The Ontario Curriculum – Exemplars
Grades 7 and 8

Science and Technology

Samples of Student Work: A Resource for Teachers
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Introduction

In 1998, the Ministry of Education and Training published a new science and technology curriculum policy document for Ontario elementary students entitled The Ontario Curriculum, Grades 1–8: Science and Technology, 1998. The new curriculum is more specific than previous curricula with respect to both the knowledge and the skills that students are expected to develop and demonstrate in each grade. The document contains the curriculum expectations for each grade and an achievement chart that describes four levels of student achievement to be used in assessing and evaluating student work.

The present document contains samples ("exemplars") of student work at each level of achievement for Grades 7 and 8. It is part of a set of four documents, each covering two grades (Grades 1 and 2, Grades 3 and 4, Grades 5 and 6, and Grades 7 and 8). These exemplar documents are intended to provide assistance to teachers in their assessment of student achievement of the curriculum expectations. The samples included in the documents represent work produced at the end of the school year in each grade.

Ontario school boards were invited by the Ministry of Education to participate in the development of the exemplars. Teams of teachers and administrators from across the province were involved in developing the assessment materials. They designed the performance tasks and scoring scales ("rubrics") on the basis of selected Ontario curriculum expectations, field-tested them in classrooms, suggested changes, administered the final tasks, marked the student work, and selected the exemplars used in this document. During each stage of the process, external validation teams and Ministry of Education staff reviewed the tasks and rubrics to ensure that they reflected the expectations in the curriculum policy documents and that they were appropriate for all students. External validation teams and ministry staff also reviewed the samples of student work.

The selection of student samples that appears in this document reflects the professional judgement of teachers who participated in the project. No students, teachers, or schools have been identified.

Samples are recorded on video for Grades 1, 2, 5, and 8. These samples were produced in partnership with TVOntario.

The procedures followed during the development and implementation of this project will serve as a model for boards, schools, and teachers in designing assessment tasks within the context of regular classroom work, developing rubrics, assessing the achievement of their own students, and planning for the improvement of students’ learning.
The samples in this document will provide parents\textsuperscript{1} with examples of student work to help them monitor their children’s progress. They also provide a basis for communication with teachers.

Use of the exemplar materials will be supported initially through provincial in-service training.

**Purpose of This Document**

This document was developed to:

- show the characteristics of student work at each of the four levels of achievement for each grade;
- promote greater consistency in the assessment of student work across the province;
- provide an approach to improving student learning by demonstrating the use of clear criteria applied to student work in response to clearly defined assessment tasks;
- show the connections between what students are expected to learn (the curriculum expectations) and how their work can be assessed using the levels of achievement described in the curriculum policy document for the subject.

Teachers, parents, and students should examine the student samples in this document and consider them along with the information in the Teacher's Notes and Comments/Next Steps sections. They are encouraged to examine the samples in order to develop an understanding of the characteristics of work at each level of achievement and the ways in which the levels of achievement reflect progression in the quality of knowledge and skills demonstrated by the student.

The samples in this document represent examples of student achievement obtained using only one method of assessment, called performance assessment. Teachers will also make use of a variety of other assessment methods and strategies in evaluating student achievement over a school year.

**Features of This Document**

This document contains the following:

- a description of each performance task, as well as the curriculum expectations related to the task
- a task-specific assessment chart (“rubric”) for each grade
- two samples of student work for each of the four levels of achievement
- Teacher's Notes, which provide some details on the level of achievement for each sample
- Comments/Next Steps, which offer suggestions for improving achievement
- the Teacher Package that was used by teachers in administering the task

It should be noted that each sample for a specific level of achievement represents the characteristics of work at that level of achievement.

\textsuperscript{1} In this document, parent(s) refers to parent(s) and guardian(s).
The video for the Grade 8 science and technology task contains the following:

- a brief overview of the exemplar project
- an introduction to the video
- an overview of the performance task and the expectations addressed in the task
- student samples (presentations)
- comments on the rubric, the levels of achievement, and the student samples
- concluding remarks

Students whose performance was scored at level 1 or level 2 appear on the video, but only in ways that ensure that they are not identifiable.

