Open-Ended Maths Tasks

VELS EDITION

Bloom's Taxonomy
Multiple Intelligences
Habits of Mind
Thinker's Keys
Creative and Critical Thinking
Graphic Organisers

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Table of Contents

Introduction

What are open-ended tasks?

Questions prompt thinking. In order to get better thinking out of our students, we need to ask better questions. What sort of questions to you ask in your classroom? Questions can be either closed or open.

Closed questions are used to obtain knowledge or an understanding of facts and have only one correct answer. Closed questions provide little creativity and children are usually asked to find the 'right' answer to ascertain their comprehension of facts. An example would be 'If I have 3 dozen eggs, how many eggs do I have?' This question has 2 closed parts to it. Students need to know the fact that there are 12 in a dozen, and that 3 times 12 is 36. They are all facts and there is only one right answer.

Open-ended questions involve thoughtful and investigative responses . More than one correct answer is acceptable and children are encouraged to be creative when responding to open-ended questions. Some open-ended questions may have more than one right answer but a maximum of correct answers. An example would be 'My mum gave me 28 lollies to share equally between myself and my friends. How many friends could I share my lollies with and how many would we get each?' This question has several possible correct answers, but not an infinite amount of correct responses. (Myself and 1 friend 2 x 14; myself and 3 friends 4 x 7; myself and 6 friends 7 x 4). The focus of this open question is to assess students' ability to use division or multiplication accurately.

Other open-ended questions can have an almost infinite range of acceptable responses. An example would be 'How would you spend $5.00 on your lunch at the canteen?' Students can explore how to spend their money using a canteen menu and there are almost endless possibilities of acceptable responses. The focus of this open question is to assess students' ability to use addition or subtraction of money, including decimals.

A great way to engage students is to use open-ended questions to provide investigations and projects for children to explore and apply their knowledge. Being able to use processes or procedures taught in class is encouraged when responding to open-ended questions, where their skills can also be further assessed.

This book focuses on the use of open-ended questions in the maths classroom. Current trends in curriculum and learning focus on the need to prepare students for a life where problem-solving skills are a necessity. Open-ended questions promote effective problem-solving skills and can easily be incorporated with thinking tools such as Bloom's Taxonomy, Gardner's Multiple Intelligences, Costa's Habits of Mind, Creative and Critical Thinking skills and the use of various visual organisational tools.

Whilst the importance of using open-ended questions in classrooms is being encouraged, the use of closed questions is certainly not being dismissed. Closed questions are still vital and very relevant when teaching basic skills, number facts and times tables, or using processes for solving algorithms accurately and reciting knowledge of facts.

If you assess your use of closed and open questions in your classroom, closed questions may feature more predominantly. Alternatively, you may find that you ask more open-ended questions than you realise. Asking open-ended questions may appear to require more effort, however with practice, this will easily become second nature in your teaching.

A classroom which incorporates open-ended tasks into its learning program should be a classroom where students area encouraged to

- be independent thinkers
- share, reflect on and value alternative responses
- be excited about learning
- be responsible for their learning
- complete tasks reflective of their true abilities

It should also be noted that examples given in this book can certainly over-lap and are not category specific, especially when using Bloom's Taxonomy. An application task could also be used as an evaluation. Example – Demonstrate 3 ways to solve the multiplication problem of 13 x 9. Children have to apply the skills taught in class and their own abilities to demonstrate 3 accurate methods of reaching an answer. You could also evaluate their understanding of the methods taught in class and how advanced their thinking is when solving such a problem.

A creative thinking Fluency task could also be knowledge in Bloom's and an Intrapersonal Multiple Intelligence. Example – How many terms about measurement can you come up with in 3 minutes? This task requires children to fluently recall terms they are familiar with (Fluency), which requires them to access their knowledge about measurement (Knowledge) as well as being confident and in touch with their own abilities (Intrapersonal).

