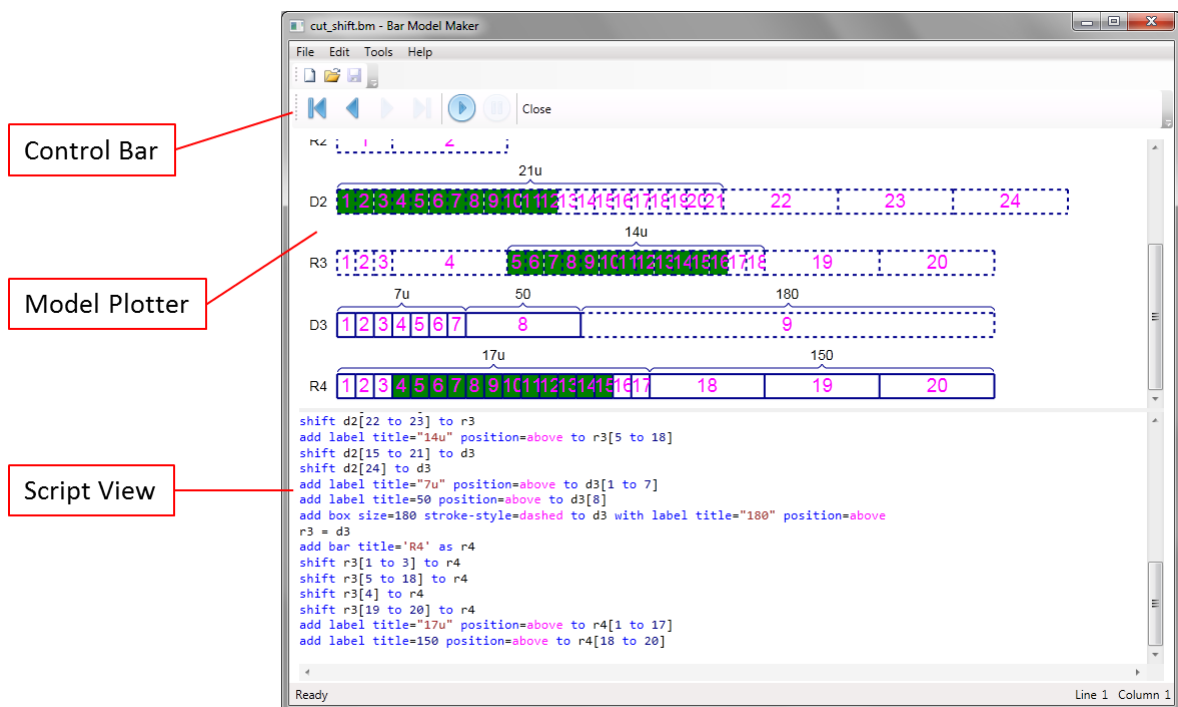


Figure 31 The Model Player

When a shift box statement is executed, you will see an animation showing the box(es) moving from the source bar to the destination bar.

4.4. System Options

BarModelMaker maintains a list of options that determine how a bar model is plotted. You can change the options with the Options dialog box. To open the dialog box, select the Tools-Options menu item.