**The Tasks**

The performance tasks were based directly on curriculum expectations selected from The Ontario Curriculum, Grades 1–8: Science and Technology, 1998. The tasks encompassed the four categories of knowledge and skills (i.e., understanding of basic concepts; inquiry and design skills; communication of required knowledge; relating of science and technology to each other and to the world outside the school), requiring students to integrate their knowledge and skills in meaningful learning experiences. The tasks gave students an opportunity to demonstrate how well they could use their knowledge and skills in a specific context.

Teachers were required to explain the scoring criteria and descriptions of the levels of achievement (i.e., the information in the task rubric) to the students before they began the assignment.

**The Rubrics**

In this document, the term *rubric* refers to a scoring scale that consists of a set of achievement criteria and descriptions of the levels of achievement for a particular task. The scale is used to assess students’ work; this assessment is intended to help students improve their performance level. The rubric identifies key criteria by which students’ work is to be assessed, and it provides descriptions that indicate the degree to which the key criteria have been met. The teacher uses the descriptions of the different levels of achievement given in the rubric to assess student achievement on a particular task.

The rubric for a specific performance task is intended to provide teachers and students with an overview of the expected product with regard to the knowledge and skills being assessed as a whole.

The achievement chart in the curriculum policy document for science and technology provides a standard province-wide tool for teachers to use in assessing and evaluating their students’ achievement over a period of time. While the chart is broad in scope and general in nature, it provides a reference point for all assessment practice and a framework within which to assess and evaluate student achievement. The descriptions
associated with each level of achievement serve as a guide for gathering and tracking assessment information, enabling teachers to make consistent judgements about the quality of student work while providing clear and specific feedback to students and parents.

For the purposes of the exemplar project, a single rubric was developed for each performance task. This task-specific rubric was developed in relation to the achievement chart in the curriculum policy document.

The differences between the achievement chart and the task-specific rubric may be summarized as follows:

- The achievement chart contains broad descriptions of achievement. Teachers use it to assess student achievement over time, making a summative evaluation that is based on the total body of evidence gathered through using a variety of assessment methods and strategies.
- The rubric contains criteria and descriptions of achievement that relate to a specific task. The rubric uses some terms that are similar to those in the achievement chart but focuses on aspects of the specific task. Teachers use the rubric to assess student achievement on a single task.

The rubric contains the following components:

- an identification (by number) of the expectations on which student achievement in the task was assessed
- the four categories of knowledge and skills
- the relevant criteria for evaluating performance of the task
- descriptions of student performance at the four levels of achievement (level 3 on the achievement chart is considered to be the provincial standard)

As stated earlier, the focus of performance assessment using a rubric is to improve students' learning. In order to improve their work, students need to be provided with useful feedback. Students find that feedback on the strengths of their achievement and on areas in need of improvement is more helpful when the specific category of knowledge or skills is identified and specific suggestions are provided than when they receive only an overall mark or general comments. Student achievement should be considered in relation to the criteria for assessment stated in the rubric for each category, and feedback should be provided for each category. Through the use of a rubric, students' strengths and weaknesses are identified and this information can then be used as a basis for planning the next steps for learning. In this document, the Teacher's Notes section indicates the reasons for assessing a student's performance at a specific level of achievement, and the Comments/Next Steps section indicates suggestions for improvement.

In the exemplar project, a single rubric encompassing the four categories of knowledge and skills was used to provide an effective means of assessing the particular level of student performance in the performance task, to allow for consistent scoring of student performance, and to provide information to students on how to improve their work. However, in the classroom, teachers may find it helpful to make use of additional rubrics.
if they need to assess student achievement on a specific task in greater detail for one or more of the four categories. For example, it may be desirable in evaluating an oral report to use one rubric for assessing the content (understanding of basic concepts), one for the research (inquiry and design skills), one for the writing and presentation (communication of required knowledge), and one for the application of knowledge (relating of science and technology to each other and to the world outside the school).

The rubrics for the tasks in the exemplar project are similar to the scales used by the Education Quality and Accountability Office (EQAO) for the Grade 3, Grade 6, and Grade 9 provincial assessments in that both the rubrics and the EQAO scales are based on the Ontario curriculum expectations and the achievement charts. The rubrics differ from the EQAO scales in that they were developed to be used only in the context of classroom instruction to assess achievement in a particular assignment.

