Specialist Mathematics 2016–2022

School-assessed Coursework report

This report is prepared following the first year of implementation of this study provides advice based on the School-based Assessment Audit and VCAA statistical data.

General comments

The 2016 school-based assessment audit showed that most teachers had followed the requirements for the School-assessed coursework of the revised study design and implemented them effectively. Respondents showed familiarity with, and an understanding of, the Unit 3 and 4 School-assessed coursework requirements for the revised study design, and many schools seemed to use its introduction as an opportunity to refresh their School-based Assessment tasks and practices. Schools are encouraged to regularly refresh their tasks for School-assessed Coursework. The proportion of exemplary responses and exemplary School-assessed Coursework tasks viewed in this audit was greater than in the previous years. Some of the tasks reviewed had too high a proportion of almost closed questions, limiting the opportunity for students to apply investigative approaches. Tasks should aim to contain an appropriate balance of guided and open-ended elements.

It is important that teachers are familiar with the VCAA publication [*Specialist Mathematics Advice for teachers*](http://www.digipubs.vic.edu.au/vcaa/vce-mathematics-specialist/vce-mathematics-specialist-introduction), which includes: advice about School-assessed Coursework, sample application tasks and modelling or problem-solving tasks and [performance criteria](http://www.digipubs.vic.edu.au/vcaa/vce-mathematics-specialist/vce-mathematics-specialist-units-3-and-4-performance) with sample assessment record sheets for both the application task and modelling or problem-solving tasks. These performance criteria may be used is several ways:

* directly in conjunction with the sample record sheets and teacher annotations for pointers with respect to key aspects of the task related to each criterion for the outcomes
* directly with the descriptive text for each criterion modified to incorporate task-specific elements as applicable
* as a template for teachers to develop their criteria and descriptive text for each criterion, including an allocation of marks for the criteria with the total mark allocation for each outcome as specified in the study design.

Alternatively, teacher developed global descriptors, rubrics or marking schemes may be used for assessment. If these are used, they need to be clearly aligned with, and mapped to, the weightings for the outcomes for tasks as specified in the study design, and the corresponding aspects, components or parts of these tasks as applicable. Whatever approach is used, the weightings for the outcomes underpin both the design of a task, and the assessment of student work in response to that task.

School-assessed Coursework enhances validity of student assessment by providing the opportunity for a context to be explored mathematically in greater depth and breadth than is possible in an examination, with non-routine and open-ended elements and aspects engaged in more fully. The tasks for School-assessed Coursework are to be implemented over a longer continuous period, where modelling, problem-solving or investigative techniques or approaches are employed, and the related use of technology as a tool for working mathematically suitably incorporated. This is specified as 4–6 hours over a period of 1–2 weeks for the application task, and 2–3 hours over a period of one week for a modelling or problem-solving task. Multiple-choice items are not suitable for either an application task or a modelling or problem-solving task.

The context on which a task is based may be practical, theoretical or a combination of both. Students should consider assumptions, definitions, conditions and constraints involved, make decisions involving general case analysis and communicate key stages of mathematical reasoning: formulation, solution, and interpretation with respect to the context. Various materials and resources from third party sources may be drawn on to assist with developing suitable tasks; however, it is the responsibility of teachers to ensure that tasks based on these materials and resources are developed in accordance with the requirements of the study design, and that authentication of student work is suitably addressed. Many respondents had attended one of the SAC professional development workshops run by the Mathematical Association of Victoria (MAV).

Several respondents appeared to be unfamiliar with VCAA requirements for lost, stolen or damaged coursework, or their school’s policies on this issue; these requirements are covered in the *VCE and VCAL Administrative Handbook*.

The audit questionnaire is intended to assist teachers in checking their planning for implementation of School-assessed Coursework as well as providing feedback to the VCAA, and almost invariably, respondents were constructive about the audit process.

For queries about School-assessed coursework for Mathematical Methods, contact Dr. David Leigh-Lancaster VCAA Mathematics Curriculum Manager: (03) 9032 1690 or email: [leigh-lancaster.david.d@edumail.vic.gov.au](https://www.edumail.vic.gov.au/owa/redir.aspx?C=vLReYsRP0fQ02oCk9nc9Iqejd6ApJxqGRJTuxdYowjk9hTvUahLUCA..&URL=mailto%3aleigh-lancaster.david.d%40edumail.vic.gov.au)

For queries about the coursework audit process or audit questionnaire, contact the VCE Curriculum Unit: (03) 9032 1735 or email: school.assessment.vcaa@edumail.vic.gov.au

Specific information

For each unit the student is required to demonstrate achievement of three outcomes. As a set these outcomes encompass all of the selected areas of study for each unit. For each of Unit 3 and Unit 4 the outcomes as a set apply to the content from the areas of study covered in that unit. A task for School-assessed Coursework need not cover all of the content from an area of study, or all of the key knowledge and key skills for an outcome.

