Mathematical Methods General Senior Syllabus 2019 v1.2

Subject report 2020

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Queensland Government

Queensland Curriculum & Assessment Authority

210028

For all Queensland schools

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Introduction

The first summative year for the new Queensland Certificate of Education (QCE) system was unexpectedly challenging. The demands of delivering new assessment requirements and processes were amplified by disruptions to senior schooling arising from the COVID-19 pandemic. This meant the new system was forced to adapt before it had been introduced — the number of summative internal assessments was reduced from three to two in all General subjects. Schools and the QCAA worked together to implement the new assessment processes and the 2020 Year 12 cohort received accurate and reliable subject results.

Queensland's innovative new senior assessment system combines the flexibility and authenticity of school-based assessment, developed and marked by classroom teachers, with the rigour and consistency of external assessment set and marked by QCAA-trained assessment writers and markers. The system does not privilege one form of assessment over another, and both teachers and QCAA assessors share the role of making high-stakes judgments about the achievement of students. Our commitment to rigorous external quality assurance guarantees the reliability of both internal and external assessment outcomes.

Using evidence of student learning to make judgments on student achievement is just one purpose of assessment. In a sophisticated assessment system, it is also used by teachers to inform pedagogy and by students to monitor and reflect on their progress.

This post-cycle report on the summative assessment program is not simply being produced as a matter of record. It is intended that it will play an active role in future assessment cycles by providing observations and findings in a way that is meaningful and helpful to support the teaching and learning process, provide future students with guidance to support their preparations for summative assessment, and promote transparency and accountability in the broader education community. Reflection and research are necessary for the new system to achieve stability and to continue to evolve. The annual subject report is a key medium for making it accessible to schools and others.

Background

Purpose

The annual subject report is an analysis of the previous year's full summative assessment cycle. This includes endorsement of summative internal assessment instruments, confirmation of internal assessment marks and external assessment.

The report provides an overview of the key outcomes of one full teaching, learning and assessment cycle for each subject, including:

- information about the application of the syllabus objectives through the design and marking of internal and external assessments
- information about the patterns of student achievement in each subject for the assessment cycle.

It also provides advice to schools to promote continuous improvement, including:

- identification of effective practices in the design and marking of valid, accessible and reliable assessments
- identification of areas for improvement and recommendations to enhance the design and marking of valid, accessible and reliable assessment instruments
- provision of tangible examples of best practice where relevant, possible and appropriate.

Audience and use

This report should be read by school leaders, subject leaders and teachers to inform teaching and learning and assessment preparation. The report is to be used by schools and teachers to assist in assessment design practice, in making assessment decisions and in preparing students for external assessment.

The report is publicly available to promote transparency and accountability. Students, parents, community members and other education stakeholders can learn about the assessment practices and outcomes for General subjects (including alternative sequences and Senior External Examination subjects, where relevant) and General (Extension) subjects.

Report preparation

The report includes analyses of data and other information from the processes of endorsement, confirmation and external assessment, and advice from the chief confirmer, chief endorser and chief marker, developed in consultation with and support from QCAA subject matter experts.

Subject data summary

Subject enrolments

Number of schools offering the subject: 418.

Completion of units	Unit 1	Unit 2	Units 3 and 4*
Number of students completed	9922	9992	9988

*Units 3 and 4 figure includes students who were not rated.

Units 1 and 2 results

Number of students	Satisfactory	Unsatisfactory	Not rated
Unit 1	9534	376	12
Unit 2	8963	1014	15

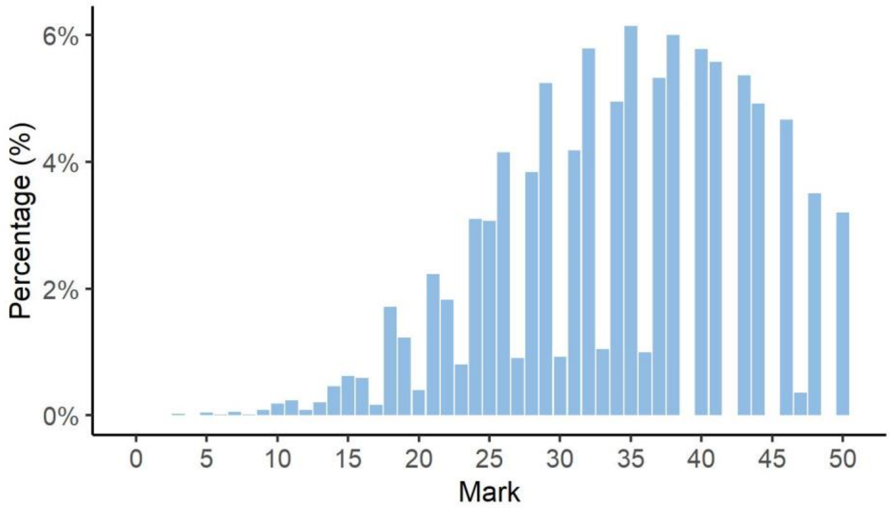
Units 3 and 4 internal assessment results

2020 COVID-19 adjustments

To support Queensland schools, teachers and students to manage learning and assessment during the evolving COVID-19 pandemic in 2020, the QCAA Board approved the removal of one internal assessment for students completing Units 3 and 4 in General and Applied subjects.

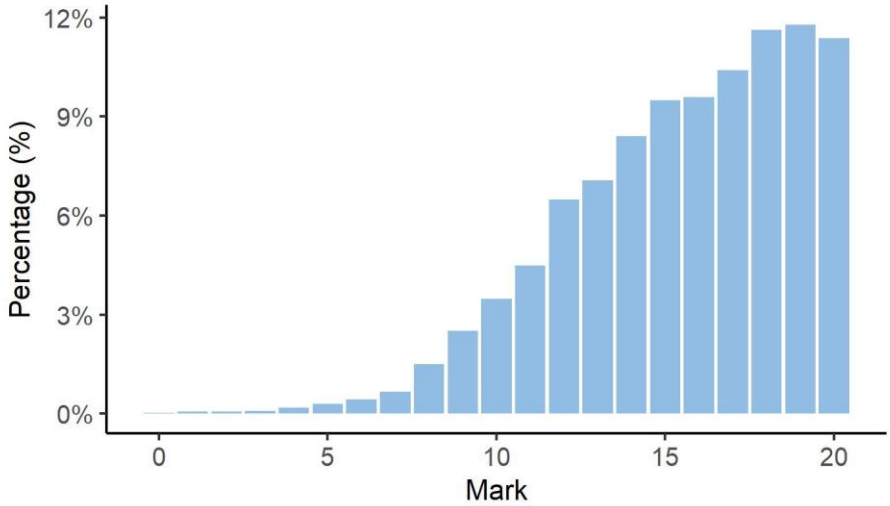
In General subjects, students completed two internal assessments and an external assessment. Schools made decisions based on QCAA advice and their school context. Therefore, across the state some instruments were completed by most schools, some completed by fewer schools and others completed by few or no schools. In the case of the latter, the data and information for these instruments has not been included.