Although rubrics were used effectively in this exemplar project to assess responses related to the performance tasks, they are only one way of assessing student achievement. Other means of assessing achievement include observational checklists, tests, marking schemes, or portfolios. Teachers may make use of rubrics to assess students’ achievement on, for example, essays, reports, exhibitions, debates, conferences, interviews, oral presentations, recitals, two- and three-dimensional representations, journals or logs, and research projects.

**Development of the Tasks**

The performance tasks for the exemplar project were developed by teams of educators in the following way:

- The teams selected a cluster of curriculum expectations that focused on the knowledge and skills that are considered to be of central importance in the subject area. Teams were encouraged to select a manageable number of expectations. The particular selection of expectations ensured that all students would have the opportunity to demonstrate their knowledge and skills in each category of the achievement chart in the curriculum policy document for the subject.
- The teams drafted one task for each grade that would encompass all of the selected expectations and that could be used to assess the work of all students.
- The teams established clear, appropriate, and concrete criteria for assessment, and wrote the descriptions for each level of achievement in the task-specific rubric, using the achievement chart for the subject as a guide.
- The teams prepared detailed instructions for both teachers and students participating in the assessment project.
- The tasks were field-tested in classrooms across the province by teachers who had volunteered to participate in the field test. Student work was scored by teams of educators. In addition, classroom teachers, students, and board contacts provided feedback on the task itself and on the instructions that accompanied the task. Suggestions for improvement were taken into consideration in the revision of the tasks, and the feedback helped to finalize the tasks, which were then administered in the spring of 2001.
In developing the tasks, the teams ensured that the resources needed for completing the tasks - that is, all the worksheets and support materials - were available.

Prior to both the field tests and the final administration of the tasks, a team of validators - including research specialists, gender and equity specialists, and subject experts - reviewed the instructions in the teacher and student packages, making further suggestions for improvement.

Assessment and Selection of the Samples
After the final administration of the tasks, student work was scored at the district school board level by teachers of the subject who had been provided with training in the scoring. These teachers evaluated and discussed the student work until they were able to reach a consensus regarding the level to be assigned for achievement in each category. This evaluation was done to ensure that the student work being selected clearly illustrated that level of performance. All of the student samples were then forwarded to the ministry. A team of teachers from across the province, who had been trained by the ministry to assess achievement on the tasks, rescored the student samples. They chose samples of work that demonstrated the same level of achievement in all four categories and then, through consensus, selected the samples that best represented the characteristics of work at each level of achievement. The rubrics were the primary tools used to evaluate student work at both the school board level and the provincial level.

The following points should be noted:

- Two samples of student work are included for each of the four achievement levels. The use of two samples is intended to show that the characteristics of an achievement level can be exemplified in different ways.
- Although the samples of student work in this document were selected to show a level of achievement that was largely consistent in the four categories (understanding of basic concepts; inquiry and design skills; communication of required knowledge; relating of science and technology to each other and to the world outside the school), teachers using rubrics to assess student work will notice that students’ achievement frequently varies across the categories (e.g., a student may be achieving at level 3 in understanding of basic concepts but at level 4 in communication of required knowledge).
- Although the student samples show responses to most questions, students achieving at level 1 and level 2 will often omit answers or will provide incomplete responses or incomplete demonstrations.
- Students’ effort was not evaluated. Effort is evaluated separately by teachers as part of the “learning skills“ component of the Provincial Report Card.
- The document does not provide any student samples that were assessed using the rubrics and judged to be below level 1. Teachers are expected to work with students whose achievement is below level 1, as well as with their parents, to help the students improve their performance.
Use of the Student Samples
Teachers and Administrators

The samples of student work included in this document will help teachers and administrators by:

• providing student samples and criteria for assessment that will enable them to help students improve their achievement;
• providing a basis for conversations among teachers, parents, and students about the criteria used for assessment and evaluation of student achievement;
• facilitating communication with parents regarding the curriculum expectations and levels of achievement for each subject;
• promoting fair and consistent assessment within and across grade levels.