Unit 3 coursework

The set of three outcomes apply to the Application task.

Outcome 1

Define and explain key concepts as specified in the content from the areas of study, and apply a range of related mathematical routines and procedures.

Outcome 2

Apply mathematical processes, with an emphasis on general cases, in non-routine contexts, and analyse and discuss these applications of mathematics.

Outcome 3

Select and appropriately use numerical, graphical, symbolic and statistical functionalities of technology to develop mathematical ideas, produce results and carry out analysis in situations requiring problem-solving, modelling or investigative techniques or approaches.

Application task

The application task is a mathematical investigation of a practical or theoretical context involving content from two or more areas of study, with the following three components of increasing complexity:

* introduction of the context through specific cases or examples
* consideration of general features of the context
* variation or further specification of assumption or conditions involved in the context to focus on a particular feature or aspect related to the context.

The application task is to be of 4–6 hours duration over a period of 1–2 weeks.

The structure of the application task continues to be the same as that first introduced in 2000, and in subsequent revised and re-accredited versions of the study.

An application task is a mathematical investigation, based on a context involving content from two or more areas of study. Typically, this covers a selection of content from the Functions and graphs, Algebra, Calculus and/or Vectors areas of study appropriate to that stage of implementation of Unit 3, as applicable to the context.

An application task has three components of increasing complexity. The first component, introduction of the context through specific cases or examples, should be designed so that students understand and engage in the context for investigation through specific cases or examples. In this component of the task, the mathematics involved and its application should be familiar and routine.

The second component,consideration of general features of the context, involves extending and generalising formulation and application introduced in the first component so that the context is explored in greater breadth and/or depth. This will typically include more open-ended work, with some unfamiliar and non-routine aspects considered. Parameters used to characterise families of functions, sets of complex numbers or vectors solutions of equations and the identification and analysis of key features are typically involved in this component of an application task.

The third component,variation or further specification of assumption or conditions involved in the context to focus on a particular feature or aspect related to the context, provides the opportunity for a particular feature or aspect of the context, or a related context, to be explored in some depth. This may occur through including additional constraints or conditions, varying constraints or conditions, or the types of functions and relations and/or combinations involved.

While Outcome 1 and Outcome 3 and the related key knowledge and key skills will be covered across all three components of an application task, for Outcome 2 the related key knowledge and key skills are likely to have particular focus with respect to the second and third components of an application task.

Some of the application tasks reviewed as further evidence through the audit had a structure more like an extended collection of Examination 2 type questions with limited progression through the three components for an application task. While various hints and suggestions can be included to assist students as they progress through the components of a task, these should not, in general, be directive or prescriptive with respect to the methods and approaches that students use in their investigation of the context.

The scheduling of the application task in Unit 3 depends on the lengths of Terms 1 and 2, and the coverage and consolidation of related content from the functions and graphs, Algebra and Calculus areas of study in Specialist Mathematics. Early in Term 2 was a common time for the application task to be run.

Themes, contexts, topics or aspects that were commonly addressed

The application tasks reviewed covered a variety of themes, contexts and topics. Those related to vectors and vector calculus were popular, in particular, applications related to position vectors, cartesian and parametric forms, vector proofs and geometric interpretation of vectors were commonly included. Most tasks incorporated calculus alongside vectors, including applications of antidifferentiation and integration, and analysis of maximums and minimums. Some tasks were designed to encourage consideration of multiple representation of a problem, including numerical, algebraic and graphical approaches. There were often opportunities for students to analyse key features of a graph, and to link these features to results obtained using non-graphical techniques.

Key knowledge and key skills that were covered well

Many tasks provided opportunities for some key knowledge and the related key skills to be covered well across all three outcomes.

