

The Sciences: An introduction

An extended essay (EE) in the sciences gives students an opportunity to apply a range of skills while researching a topic of personal interest in the field. Students working on a science EE must demonstrate an in-depth analysis of the subject matter studied, be it biology, chemistry, computer science, design technology, physics or sports, exercise and health science. This understanding must be shown in the form of a research paper involving a well-formulated research question.

Students should be advised that while there is overlap between the subjects, their study should reflect one specific science area. For example:

- biology—dealing with living organisms and life processes
- chemistry—dealing with the composition, characterization and transformation of substances
- computer science—exploring advances in hardware and software development, network systems and computer control systems.

The nature of the topic under investigation should be different for each subject area and students should be careful if they undertake essays that may blur the boundaries between two science subjects. For example, when studying the pH of a body of water, students may investigate the chemicals responsible for the observed pH (chemistry), or the effect of the pH on the biota (biology).

A critical stage in preparing for the EE is the formulation of a logical and coherent rationale for selecting a particular topic. Students need to identify a topic that offers enough scope for the essay. They also require a research question that allows them to either generate data or examine existing data in order to support or refute their argument.

The outcome of the research should be a coherent and structured piece of writing that effectively addresses the research question and arrives at a particular objective conclusion based on the evidence presented. In addition, students are expected to think critically about their methodology, especially when the data may not support their initial thoughts. Students should consider a range of factors that may have contributed to this.

The process of topic selection

Students should initially identify the broad area of inquiry they are interested in within one of the science subjects: biology, chemistry, computer science, design technology, physics or sports, exercise and health science. If interested in a topic that falls between two sciences, students must be reminded that their essay will be graded on a specific subject content. For example, an EE in an interdisciplinary area such as materials science will, if registered as a physics EE, be judged on its physics content, not its chemical content. In other words, students must align their research to one subject area.

The topic may relate to an area of the Diploma Programme science courses, but this is not a requirement and other areas of the subject may be explored. Crucially, the topic should reflect the student's particular interest and enthusiasm within the subject area. The student must be personally involved with the subject matter and not simply be an informant.

Students need to narrow down the topic by dividing the area into more specific and detailed subtopics. The chosen topic should enable students to discuss conflicting ideas and theories, and to produce an in-depth analysis within the 4,000-word limit.

Students should avoid research topics that go beyond the boundaries of conventional science into areas that are more related to pseudo-science.

If students choose a topic that is already well documented they should try to apply their understanding in a different way. For example, a student may use a standard technique in a novel situation, thus demonstrating personal input or intellectual initiative.

Some topics may be inappropriate for investigation due to safety issues. Experiments involving dangerous or carcinogenic substances, radioactive materials, toxic substances, ionizing radiation, loud sounds or heavy equipment should be avoided unless adequate safety apparatus and qualified supervision are available. Students must check and understand all IB policies related to carrying out experiments with animal or human subjects, including both safety issues and those of an ethical nature. Before embarking on any practical experiment students should undertake a risk assessment and discuss this with their supervisor.

Often their previous experiences help students to decide on their topic.

It is strongly recommended that students choose a topic within a subject area they are currently studying within the Diploma Programme. This will ensure they already have the basic knowledge to complete the task. For some, a topic that extends beyond work already undertaken as part of the course might be a great source of research ideas. This is usually the case when students are pursuing topics in literature-based EEs.

Students undertaking an experimental science EE are not permitted to use the same investigations covered in the science courses. A student may, however, undertake research in a related area, or use the same techniques in a different scenario.

Students should discuss the appropriateness of their topic with their supervisor in the early stages of the research process.

Literature review—demonstrating knowledge and understanding in context

Literature-based research is an essential element of the EE. Students should review the existing literature on the topic to inform the construction of their own research question and design. In many instances, they will conduct their review in the early stages of the research process.

Once they have discussed their choice of topic with their supervisor, a student can begin to outline main points to be discussed in their essay. Their research plan should be flexible enough to allow the student to explore the topic in a creative manner.

Students should not be afraid to take risks throughout the research process: originality is encouraged, as is the use of a number of different research models.

A comprehensive literature review will help to guide and improve the students' own work as it will enable them to contextualize their findings. Students should be recommended to use statistics or data that they are able to demonstrate are linked to their research question. They should not necessarily ignore anomalies or even eliminate them from their data set on the basis that they are not reliable, but instead should discuss them critically.

Students should consult a range of appropriate sources. They must take particular care to ensure that all sources of information consulted are up to date and relevant to the research question posed.

Research question

When working on the research question, students should be guided by the rationale that their piece of writing is important and that it fills a gap in personal curiosity.

Thus, their research question should be non-trivial and follow from the existing body of literature on the topic. A well-constructed research question needs to:

- be specific and sharply focused on the particular aspect and/or area of subject matter being explored

- be stated clearly on the title page and in the introduction of the essay
- fit into one of the science subjects
- offer an alternative perspective compared to previous research findings
- be formulated as an actual question.

Students need to avoid researching a question that is too narrow or too obvious as this will limit their ability to formulate reasoned arguments and engage in critical thinking.