Teachers may choose to:

• use the teaching/learning activities outlined in the performance tasks;
• use the performance tasks and rubrics in the document in designing comparable performance tasks;
• use the samples of student work at each level as reference points when assessing student work;
• use the rubrics to clarify what is expected of the students and to discuss the criteria and standards for high-quality performance;
• review the samples of work with students and discuss how the performances reflect the levels of achievement;
• adapt the language of the rubrics to make it more “student friendly”;
• develop other assessment rubrics with colleagues and students;
• help students describe their own strengths and weaknesses and plan their next steps for learning;
• share student work with colleagues for consensus marking;
• partner with another school to design tasks and rubrics, and to select samples for other performance tasks.

Administrators may choose to:

• encourage and facilitate teacher collaboration regarding standards and assessment;
• provide training to ensure that teachers understand the role of the exemplars in assessment, evaluation, and reporting;
• establish an external reference point for schools in planning student programs and for school improvement;
• facilitate sessions for parents and school councils using this document as a basis for discussion of curriculum expectations, levels of achievement, and standards.
Parents
The performance tasks in this document exemplify a range of meaningful and relevant learning activities related to the curriculum expectations. In addition, this document invites the involvement and support of parents as they work with their children to improve their achievement. Parents may use the samples of student work and the rubrics as:
- resources to help them understand the levels of achievement;
- models to help monitor their children’s progress from level to level;
- a basis for communication with teachers about their children’s achievement;
- a source of information to help their children monitor achievement and improve their performance;
- models to illustrate the application of the levels of achievement.

Students
Students are asked to participate in performance assessments in all curriculum areas. When students are given clear expectations for learning, clear criteria for assessment, and immediate and helpful feedback, their performance improves. Students’ performance improves as they are encouraged to take responsibility for their own achievement and to reflect on their own progress and “next steps”.

It is anticipated that the contents of this document will help students in the following ways:
- Students will be introduced to a model of one type of task that will be used to assess their learning, and will discover how rubrics can be used to improve their product or performance on an assessment task.
- The performance tasks and the exemplars will help clarify the curriculum expectations for learning.
- The rubrics and the information given in the Teacher’s Notes section will help clarify the assessment criteria.
- The information given under Comments/Next Steps will support the improvement of achievement by focusing attention on two or three suggestions for improvement.
- With an increased awareness of the performance tasks and rubrics, students will be more likely to communicate effectively about their achievement with their teachers and parents, and to ask relevant questions about their own progress.
- Students can use the criteria and the range of student samples to help them see the differences in the levels of achievement. By analysing and discussing these differences, students will gain an understanding of ways in which they can assess their own responses and performances in related assignments and identify the qualities needed to improve their achievement.
The Galapagos Islands: Oil Spill Near the Coast

The Task
Students were to research and examine environmental issues related to an oil spill off the coast of the Galapagos Islands. They were then to present their findings in graphic and written formats to be submitted to a fictitious youth science magazine. Specifically, they were to:

- conduct the research;
- create a graphic organizer to present information;
- create a flow chart depicting short-term and long-term effects of the spill;
- write a letter to the editor of a youth science magazine, supported with scientific facts, to express agreement or disagreement with an expert's statement on the effects of the spill and to suggest ways of reducing the risk of such a spill in the future.

Expectations
This task gave students the opportunity to demonstrate their achievement of all or part of each of the following selected overall and specific expectations from the strand Life Systems: Grade 7 – Interactions Within Ecosystems. (The codes that follow the expectations are from the Ministry of Education's Curriculum Unit Planner.)

Students will:
1. demonstrate an understanding of the interactions of plants, animals, fungi, and micro-organisms in an ecosystem (7s1);
2. investigate the interactions in an ecosystem, and identify factors that affect the balance among the components of an ecosystem (7s2);
3. demonstrate an understanding of the effects of human activities and technological innovations, as well as the effects of changes that take place naturally, on the sustainability of ecosystems (7s3);
4. identify living (biotic) and non-living (abiotic) elements in an ecosystem (7s4);
5. interpret food webs that show the transfer of energy among several food chains, and evaluate the effects of the elimination or weakening of any part of the food web (7s9);
6. investigate ways in which natural communities within ecosystems can change, and explain how such changes can affect animal and plant populations (7s11);
7. use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (7s15);
8. communicate the procedures and results of investigations for specific purposes and to specific audiences, using media works, oral presentations, written notes and descriptions, charts, graphs, and drawings (7s17);
9. investigate the impact of the use of technology on the environment (7s18);

10. identify and explain economic, environmental, and social factors that should be considered in the management and preservation of habitats (7s24).

