Open-Ended Maths Tasks

Geometry, Statistics and Probability

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

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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 do 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 require little creativity and children are usually asked to find the "right" answer to ascertain their comprehension of facts. An example would be *"The news is on television every night. Which of the following is the correct answer to describe the probability of the event happening? 100%, 50:50, 3 out of 10, or maybe."* Students need to know what the terms mean and how they relate to probability. There is only one right answer, 100%.

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 *"What words describe the chance of the news being on television tonight?"* This question is an example of providing a scenario where there is a "certain" chance of the event taking place. To rationalise the scenario, students use prior knowledge to ascertain the appropriate term to explain the chance. "The news is on television every night, so it would have to be on tonight. I am certain it will be on TV tonight". There are several possible correct answers though. Students can display an understanding of alternative terms for "certain chance". However there would only be a limited number of appropriate terms – definite, absolute, 100%, etc. The focus of this open question is to assess students' ability to understand the different terminology used to describe chance events and that certain factors influence the accuracy of the terms that can be used.

Other open-ended questions or tasks can have an almost infinite range of acceptable responses. An example would be *"Create a question and survey the class for answers. Show your results using an appropriate graph and make statements about your findings."* Students can decide on the survey question based on their own interests and there are almost endless possibilities of acceptable questions that could be posed. Students then use their prior experiences and knowledge in deciding what type of graph would be appropriate to display the survey results. Finally, students can decide on what findings were of interest to them and how to make conclusions about the results. The focus of this open question is to assess students' ability to apply their skills in planning and conducting surveys or questionnaires and displaying the data using appropriate techniques.

A great way to engage students is using open-ended questions or tasks which 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 the teacher can further assess their skills.

This book focuses on the use of open-ended questions or tasks 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 the Mind, Creative and Critical Thinking skills, and using 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 such as correct names and terminology used in identifying shapes, ordering chance events or using processes for finding the mean, median or mode of data collected.

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 what you realise. Asking open-ended questions can require more effort and preparation; however, with practice, they can easily become second nature in your teaching.

A classroom which incorporates open-ended tasks into their learning programs should be a classroom where students are 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 overlap and are not category specific, especially when using Bloom's Taxonomy.

An application task could also be used as an evaluation. Example – *Write three questions which people can only give a yes or no answer to*. Children have to apply the skills taught in class about survey questioning to demonstrate an understanding that in order for data to be collected accurately, the question needs to be specific. This task can also help you evaluate their understanding of this skill and could be followed up with them completing a survey and displaying the results using a graph.

A creative thinking Fluency task could also be Remembering in Bloom's and an Intrapersonal and Interpersonal Multiple Intelligence. Example – *How many terms can you come up with that would describe the chance of you going for a swim on a 30 degree day? Compare your terms with a friend. What did you discover?* This task requires children to fluently recall terms they are familiar with (fluency), which requires them to access their knowledge about chance (remembering/understanding), as well as being confident and in touch with their own abilities (Intrapersonal) and being able to share and compare with a classmate (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. Feel free to use them in a way that suits your teaching style and the learning preferences of your students.

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 closed 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:

Section two contains reproducible copies of the task cards. The task cards can be printed and laminated as desired.

The cards have been separated into levels of

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

These chapters are organised in the following way, each addressing the curriculum content for that stage in one of two topics, Statistics and Probability or Geometry.

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.

The Australian Curriculum

As Australian teachers, we acknowledge the importance and significance of directives in teaching and student learning from ACARA (Australian Curriculum, Assessment and Reporting Authority) in the development and implementation of the Australian Curriculum.

The stated aims of the Mathematics Learning Area from the Australian Curriculum are to "ensure that students:

- are confident, creative users and communicators of mathematics, able to investigate, represent and interpret situations in their personal and work lives and as active citizens
- develop an increasingly sophisticated understanding of mathematical concepts and fluency with processes, and are able to pose and solve problems and reason in *Number and Algebra, Measurement and Geometry, and Statistics and Probability*
- recognise connections between the areas of mathematics and other disciplines and appreciate mathematics as an accessible and enjoyable discipline to study."