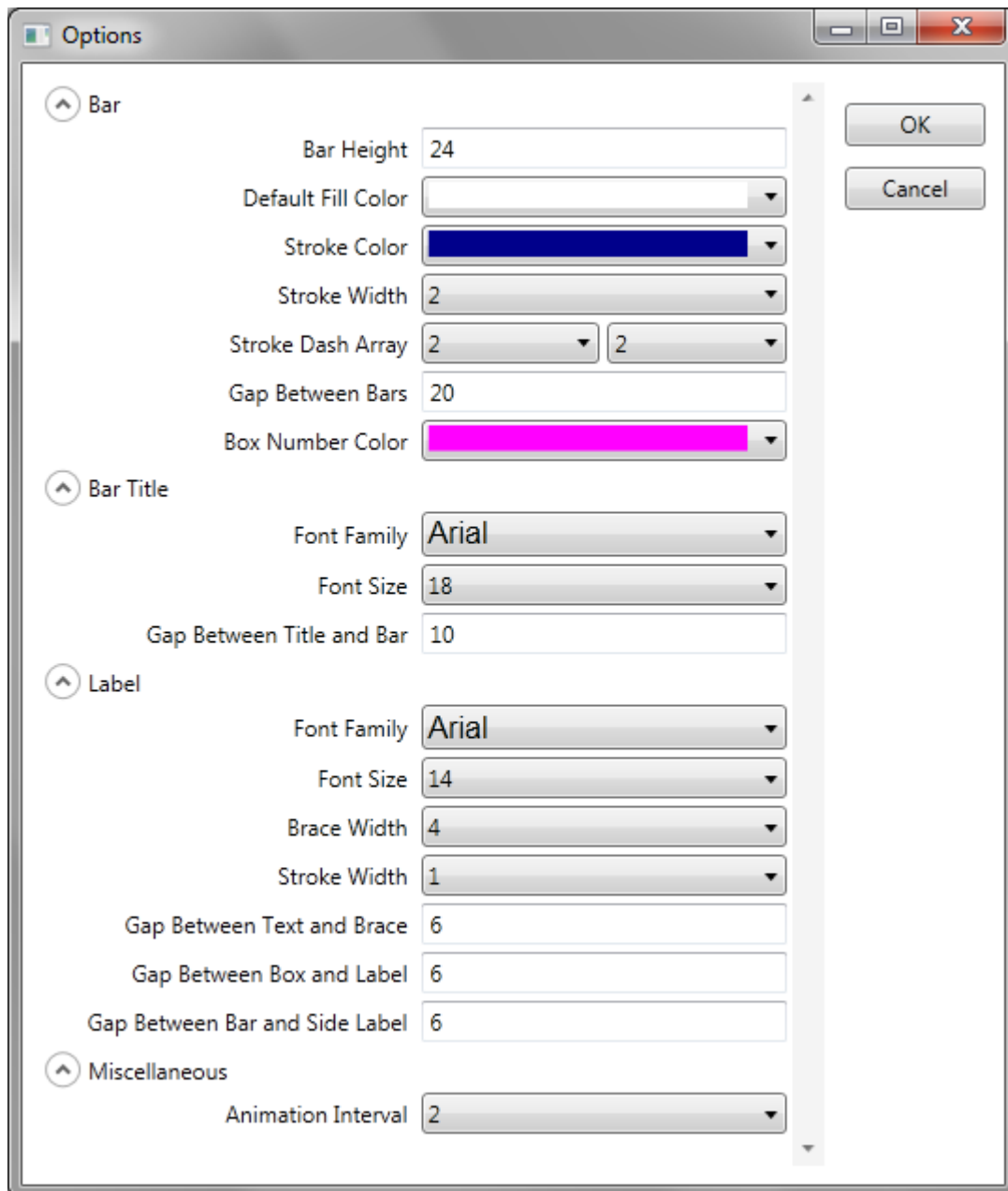


Figure 32 The Options Dialog

There are 4 groups of options: bar, bar title, label, and miscellaneous.

Options		Description
Bar	Bar Height	The height of the bars.
	Default Fill Color	The default fill color of boxes.
	Stroke Color	The stroke color of boxes.
	Stroke Width	The stroke width of boxes.
	Stroke Dash Array	The lengths of alternating dashes and gaps.

	Gap Between Bars	The gap between neighbouring bars
	Box Number Color	The text color of box numbers displayed inside boxes.
Bar Title	Font Family	The font family of bar titles
	Font Size	The font size of bar titles
	Gap Between Title and Bar	The gap between title and bar
Label	Font Family	The font family of labels
	Font Size	The font size of labels
	Brace Width	The height of braces of box labels and the width of braces of side labels
	Stroke Width	The stroke width of labels
	Gap Between Text And Brace	The gap between the text and the label of a label
	Gap between Box and Label	The gap between box and label
	Gap between Bar and Side Label	The gap between the longest bar and the left most label.
Miscellaneous	Animation Interval	The interval, in seconds, that the 2 statements are played.

Table 8 System Options

Figure 33 to Figure 35 illustrate how the options are used in bar models.