Open-ended task cards can be quite flexible in terms of the context in which you use them and the purpose of the activity.

How to use this book

This book is split into two sections. Section one presents a selection of models of thinking skills that can be used in preparing open-ended maths tasks. Each chapter features an outline of the model and an explanation of how it can be used in creating open-ended maths tasks followed by a selection of example activities. The final part of the chapter is a more detailed explanation of the history behind the model and features a list of resources providing further information on the thinking tools and examples of how to use them in the classroom.

Chapter 7, 'Converting traditional questions to open-ended,' gives examples of how units of work using open-ended tasks and incorporating Bloom's Taxonomy, creative and critical thinking and Multiple Intelligences can be created from traditional maths questions. This chapter is organised in the following way:

	Junior Primay	Middle Primary	Upper Primary
Number			
Decimal Fractions			Page 43
Division		Page 46	
Addition	Page 50		
Measurement			
Perimeter			Page 45
Mass		Page 48	
Time	Page 51		

Section two contains reproducible copies of the task cards. The task cards can also be found on the accompanying CD-ROM to be printed and laminated as desired.

The cards have been separated into levels of

- Junior primary (years prep, 1 and 2)
- Middle primary (years 3 and 4)
- Upper primary (years 5 and 6)

each addressing the curriculum content for that stage in one of two topics, number or measurement.

However, the levels indicated can also be used as a guide, and you will be able to work out from your students' ability which cards are most appropriate.

Within each level, tasks are separated into either

- 5–10 minutes. This indicates the task is suitable for a topic intro and warm-up.
- 15+ minutes. This denotes it is to be used as a project-based and extension task.

- Although task cards could be prepared using any of the thinking tools outlined in this book, we have chosen to use the levels of the revised Bloom's Taxonomy (Anderson and Krathwohl, 2001, and see p. 33). Each task has been developed to encourage critical thinking at one of the six levels.

Ideas for using the task cards

- Introducing a topic, warm-up activity.
- At the start of maths lesson offer an open-ended task to the whole class.
- Write the question on the board and students can write their responses in their maths workbooks or give the question and answers orally as a discussion to get warmed up for a lesson on worded problem-solving.

Early finishers

Give task cards out to individuals, pairs or small groups of students to work on when their other work is finished. If they have completed page 30 of their textbook on perimeter, they then are given the card 'How many different fence designs can you create to go around a house with a perimeter of 40 metres?' Use the scale 1 cm=1 m.

Homework

Photocopy the task cards or retype the question/s for students to glue into their homework books. Open-ended tasks are a great activity to involve students with their parents/families at home. Share responses and answers at the end of the week. Create a poster or display of students' answers to the question.

Evaluation of student learning

At the end of a unit of work or at the end of a week/fortnight/month, design a test or assessment task with a range of open-ended questions and closed questions as comparison.

Number the task cards and keep a checklist of how many students complete in a week, month, term.

Create a chart on the classroom wall for students to tick off when they have completed a task, or use your teacher records book. Give out certificates or rewards if you choose.

Weekly class challenge

For example, 'What jobs use measurement tools?'

Make a class list of jobs children think of during the week and how each uses a measurement tool. Compare which jobs use the greatest variety of tools and which jobs use the same type of tools. Create a display, draw pictures of the job and tool. At the end of the week, discuss their discoveries about measurement tools.

Rotating groups

To revise topics and encourage cooperative skills place students into groups of mixed or same ability. To revise units on addition, multiplication, subtraction and division divide the class into 4, with a task card each. Students could write their responses

as a group on a poster or in a booklet, or individuals or pairs of students can record their own answers. Give each group 10 minutes on each task (or an appropriate time, depending on the task), ring a bell, then rotate again. Get together after all 4 rotations and discuss the tasks.

BRAIN book

Students use a special workbook – blank project books are ideal. Type up, then glue in an open-ended question at the top of a page. Students use the whole page to generate solutions to the task. Get the class together to compare different methods used for the task. Can also be used as an assessment book or take home to show parents.