**Prior Knowledge and Skills**

To complete this task, students were expected to have some knowledge or skills related to the following:

- investigating the interactions of components within an ecosystem
- using research materials to create point-form notes
- developing and using graphic organizers such as mind maps, webs, chains, and flow charts
- developing and creating a supported opinion piece

For information on the process used to prepare students for the exemplar task and on the materials and equipment required, see the Teacher Package reproduced on pages 42–48 of this document.
**Task Rubric – Grade 7: The Galapagos Islands: Oil Spill Near the Coast**

<table>
<thead>
<tr>
<th>Expectations*</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Understanding of Basic Concepts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The student:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1, 4, 5</td>
<td>- identifies a few relevant abiotic and biotic components of the ecosystem</td>
<td>- identifies some relevant abiotic and biotic components of the ecosystem</td>
<td>- identifies a considerable number of relevant abiotic and biotic components of the ecosystem</td>
<td>- identifies many relevant abiotic and biotic components of the ecosystem</td>
</tr>
<tr>
<td></td>
<td>- correctly depicts a few interactions between components of the ecosystem</td>
<td>- correctly depicts some interactions between components of the ecosystem</td>
<td>- correctly depicts a considerable number of interactions between components of the ecosystem</td>
<td>- correctly depicts many interactions between components of the ecosystem</td>
</tr>
<tr>
<td><strong>Inquiry Skills</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The student:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2, 6, 9</td>
<td>- supports opinion(s) with limited use of scientific facts</td>
<td>- supports opinion(s) with some use of scientific facts</td>
<td>- supports opinion(s) with adequate use of scientific facts</td>
<td>- supports opinion(s) with significant use of scientific facts</td>
</tr>
<tr>
<td><strong>Communication of Required Knowledge</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The student:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7, 8</td>
<td>- communicates understanding of components and interactions within ecosystems with limited clarity</td>
<td>- communicates understanding of components and interactions within ecosystems with some clarity</td>
<td>- clearly communicates understanding of components and interactions within ecosystems</td>
<td>- clearly and precisely communicates understanding of components and interactions within ecosystems</td>
</tr>
<tr>
<td></td>
<td>- makes limited use of appropriate science and technology vocabulary</td>
<td>- makes some use of appropriate science and technology vocabulary</td>
<td>- makes general use of appropriate science and technology vocabulary</td>
<td>- makes extensive use of appropriate science and technology vocabulary</td>
</tr>
<tr>
<td><strong>Relating of Science and Technology to Each Other and to the World Outside the School</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The student:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3, 9, 10</td>
<td>- makes limited predictions about the short-term and long-term effects of oil spills</td>
<td>- makes simple predictions about the short-term and long-term effects of oil spills</td>
<td>- makes reasonable predictions about the short-term and long-term effects of oil spills</td>
<td>- makes sophisticated predictions about the short-term and long-term effects of oil spills</td>
</tr>
<tr>
<td></td>
<td>- makes limited recommendations for reducing the risk of similar future events</td>
<td>- makes somewhat reasonable recommendations for reducing the risk of similar future events</td>
<td>- makes reasonable recommendations for reducing the risk of similar future events</td>
<td>- makes insightful and reasonable recommendations for reducing the risk of similar future events</td>
</tr>
</tbody>
</table>

*The expectations that correspond to the numbers given in this chart are listed on pages 12–13.

Note: This rubric does not include criteria for assessing student performance that falls below level 1.
Student Task Description

Students were presented with the following scenario and set of instructions:

Your science class regularly receives the science magazine Youth Science, which is aimed at teenagers and young adults. In the most recent issue, there is an article about an oil spill near the coast of the Galapagos Islands. In the article, an oil industry expert makes the following statement:

The recent oil spill off the coast of the Galapagos Islands will not cause any significant long-term damage to the environment because the components of the ecosystem will be able to cope with any changes caused by the spill.

Since your class has just finished studying ecosystems, your teacher has asked you to use information recently learned in class, as well as information gathered through your own research, to prepare a submission to Youth Science magazine in response to the expert’s statement.