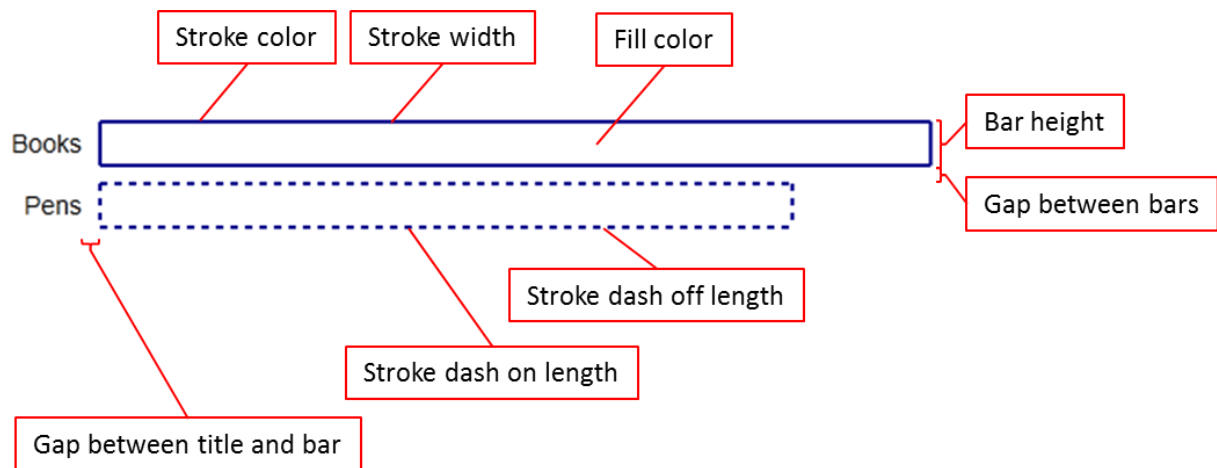


Figure 33 Bar options

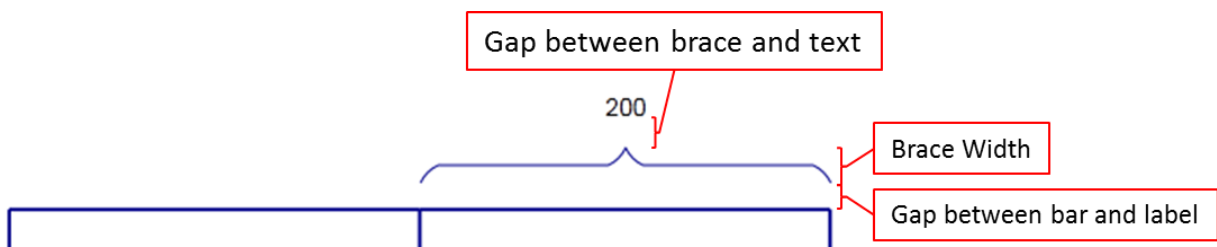


Figure 34 Box Label Options

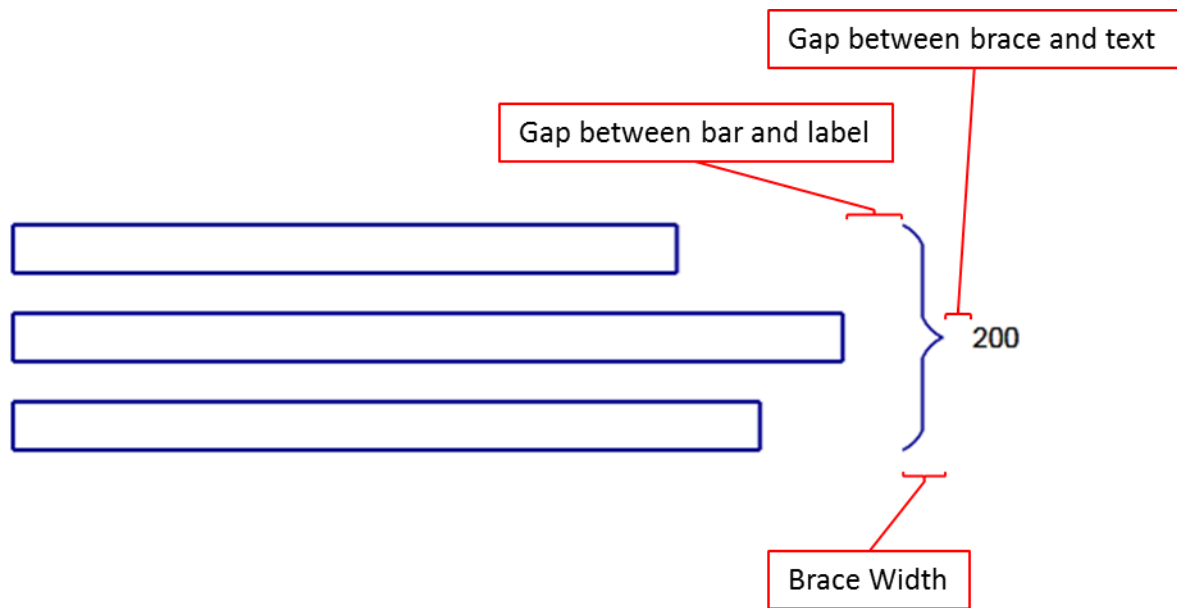


Figure 35 Side label options

5. Samples

5.1 Part-Whole Model

Problem

There are 14 boys and 18 girls in a class room. How many children are there in the class room altogether?