Total results for internal assessment

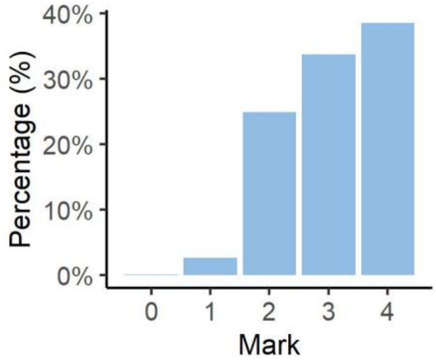


IA1 results

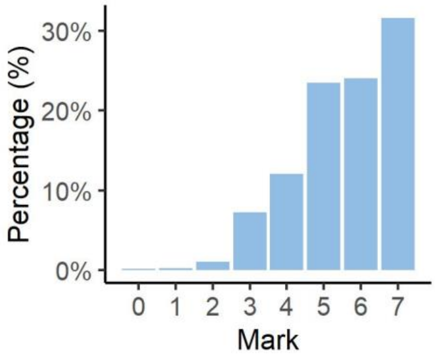
IA1 total



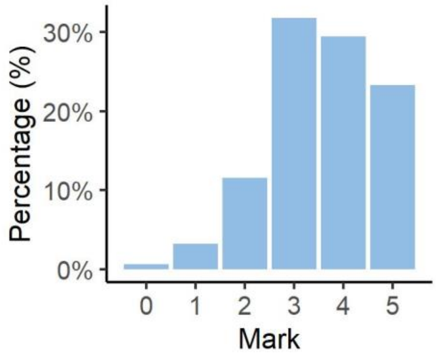
IA1 Criterion 1



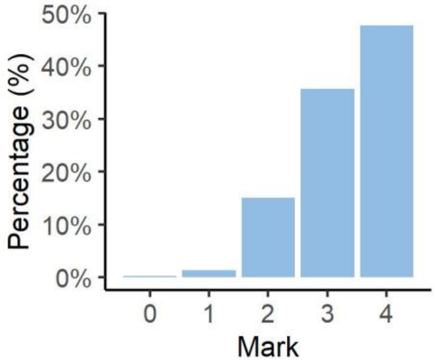
IA1 Criterion 2



IA1 Criterion 3

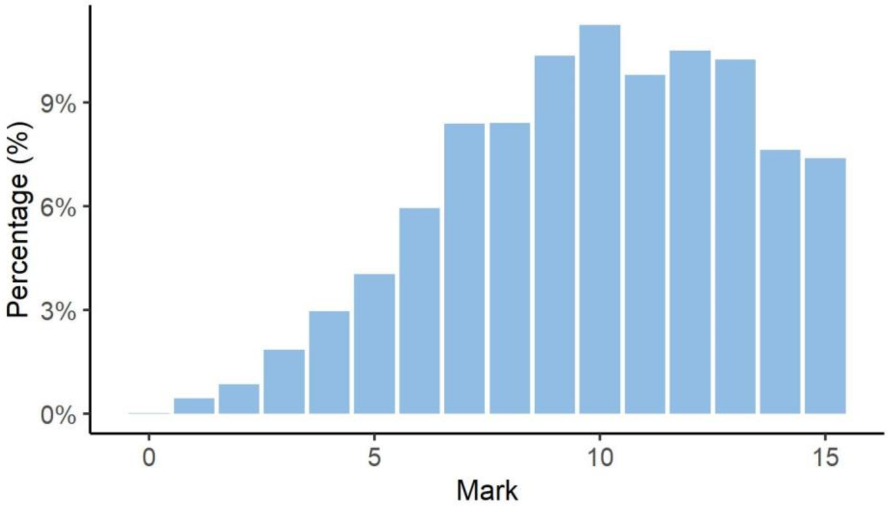


IA1 Criterion 4

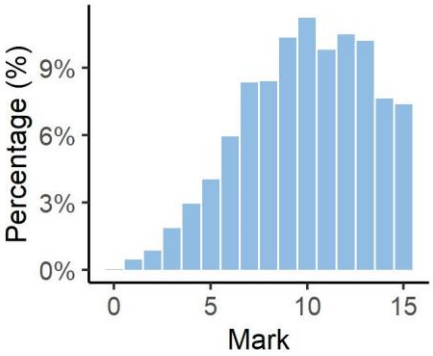


IA2 results

IA2 total

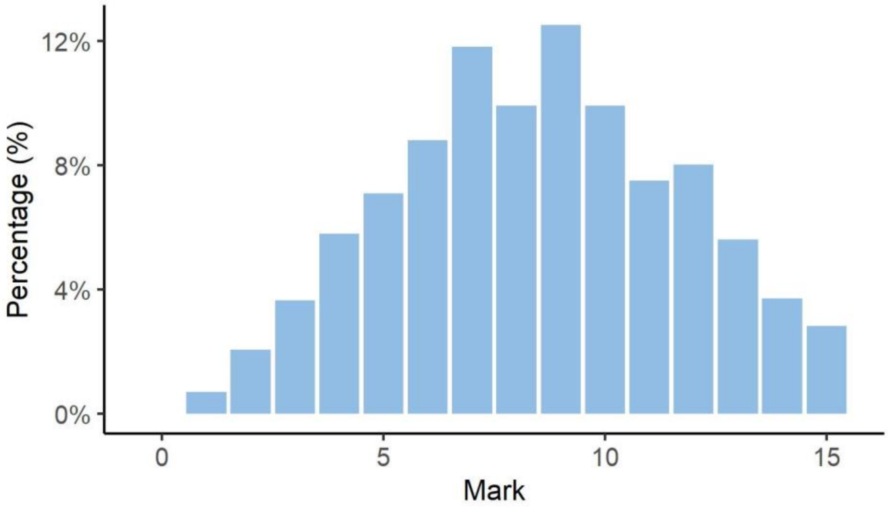


IA2 Criterion 1

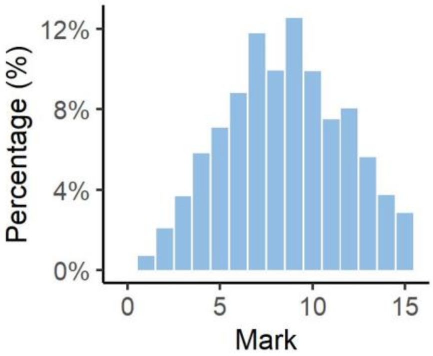


IA3 results

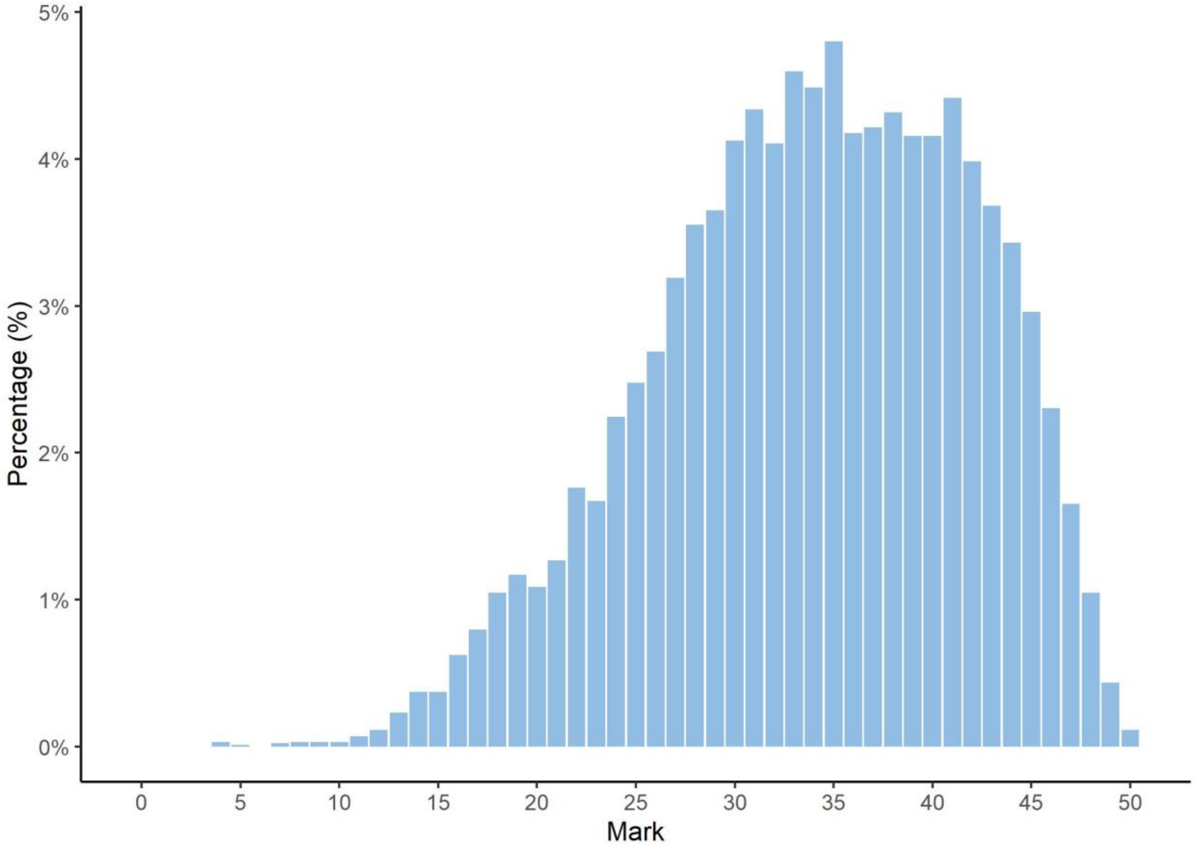
IA3 total



IA3 Criterion 1



External assessment results



Final standards allocation

The number of students awarded each standard across the state are as follows.

Standard	A	B	C	D	E
Number of students	2451	3755	3106	622	2

Grade boundaries

The grade boundaries are determined using a process to compare results on a numeric scale to the reporting standards.

Standard	A	B	C	D	E
Marks achieved	100–81	80–64	63–44	43–18	17–0

Internal assessment

The following information and advice pertain to the assessment design and assessment decisions for each IA in Units 3 and 4. These instruments have undergone quality assurance processes informed by the attributes of quality assessment (validity, accessibility and reliability).

Endorsement

Endorsement is the quality assurance process based on the attributes of validity and accessibility. These attributes are categorised further as priorities for assessment and each priority can be further broken down into assessment practices. Data presented in the assessment design sections identifies the reasons why IA instruments were not endorsed at Application 1, by the priority for assessments. An IA may have been identified more than once for a priority for assessment, e.g. it may have demonstrated a misalignment to both subject matter and to the assessment objective. Refer to the quality assurance tools for detailed information about the assessment practices for each assessment instrument.