The study design allocates 15 of the 50 available marks to Outcome 1, and the key knowledge and key skills for this outcome were generally covered very well. In particular, the following key knowledge and related skills appeared across different themes and contexts:

* the definition and properties of vectors, vector operations, the geometric representation of vectors and the geometric interpretation of linear dependence and independence
* techniques for finding anti-derivatives of functions, the relationship between the graph of a function and the graph of its anti-derivative functions, and graphical interpretation of definite integrals.

Most tasks progressed through the three components of increasing complexity, which presented opportunities to address a key skill for Outcome 2, namely, giving mathematical formulations of specific and general cases used to derive results for analysis within a given application context.

In accordance with Outcome 3, most tasks required the selection of an appropriate functionality of technology in one or more situations. Some tasks also encouraged students to identify the relation between numerical, graphical and symbolic forms of information about a function or equation, and the corresponding features.

Key knowledge/key skills not covered well, but important for demonstration of the outcome

The Application task has a major focus on Outcome 2, with an allocation of 20 marks to this outcome, and components related to consideration of general features and further specification of the context. However, the scaffolding of some tasks appeared to limited opportunities to:

* use a variety of techniques to verify results
* make inferences and use these to draw valid conclusions related to the context
* interpret results and communicate conclusions.

Strengths and weaknesses of task design

The structure of most tasks was consistent with the structure of the sample application tasks provided in the *Specialist Mathematics* *Advice for teachers*. In accordance with the intent illustrated by the sample tasks, many tasks displayed the following elements:

* a consistent theme and context that spanned the entire task
* a first component that was accessible, dealt with specific cases and used numerical values in equations, functions
* increasingly more challenging questions in the second and third components, with greater generalisation, including some numerical values being replaced with parameters, and some consideration of variants to the situation.

Some reviewed tasks did not meet VCAA requirements, in particular because they:

* consisted of a set of standard or examination type questions on a particular topic, and did not accord with the application task description of a mathematical investigation of a practical or theoretical context
* were not a coherent investigation; for example, the task was made up of two or more unrelated parts, and was not consistent with the descriptions of the three components specified in the study design.

Advice on how the application task could be improved

In addition to incorporating the structure elements described in the previous section, exemplary tasks generally provided considerable scope for students to achieve Outcome 2 through a wider range of key knowledge and key skills, including exploring possibilities, making inference, drawing conclusions, explaining results and communicating mathematically. Some of the tasks that met VCAA requirements could have been improved by the inclusion of more open-ended questions. These tasks would then have been less limiting, by providing students additional opportunities to explore, formulate and test conjectures, and explain and justify conclusions.

Assessment of the application task

Schools used various suitable approaches to assess the application task. Schools that based their task on a commercially-produced task generally also based their assessment on the assessment approach that accompanied the task.

A range of schools based their assessment on the performance criteria suggested in the Advice for Teachers. In these cases, the suggested weightings were generally used; for example, four out of 20 marks allocated to identification of important information, variables and constraints.

Many schools used a marking guide to assess the task, with marks allocated to each part of each question. This was a suitable approach, provided that an appropriate mapping of the marks for the outcomes to the components, parts and questions of the task was clearly indicated.

Unit 4 coursework

The set of three outcomes apply to each of the two modelling or problem-solving tasks, one of which is to be related to the Mechanics or Probability and statistics area of study.

Outcome 1

Define and explain key concepts as specified in the content from the areas of study, and apply a range of related mathematical routines and procedures.

Outcome 2

Apply mathematical processes, with an emphasis on general cases, in non-routine contexts, and analyse and discuss these applications of mathematics.

Outcome 3

Select and appropriately use numerical, graphical, symbolic and statistical functionalities of technology to develop mathematical ideas, produce results and carry out analysis in situations requiring problem-solving, modelling or investigative techniques or approaches.

Modelling or problem-solving tasks

The modelling or problem-solving tasks are to be of 2–3 hours duration over a period of one week, and one of the two modelling or problem-solving tasks is to be related to the Mechanics or Probability and statistics area of study.

Each task can be either a modelling task or a problem-solving task. A task may be designated as a modelling task or a problem-solving task based on the context and the nature and emphasis of the processes involved in relation to the context under consideration.

The modelling or problem-solving tasks that were not related to the Probability and statistics area of study were generally based in real-life contexts where both differentiation and integration could be applied. In many cases a modelling scenario or a problem was suitably developed, progressing from easier routine aspects at the beginning to more difficult analysis of non-routine aspects, often involving the use of parameters.