Bar Model

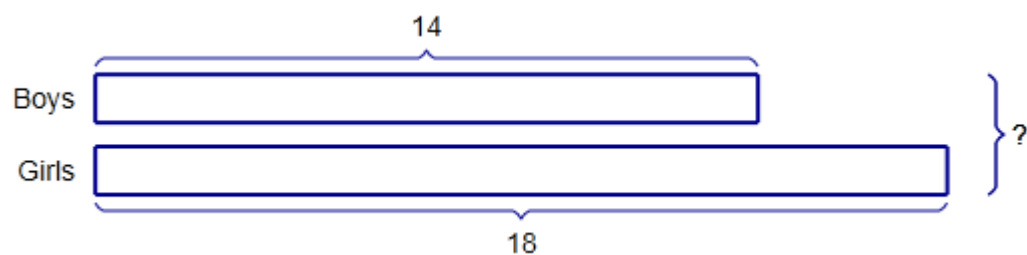


Figure 36 Part-Whole Model

Script

```
add bar title=Boys
add bar title=Girls
add box size=14 to bar[1] with label title=14 position=above
add box size=18 to bar[2] with label title=18 position=below
add label title=? to bar[1 to 2]
```

5.2. Additive Comparison Model

Problem

Mike has 3 less books than Alice. Wendy's books are 3 times as Alice. Alice and Mike's total books are 15 less than Wendy's. How many books does Wendy have?

Bar Model

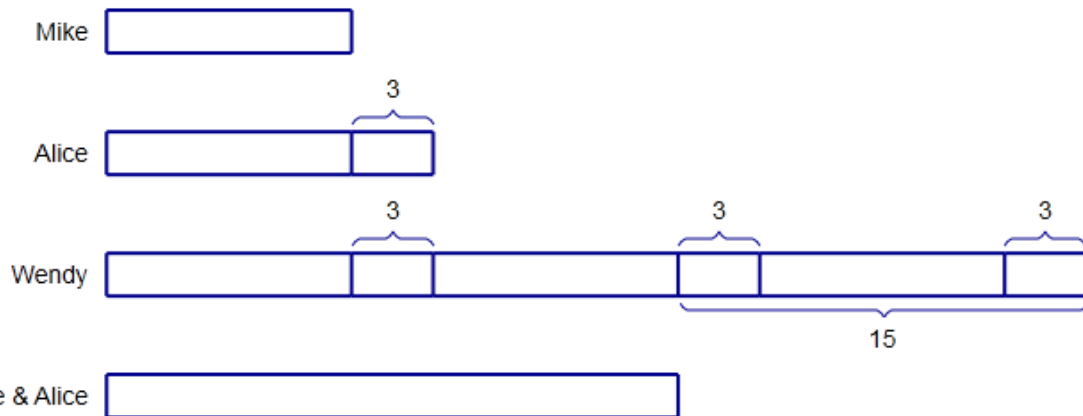


Figure 37 Additive Comparison Model

Script

```
add bar title=Mike
add bar title=Alice
add bar title=Wendy
add box to bar[1]
add box to bar[2]
box[1] + 3 = box[2]
add box to bar[3]
box[1] + box[2] = box[3] - 15
cut box[3] into 3
box[2] = box[3,1]
cut box[2] from right size=3
cut box[3,1 to 3] from right size=3
add label title=3 position=above to box[2,2]
add label title=3 position=above to box[3,2]
add label title=3 position=above to box[3,4]
add label title=3 position=above to box[3,6]
add bar title="Mike & Alice"
add box to bar[4]
box[4] = box[1] + box[2]
add label title=15 position=below to box[3,4 to 6]
```

5.3. Cut and shift

Problem

Ryan had \$200 more than Danish at first. Ryan gave $\frac{3}{4}$ of his money to Danish. Danish in return gave $\frac{2}{3}$ of his money to Ryan. In the end, Ryan had \$180 more than Danish. Find the amount of money Danish had in the end.