Total number of items endorsed in Application 1

Number of items submitted each event	IA1	IA2	IA3
Total number of instruments	427	427	427
Percentage endorsed in Application 1	56%	31%	23%

Confirmation

Confirmation is the quality assurance process based on the attribute of reliability. Teachers make judgments about the evidence in students' responses using the instrument-specific marking guide (ISMG) to indicate the alignment of students' work with performance-level descriptors and determine a mark for each criterion. These are provisional criterion marks. The QCAA makes the final decision about student results through the confirmation processes. Data presented in the assessment decisions section identifies the level of agreement between provisional and final results.

Number of samples reviewed at initial, supplementary and extraordinary review

IA	Number of schools	Number of samples requested	Supplementary samples requested	Extraordinary review	School review	Percentage agreement with provisional
1	417	2329	203	106	21	99.29
2	301	1790	0	0	0	100
3	120	593	0	0	0	99.94

Internal assessment 1 (IA1)

Problem-solving and modelling task (20%)

The problem-solving and modelling task must use subject matter from Unit 3 Topic 2: Further differentiation and applications and/or Topic 3: Integrals. A problem-solving and modelling task is an assessment instrument developed in response to a mathematical investigative scenario or context. It requires students to respond with a range of understanding and skills, such as using mathematical language, appropriate calculations, tables of data, graphs and diagrams. Students must provide a response to a specific task or issue that is set in a context that highlights a real-life application of mathematics. The task requires students to use relevant stimulus material involving the selected subject matter and must have sufficient scope to allow students to address all the stages of the problem-solving and modelling approach. Technology must be used.

Assessment design

Validity

Validity in assessment design considers the extent to which an assessment item accurately measures what it is intended to measure and that the evidence of student learning collected from an assessment can be legitimately used for the purpose specified in the syllabus.

Reasons for non-endorsement by priority of assessment — validity practices

Validity priority	Number of times priority was identified in decisions*
Alignment	104
Authentication	29
Authenticity	66
Item construction	19
Scope and scale	40

*Total number of submissions: 427. Each priority might contain up to four assessment practices.

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that featured:

- opportunity for students to develop a unique response, e.g. providing an open-ended task, individual datasets or models such that students made choices about how to use the data and what concepts and techniques were relevant to solve the problem
- realistic contexts that were accessible to students, e.g. designing a logo or golf course, modelling the rate of population growth or designing a rollercoaster.

Practices to strengthen

It is recommended that assessment instruments:

- clearly align to the subject matter within Unit 3 Topic 2: Further differentiation and applications and/or Topic 3: Integrals and correctly identify the topic/s being assessed

- avoid scaffolding or task instructions that indicate to students how to solve the problem (e.g. ‘integrate the area between the curves to …’) as this interferes with students’ ability to demonstrate their knowledge and understanding of the relevant criteria and to provide a unique, authentic response
- focus on interpretation, analysis and evaluation of ideas and information rather than having research (to locate, gather, record and analyse information to develop understanding) as a focus
- are sufficiently different to textbook practice assessments and QCAA sample assessment instruments to ensure responses are not rehearsed and that work submitted is the student’s own
- include checkpoints that reflect the school’s assessment policy and clearly indicate when and how teachers provide feedback on one draft.

Accessibility

Accessibility in assessment design ensures that no student or group of students is disadvantaged in their capacity to access an assessment.

Reasons for non-endorsement by priority of assessment — accessibility practices

Accessibility priority	Number of times priority was identified in decisions*
Transparency	27
Language	34
Layout	11
Bias avoidance	8

*Total number of submissions: 427. Each priority might contain up to four assessment practices.

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that featured:

- a scenario or context that was directly related to the task and accessible to students
- a specific task or issue that
  - was written in a straightforward manner and explicit about the nature of the problem
  - used appropriate language, diagrams and images
- text that was free from punctuation, grammatical, spelling and typographical errors.

Practices to strengthen

It is recommended that assessment instruments:

- only include information relevant to the problem-solving and modelling task to ensure students focus on what is required and are not distracted by extraneous material
- include task constraints or specifications that assist students to develop a response of an appropriate scope and scale, e.g. limiting the number of functions to model a design encourages students to be more discerning in their application of mathematical concepts in order to address all aspects of the problem-solving and modelling process within specified conditions

- are viewed using Print Preview, prior to submission, to ensure that the layout is clear and not distracting (e.g. avoiding misaligned text), and that items such as tables appear in their entirety on the page.

Additional advice

It is recommended that schools develop their own solutions for problem-solving and modelling tasks prior to endorsement. This does not require writing a full report, but rather considering what an expected response would demonstrate for all criteria. The advantages of this include:

- ensuring that the task allows students to address all criteria at all performance levels within syllabus conditions
- fuller awareness of strategies to assist students to manage response length, e.g. including an example of calculations in the response but recording repeated calculations and/or spreadsheet data in an appendix
- promoting consistent marking reliability.

Assessment decisions

Reliability

Reliability is a judgment about the measurements of assessment. It refers to the extent to which the results of assessments are consistent, replicable and free from error.

Agreement trends between provisional and final results

Criterion number	Criterion name	Percentage agreement with provisional	Percentage less than provisional	Percentage greater than provisional
1	Formulate	99.20	0.78	0.02
2	Solve	99.22	0.76	0.02
3	Evaluate and verify	99.15	0.73	0.12
4	Communicate	99.56	0.44	0.00

Effective practices

Accuracy and consistency of the application of the ISMG for this IA was most effective when:

- making judgments about the use of technology within the Solve criterion, as ‘accurate and appropriate use of technology’ was clearly differentiated from ‘use of technology’ regardless of the choice of technology, e.g. online graphing programs, such as Desmos, or the use of graphics calculator functions
- making judgments within the Communicate criterion, judgments accurately identified where responses adhered to appropriate mathematical, statistical and everyday language conventions and where there was evidence of a structured, coherent and organised response that communicated the solution and/or model clearly and fully
- student responses were annotated to show the evidence schools used to make decisions.

Samples of effective practices

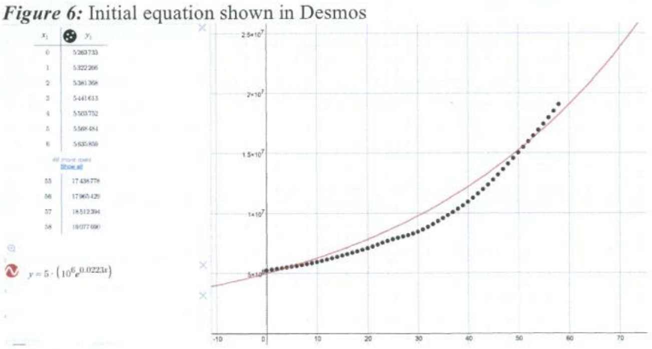
The following excerpts are from responses that illustrate the characteristics for the criterion at the performance level indicated. The sample may provide evidence of more than one criterion. The characteristics highlighted may not be the only time the characteristics have occurred throughout the response.

Solve (4–5 marks)
This response provides use of multiple technologies (screenshots of graphics calculator) to demonstrate technology use.

Refining Model

In order to create a more precise and accurate equation, the use of Desmos was required. A more accurate equation that has a strong relationship with the trend line of the population growth, will result in a more accurate representation of the population rate, and a more reliable prediction for the population of 2040. Formulating a refined equation will help support and final statements and conclusions made in the investigation and further prove why an exponential function in the most sufficient model in this case. In figure 2, it is evident that the initial formula Microsoft Excel formulated was not the most effective equation in this instance. The equation: $y = 5x10^6e^{0.0223x}$, was graphed in Desmos to see a relationship of the trend lines in a more accurate form, Figure 6 shows the design and the implications evident.

Figure 6: Initial equation shown in Desmos



As evident in figure 6, the equation required refining, in order to improve the reliability and accuracy of the model and future predictions. Creating an equation that will fit the trend line as close as possible will result in more exact prediction and will benefit the future of Mali as it will provide a close representation of the future of their country and concerns they must consider. To formulate a new equation, the exponential function, shown in table 1 that was provided in the stimulus was used. The equation, $y = Ae^{Bt} + C$, was plugged into Desmos to create a trend line that will fit the population data to a more accurate extent. Desmos formulated a new equation with all the points assessed and as Figure 7 portrays, the equation fits the model entirely and has no detachments between the junctions.

Communicate (3–4 marks)
This response demonstrates coherent and concise organisation of the response, appropriate to the genre, including a suitable introduction, body and conclusion, which can be read independently of the task sheet.

Problem Identification & Mathematical Modelling

As the population of Australia continues to grow, it is crucial that we plan ahead. Important aspects in life such as resources, housing, and medical products and services need to account for this growing population before the demand for necessary requirements of life have such a demand that cannot be catered for (Sommerfeld, 2018). By knowing predictions for a future population count, we can plan ahead and make choices that will benefit the future now.

The purpose of this task is to determine a prediction for the rate of population growth in Australia for 2061 by exploring multiple mathematical models. A multitude of mathematical techniques will be utilised throughout this task, including; modelling of exponential, logarithmic, logistic, and sinusoidal functions, as well as deriving to find a rate of change, determining percentage error, and using technology such as GeoGebra, a TI-84 Plus CE Graphics Calculator and Excel to model equations and manage data.