Your response is to include:
1. a graphic organizer in the form of a web that will inform readers about the abiotic and biotic components of the Galapagos Islands as well as show how they interact;
2. a flow chart depicting the potential short-term and long-term effects of the spill on the components of the ecosystem;
3. a letter to the editor of Youth Science magazine, supported with scientific facts, expressing your agreement or disagreement with the expert’s statement, and suggesting ways of reducing the risk of such a spill in the future.
The Galapagos Islands: Oil Spill Near the Coast

Level 1, Sample 1

A

Web Organizer - Abiotic and Biotic Interactions

Instructions

Use the space provided below or the back of this page to create a web organizer:
- which shows the specific abiotic and biotic components of the Galapagos Islands' ecosystems;
- which clearly shows the relationships between the abiotic and biotic components;
- which is organized in a way that is easy to understand; and
- which includes labels that explain the connections between components.

Note: You may use words, arrows, small pictures, symbols, and colour to clarify the relationships.

B

Flow Chart Organizer - Short- & Long-Term Effects

Instructions

Add to the template provided below to build a flow chart organizer of the environmental, social, and economic consequences of the oil spill:
- which shows the short- and long-term effects;
- which shows a reasonable sequence of events for each consequence; and
- which lists as many ideas as possible for each heading.

Note: You may use words, arrows, small pictures, symbols, and colour to clarify the relationships.
Supported Opinion – Letter to the Editor

Instructions

Using your planning sheet, point-form notes, and any posted information in your classroom, create a Letter to the Editor of Youth Science magazine which:

- states whether you agree or disagree with the expert’s statement about the oil spill;
- supports your opinion with scientific facts using the information from your graphic organizers;
- suggests some reasonable actions to reduce the chance of such situations happening again;
- summarizes your viewpoint; and
- uses proper letter format (complete sentences and paragraphs).

[Letter to the Editor]

[Insert school, The Editor, Ontario, Youth Science magazine, May 2, 2001]

Dear Sir or Madam,

I agree with the statement that you put in the magazine.

My supporting arguments are when they clean up the spill, some oil particles will remain in the water and on shore but their will not be enough to harm the animals, plants, the ecosystem will be able to cope with any changes caused by the oil spill. The spill will not cause any long term damage.

Sincerely,

[Additional text if needed]
Teacher’s Notes

Understanding of Basic Concepts
- The student identifies a few relevant abiotic and biotic components of the ecosystem (e.g., Web Organizer: includes two abiotic components in drawing [sun and water], but does not label them; identifies the general group “bugs”, includes unlabelled drawings of land plants, and names a few bird and animal species, but includes no aquatic plants).
- The student correctly depicts a few interactions between components of the ecosystem (e.g., Web Organizer: uses words, arrows, and pictures/symbols to show a few interactions).

Inquiry Skills
- The student supports opinions with limited use of scientific facts (e.g., Letter: “Some oil particles will remain in the water and on shore but their will not be enough to harm the animals, plants.”).

Communication of Required Knowledge
- The student communicates understanding of components and interactions within ecosystems with limited clarity (e.g., Web Organizer: uses arrows to show that all living things need water to survive and each bird or animal eats at least one living thing: water → woodpecker → bugs).
- The student makes limited use of appropriate science and technology vocabulary (e.g., Web Organizer: labels some components [“water, woodpecker, dolphin”] but represents others only pictorially).

Relating of Science and Technology to Each Other and to the World Outside the School
- The student makes limited predictions about the short-term and long-term effects of oil spills (e.g., Flow Chart: clearly indicates only short-term effects: “Water pollution → plants will die ... fish will get sick”; shows no long-term effects).
- The student makes limited recommendations for reducing the risk of similar future events (e.g., Letter: “you can go on a different course, higher standards, build a stronger ship ...”).

Comments/Next Steps
- The student should work on developing science and technology vocabulary to communicate understanding more effectively (e.g., include labels to explain the relationships in the graphic organizers).
- The student should develop a more thorough understanding of key concepts related to ecosystems (e.g., more complex interactions, continuing cause-and-effect relationships).
- The student should correct spelling errors by referring to resources such as wall charts and a dictionary.
The Galapagos Islands: Oil Spill Near the Coast

Level 1, Sample 2

A

Web Organizer - Abiotic and Biotic Interactions

Instructions
Use the space provided below or the back of this page to create a web organizer:
- which shows the specific abiotic and biotic components of the Galapagos Islands' ecosystems;
- which clearly shows the relationships between the abiotic and biotic components;
- which is organized in a way that is easy to understand; and
- which includes labels that explain the connections between components.

