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# Higher-order thinking in mathematics



# Higher-order thinking in mathematics

## — overview

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*What is higher-order thinking and why should we use it?*

*What does higher-order thinking look like in mathematics?*

*What resources are available?*

# Why teach higher-order thinking skills?

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Higher-order thinking skills are valued because they are believed to better prepare students for the challenges of adult work and daily life and advanced academic work. Higher-order thinking may also help raise standardized test scores. A curriculum emphasizing higher-order thinking skills has been found to substantially increase math and reading comprehension scores of economically disadvantaged students (Pogrow, 2005).

<http://www.learnnc.org/reference/higher+order+thinking>

(Accessed May 7 2012)



Queensland Government

Higher-order thinking is thinking on a higher level than memorizing facts or telling something back to someone exactly the way the it was told to you.

“Higher-order thinking” Alice Thomas, M.Ed. and Glenda Thorne, Ph.D  
<http://www.cdl.org/resource-library/articles/highorderthinking.php>  
(accessed May 7 2012)

**Higher-order thinking** requires students to **manipulate information and ideas** in ways that transform their meaning and implications. This transformation occurs when students combine facts and ideas in order to **synthesise, generalise, explain, hypothesise or arrive at some conclusion or interpretation**. Manipulating information and ideas through these processes allows students to **solve problems and discover new (for them) meanings and understandings**. When students engage in the construction of knowledge, an element of uncertainty is introduced into the instructional process and makes instructional outcomes not always predictable; i.e., the *teacher is not certain what will be produced by students*. In helping students become producers of knowledge, the teacher's main instructional task is to create activities or environments that allow them opportunities to engage in higher-order thinking.

<http://education.qld.gov.au/corporate/newbasics/html/pedagogies/intellect/int1a.html>

(accessed May 7 2012)



# How to develop an investigation from a closed question



*Closed question*

$$6 + 4 = ?$$

*Open question*

*What numbers could you add together to make 10?*

*Investigation*

There are chickens and calves in the farmers paddock. *If there are 24 legs altogether, how many of each animal could there be?*

*Could there be more than one answer? How many different answers could you find for this question? How did you work it out? What materials might help you?*



# Noah's Ark

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Noah counted 24 legs  
as the animals walked  
into the ark.

*What types of animals  
might they have been?*



[istockphoto.com/stock-photo-14236407-noah-s-ark.php?st=654b38f&](https://istockphoto.com/stock-photo-14236407-noah-s-ark.php?st=654b38f&)  
Noahs Ark © Keith Reicher .



# How to develop an investigation from a closed question

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## *Closed question*

Find the area of this rectangle



## *Open question*

What might the perimeter be if the area of a rectangle is 24 square metres?

What are the perimeters of other rectangles that have an area of 24 square metres? How many answers could there be? How will you know if you have them all? Explain your thinking and include diagrams.

## *Investigation*

You have been asked to design a pool that has an area of 24 square metres. Design different shaped pools that would allow the customer several options. Compare the costs of the surrounding tiled area.



# Levels of thinking, reasoning and working mathematically

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Investigating issues and problem situations

Solving specific problems in novel situations

Applying rules and formulae in standard situations

Learning of rules and facts

Ensure that each level is used in your lessons, in each unit.

# Resources

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- Productive pedagogies — [Higher-order thinking](http://education.qld.gov.au/corporate/newbasics/html/pedagogies/intellect/int1a.html)  
(<http://education.qld.gov.au/corporate/newbasics/html/pedagogies/intellect/int1a.html>)
- Tomorrow's Citizens — [Higher-order thinking](http://www.learningplace.com.au/deliver/content.asp?pid=45287)  
(<http://www.learningplace.com.au/deliver/content.asp?pid=45287>)
- Towards independent learning — [Teaching strategies](https://www.learningplace.com.au/deliver/content.asp?pid=49273)  
(<https://www.learningplace.com.au/deliver/content.asp?pid=49273>)
- [Integrating rich tasks — Introduction](http://nrich.maths.org/6089) (<http://nrich.maths.org/6089>)
- [Examples of activities that promote higher-order thinking](http://teaching.uncc.edu/articles-books/best-practice-articles/instructional-methods/promoting-higher-thinking)  
(<http://teaching.uncc.edu/articles-books/best-practice-articles/instructional-methods/promoting-higher-thinking>)
- Almond S Wells J and Makar K, 2010 *Thinking through mathematics: engaging students with inquiry-based learning* Curriculum Press