Commented [WA1]: Comm: introduction

Commented [WA2]: Comm: appropriate to the genre of a problem-solution report

Commented [WA3]: Comm: read independently of the task sheet,

Commented [WA4]: Comm: correct use of technical vocabulary

Conclusion

The purpose of this report was to use function and derivatives to create a reasonable prediction for the rate of change for the Australian population in 2061. It was found that the most reasonable model was solution three as it produces a reasonable population and somewhat reasonable rates of change. Therefore, using this logistic function, it is predicted that the population will reach approximately 39.6 million in 2061, with a percentage rate of change of 0.95% and an instantaneous rate of change of approximately 370000 addition people per year.

Commented [WA26]: Comm: conclusion

Commented [WA27]: Comm: coherent and concise organisation of the response

Practices to strengthen

To further ensure accuracy and consistency of the application of the ISMG in this IA, it is recommended that:

- within the Formulate criterion, the syllabus glossary definitions are used to distinguish between the terms 'documentation' and 'statement', and 'assumption' and 'observation'
  - Responses that demonstrated 'documentation of appropriate assumptions' not only included assumptions related to the student's model/solution but also evidence to support the assumption. Some examples of this are explaining the likely effect of an important assumption and how this is considered in the model/solution, or the impact of not making the assumption.
  - Responses that unambiguously demonstrated 'accurate documentation of relevant observations' provided evidence to support observations (information/data) used in a student's model/solution, such as explaining how the observations were collected, the source of the observations, what made the observations valid and reliable, or identifying a specific feature of an observation that made it relevant to the model/solution, e.g. from the plotted data points it is clearly observed that there is one turning point at (x, y) and that the curve is symmetrical about that turning point.
- within the Solve criterion, judgments reflect the syllabus glossary definitions of the terms 'discerning', 'use of complex procedures' and 'valid and reasonable solution'
  - Responses that unambiguously demonstrated 'discerning application of mathematical concepts and techniques relevant to the task' use a discriminating selection of mathematical methods by making thoughtful and astute choices as to which concepts and techniques to apply in order to enhance the solution.
  - Responses that demonstrated 'accurate use of complex procedures to reach a valid solution' attained a valid solution using methods made up of multiple elements and/or interconnected parts. In general, using a trial-and-error approach to develop a function against certain restraints did not demonstrate use of complex procedures.
  - Teachers annotate the ISMG to show the typical characteristics evident in student work and not necessarily an entire descriptor, e.g. a response may 'reach a reasonable solution' from the mid-level descriptor and show 'use of simple procedures' from the lower descriptor.
- within the Evaluate and verify criterion, judgments align to the performance-level descriptors and their associated characteristics
  - evaluation of the reasonableness of solutions by considering the results, assumptions and observations
    - To demonstrate these characteristics, responses needed to demonstrate that the results, assumptions and observations had been considered to appraise and justify their solutions. Any assumptions and observations introduced throughout the report could be used while evaluating the reasonableness of solutions.
    - The format of the evaluation varied depending on the situation, but could include the use of technology to verify solutions or the use of both mathematical and everyday language to justify solutions.
  - documentation of relevant strengths and limitations of the solutions and/or model
    - A strength is an aspect or feature of the solution and/or model that makes it useful. A limitation is an aspect or feature of the solution and/or model that limits its usefulness; a

weakness. Limitations in particular are often a direct consequence of assumptions (making less restrictive assumptions gives opportunities for refinement).

  - For ‘documentation’ to be demonstrated, there needed to be evidence in the student work of why elements of their solution and/or model were strengths or limitations.
  - Responses that unambiguously demonstrated these characteristics considered whether the model/solution fulfilled its intended purpose, how it compared to the real world, its generalisability and overall utility, and/or any caveats or conditions where the model/solution was no longer useful.
- justification of decisions made using mathematical reasoning
  - In responses that featured technological or trial-and-error methods, this was demonstrated where students explained their mathematical thinking and decisions for their chosen approach.

Additional advice

It is recommended that teachers use and annotate the correct QCAA-formatted ISMG downloaded from the QCAA Portal by clearly highlighting or underlining relevant characteristics and indicating the subsequent mark allocation.

Internal assessment 2 (IA2)

Examination — short response (15%)

The examination assesses the application of a range of cognitions to a number of items using a representative sample of subject matter from all Unit 3 topics. Where relevant, the focus of this assessment should be on subject matter not assessed in the problem-solving and modelling task. Subject matter from Units 1 and 2 is considered assumed knowledge.

Student responses must be completed individually, under supervised conditions, and in a set timeframe (120 minutes plus 5 minutes perusal). The percentage allocation of marks must match the degree of difficulty specifications: ~20% Complex unfamiliar, ~20% Complex familiar, ~60% Simple familiar.

Assessment design

Validity

Validity in assessment design considers the extent to which an assessment item accurately measures what it is intended to measure and that the evidence of student learning collected from an assessment can be legitimately used for the purpose specified in the syllabus.

Reasons for non-endorsement by priority of assessment — validity practices

Validity priority	Number of times priority was identified in decisions*
Alignment	195
Authentication	0
Authenticity	89
Item construction	18
Scope and scale	59

*Total number of submissions: 427. Each priority might contain up to four assessment practices.

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that featured:

- questions that assessed a selection of subject matter that accurately reflected the intended learning of all topics in Unit 3
- stimulus, where used, that was relevant to the question and necessary to solve the problem
- a balance of items requiring both technology-free and technology-active responses, which could be identified by specifying the questions (or sections of the paper) requiring a technology-free or technology-active approach
- an appropriate number of questions that matched the degree of difficulty specifications in the syllabus and allowed students to respond within the time conditions
- a correct marking scheme that indicated clearly how marks would be allocated as this assists schools to check the scope and scale of the assessment and promotes consistency in the awarding of marks

- QCAA approval for any amendment to an endorsed instrument to uphold the integrity of school-based assessment practices.

Practices to strengthen

It is recommended that assessment instruments:

- require students to demonstrate knowledge and understanding of Unit 3 subject matter and do not solely assess subject matter from Units 1 and 2, e.g. a question that only involves polynomial differentiation
- assess subject matter within the scope and scale of the syllabus, e.g. the syllabus does not require students to find the area under a curve using Simpson's Rule
- provide complex unfamiliar opportunities such that
  - relationships and interactions have a number of elements, e.g. an algebraic component included in a technology-active question (if required)
  - all the information to solve the problem is not immediately identifiable, by avoiding scaffolding, e.g. not providing a series of parts that step through a problem, cues that indicate the procedure to use, or diagrams or graphs in technology-active questions that simplify the nature of the problem
- provide opportunities for students to respond to assessment objective 4: 'evaluate the reasonableness of solutions'
- provide opportunities for students to respond to assessment objective 5: 'justify procedures and decisions by explaining mathematical reasoning'
- are sufficiently different to QCAA sample questions, textbook questions and practice assessments to ensure responses are authentic and not rehearsed.

Accessibility

Accessibility in assessment design ensures that no student or group of students is disadvantaged in their capacity to access an assessment.

Reasons for non-endorsement by priority of assessment — accessibility practices

Accessibility priority	Number of times priority was identified in decisions*
Transparency	50
Language	90
Layout	17
Bias avoidance	9

*Total number of submissions: 427. Each priority might contain up to four assessment practices.

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that featured:

- simple familiar questions where what was being asked was clearly identifiable
- the language of the assessment objectives, e.g. 'evaluate the reasonableness of ...' rather than 'discuss limitations of …'

- correct language conventions, and were free of punctuation, grammatical, spelling and typographical errors
- correct mathematical notation, e.g. $\frac{d^2y}{dx^2}$ instead of d2y/dx2
- limited use of bold and italics
- adequate response space for each question
- clear, relevant images where appropriate.

Practices to strengthen

It is recommended that assessment instruments:

- are designed such that solutions can be obtained under the conditions of the examination, e.g. a complete solution can be obtained under technology-free conditions
- are reviewed using the Print Preview button, prior to submission, to ensure that the layout is clear and not distracting (e.g. avoiding misaligned text), and that items such as tables appear in their entirety on the page.

Assessment decisions

Reliability

Reliability is a judgment about the measurements of assessment. It refers to the extent to which the results of assessments are consistent, replicable and free from error.

Agreement trends between provisional and final results

Criterion number	Criterion name	Percentage agreement with provisional	Percentage less than provisional	Percentage greater than provisional
1	Foundational knowledge and problem-solving	100	0	0

Effective practices

Accuracy and consistency of the application of the ISMG for this IA was most effective when:

- there was clear alignment between a school's submitted marking scheme and the awarded marks, which was most effective where schools provided marking schemes that detailed where marks were awarded
- annotations were used by teachers within the response to indicate where marks were awarded
- schools recorded on the ISMG the total possible and awarded marks for the examination and the calculated percentage
- the 'greater than x%' cut-offs were correctly applied to the percentage calculations to determine accurate provisional marks, for example
  - results are not to be rounded to the nearest percentage before applying the ISMG
  - a student who receives > 80% is allocated 13/15, whereas a student who receives 80% (exactly) is allocated 12/15

- only the percentage cut-offs in the ISMG were used to determine the mark out of 15, not the performance-level descriptors. The performance-level descriptors are not used to directly make a judgment or allocate a mark. As the percentage allocation of marks in endorsed examinations must match the degree of difficulty specifications (~20% Complex unfamiliar, ~20% Complex familiar, ~60% Simple familiar), a student who is allocated 14 marks, for example, meets the performance-level descriptor for that performance level.

