Mathematics HL

Contents

Higher level internal assessment

Range and suitability of submissions

Unfortunately, we still come across too many explorations that are over reliant on source material. Often these are just attempting to reproduce and explain material based on video clips or rewording of proofs found on the internet.

It is also worth mentioning that some teachers seem to encourage students to write explorations involving mathematics that is way beyond the syllabus, sometimes including work that is covered in the third or fourth semester at University; e.g. Fourier Transforms, Second Order Partial Differential Equations as well as Laplace Transforms for complex variable functions. The work is then assessed very generously by the teacher. Teachers and candidates need to understand that the target audience is a peer and that the work needs to be accessible to an average HL student without having to rely on any outside sources. At the other extreme, topics involving the use of basic statistics / probability tools which do not allow candidates to achieve top marks in criterion E have become rather popular. Topics such as Rubik's Cube, RSA cryptography, Maxwell Equations and examples that involve the mathematics of games that are not accessible to everyone should be discouraged. Unsurprisingly, there were a number of explorations based on infectious diseases using the SIR model.

Teachers need to consider carefully effective ways to guide students when choosing their topic. Although the topic should be chosen by the student, the teacher may refuse a proposal if this suggests that low achievement levels will be awarded.

Having said that, there were a number of interesting, original explorations that allowed the candidate to attain high achievement levels on all criteria.

Candidate performance against each criterion

Criterion A

It is a pity to see that few candidates attain full marks on this criterion. These 4 marks should be very accessible, but unfortunately candidates miss out for various reasons. A key instruction to candidates should be that the exploration should be understood by a peer. Very often candidates are allowed to choose a topic with an aim which is either too ambitious or which leads to a report which is heavily reliant on research. In such cases the work consists of a random selection of examples without clear coherent transitions from one part to the other. Other times candidates do not link back to the aim of the exploration throughout the work and this leads to sections which are linked to the topic but irrelevant to the aim making the exploration not concise. The use of sub-headings does not help with the flow of reading. Although candidates may use subheadings to ensure that all the essential parts are included when writing a first draft of the exploration, these should be removed when the work is edited for continuity in presentation. The exploration needs to flow from one section to another without sudden jumps in focus for no apparent reason.

Criterion B

In general candidates do well in this criterion, but there are still a number of careless mistakes like unlabelled diagrams and use of computer notation. This is easily avoidable, especially since candidates receive

feedback from teachers on a submitted draft. The use of "*" for multiplication was still accepted as correct by several teachers.

Candidates need to be careful about precision, whether it is mixed variables in integration, axes not labelled, mathematical terms used incorrectly or poorly defined variables and parameters. Words like function, expression, equation need to be used correctly. "Plug in" is not a mathematical term but "substitute" is. Subscripts were often either missing or simply substituted by a full-size number; e.g. $P1$ instead of P_1. Tables should not be split over two pages and equations / expressions should not be split over two lines.

Criterion C

There were few instances when a candidate did not do relatively well in this criterion, however few students were able to demonstrate personal engagement at a significant level. Usually this either happened when work was rushed or if the work was highly reliant on external sources and known proofs were presented.

Personal engagement is not about effort but should be the driving force of the exploration. The personal connection to the chosen topic should be evident through engagement in the work when developing the mathematics. Students need to show their own ideas and creativity when considering approaches. The inclusion of an example usually borrowed and edited from a source, does not reflect significant personal engagement.

Criterion D

It remains difficult for students and sometimes teachers to make a distinction between meaningful, critical reflection and a description of results or listing of assumptions on a model, especially if the model is reliant on these assumptions, e.g. when a candidate is looking into the spread of infections and uses the SIR model.

