 Depth study - models and laws

Module 4 - Theories and Laws

Outcomes

Working scientifically

Compulsory Working Scientifically outcomes

* INS11/12-1 develops and evaluates questions and hypotheses for scientific investigation
* INS11/12-7 communicates scientific understanding using suitable language and terminology for a specific audience or purpose

Two or more outcomes must be selected from the following Working Scientifically outcomes

* INS11/12-2 designs and evaluates investigations in order to obtain primary and secondary data and information
* INS11/12-3 conducts investigations to collect valid and reliable primary and secondary data and information
* INS11/12-4 selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media
* INS11/12-5 analyses and evaluates primary and secondary data and information
* INS11/12-6 solves scientific problems using primary and secondary data, critical thinking skills and scientific processes

Knowledge and understanding

* INS11-11 describes and assesses how scientific explanations, laws and theories have developed

Teacher notes

This depth study is intended to be worked on concurrently with the course content, eg allocated time each week should be given to students to develop an inquiry question and hypothesis for the depth study as well as time to conduct a primary or secondary sourced research investigation, including analysis of data and communicate findings in an appropriate medium.

It is highly recommended that students keep a journal of their work. In this way the teacher may request to see the journal and provide feedback ‘as learning’ for the student throughout the process. This may be scaffolded for students by completing a Depth study inquiry proposal as well as using a working scientifically skills checklist of their progress.

Task

The various theories and laws developed by science are the result of the patient accumulation and collection of data derived from the observation, collection and recording of data which is then analysed to make inferences based on trends and patterns by generations of scientists. Scientists seek to explain and understand these trends and patterns by developing theories and laws to determine cause and effect or by establishing the circumstances under which an event occurs.

Students are to develop an inquiry question based on an established theory or law and research how diverse phenomena have been unified to develop the theory or law up to the present day. The investigation may be conducted using primary or secondary sources, or a combination of both with the findings presented in an appropriate format for the target audience.

Theories or laws that could be investigated include, but are not limited to:

* atomic theory
* theory of evolution by natural selection
* big bang theory
* plate tectonic theory
* Ohm’s law
* law of conservation of energy
* Avogadro’s law
* Newton’s laws of motion
* law of superposition
* germ theory
* oxygen theory of combustion
* law of conservation of mass
* Mendel's laws
* cell theory
* game theory
* Statistical mechanics
* theory of general and/or special relativity
* quantum theory
* heliocentrism
* information theory
* social identity theory
* Hubble’s law of cosmic expansion
* Kepler's laws of planetary motion
* universal law of gravitation
* Archimedes' buoyancy principle
* Heisenberg's uncertainty principle
* Hooke’s law of elasticity
* Bernoulli's law of fluid dynamics
* Dalton's law of partial pressures
* Fourier's law of heat conduction

Task Criteria

* Outline the original hypothesis proposed by the scientist/s credited for developing the theory or law
* Describe the observation/s that form the basis of the theory or law
* Discuss the evidence that has been collected or generated by both the original scientist/s or subsequent scientists to support the theory or law
* Explain how the theory or law is applied or used in modern society
* Analyse any observations or evidence that may conflict with the theory or law as it is currently stated.

The investigation is to be presented using appropriate understanding and terminology; presentation options may include a report, a practical demonstration, a poster, a video or slide-show.

Marking guideline/rubric

Depth Study Marking Rubric – mandatory outcomes (2 WS + 1 KU)