Victorian Essential Learning Standards

As Victorian teachers, we acknowledge the importance and significance of changes in attitude to teaching and student learning in recent directive documents. The inclusion of thinking as part of 'Interdisciplinary learning' acknowledges that the ever-changing world we live in requires a population of competent thinkers. Students need to use existing knowledge to produce new understandings in creative ways. VELS states

'Our world and the world of the future demand that all students are supported to become effective and skilful thinkers.'

We believe that approaching mathematics with tasks that provide for a wide number of creative solutions assists in the development of skilful thinkers.

In developing this set of cards we acknowledge the different models of strategies, practices and taxonomies suggested by many informed people to improve student thinking. Gardner, Blooms, Costa and Kallick are a few. The VELS Teaching and Learning Resource, Support Materials lists a great variety of 'learning theory, principles and strategies for teachers.' We, too, have included many of these ideas in the development of these task cards. The VELS Thinking document states, 'Students need to be supported to move beyond the lower-order cognitive skills of recall and comprehension to the development of higher-order processes required for creative problem-solving, decision making and conceptualising.' We hope that these cards do just that!

The three dimensions listed for consideration at each level documented in the VELS Thinking curriculum reinforce the need to provide for more flexible teaching and learning. The first, 'Reasoning, processing and inquiry,' points out the need for critical thinking in organising information and making judgments. 'Creativity,' the second dimension, documents the need for students to use their imagination to be innovative problem solvers. Thirdly, 'Reflection, evaluation and metacognition,' encourages learners to think about their thinking and to use learned information or skills for future learning. These dimensions are applicable at each level with increasing complexity as students advance through the levels.

We believe that by allowing our students to solve mathematical tasks that are meaningful, interesting and challenging, and providing them with appropriate and varied means of solving them, we will develop students who automatically use their higher-order thinking to attempt to solve all problems that life presents them in the future. It is pleasing to see this acknowledged in VELS materials also.

References and suggested further reading

Anderson, Lorin W. and David R. Krathwohl (eds) (2001). *A Taxonomy for Learning, Teaching and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. New York, USA: Longman.

1 Creative and critical thinking

The task card questions developed for this book can be easily incorporated into a program that uses the creative and critical thinking skills approach to the explicit teaching of thinking skills (See boxed text, p. 17) Critical thinking tends to involve tasks that are logical, rational, sequential, analytical and convergent. This is 'left brain' thinking. Creative thinking tends to involve tasks that are spatial, flexible, spontaneous, analogical and divergent. This is 'right brain' thinking.

One model of teaching using creative and critical thinking skills was outlined in the title, *Activities for Developing Thinking Skills* (Wellner and Yoder, 2005). Their approach incorporates the four creative thinking skills in the cognitive domain identified by Frank E. Williams (1970, see boxed text on p. 17). In this model, they identify four key components to both creative and critical thinking. These skills are often introduced sequentially, with each new thinking approach building upon the thinking skills developed in the previous component.

Creative thinking	Critical thinking
Fluency Flexibility Elaboration Originality	Evaluation Planning Forecasting Decision Making

Creative thinking

Fluency

Fluency is the beginning of divergent thinking or the recall and use of stored knowledge. Fluent thinkers have the ability to think of many related ideas, questions, responses and solutions. Students can be encouraged to work independently or in small groups on fluency lists and fluency thinking tasks. These tasks may be used as a warm-up activity, for class or group discussions or as part of a lesson.

Example tasks

Junior:

Number: Write down everything you know about the number 12.

Measurement: Make a list of all the measurement tools you can think of.

Middle:

Number: When can you see one hundred, one thousand, one million, and one billion objects?

Example tasks

Junior:

Number: Decide what you would buy from the canteen if you had $2.00 to spend.

Measurement: What is the best way to measure your feet?