  (ACARA, 2013, http://www.australiancurriculum.edu.au/Mathematics/Aims)

The Australian Curriculum further identifies Numeracy as one of seven general capabilities which "encompass the knowledge, skills, behaviours and dispositions that, together with curriculum content in each learning area and the cross-curriculum priorities, will assist students to live and work successfully in the twenty-first century."

"Students become numerate as they develop the knowledge and skills to use mathematics confidently across all learning areas at school and in their lives more broadly. Numeracy involves students in recognising and understanding the role of mathematics in the world and having the dispositions and capacities to use mathematical knowledge and skills purposefully."

"Mathematics has a central role in the development of numeracy in a manner that is more explicit and foregrounded than is the case in other learning areas. It is important that the Mathematics curriculum provides the opportunity to apply mathematical understanding and skills in context, both in other learning areas and in real world contexts. A particularly important context for the application of Number and Algebra is financial mathematics. In *Measurement and Geometry*, there is an opportunity to apply understanding to design. The twenty-first century world is information driven, and through *Statistics and Probability* students can interpret data and make informed judgments about events involving chance." (http://www.australiancurriculum.edu.au/Mathematics/General-capabilities)

CRITICAL AND CREATIVE THINKING

The Australian Curriculum identifies another of the seven general capabilities as "Creative and Critical Thinking".

"In the Australian Curriculum, students develop capability in critical and creative

thinking as they learn to generate and evaluate knowledge, clarify concepts and ideas, seek possibilities, consider alternatives and solve problems. Critical and creative thinking are integral to activities that require students to think broadly and deeply using skills, behaviours and dispositions such as reason, logic, resourcefulness, imagination and innovation in all learning areas at school and in their lives beyond school.

The Melbourne Declaration on Educational Goals for Young Australians (MCEETYA, 2008) recognises that critical and creative thinking are fundamental to students becoming successful learners. Thinking that is productive, purposeful and intentional is at the centre of effective learning. By applying a sequence of thinking skills, students develop an increasingly sophisticated understanding of the processes they can employ whenever they encounter problems, unfamiliar information and new ideas. In addition, the progressive development of knowledge about thinking and the practice of using thinking strategies can increase students' motivation for, and management of, their own learning. They become more confident and autonomous problem-solvers and thinkers.

Responding to the challenges of the twenty-first century – with its complex environmental, social and economic pressures – requires young people to be creative, innovative, enterprising and adaptable, with the motivation, confidence and skills to use critical and creative thinking purposefully." (http://www.australiancurriculum.edu.au/GeneralCapabilities/Critical-and-creative-thinking/Introduction/Introduction)

In developing this set of cards we acknowledge the different models of strategies, practices and taxonomies suggested by many theorists to improve student thinking. Gardner, Bloom, Costa and Kallick are a few. The Australian Curriculum identifies a variety of theorists in the background summary for the general capability of Critical and Creative Thinking. "It draws on foundational and recent international and national research, as well as initiatives and programs that focus on critical and creative thinking across the curriculum." (http://www.australiancurriculum.edu.au/GeneralCapabilities/Pdf/Critical-and-creative-thinking)

We, too, have included many of these ideas in the development of these task cards. The Australian Curriculum states that, "students develop capability in critical and creative thinking as they learn to generate and evaluate knowledge, clarify concepts and ideas, seek possibilities, consider alternatives and solve problems. Critical and creative thinking are integral to activities that require students to think broadly and deeply using skills, behaviours and dispositions such as reason, logic, resourcefulness, imagination and innovation in all learning areas at school and in their lives beyond school." (http://www.australiancurriculum.edu.au/GeneralCapabilities/Pdf/Critical-and-creative-thinking, page 1 Introduction)

We hope that these cards promote the development of these skills. 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.

