

Interpreting the EE assessment criteria

Criterion A: Focus and method

(Strands: Topic, Research question, Methodology)

In mathematics the title of the essay, which may be in the form of a question, a proposition or a statement, can by itself clearly describe the topic and/or aim of the essay. It must not be too long and any necessary clarification of it, together with a clear indication of the mathematical areas and the techniques, should be provided early in the essay.

For example, “Methods for approximating π throughout history”. In this essay I will describe methods of approximating π from the work of Archimedes to the use of infinite series, infinite products and continued fractions in subsequent periods.” In other words, the focus and purpose of the essay must be made clear to the reader and appropriately related to the knowledge and understanding in context. This is clearly demonstrated when the research question indicates the mathematical techniques to be applied.

The sources consulted must be sufficient and each must contribute to the research focus of the essay.

The essay must be set out in sequential form in the manner of good mathematical writing, that is each section following on from and connected to the previous one.

A sharply written clear focus and research question can help the student ensure the essay remains within 4,000 words.

Criterion B: Knowledge and understanding

(Strands: Context, Subject-specific terminology and concepts)

The essay must show clear evidence of understanding of the mathematics that is relevant to the focus of the essay. Students will not be rewarded for attempting to exhibit a wider knowledge of mathematics that is not essential to exploring the research question.

For example, in an essay on fractals, students must describe the mathematical concepts that underlie them without resorting to advanced theorems and results in analysis.

Students can demonstrate their understanding by:

- giving accurate and complete explanations of subject-specific terminology
- making knowledgeable comments on source material
- using source material in a relevant and appropriate way.

Students should ensure that the essay’s content is accessible to readers with a strong interest in the subject as well as to those with an advanced knowledge of it.

Students need to clearly communicate and explain their mathematics. They must not just talk about it but actually do the mathematics, and must show all steps in mathematical reasoning to make it clear that they understand it.

Students must make sure definitions are fully explained. If a theorem is used whose proof is too difficult, it should at least be explained by a clear example. Throughout, students need to demonstrate that they fully understand what they are doing.

Criterion C: Critical thinking

(Strands: Research, Analysis and Discussion and evaluation)

Students should be aware of the particular demands of critical thinking in mathematics.

At each opportunity in the essay, students must demonstrate their abilities in:

- correct deductive reasoning and argument
- establishing hypotheses
- formulating mathematical models.

For example, in the use of statistics to establish a hypothesis, students must collect the correct data, then display summary data and graphs, so that they choose, apply and interpret correctly the appropriate test or tests.

Students' discussion and evaluation of their results should be concise.

It is important that students do the mathematics rather than merely describe it. They must show the steps in the algebra to demonstrate that they really understand what is going on. If they take any element from a source, they must cite that source.

Students should prove conjectures that can readily be proved. The essay must not just quote results; there must be evidence of the student doing mathematics.

Criterion D: Presentation

(Strands: Structure, Layout)

This criterion relates to the extent to which the essay conforms to accepted academic standards in relation to how research papers should be presented. It also relates to how well these elements support the reading, understanding and evaluation of the essay.

Students must provide a section and subsection structure to their essays, with appropriate informative headings. Students should aim to demonstrate their mastery of appropriate concepts and an ability to present these in an effective way using mathematical means. Concise, elegant mathematics supported by graphs, diagrams and important proofs that do not interrupt the development of the essay are encouraged.

Use of charts, images and tables

Diagrams and pictures should be in the text, immediately close to an explanation of them. Small data tables can be included in the body of the essay but larger ones should appear as an appendix, with means, standard deviations, correlation coefficients etc given in the text.

Students should include computer routines only if they are absolutely necessary for the understanding of the essay. These must always appear as an appendix.

Any material that is not original must be carefully acknowledged, with specific attention paid to the acknowledgment and referencing of quotes and ideas. This acknowledgment and referencing is applicable to audiovisual material, text, graphs and data published in print and electronic sources. If the referencing does not meet the minimum standard as indicated in the guide (name of author, date of publication, title of source and page numbers as applicable), and is not consistently applied, work will be considered as a case of possible academic misconduct.

A bibliography is essential and has to be presented in a standard format. Title page, table of contents, page numbers, etc must contribute to the quality of presentation.

Word count is rarely an important factor in a good mathematics EE. Since equations and formulas (indicating the student's mathematical reasoning) are not included in the word count, a substantial essay can be produced that contains comparatively few words.

Concise, elegant mathematics supported by graphs, diagrams and important proofs that do not interrupt the development of the essay are encouraged. However, an essay that is excessive in length will be penalized, especially if this is because of unnecessary content. Students should be aware that examiners will not read beyond the 4,000-word limit, or assess any material presented past this.

There is no mandatory minimum length for an essay in mathematics, and credit will be given for organizing the content in an efficient and readable style, rather than for a page or word count. Mastery of appropriate concepts, and an ability to present these in an effective way using mathematical means, should be the aim. Students should use an appendix as appropriate (eg for large amounts of raw data or for computer routines). However, any mathematics that is essential to the understanding of the essay must appear in the main body of the essay.

Criterion E: Engagement

(Strands: Reflections on planning and progress)

This criterion assesses the student's engagement with their research focus and the research process.

It will be applied by the examiner at the end of the assessment of the essay, and is based solely on the candidate's reflections as detailed on the [RPPF](#), with the supervisory comments and extended essay itself as context.

Students are expected to provide reflections on the decision-making and planning process undertaken in completing the essay. Students must demonstrate how they arrived at a topic as well as the methods and approach used. This criterion assesses the extent to which a student has evidenced the rationale for decisions made throughout the planning process and the skills and understandings developed.

For example, students may reflect on:

- the approach and strategies they chose, and their relative success

- the *Approaches to learning* skills they have developed and their effect on the student as a learner
- how their conceptual understandings have developed or changed as a result of their research
- challenges they faced in their research and how they overcame these
- questions that emerged as a result of their research
- what they would do differently if they were to undertake the research again.

Effective reflection highlights the journey the student has engaged in through the EE process. Students must show evidence of critical and reflective thinking that goes beyond simply describing the procedures that have been followed.

The reflections must provide the examiner with an insight into **student** thinking, creativity and originality within the research process. The **student** voice must be clearly present and demonstrate the learning that has taken place.