| Outcomes | Excellent | Substantial | Satisfactory | Developing | Elementary |
| --- | --- | --- | --- | --- | --- |
| INS11/12-1 develops and evaluates questions and hypotheses for scientific investigation | Inquiry question/s independently developed and evaluated and provides specific parameters for the scope of the investigation. Hypothesis (as appropriate) is developed and evaluated with reference to the independent and dependent variable and relates to the objectives and feasibility of the investigation.  New evidence is used to modify and/or inform the question | Inquiry question/s developed or evaluated and provides parameters for the scope of the investigation. Hypothesis (as appropriate) is developed and discussed with reference to the independent and dependent variable and relates to the objectives of the investigation.  New evidence is used to inform the question | Inquiry question/s developed or discussed and provides some parameters for the scope of the investigation. Hypothesis (as appropriate) is described with reference to variables and relates to the objectives of the investigation. | Inquiry question/s described and provides few parameters for the scope of the investigation. Hypothesis (as appropriate) is described with reference to variables | Inquiry question/s identified. Hypothesis (as appropriate) is identified. |
| INS11/12-7 communicates scientific understanding using suitable language and terminology for a specific audience or purpose | The prior knowledge and understanding of the audience is considered in the selection of the presentation format and the task requirements.  Scientific understanding is communicated through the appropriate use of language, terminology and presentation style suited to the text type.  Able to support and evaluate arguments/position effectively by engaging in peer feedback. | The nature of the audience is considered in the selection of the presentation format and the task requirements. Scientific understanding is communicated using language, terminology and presentation style using a text type format.  Able to support arguments/position effectively by engaging in peer feedback. | A presentation is made to an audience and is in a format is suitable for the task requirements. Some scientific understanding is communicated using language, terminology and presentation style using a text type format.  Engages in peer feedback | A presentation is made to an audience and is in a format that meets task requirements. Limited scientific understanding is communicated using language and presentation style using some text type formatting. | A presentation is made to an audience. Limited scientific understanding is communicated using language. |
| INS11-11 describes and assesses how scientific explanations, laws and theories have developed | The hypothesis developed by the scientist/s that is credited with the theory or law is outlined. The observational basis for the theory or law is described. Supporting evidence generated over time is discussed. An explanation of how the theory or law is applied is provided with an example. An analysis of conflicting and potentially conflicting observations or evidence is provided. | The hypothesis developed by the scientist/s that is credited with the theory or law is outlined. Some of the observational basis for the theory or law is described. Supporting evidence generated over time is described. An explanation of how the theory or law is applied is provided. An analysis of conflicting observations or evidence is provided. | The hypothesis developed by the scientist/s that is credited with the theory or law is identified. The observational basis for the theory or law is outlines. Some supporting evidence generated over time is described. A description of how the theory or law is used is provided. A discussion of conflicting observations or evidence is provided. | The hypothesis for the theory or law is identified. Observations related to the theory or law are outlined. Some supporting evidence generated over time is outlined. An outline of how the theory or law is used is provided. A description of conflicting observations or evidence is provided. | The hypothesis is stated. Observations related to the theory or law are identified. Some supporting evidence generated over time is identified. The application of the theory or law is identified. An outline of conflicting observations or evidence is provided. |

Additional working scientifically outcomes

Two or more outcomes must be selected (You may copy and paste the appropriate outcomes into the table above).