The question must give an appropriate context and encourage an investigative approach. It should be centred on science and not on peripheral issues such as the history of a subject or social implications of discoveries in a subject.

Research methods

The emphasis of the EE should always be on:

- written analysis
- interpretation of data
- evaluation
- construction and development of a reasoned argument.

Therefore, it is vital that the chosen methodology and experimental work of the essay is tailored to the research question and allows for an in-depth exploration.

In experimental essays, students should choose feasible experiments that do not require extensive lengths of time for the construction of apparatus or apparatus that is beyond the resources of their school.

Students should be guided by content analysis of primary and secondary sources in conducting research. Every science EE will involve some research into the background or theory of the topic selected. Therefore, students may choose any of the following approaches:

- experimental—design and implementation of an experiment, then personal collection and analysis of the data
- data-based—location and extraction of raw or processed data, which is then further refined and analysed
- theoretical—development of a quantitative or semi-quantitative description of the phenomenon, development or construction of a model, predictions about its behaviour and limitations.

Students working on an EE in computer science may choose data for analysis from a program written by themselves.

In biology essays this data may come through experimentation, microscopic observations, fieldwork or some other appropriate scientific approach.

In design technology it might be appropriate to include surveys, user observations and structured interviews with users or experts.

A secondary source of information refers to the collection of books, academic journals, newspaper and magazine articles, textbooks, reviews and websites that may be used to collect data as the focus of the student's research.

All students should consult secondary sources even if their EE is experimental.

Students who choose to undertake a literature-based EE must ensure that the range of sources used clearly relate to their chosen topic and are discussed critically.

For essays that are based on data taken from written sources, the student should explain clearly how the data has been selected in order to comment on its reliability.

For experimental work, sufficient information on the methodology should be provided to allow the work to be repeated by an independent researcher.

Students must carry out the research for the essay solely under the direction of the school supervisor. Students must provide evidence in the essay of their personal contribution to the research approach and to the selection of the methods used.

In the rare circumstances that a student undertakes their research outside the school, they must do so with the permission of the DP/EE coordinator and adhering to the requirements outlined in the important note on external mentors.

Supervisors also need to ensure that students are aware of their responsibility to properly cite the resources used and check their work for plagiarism. Citations should adhere to the requirements of the IB and be consistently applied throughout the EE.

Framework for the EE in the sciences

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| Introduction | An EE in the sciences is intended for students who are interested in undertaking research in an area of biology, chemistry, computer science, design technology, physics or sports, exercise and health science. Qualitative and quantitative methods are used. |
| Methods most relevant to subjects in this group | Primary methods involve analysis of original scientific publications, experiments, analysis of data, use of databases, modelling, written computer programs, surveys, questionnaires, observations, personal communications and interviews. Secondary sources include the collection of information from books, academic journals, newspaper and magazine articles, textbooks, reviews and websites. |
| Suggestions for possible sources | Use of peer-reviewed journals, newspaper articles, books, e-resources and publications online, specialized academic research engines, unpublished conference papers and previously published essays. Where relevant and possible, students may wish to consult practitioners and professionals to stimulate original ideas, provide models of disciplined, structured and informed approaches and encourage direct and personal involvement with the essay topic. |
| Particular things to be aware of | Students need to be aware that their work will be checked in terms of the IB's academic honesty policy and so all students must ensure that they are familiar with this document. When collecting data and conducting experimental procedures with human subjects (especially in biology and sports, exercise and health science), students must gain informed consent from the research participants. Research participants should be informed of the purpose, procedures and potential risks involved in a study. Investigations that are based on experiments likely to inflict pain on, or cause unnecessary stress to, living organisms are inadmissible. For greater clarification all students and supervisors are advised to read the IB Animal experimentation policy. It is recommended that all test subjects complete a physical activity readiness questionnaire (PAR-Q) or similar readiness questionnaire prior to partaking in |

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| | <p>rigorous exercise to ensure that they are suitable candidates for the investigation. Experiments involving bodily fluids must not be performed under any circumstances due to the risk of the transmission of pathogens.</p> <p>Experiments involving dangerous or carcinogenic substances, radioactive materials, toxic chemicals, ionizing radiation, loud sounds or heavy equipment should be avoided unless adequate safety apparatus and qualified supervision are available.</p> |
| Summary | <p>Undertaking an EE is a challenge and so planning is crucial. Students need to start writing their papers early and discuss any emerging difficulties with their supervisor, especially those that relate to experimental work that needs to be undertaken over a period of time, as with, for example, experiments with plants.</p> <p>Supervisors, practitioners and professionals in the field are a great source of information, advice and support for students.</p> <p>Students writing a science EE should search for primary and secondary sources of information prior to initiating the writing process.</p> <p>The framing of a good research question that is well structured and thought through will aid students in establishing a reasoned argument.</p> |
| The EE and internal assessments | <p>The EE is not an extension of the internal assessment, or any other assessment component, and students must ensure that they do not use material submitted for any other assessment component as part of the EE submission.</p> <p>In the sciences this explicitly means that data collected for experiments undertaken as part of science lessons or the internal assessment task cannot be used as the basis of the EE in that subject.</p> |