Samples of effective practices

The following example illustrates appropriate application of the percentage cut-off ISMG to determine the correct mark allocation.

Foundational knowledge and problem-solving

This example shows an annotated ISMG that clearly indicates the response was awarded 60 marks out of a possible 75 marks. This equates to 80% (exactly) and the response is therefore allocated 12 marks.

Instrument-specific marking guide (IA2): Examination (15%)

Criterion: Foundational knowledge and problem-solving

Assessment objectives

1. select, recall and use facts, rules, definitions and procedures drawn from all Unit 3 topics
2. comprehend mathematical concepts and techniques drawn from all Unit 3 topics
3. communicate using mathematical, statistical and everyday language and conventions
4. evaluate the reasonableness of solutions
5. justify procedures and decisions by explaining mathematical reasoning
6. solve problems by applying mathematical concepts and techniques drawn from all Unit 3 topics

$\frac{60}{75} = 80\%$

The student work has the following characteristics:	Cut-off	Marks
• consistently correct selection, recall and use of facts, rules, definitions and procedures; authoritative and accurate command of mathematical concepts and techniques; astute evaluation of the reasonableness of solutions and use of mathematical reasoning to correctly justify procedures and decisions; and fluent application of mathematical concepts and techniques to solve problems in a comprehensive range of simple familiar, complex familiar and complex unfamiliar situations.	> 93%	15
	> 87%	14
• correct selection, recall and use of facts, rules, definitions and procedures; comprehension and clear communication of mathematical concepts and techniques; considered evaluation of the reasonableness of solutions and use of mathematical reasoning to justify procedures and decisions; and proficient application of mathematical concepts and techniques to solve problems in simple familiar, complex familiar and complex unfamiliar situations.	> 80%	13
	> 73%	12
• thorough selection, recall and use of facts, rules, definitions and procedures; comprehension and communication of mathematical concepts and techniques; evaluation of the reasonableness of solutions and use of mathematical reasoning to justify procedures and decisions; and	> 67%	11

Practices to strengthen

To further ensure accuracy and consistency of the application of the ISMG in this IA, it is recommended that:

- schools update marking schemes for an endorsed instrument to correctly allocate marks to student responses when it is necessary to correct errors in questions or sample responses, change mark allocations and/or accept alternative solutions. The communication of these changes in a timely manner to the QCAA, either through the amendment process or at the time of confirmation submission, is required to assist confirmers to make appropriate decisions during the confirmation process
- the correct marking scheme is used and submitted for a comparable assessment
- schools use internal practices to quality assure judgments and check mark totals, percentage calculations and correct application of the percentage cut-off ISMG.

Internal assessment 3 (IA3)

Examination — short response

The examination assesses the application of a range of cognitions to a number of items using a representative sample of subject matter from all Unit 4 topics. Subject matter from Units 1, 2 and 3 is considered assumed knowledge. Student responses must be completed individually, under supervised conditions, and in a set timeframe (120 minutes plus 5 minutes perusal).
The percentage allocation of marks must match the degree of difficulty specifications:
~20% Complex unfamiliar, ~20% Complex familiar, ~60% Simple familiar.

Assessment design

Validity

Validity in assessment design considers the extent to which an assessment item accurately measures what it is intended to measure and that the evidence of student learning collected from an assessment can be legitimately used for the purpose specified in the syllabus.

Reasons for non-endorsement by priority of assessment — validity practices

Validity priority	Number of times priority was identified in decisions*
Alignment	283
Authentication	0
Authenticity	14
Item construction	21
Scope and scale	86

*Total number of submissions: 427. Each priority might contain up to four assessment practices.

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that featured:

- questions that assessed a selection of subject matter that accurately reflected the intended learning of all topics in Unit 4
- questions that explicitly provided opportunities to address all assessment objectives
- realistic contexts where appropriate, which generally occurred in technology-active items
- stimulus, where used, that was relevant to the question and necessary to solve the problem
- a balance of items requiring both technology-free and technology-active responses, which could be identified by specifying the questions (or sections of the paper) requiring a technology-free or technology-active approach
- an appropriate number of questions that matched the degree of difficulty specifications in the syllabus and allowed students to respond within the time conditions
- a correct marking scheme that indicated how marks would be allocated and provided solutions that used methods from the syllabus

- QCAA approval for any amendment to an endorsed instrument to uphold the integrity of school-based assessment practices.

Practices to strengthen

It is recommended that assessment instruments:

- are explicitly aligned to the subject matter from Unit 4 and do not solely reference subject matter from Units 1, 2 and 3, e.g. a question that involves calculating the expected value of a uniform discrete random variable only
- do not go beyond the scope and scale of the syllabus, e.g. the syllabus does not require students to determine confidence intervals for means
- provide complex unfamiliar opportunities such that
  - relationships and interactions have a number of elements, e.g. an algebraic component included in a technology-active question (if required)
  - all the information to solve the problem is not immediately identifiable, by avoiding scaffolding, e.g. not providing a series of parts that step through a problem, cues that indicate the procedure to use, or diagrams or graphs in technology-active questions that simplify the nature of the problem
- provide opportunities for students to respond to assessment objective 4: ‘evaluate the reasonableness of solutions’
- provide opportunities for students to respond to assessment objective 5: ‘justify procedures and decisions by explaining mathematical reasoning’
- are designed such that solutions can be obtained under the conditions of the examination, e.g. a technology-free response that can be obtained under technology-free conditions
- are sufficiently different to QCAA sample questions, textbook questions and practice assessments to ensure responses are authentic and not rehearsed.

Accessibility

Accessibility in assessment design ensures that no student or group of students is disadvantaged in their capacity to access an assessment.

Reasons for non-endorsement by priority of assessment — accessibility practices

Accessibility priority	Number of times priority was identified in decisions*
Transparency	41
Language	121
Layout	31
Bias avoidance	19

*Total number of submissions: 427. Each priority might contain up to four assessment practices.

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that featured:

- simple familiar questions where what was being asked was clearly identifiable
- the language of the assessment objectives, e.g. 'evaluate the reasonableness of ...' rather than 'explain the associated effect of this assumption …'
- questions that did not reference specialised language or non-accessible contexts
- correct language conventions and were free of punctuation, grammatical, spelling and typographical errors
- correct mathematical notation (e.g. $\hat{p}$ and not p^)
- limited use of bold and italics
- adequate response space for each question
- clear, relevant images where appropriate.

Practices to strengthen

It is recommended that assessment instruments:

- are designed such that solutions can be obtained under the conditions of the examination, e.g. a technology-free response that can be obtained under technology-free conditions
- are reviewed using the Print Preview button, prior to submission, to ensure that the layout is clear and not distracting (e.g. avoiding misaligned text), and that items such as tables appear in their entirety on the page.

Assessment decisions

Reliability

Reliability is a judgment about the measurements of assessment. It refers to the extent to which the results of assessments are consistent, replicable and free from error.

Agreement trends between provisional and final results

Criterion number	Criterion name	Percentage agreement with provisional	Percentage less than provisional	Percentage greater than provisional
1	Foundational knowledge and problem-solving	99.94	0.06	0

Effective practices

Accuracy and consistency of the application of the ISMG for this IA was most effective when:

- there was clear alignment between a school's submitted marking scheme and the awarded marks, which was most effective where schools provided marking schemes that detailed where marks were awarded
- annotations were used by teachers within the response to indicate where marks were awarded
- schools recorded on the ISMG the total possible and awarded marks for the examination and the calculated percentage

- the ‘greater than *x*%’ cut-offs were correctly applied to the percentage calculations to determine accurate provisional marks, for example
  - results are not to be rounded to the nearest percentage before applying the ISMG
  - a student who receives > 80% is allocated 13/15, whereas a student who receives 80% (exactly) is allocated 12/15
- only the percentage cut-offs in the ISMG were used to determine the mark out of 15, not the performance-level descriptors. The performance-level descriptors are not used to directly make a judgment or allocate a mark. As the percentage allocation of marks in endorsed examinations must match the degree of difficulty specifications (~20% Complex unfamiliar, ~20% Complex familiar, ~60% Simple familiar), a student who is allocated 14 marks, for example, meets the performance level descriptor for that performance level.

Samples of effective practices

The following example illustrates appropriate application of the percentage cut-off ISMG to determine the correct mark allocation.

Foundational knowledge and problem-solving

This example shows an annotated ISMG that clearly indicates the response was awarded 74.5 marks out of a possible 80 marks. This equates to 93.1% and the response is therefore allocated 15 marks. The calculated percentage is not rounded to the nearest whole number when using the ISMG.