| Outcomes | Excellent | Substantial | Satisfactory | Developing | Elementary |
| --- | --- | --- | --- | --- | --- |
| INS11/12-2 designs and evaluates investigations in order to obtain primary and secondary data and information | Investigation is planned and designed to obtain required primary or secondary data and information with consideration of the available equipment, capability of investigator, appropriate methodology and sample sizes. The quality, reliability and validity of data and information that can be obtained is evaluated and the potential limitations are discussed.  Design is evaluated and modified, with justification, in response to new evidence | Investigation is planned and designed to obtain required primary or secondary data and information. Design has some consideration of the available equipment, capability of investigator, appropriate methodology and sample sizes. The reliability and validity of data and information that can be obtained is explained and the potential limitations are discussed.  Design is evaluated and modified, in response to new evidence | Investigation is planned and designed to obtain primary or secondary data and information. Design has few considerations of the some of the following, eg available equipment, capability of investigator, appropriate methodology and sample sizes. The reliability and validity of data and information that can be obtained is explained.  Design is discussed and modified in response to new evidence | Investigation is planned and designed to obtain primary or secondary data and information. Design consider one of the following, eg. available equipment, capability of investigator, appropriate methodology and sample sizes. The reliability or validity of data and information that can be obtained is outlined.  Design is discussed | Investigation is planned and designed to obtain primary or secondary data and information. |
| INS11/12-3 conducts investigations to collect valid and reliable primary and secondary data and information | Data and information is collected and collated: -using correctly calibrated equipment, appropriate methodology and sample size required to obtain primary data.  and/or  -using numerous verified secondary source material, with the use of cross referencing to ensure reliability and validity of the gathered data.  Investigation is conducted in accordance to ethical guidelines. | Data and information is collected and collated:  -using appropriate equipment, methodology and sample size required to obtain primary data.  and/or  -using numerous secondary source material, with the use of referencing to ensure reliability and validity of the gathered data.  Investigation is conducted with reference to ethical guidelines. | Some data and information is collected and collated:  -using appropriate equipment, and methodology required to obtain primary data.  and/or  -using some secondary source material, with referencing of the gathered data.  Investigation is conducted with some reference to ethical considerations. | Limited data and information is collected and collated:  -with an attempted use of equipment, or a methodology to obtain primary data  and/or  -using a limited range of secondary source material, with an attempt at referencing of the gathered data.  Ethical considerations are described. | Limited data and information is collected and collated:  -with inappropriate use of equipment or methodology to obtain primary data  and/or  -using limited range of secondary source material.  Ethical considerations are identified. |
| INS11/12-4 selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media | The appropriate type of data and information is collected i.e. qualitative and/or quantitative and the processes selected for the analysis and evaluation of the data is justified as the most appropriate for to the objectives of the inquiry question/s and hypotheses.  All data sources are appropriately referenced in a consistent format. | The appropriate type of data and information is collected i.e. qualitative and/or quantitative and the processes selected for the analysis and evaluation of the data is appropriate for to the objectives of the inquiry question/s and hypotheses.  All data sources are appropriately referenced. | Data and information collected i.e. qualitative and/or quantitative has some applicability to the objectives and the inquiry question. The processes selected for the analysis and evaluation of the data meets the objectives of the inquiry question/s and hypotheses.  All data sources are referenced. | Data and information collected i.e. qualitative and/or quantitative has limited applicability to the objectives and the inquiry question. The processes selected for the analysis and evaluation of the data meets some of the objectives of the inquiry question/s and hypotheses.  Some data sources are referenced. | Inappropriate data and information is collected i.e. qualitative and/or quantitative and the processes selected for the analysis and evaluation of data is unsuited to the objectives of the inquiry question/s and hypotheses. |
| INS11/12-5 analyses and evaluates primary and secondary data and information | Data and information is analysed and evaluated for reliability and validity. Primary data and information sources are analysed and evaluated for statistically relevant patterns or trends to generate an inference/conclusion on the phenomena investigated. Secondary data and information sources are analysed and evaluated for sources of agreement and conflict in relation to a phenomenon being investigated. | Data and information is analysed for reliability and validity. Primary data and information sources are analysed for statistically relevant patterns or trends to generate an inference/conclusion on the phenomena investigated. Secondary data and information sources are analysed for sources of agreement and conflict in relation to a phenomenon being investigated. | Data and information is explained in terms of reliability and validity. Primary data and information sources are examined for statistically relevant patterns or trends to explain the generation of an inference/conclusion on the phenomena investigated. Secondary data and information sources are examined for sources of agreement and conflict in relation to a phenomenon being investigated. | Data and information is described in terms of reliability and validity. Primary data and information sources are described and an inference/conclusion on the phenomena investigated generated. Secondary data and information sources are described for sources of agreement or conflict in relation to a phenomenon being investigated. | Data and information is outlined in terms of reliability or validity. Primary data and information sources are outlined and an inference/conclusion on the phenomena investigated generated. Secondary data and information sources are outlined in relation to a phenomenon being investigated. |
| INS11/12-6 solves scientific problems using primary and secondary data, critical thinking skills and scientific processes | Comprehensive list of problems or unresolved issues in first and secondary data and information sources are described. Appropriate and feasible means of addressing and resolving problems and issues are analysed and recommendations on how to proceed are justified.  Critical evaluation of peer consultation/feedback is provided with modification (or lack of modification) of investigation is justified. | Problems or unresolved issues in first and secondary data and information sources are described. Means of addressing and resolving problems and issues are discussed and recommendations on how to proceed are explained.  Evaluation of peer consultation/feedback is provided with modification (or lack of modification) of investigation is discussed. | Problems or unresolved issues in first and secondary data and information sources are identified. Means of addressing and resolving problems and issues are discussed and recommendations on how to proceed are described.  Discussion of peer consultation/feedback is provided with modification (or lack of modification) of investigation is described. | Some problems or unresolved issues in first and secondary data and information sources are identified. Means of addressing and resolving problems and issues are outlined and recommendations on how to proceed are identified.  Evidence of peer consultation/feedback is provided with modification (or lack of modification) of investigation identified. | Limited problems or unresolved issues in first and secondary data and information sources are identified. Means of addressing and resolving problems and issues are identified.  Evidence of peer consultation/feedback is provided. |