Bar Model

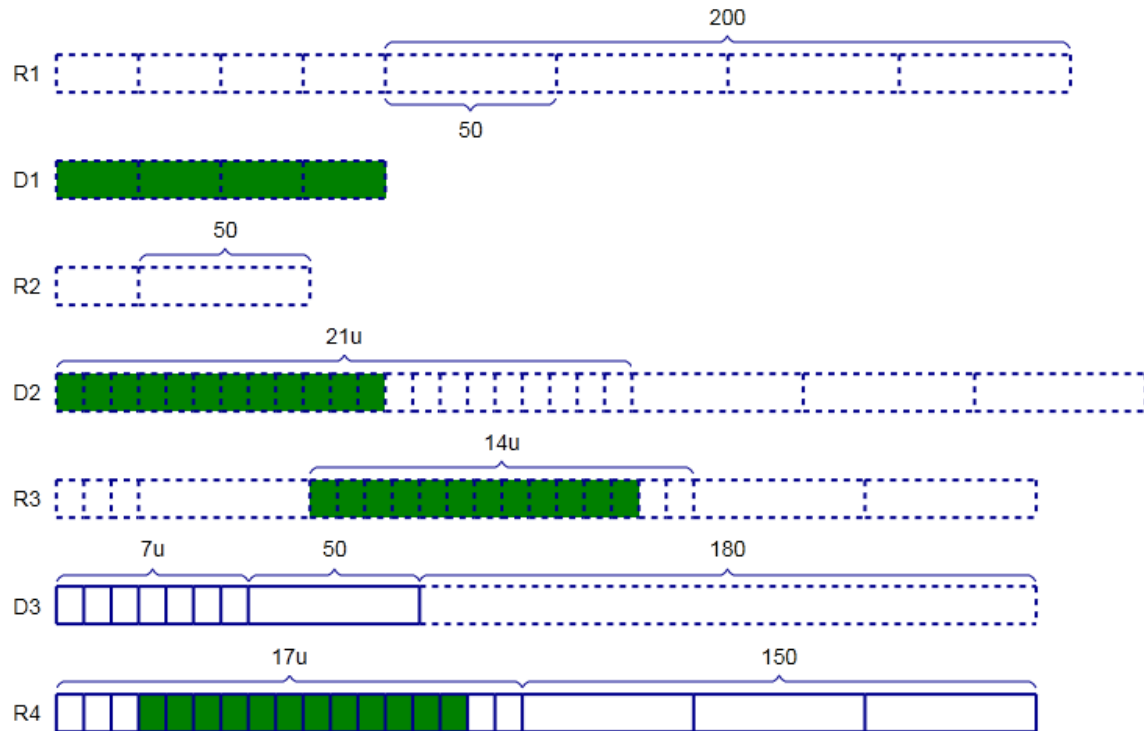


Figure 38 Cut and shift

Script

```

add bar title='R1' as r1
add bar title='D1' as d1
add box to r1
add box fill=green to d1
r1 - d1 = 200
cut r1 from right size=200
add label title="200" position=above to r1[2]
cut r1[1 to 2] into 4
add label title="50" position=below to r1[5]
cut d1 into 4
add bar title='R2' as r2
add bar title='D2' as d2
shift r1[1] to r2
shift r1[5] to r2
add label title="50" position=above to r2[2]
shift d1[1 to 4] to d2
shift r1[2 to 4] to d2
shift r1[6 to 8] to d2
cut d2[1 to 7] into 3
add label title="21u" position=above to d2[1 to 21]
add bar title='R3' as r3
add bar title='D3' as d3
shift r2[1 to 2] to r3
cut r3[1] into 3
shift d2[1 to 14] to r3
shift d2[22 to 23] to r3
add label title="14u" position=above to r3[5 to 18]

```

```
shift d2[15 to 21] to d3
shift d2[24] to d3
add label title="7u" position=above to d3[1 to 7]
add label title=50 position=above to d3[8]
add box size=180 stroke-
style=dashed to d3 with label title="180" position=above
r3 = d3
add bar title='R4' as r4
shift r3[1 to 3] to r4
shift r3[5 to 18] to r4
shift r3[4] to r4
shift r3[19 to 20] to r4
add label title="17u" position=above to r4[1 to 17]
add label title=150 position=above to r4[18 to 20]
```