The expectation in this criterion is for students to pause and reflect on their work as the exploration is being developed. In general, if a reader can ask the question "why?" at any stage, then it is most likely that the exploration needed more reflection. If there is no purpose for the comments made the reflection is not meaningful. This can be done in different ways; e.g. thinking about the correctness of their work, or the relevancy of their strategies and / or analysis. Merely noting possible limitations or extensions does little to validate meaningful or critical reflection. Candidates should not be credited with reflection for stating how well they understood the topic. In some cases, reflection was credited for a conclusion that gave a general report on the topic explored without any links to the mathematics done. It is difficult to reflect critically when the exploration is based around standard proofs or theoretical findings. During such a process the student will need to reflect on the challenges and key mathematical steps, and what it is that they have done to enhance their understanding of the problem at hand. This is almost impossible to achieve if a student chooses an ambitious topic. If on the other hand a candidate has come up with a mathematical model, this needs to be interrogated. If the output of the model developed does not really make sense in the real world it cannot simply be brushed over. Any model developed would need to be tested for viability.

Criterion E

When awarding achievement levels in this criterion, a priority of sophistication, rigour and precision is understanding. It is therefore not surprising that those candidates who stayed within the HL syllabus or ventured just slightly beyond did better than those who went straight into topics that were well beyond this level. It is more accessible for a student to explore a topic that they understand than one that by nature consists of sophisticated mathematical methods and concepts that are not understood. Unfortunately,

when candidates look into topics like Fourier Transforms, or Partial Differential Equations, they do not have the opportunity to demonstrate understanding. Even if they do understand the mathematics, the restriction on length does not allow such students to address the target audience when explaining the mathematics. At the other end of the spectrum students simply produce formulae from within the Maths HL syllabus, but their own work merely consists of substituting specific values into them. This is decidedly not commensurate with the expectations at this level.

When reproducing bookwork or using a programme to choose and fit a curve to data, it is difficult to demonstrate thorough understanding. Some candidates, aiming to produce work that reflects sophistication, end up using complex mathematical ideas in which they are unable to show proper understanding of the underlying concepts. Very often this has the opposite effect when candidates do not explain the work or when errors are noted in one line and are magically correct in the next. When a candidate tries to pass off understanding of difficult concepts by using flowery language and confident sentences it does not work. It is of vital importance that the work should be understood by a peer without any access to outside sources. It is also not appropriate for candidates to apply advanced unfamiliar mathematics by merely quoting formulae and substituting numbers to obtain results. Irrespective of how sophisticated the mathematics used in the formulae may be, such work does not reflect sophistication. The degree of sophistication is measured by explaining how the formula is obtained and placing it within context.

Recommendations and guidance for the teaching of future candidates

There was evidence to suggest that some candidates did not receive proper guidance when choosing the topic or during their development of the exploration. It is one of the teacher responsibilities to spend appropriate time to build the skills required for writing an exploration independently. The key guidance is that the student chooses a topic that they can firstly understand and secondly explain within the page limit stipulated. Teachers need to understand that although the topic is the students' choice, it is within their remit to refuse a proposal if it suggests an aim that is too ambitious or mathematics that is way beyond the HL mathematics course.

In some cases, there was also evidence that the teacher did not interpret the different criterion descriptors correctly and hence the wrong message was transmitted to the students. It was also quite clear that some students were left to their own devices after having submitted their topic / subject proposal. Teachers should read the documents about IA procedures published in the TSM, taking note of the teacher responsibilities.

It is essential that teachers understand and emphasise to students the difference between an Exploration and an Extended Essay. A number of scripts read more like a mini Extended Essay with a research question and result citation but little or no personal input in the mathematics being used.

Although it is understood that within schools' different deadlines for different subject IA's are set, it is not recommended that the exploration is done too early in the course, when not enough of the core syllabus has been covered. This precludes the candidates on achieving higher levels or having to learn topics on their own. Unfortunately, when this happens, candidates miss out on the sophistication and rigour of the mathematics that is required.

It is also essential that both teachers and students read the subject report.

Further comments

It is unfortunate that some teachers continue to provide little or no annotations on the candidate work. It is understandable that this session was special, and all student work had to be uploaded, however annotations are important when marking a piece of work holistically whether the work is submitted for moderation. This is good practice and it also provides good feedback to the student and to colleagues when standardization is done within the school.