Many of the modelling or problem-solving tasks related to the Probability and statistics area of study included material related to statistical inference, and drew on and incorporated the sorts of scenarios used in Examination 2 extended response questions. As teachers become familiar with a repertoire of scenarios and range of sources of data related to this content, they are encouraged to use them to develop related modelling and problem-solving tasks based on these scenarios and data, including hypothesis testing.

For both of the Unit 4 modelling or problem-solving tasks some of the tasks presented during the audit were more of the nature of a large collection of Examination 2 extended response questions across several contexts than a modelling or problem-solving task based on a particular context explored in some depth. These tasks tended to be more directive in terms of expected response from students.

Observations about the modelling or problem-solving tasks

Many of the comments made about the application task in the Unit 3 section are also relevant to the Unit 4 tasks. It is therefore advisable that those comments be read first.

A range of contexts in the two modelling or problem-solving tasks were observed. However, in terms of the areas of study to which the tasks related, frequently occurring combinations were:

* Task 1: Mechanics; and Task 2: Probability and statistics
* Task 1: Applications of calculus (sometimes focused on differential equations); and Task 2: Mechanics.

Among schools that chose statistical inference and hypothesis testing as the Task 2 topic, several of the tasks were adapted from a commercially-produced task that used a forestry context. A range of teachers wrote entirely original tasks for their students.

Key knowledge and key skills

Outcome 1 key knowledge and key skills, relevant to the particular task, were generally covered very well. In particular, where the task related to the Probability and statistics area of study, the following were thoroughly covered:

* set up and solve problems involving the distribution of sample means
* construct approximate confidence intervals for sample means
* undertake a hypothesis test for a mean of a sample from a normal distribution or a large sample.

Some tasks provided excellent opportunities to use technology effectively, and cover many key knowledge and key skills for Outcome 3. This was particularly the case with some of the tasks related to statistical inference, with analysis of data sets and the conduct of simulations related, for example, to the sampling distribution of a sample mean and random confidence intervals. Some schools allowed students to submit statistical inference data files in digital format to support their work.

There are some aspects of the Outcome 2 key knowledge and key skills that are integral to a modelling or problem-solving task, but which were sometimes not covered particularly well. In particular, the question structure of some tasks did not actively encourage:

* verification of results using a variety of techniques (for example, using a simulation to verify a statistical calculation)
* communication of reasoning or justification of results.

Strengths and weaknesses of task design

Some tasks viewed were deemed to be exemplary. Each exemplary task was unique, but most shared some common characteristics. An exemplary task might begin with a relatively straightforward problem, but one that requires careful consideration of factors which might influence the reasonableness of the solution. The task might progress with additional complexities or variations of the initial problem. The task will also incorporate some flexible elements that actively encourage individual initiative, perhaps to extend the problem or to further generalise earlier results.

Tasks that did not meet VCAA requirements included any task made up of a set of unrelated multiple-choice, short answer and extended response questions on a particular topic. This assignment-style task type is not suitable as a modelling or problem-solving task.

Advice on how the assessment tasks could be improved

All tasks were designed as a series of questions, which is totally appropriate as a means of guiding students through an exploration of the modelling context or problem. However, tasks could be improved by incorporating some of the characteristics of exemplary tasks, as outlined earlier. In particular, a perceived weakness of some tasks is that the nature of the questions in these tasks provided few opportunities for students to display individual initiative, or to explain their reasoning or justify results.

As with some of the Unit 3 application tasks, some modelling or problem-solving tasks consisted almost entirely of closed questions. The inclusion of additional open-ended questions in these tasks would provide students additional opportunities to engage in the problem-solving elements of creating, conjecturing, exploring, testing and verifying.

Assessment of modelling or problem-solving tasks

As with the Unit 3 application task, schools used various approaches to suitably assess the modelling or problem-solving tasks. Some schools based their assessment on the performance criteria suggested in the Advice for Teachers. In these cases, the suggested VCAA weightings were generally used.

Many schools used a marking guide to assess the tasks, with marks allocated to each part of each question. This was deemed a suitable approach, provided that an appropriate mapping of the marks to the outcomes was included. This needed to show evidence of a genuine correspondence of marks to Outcomes 1, 2 and 3 in the ratio of 8:10:7 for Task 1, and 7:10:8 for Task 2. These ratios should be reflected in the development and assessment of the task. This assessment approach was deemed not to meet VCAA requirements in cases where the total available marks were distributed to the outcomes, without the supporting evidence of a suitable mapping.