Generic Skills Table

Refer to this table to quickly find a specific task card that is related to a particular strand or set of skills for Junior, Middle or Upper primary year levels. These task cards are useful for revision of concepts, and their content can be easily adapted to suit any curriculum or year level.

Content Strand		Task Card Number
GEOMETRY	2-D Shapes – Naming, Making	JG1, JG5, JG6, JG7, JG12, JG13, JG14, JG20, JG23, JG26, JG29, JG30, JG32, MG1, MG2, MG5, MG6, MG8, MG10, MG11, MG14, MG20, MG23, MG24, MG30, MG31UG4, UG7, UG8, UG14, UG15, UG25
	3-D Shapes – Naming, Making, Comparing, Properties	JG13, JG30, JG33, MG2, MG8, MG9, MG18, MG23, MG25, MG26, UG5, UG10, UG11, UG13, UG19, UG20, UG24, UG28, UG30, UG31
	Lines	JG16, MG29, MG32, UG33
	Location, Position, Directions	JG2, JG11, JG18, JG34, MG7, MG12, MG15, MG16, MG22, MG27, MM35, UG2, UG3, UG9, UG16, UG18, UG21, UG23, UG26, UG33, UG34
	Mapping	JG4, JG8, JG10, JG15, JG19, JG21, JG22, JG25, JG28, JG31, JG35, MG15, MG17, MG20, MG22, MG27, MG29UG6, UG9, UG12, UG19, UG21, UG23, UG33
	Symmetry	JG3, JG9, JG24, JG27, MG19, MG28
	Transformations, Flips Slides, Turns Tessellations	JG17, MG3, MG21, UG8, UG14, UG27, UG29, UG35
	Angle Types and Use	MG4, MG13, MG14, MG32, UG1, UG7, UG17, UG22, UG25, UG32
	Investigations/Problem Solving	UG18, UG26, UG29, UG31
STATISTICS AND PROBABILITY	Chance/Probability Terms, Events	JSP2, JSP6, JSP15MSP1, MSP3, MSP4, MSP5, MSP6, MSP7, MSP13, MSP14USP1, USP2, USP16, USP23, USP35
	Chance Activities/Predictions/ Experiments/Trials	JSP3, JSP4, JSP7, JSP13, JSP22, JSP23, JSP24, JSP30, JSP31, JSP32, JSP33, JSP35, JSP36, JSP37MSP14, MSP15, MSP16,MSP19, MSP20USP13, USP14, USP25, USP26, USP28, USP30, USP33, USP34
	Graph Types, Making, Using, Features	JSP1, JSP5, JSP9, JSP12, JSP14, JSP16, JSP18, JSP20, JSP21, JSP25, JSP31MG23, MG24, MSP2, MSP9, MSP10, MSP11, MSP12, MSP14, MSP17, MSP18, MSP23USP4, USP11, USP17, USP20, USP21, USP24, USP27, USP29, USP31, USP34
	Questions and Surveys	JSP8, JSP9, JSP17, JSP26, JSP27, JSP29, JSP31MG26, MSP8, MSP21, MSP22, MSP24, MN31USP5, USP7, USP8, USP9, USP13, USP15, USP18, USP20, USP25, USP32
	Data Collection	JSP10, JSP11, JSP17, JSP18, JSP19, JSP20, JSP27, JSP29, JSP34,MSP17, MSP21, MSP22, MSP25USP3, USP6, USP9, USP13, USP24, USP25, USP27, USP28, USP34
	Interpreting/Comparing Data	JSP10, JSP12, JSP25, JSP29, JSP31, JSP32, JSP34MSP8, MSP11, MSP17, MSP18USP3, USP6, USP10, USP12, USP22, USP25, USP26, USP27, USP28, USP29, USP31, USP34
	Investigations/Exploring/ Problem Solving	JSP28, JSP33, JSP34, JSP35, JSP36MSP13, MSP15, MSP16, MSP19, MSP20, MSP21, MSP22, MSP25USP9, USP12, USP14, USP26, USP29, USP30, USP31, USP33, USP34, USP35