Instrument-specific marking guide (IA2): Examination (15%)

Criterion: Foundational knowledge and problem-solving

Assessment objectives

1. select, recall and use facts, rules, definitions and procedures drawn from all Unit 3 topics
2. comprehend mathematical concepts and techniques drawn from all Unit 3 topics
3. communicate using mathematical, statistical and everyday language and conventions
4. evaluate the reasonableness of solutions
5. justify procedures and decisions by explaining mathematical reasoning
6. solve problems by applying mathematical concepts and techniques drawn from all Unit 3 topics

$\frac{74\frac{1}{2}}{80} = 93.1\%$

The student work has the following characteristics:	Cut-off	Marks
• consistently correct selection, recall and use of facts, rules, definitions and procedures; authoritative and accurate command of mathematical concepts and techniques; astute evaluation of the reasonableness of solutions and use of mathematical reasoning to correctly justify procedures and decisions; and fluent application of mathematical concepts and techniques to solve problems in a comprehensive range of simple familiar, complex familiar and complex unfamiliar situations.	> 93%	15
	> 87%	14

Practices to strengthen

To further ensure accuracy and consistency of the application of the ISMG in this IA, it is recommended that:

- schools update marking schemes for an endorsed instrument to correctly allocate marks to student responses when it is necessary to correct errors in questions or sample responses, change mark allocations and/or accept alternative solutions. The communication of these changes in a timely manner to the QCAA, either through the amendment process or at the time of confirmation submission, is required to assist confirmers to make appropriate decisions during the confirmation process
- the correct marking scheme is used and submitted for a comparable assessment
- schools use internal practices to quality assure judgments and check mark totals, percentage calculations and correct application of the percentage cut-off ISMG.

External assessment

Summative external assessment (EA): Examination (50%)

Assessment design

Assessment specifications and conditions

Summative external assessment is developed and marked by the QCAA. In Mathematical Methods, it contributes 50% to a student's overall subject result. Summative external assessment assesses learning from Units 3 and 4. Subject matter from Units 1 and 2 is assumed knowledge and may be drawn on, as applicable, in the development of the examination. The external assessment in Mathematical Methods is common to all schools and administered under the same conditions, at the same time, on the same day.

Conditions

- Time
  - Paper 1 (technology-free, 25%); 90 minutes plus 5 minutes perusal
  - Paper 2 (technology-active, 25%); 90 minutes plus 5 minutes perusal.
- Length: the number of short-response items should allow students to complete the response in the set time.
- Short-response format, consisting of a number of items that ask students to respond to the following activities
  - calculating using algorithms
  - drawing, labelling or interpreting graphs, tables or diagrams
  - short items requiring multiple-choice, single-word, term, sentence or short-paragraph responses
  - justifying solutions using appropriate mathematical language where applicable
  - responding to seen or unseen stimulus materials
  - interpreting ideas and information.
- Other
  - the QCAA formula sheet will be provided for both papers
  - no calculator or technology of any type is permitted in Paper 1 (technology-free); access to a QCAA-approved handheld graphics calculator (no CAS functionality) is a requirement for Paper 2 (technology-active) of the external assessment, and scientific calculators may also be used.

The assessment instrument consisted of two papers: technology-free (Paper 1) and technology-active (Paper 2). The examination assesses the application of a range of cognitions to a number of items drawn from Units 3 and 4. Student responses must be completed individually, under supervised conditions, and in a set timeframe. This assessment was used to determine student achievement in the following assessment objectives:

1. select, recall and use facts, rules, definitions and procedures drawn from Units 3 and 4
2. comprehend mathematical concepts and techniques drawn from Units 3 and 4
3. communicate using mathematical, statistical and everyday language and conventions
4. evaluate the reasonableness of solutions
5. justify procedures and decisions by explaining mathematical reasoning
6. solve problems by applying mathematical concepts and techniques drawn from Units 3 & 4

Paper 1 Section 1 was 10 multiple-choice questions.

Paper 1 Section 2 was 10 short-response questions.

Paper 2 Section 1 was 10 multiple-choice questions.

Paper 2 Section 2 was 10 short-response questions.

Assessment decisions

Overall, students responded well to the following assessment aspects:

- assessment objectives 1 and 2
- demonstrating knowledge and understanding of the subject matter and application of skills in simple familiar problems
- calculating using algorithms in simple familiar situations.

Effective practices

The following samples were selected to illustrate highly effective student responses in some of the assessment objectives of the syllabus.

Multiple choice item response

Item: Question 8 — Paper 1 (Technology free)

Assessment objectives: 1 and 2 — Simple familiar

The following question highlights the validity arguments of the distractors when designing multiple choice items for possible student responses in a technology-free examination.

This simple familiar question has been included to illustrate the subject matter:

- identify contexts suitable to model binomial distributions and associated probabilities to solve practical problems, including the language of ‘at most’ and ‘at least’.

Foundational knowledge and problem solving	**QUESTION 8** A test includes six multiple choice questions. Each question has four options for the answer. If the answers are guessed, the probability of getting at most two questions correct is represented by (A) $\binom{6}{0}0.25^0 \times 0.75^6 + \binom{6}{1}0.25^1 \times 0.75^5$ (B) $\binom{6}{0}0.25^0 \times 0.75^6 + \binom{6}{1}0.25^1 \times 0.75^5 + \binom{6}{2}0.25^2 \times 0.75^4$ (C) $1-\left(\binom{6}{0}0.25^0 \times 0.75^6 + \binom{6}{1}0.25^1 \times 0.75^5\right)$ (D) $1-\left(\binom{6}{0}0.25^0 \times 0.75^6 + \binom{6}{1}0.25^1 \times 0.75^5 + \binom{6}{2}0.25^2 \times 0.75^4\right)$

Validity arguments for the options:

(A) Students incorrectly determined that at most two questions correct means that 0 or 1 questions are correct.

(B) Students correctly recognised that at most 2 questions correct means that 0, 1 or 2 questions could be correct and recognised the appropriate binomial calculation.

(C) Students determined the complementary event of calculating 0 or 1 questions correct.

(D) Students determined the complementary event of calculating 0, 1 or 2 questions correct.

Item: Question 3 — Paper 2 (Technology active)

Assessment objectives: 1 and 2 — Simple familiar

The following question highlights the validity arguments of the distractors when designing multiple choice items for possible student responses in a technology-active examination.

This simple familiar question has been included to illustrate the subject matter:

- interpret the definite integral $\int_a^b f(x)dx$ as area under the curve if $y = f(x)$ if $f(x) > 0$
- calculate the area under a curve.

It also provided students with the opportunity to make decisions regarding the efficient use of technology over a less efficient analytic procedure.

Foundational knowledge and problem solving	**QUESTION 3** Let R be the region enclosed by the graph of $y = xe^x$, the x-axis, and the lines $x = -1$ and $x = 1$. The area of R is closest to (A) 0.74 (B) 1.26 (C) 2.35 (D) 3.09

Validity arguments for the options:

(A) $\int_{-1}^{1} xe^x dx = 0.74$. This is incorrect as $xe^x \geq 0$ if $x \geq 0$ and $xe^x < 0$ if $x < 0$.

(B) $\left|\int_{-1}^{0} xe^x dx\right| + \int_{0}^{1} xe^x dx = 1.26$. This is the correct response.

(C) The student incorrectly integrates xe^x to be x^2e^x and finds $|[x^2e^x]_{-1}^{1}| = 2.35$.

(D) The student incorrectly finds $[xe^x]_{-1}^{1} = 3.09$.

Short response

Item: Question 13 — Paper 1 (Technology free)

Assessment objective: 1, 2, 3 and 4 — Simple familiar

This question required students to use calculus and logarithmic functions to solve problems.

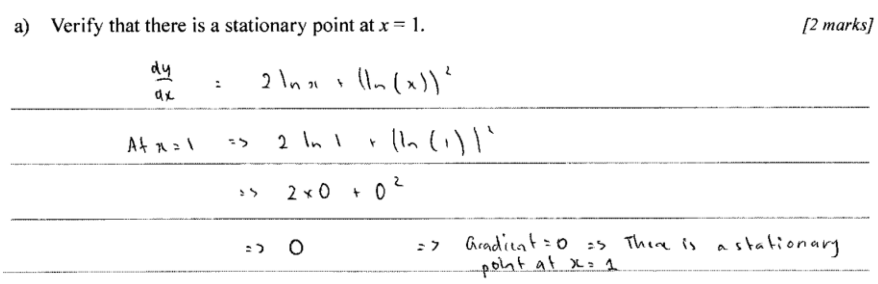
Effective student responses:

- used the chain rule to differentiate
- used the relationship between first derivative and stationary points
- used the relationship between second derivative and points of inflection
- understood the relationship between $\ln x$ and e^x.

Student sample of effective response

This excerpt has been included to:

- model an efficient method to verify that there is a stationary point at $x = 1$. As the location of the stationary point is known, students needed to demonstrate that $\frac{dy}{dx} = 0$ at that point. It was not necessary to solve $\frac{dy}{dx} = 0$ to locate stationary points
- model the use of mathematical and everyday language and conventions.