Middle:

Number: How many people do we, as a class, know? Record and present the information.

Measurement: You and a friend are in charge of the homemade sweets stall for the country fair. Decide what you are going to make and make a shopping list of the ingredients.

Upper:

Number: Using a store catalogue select a range of gifts to buy for 4 friends or family members. What is the total cost? If you put them on layby, how much would you need to pay every week to have it paid off in 6 weeks?

Measurement: You are at home sick. Use a TV guide to plan 5 hours worth of television viewing for the day.

Theory into Practice

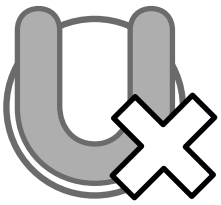
In 1956, Benjamin Bloom headed a group of educational psychologists who developed a classification of levels of intellectual behaviour important in learning. This became a taxonomy including three overlapping domains; the cognitive, psychomotor and affective (Bloom et al., 1956, and see chapter 5). Creative and critical thinking are established higher-order components of Bloom's Taxonomy of cognitive processes. Tasks that involve critical thinking call for cognitive processes throughout the levels of Bloom's Taxonomy.

Many definitions of critical thinking have been put forward but perhaps the most simplistic, and that most closely aligned to the original 1956 work of Bloom, is that, 'critical thinking involves reasonable reflective thinking focused on deciding what to believe or do,' (Ennis, 1992).

Similarly, many models have been presented that employ the use of critical along with creative thinking skills. For this book the authors have chosen to use those in *Activities for Developing Thinking Skills* (Wellner and Yoda, 2005).

The widely-used model for using the creative thinking skills approach was developed by Frank B. Williams and outlined in his 1970 title, *Classroom Ideas for Thinking and Feeling*. This taxonomy for creative thinking consists of eight different levels. The first four levels relate to cognitive areas of intellectual development, the remaining four levels relate to affective areas of personal development.

7 Converting traditional questions to open-ended



Number: Decimal fractions, Upper Primary

Traditional questions

8.09 + 4.12	Write these decimals as vulgar fractions. 0.50 1.40 0.20 3.75	Write these vulgar fractions as decimals. 1 2/10 5 6/10 9 13/100 22 4/100 38 90/100	What are all of the decimal fractions that can be made using only a 3, a 7 and a decimal point?

Changed to open-ended using thinking tools

Bloom's Taxonomy

Remember – Give a simple explanation for what a decimal fraction is.

Understand – Give some examples of where or how decimals fractions are used in the real world.

Apply – Illustrate in different ways what the decimal fraction 4.15 can look like.

Analyse – Use the digits of the current year to make 6 different decimal fractions and rank them in order from smallest to largest. Explain your understanding of ordering these numbers.

Evaluate – Convince the teacher you understand the place value in decimal fractions. Use a stopwatch to time 10 different people to run 10 metres, rank them and explain the time differences between each person using seconds, tenths and hundredths of seconds.

Create – Create a number sentence that gives the answer of 12.65.

Creative thinking

Fluency – How many decimal fractions can you create in 1 minute using the digits 1 through to 5?

Junior Primary

Remember

Number

15+ minutes

- List everything you know about money.

Junior Primary

Understand

Number

15+ minutes

- Mandy from Mars has a friend from Saturn. He has 5 eyes, 6 arms, 3 legs, 18 fingers and lots of spots. What does he look like? What is his name? Create number sentences about him/her.

Middle Primary

Evaluate

- When can you see one hundred, one thousand, one million, and one billion things?

Number

5-10 minutes

Middle Primary

Create

- Use the digits of the current year and any number of the operations. How many number sentences can you make in 5 minutes?

Number

5-10 minutes

Upper Primary

Remember

- What is the Australian dollar worth today in 5 other currencies?

Number

15+ minutes

Upper Level

Understand

- If the average of 6 numbers was 58, what could the 6 numbers be?

Number

15+ minutes