Foundational knowledge and problem solving	 a) Verify that there is a stationary point at $x = 1$. *[2 marks]* $\frac{dy}{dx} = 2\ln x + (\ln(x))^2$ At $x=1$ => $2\ln 1 + (\ln(1))^2$ => $2 \times 0 + 0^2$ => 0 => Gradient = 0 => There is a stationary point at x = 1

b) Determine the coordinates of *A*. *[3 marks]*

$f'(x) = 2\ln(x) + (\ln(x))^2$

$0 = 2\ln(x) + (\ln(x))^2$

Let $u = \ln(x) \Rightarrow 0 = 2u + u^2 + 0$

$\Rightarrow u^2 + 2u$

$\Rightarrow u(u+2)$

$u = 0$ or $u = -2$

$x = 1 \leftarrow \ln(x) = 0$ or $\ln(x) = -2$

~~$e^1 = 0$~~ or $e^{-2} = x$

coordinates $\Rightarrow e^{-2}$ ~~ln~~ $\times (\ln(e^{-2}))^2 \Rightarrow e^{-2} \times -2^2 = 4e^{-2}$

$\Rightarrow$ coordinates $\Rightarrow (e^{-2}, 4e^{-2})$

The graph of the function has a point of inflection at $x = e^p$

c) Determine p. *[2 marks]*

$\frac{dy}{dx} = 2\ln(x) + (\ln(x))^2$

$\frac{d^2y}{dx^2} \Rightarrow \frac{2}{x} + \frac{2\ln x}{x}$

$0 = \frac{2}{e^p} + \frac{2\ln e^p}{e^p}$

$= \frac{2 + 2\ln e^p}{e^p}$

$= \frac{2 + 2p}{e^p}$

$0 = 2 + 2p$

$-2p = 2$

$p = -1$

$\frac{d}{dx}(\ln(x))^2$

= Chain Rule $\Rightarrow u = \ln x$, $v = u^2$

$\frac{du}{dx} = \frac{1}{x}$, $\frac{dv}{dx} = 2u$

$\frac{dy}{dx} = \frac{2\ln x}{x}$

Item: Question 14 — Paper 1 (Technology free)

Assessment objective: 1, 2 and 3 — Simple familiar

This question required students to determine the area of a given scalene triangle.

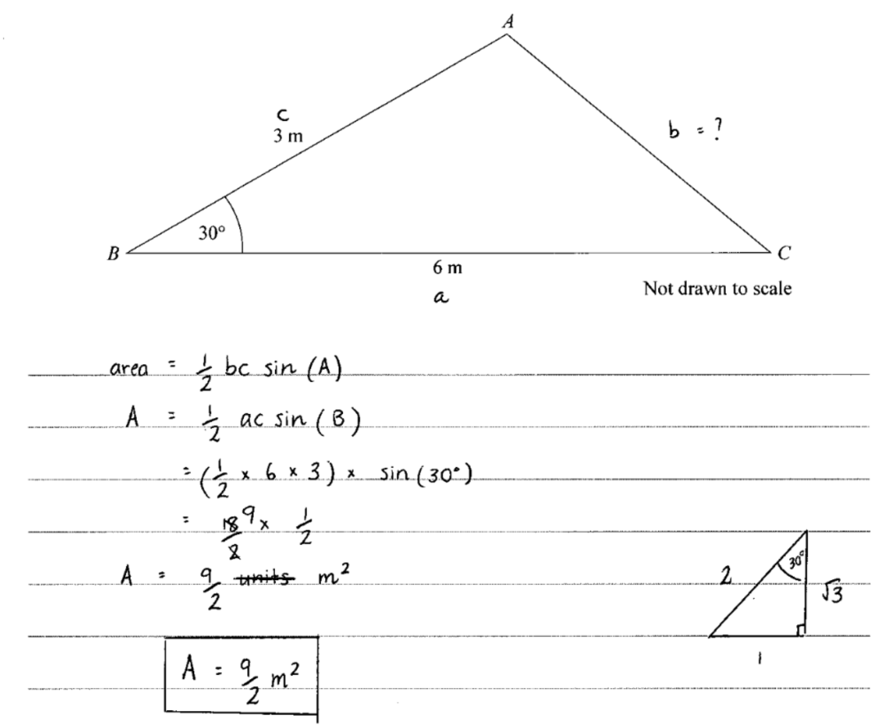
Effective student responses:

- selected the area of a triangle rule from the formula sheet
- substituted appropriate values
- used exact trigonometric values to determine the area.

Student sample of effective response

This excerpt has been included to:

- illustrate the clear identification of the chosen formula
- illustrate the substitution of the correct values into the area formula
- illustrate the use of exact trigonometric values to correctly determine the area.

Foundational knowledge and problem solving	

Item: Question 16 — Paper 1 (Technology free)

Assessment objective: 1, 2 and 5 — Simple familiar

This question required students to show their understanding of the concept of the second derivative by identifying the sketch of the second derivative.

Note: A minor amendment needed to be made to the wording of this question and an erratum was issued. Student responses to the original wording and to the amended wording were still able to obtain full marks as demonstrated in the samples of effective responses below. In addition, the QCAA conducted a review of the performance of students across all exam questions. The QCAA's Ratification Committee (which includes independent technical experts) also reviewed the data, comparing the results of those who responded to the original question compared to those who responded to the amended question. There was no evidence that there was a difference in performance between these two groups across the examination.

Effective student responses:

- selected the diagram that represented the second derivative
- provided justification for the selection.

Student sample of effective response to amended question

amp = 1 per. $\frac{2\pi}{3}$, ps = 0, mp = 1

A = 1, B = 3, C = 0, D = 1 (from graph)

peri = $\frac{2\pi}{B\pi}$ = 2

$\pi \approx 3.1\ldots$

$\pi^2 \approx 9\ldots$

$4 \times 9 \approx 36\ldots$

=> from graph $f(x) = -\cos(Bx) + 1$ ∴ Diagram 1 [starts at +cos,

$f'(x) = B\sin(Bx)$ mp = 0, no phase shift,

$f''(x) = B^2\cos(Bx)$ ← which is equal to $f''(x)$]

+cos, no p.s., mp = 0

This response was awarded 4 marks. This excerpt has been included to:

- illustrate that the student has identified an appropriate method to determine the graph of $f''(x)$.
- show that the student has identified that $f(x)$ is a cosine curve with no phase shift
- illustrate that the student has identified that $f''(x)$ will also be a cosine curve with no phase shift
- show that the student has correctly identified that $f''(x)$ is diagram 1.

Student samples of effective response to original question

$f'(x)$ is Diagram 2

$f''(x)$ is Diagram 1

For $f'(x)$, x-axis intercepts occur when $f(x)$ has a stationary point. Diagram 2 represents this, and is above the x-axis when gradient is ascending.

$f''(x)$ should have x-axis intercepts when $f(x)$ has any points of inflection, Diagram 1 represents this.

This response was awarded 4 marks.

- The student has used stationary points and concavity to identify $f'(x)$.
- The student has identified that $f'(x)$ is diagram 2.
- The student has identified that $f''(x)$ will intercept the x-axis when $f(x)$ has points of inflection.

- The student has correctly identified that $f''(x)$ is diagram 1.

Justify your decisions using mathematical reasoning.

consider stationary points at ~ (0,0), (1.5, 2), (3,0) ...

∴ at those points x = 0, 1.5, 3 ... $f'(x) = 0$

* diagram 3 satisfies this, ∴ $f'(x)$ = diagram 3

consider point of inflection at ~ x = 0.8, 2.2, 3.8 ..

∴ at these points $f''(x) = 0$

* diagram 1 satisfies this, ∴ $f''(x)$ = diagram 1

This response was awarded 4 marks.

- The student has used stationary points to identify $f'(x)$.
- As diagram 2 does not pass through the origin, the student has indicated that $f'(x)$ is diagram 3.
- The student has identified that $f''(x)$ will be equal to 0 when $f'(x)$ has points of inflection.
- The student has correctly identified that $f''(x)$ is diagram 1.

Item: Question 16 — Paper 2 (Technology active)

Assessment objective: 1, 2, 3 and 6 — Complex familiar

This question required students to use standardised normal variables to solve a practical problem.

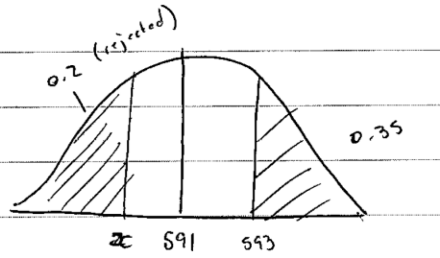
Effective student responses:

- used the definition of a percentile to determine a z-score
- determined the standard deviation of the population
- determined the value of the 20th percentile.

Student sample of effective response

This excerpt has been included to:

- illustrate effective communication about the normal distribution (tail area, mean, standard deviation) that have been used to determine the relevant z-scores. Graphic calculator functions are not referred to
- illustrate concise justification of procedures and decisions, e.g. the use of a diagram, communication about normal distribution values, labelling the answer as smallest volume.

Foundational knowledge and problem-solving	Assuming the volumes are normally distributed, determine the smallest volume (in mL) that will be accepted.  ~~$z = \frac{x-\mu}{\sigma}$~~ Inv Norm – left tail Area = 0.2 $\sigma = 1$ $\mu = 0$ $z = -0.8416$ $\therefore -0.8416 = \frac{x - 591}{\sigma}$ Inv Norm – right tail Area = 0.35 $\sigma = 1$ $\mu = 0$ $z = 0.3853$ $\therefore 0.3853 = \frac{593 - 591}{\sigma}$ $\therefore \sigma = 5.1908$ sub $\sigma = 5.1908$ $-0.8416 = \frac{x - 591}{5.1908}$ $\therefore x = 586.6314$ Smallest volume = 587 ml (586.6314)

Item: Question 19 — Paper 2 (Technology active)

Assessment objective: 1, 2, 3, 5 and 6 — Complex unfamiliar

This question required students to use a logarithmic function and its derivative to solve a practical problem.

Effective student responses:

- determined when a given curve is decreasing
- interpreted the information given about the length of a curve to determine the length of the decreasing curve.

Student sample of effective response

This excerpt has been included to:

- illustrate a clear and concise communication of the solution method
- model how the turning point will be the end point of travelling downhill.
- model an efficient use of technology.

Note: An erroneous answer of 0.33 hours, corresponding to a distance of 13.25 km, was obtained when students failed to ensure that x and $D(x)$ were measured in the same units. This was awarded full marks as the length of a curve formula was unfamiliar to students.

Foundational knowledge and problem-solving	Determine the time you spend driving downhill, if you drive downhill at an average speed of 40 km/h. $D'(x) = \frac{1}{x^2-3x+e} \times 2x-3$ $= \frac{2x-3}{x^2-3x+e}$ using calculator $\rightarrow$ $D'(x) = 0$ @ $x = 1.5$ $d = \int_{-10}^{1.5} \sqrt{1+[D'(x)]^2}\, dx$ $d = 13.25485938$ km $t = \frac{d}{v}$ $= \frac{13.25\ldots}{40}$ $= 0.3313714844$ $= 0.33$ hours (2d.p.)

Practices to strengthen

It is recommended that when preparing students for external assessment, teachers consider:

- assessment objective 1 — select, recall and use facts, rules, definitions and procedures drawn from Units 3 and 4, in particular, the
  - knowledge of exact values in trigonometry, e.g. $\sin(30°)$
  - accurate use of assumed numeracy and algebra skills, e.g. appropriate use of brackets, fractions and order of operations
  - selection of the appropriate formula from the formula book
- assessment objective 2 — comprehend concepts and techniques drawn from Units 3 and 4, in particular, the
  - use of trigonometric and logarithmic differentiation rules, especially in conjunction with the product, chain and quotient rules
  - use of a negative value for a decreasing rate of change, especially in worded questions
- assessment objective 3 — communicate using mathematical, statistical and everyday language and conventions, in particular, the
  - correct use of integral notation, especially the correct usage of the differential of the variable of integration, e.g. dx, dt
  - logical organisation of key steps for complex familiar and complex unfamiliar problems
  - appropriate communication when a graphics calculator is used. This could be through the statement of the equation solved or the parameters used rather than the statement of calculator instructions

- correct use of probability notation
- consistent use of variables, e.g. not interchanging x and t

- assessment objective 4 — evaluate the reasonableness of solutions, in particular, the
  - verification of a solution through substitution into an appropriate equation
  - use of mathematical reasoning to reject a possible solution, e.g. this possible solution is not valid as it is not in the given domain
- assessment objective 5 — justify procedures and decisions by explaining mathematical reasoning, in particular
  - the labelling of equations so that they can be easily referenced in later working, e.g. to communicate when equations are being equated
  - explicitly stating when substitution occurs and clearly linking to values or expressions that are being substituted
- assessment objective 6 — solve problems by applying mathematical concepts and techniques drawn from Units 3 and 4, in particular, be able to
  - identify when use of technology obviates time-consuming analytic procedures
  - use conceptual understanding of the subject matter from Units 3 and 4 to make connections to new information.

Further recommendations for preparing students for external assessment include:

- ensuring students are aware that many simple familiar questions are scaffolded and subsequently recognise the significance of phrases such as ‘use the result from …’ or ‘show that the result is … ’ in providing guidance to the use of such results in their response to the following parts of that question. Students should also be aware that questions worth more than 1 mark require evidence of suitable mathematical reasoning in order to gain full marks
- ensuring students are aware that if they are precluded from completing a verification of a result because of an error in their previous working, they can still be awarded a ‘follow through mark’ by including a mathematical statement indicating the intended verification requirement and/or a relevant comment
- supporting students in responding to complex familiar and complex unfamiliar questions by presenting their working clearly using a logical sequence of key steps. Students should be encouraged to use explanatory and linking statements, use suitable mathematical notation and/or vocabulary of the syllabus, and arrange their responses in a top-to-bottom, left-to-right structure. Units should also be included in the final answer of questions, where appropriate
- enhancing students’ abilities in their use of a graphics calculator in the technology-active section of the examination. Such abilities include
  - graphing functions
  - solving equations where one solution only is required, e.g. use of a numerical solve technique
  - solving equations where multiple solutions may be possible, e.g. use of a graphical technique or an advanced use of a numerical solve technique
  - solving simultaneous equations
  - solving equations involving calculus, e.g. solving for the unknown value of the upper limit of a definite integral

  - using statistical facilities, e.g. determining normal distribution probabilities, inverse normal calculations and confidence intervals calculations
  - calculus calculations, e.g. finding the derivative at a known point on a given function, determining the value of a definite integral
  - using the appropriate mode setting (radian/degree) to respond to the requirements of a question
- providing students with opportunities to analyse the context of mathematical problems and make decisions about the concepts, techniques and technology that should be used in their solution. This is an important part of the problem-solving process and students should be supported in practising these skills independently
- providing students with opportunities to move beyond the practising of basic techniques to developing a deeper conceptual understanding of the subject matter to enhance their ability to connect what they already know to new information.

Senior External Examination

The following information relates to the Mathematical Methods Senior External Examination, a standalone examination offered to eligible Year 12 students and adult learners. For information about Senior External Examination 2 (SEE 2), this commentary should be read in conjunction with the external assessment section of the preceding comments for the General subject.

Summative external examination 1 (SEE 1): Examination (50%)

Assessment design

Assessment specifications and conditions

Summative external examination 1 is developed and marked by the QCAA. In Mathematical Methods SEE, it contributes 50% to a student's overall subject result. Summative external examination 1 is a problem-solving and modelling task drawing from subject matter from Topics 2 and/or 3 in Unit 3. Subject matter from Units 1 and 2 is assumed knowledge and may be drawn on, as applicable, in the development of the examination. The external examination 1 in Mathematical Methods SEE is common to all schools and administered under the same conditions, at the same time, on the same day.

Conditions

- Time: 3 hours plus 15 minutes planning time
- Length: the task should allow candidates to complete the response in the set time.
- Other: The use of a QCAA-approved handheld graphics calculator is required.

A problem-solving and modelling task is developed in response to a mathematical investigative scenario or context. It requires candidates to respond with a range of understanding and skills, such as using mathematical language, appropriate calculations, tables of data, graphs and diagrams.

Candidates must provide a written response to a specific task or issue set in a context that highlights a real-life application of mathematics. The task requires candidates to use provided stimulus material involving subject matter from the nominated topic/s, which will have sufficient scope to allow candidates to address all the stages of the problem-solving and mathematical modelling approach (see Figure 4). This assessment was used to determine student achievement in the following assessment objectives:

1. select, recall and use facts, rules, definitions and procedures drawn from Unit 3 Topics 2 and/or 3
2. comprehend mathematical concepts and techniques drawn from Unit 3 Topics 2 and/or 3
3. communicate using mathematical, statistical and everyday language and conventions
4. evaluate the reasonableness of solutions
5. justify procedures and decisions by explaining mathematical reasoning
6. solve problems by applying mathematical concepts and techniques drawn from Unit 3 Topics 2 and/or 3

Number of students completing senior external assessment for the Mathematical Methods Senior External Examination: 32.

Standards allocation

The number of students awarded each standard across the state are as follows.

Standard	A	B	C	D	E
Number of students	2	4	7	5	0

Effective practices

Overall, students responded well to the following assessment aspects:

- creating accurate scatterplots
- using a given function to generate data values
- using technology to generate a linear model
- representing a model with a sketch that highlights significant features.

Practices to strengthen

It is recommended that when preparing for the assessment for the Senior External Examination consideration be given to:

- using logarithmic laws in complex situations to simplify models and where necessary to determine parameters for these models
- determining the maximum rate of change of models
- evaluating the reasonableness of a model using quantitative analysis (in this case residual analysis)
- adapting models in complex situations to account for modified situations.