Note: You may use words, arrows, small pictures, symbols, and colour to clarify the relationships.

B

Flow Chart Organizer - Short- & Long-Term Effects

Instructions
Add to the template provided below to build a flow chart organizer of the environmental, social, and economic consequences of the oil spill:
- which shows the short- and long-term effects;
- which shows a reasonable sequence of events for each consequence; and
- which lists as many ideas as possible for each heading.

Note: You may use words, arrows, small pictures, symbols, and colour to clarify the relationships.
C

Supported Opinion - Letter to the Editor

Instructions

Using your planning sheet, point-form notes, and any posted information in your classroom, create a Letter to the Editor of Youth Science magazine which:

- states whether you agree or disagree with the expert’s statement about the oil spill;
- supports your opinion with scientific facts using the information from your graphic organizers;
- suggests some reasonable actions to reduce the chance of such situations happening again;
- summarizes your viewpoint; and
- uses proper letter format (complete sentences and paragraphs).

School

Ontario

May 2nd, 2001

The editor

Youth Science Magazine

Dear Editor,

I disagree with the expert’s statement about the oil spill. I disagree because the plants and animals will die because the oil will go into the water, the fish will die, then the birds and animals will die.

D

and when some of the water evaporates it will rain onto the plants, and the plants will die.

Some ways to avoid this may be to properly equip the boats for a 100% safe that the oil will not spill or watch people don’t spill it on purpose. I disagree with the experts.

yours truly,
**Teacher’s Notes**

**Understanding of Basic Concepts**
- The student identifies a few relevant abiotic and biotic components of the ecosystem (e.g., Web Organizer: identifies two abiotic components; identifies the general groups “flowers” and “trees” but no aquatic plants; names a few bird and animal species).
- The student correctly depicts a few interactions between components of the ecosystem (e.g., Web Organizer: connects “bugs” to both “flowers” and “woodpecker”; misses a number of obvious connections such as “bugs” to “trees” or “trees” to “woodpecker”).

**Inquiry Skills**
- The student supports opinions with limited use of scientific facts (e.g., Letter: “the plants and animals will die because the oil will go into the water …”).

**Communication of Required Knowledge**
- The student communicates understanding of components and interactions within ecosystems with limited clarity (e.g., Web Organizer: uses arrows to indicate simple relationships of plants and animals not all of which are specific to the ecosystem of the Galapagos Islands).
- The student makes limited use of appropriate science and technology vocabulary (e.g. “soil pollution, water pollution, evaporates”; uses general terms, such as “flowers”, “trees”, rather than names for specific species).

**Relating of Science and Technology to Each Other and to the World Outside the School**
- The student makes limited predictions about the short-term and long-term effects of oil spills (e.g., Flow Chart: indicates mostly short-term effects such as “plants receive chemicals”, “media will report negatively”; identifies two medium-term effects: “company receives a bad reputation”, “people avoid the island”).
- The student makes limited recommendations for reducing the risk of similar future events (e.g., Letter: “properly equip the boats for a 100% sure that the oil won’t spill. Or watch people don’t spill it on purpose.”).

**Comments/Next Steps**
- The student needs to develop science and technology vocabulary in order to communicate more clearly and effectively.
- The student needs to use more information from previous learning and research to support opinions with facts and examples.
- The student should correct spelling errors by referring to resources such as wall charts and a dictionary.
The Galapagos Islands: Oil Spill Near the Coast  

Level 2, Sample 1

A

Web Organizer – Abiotic and Biotic Interactions

Instructions:
- Use the space provided below or the back of this page to create a web organizer:
  - which shows the specific abiotic and biotic components of the Galapagos Islands’ ecosystems;
  - which clearly shows the relationships between the abiotic and biotic components;
  - which is organized in a way that is easy to understand; and
  - which includes labels that explain the connections between components.

Note: You may use words, arrows, small pictures, symbols, and colour to clarify the relationships.

B

Flow Chart Organizer – Short- & Long-Term Effects

Instructions:
Add to the template provided below to build a flow chart organizer of the environmental, social, and economic consequences of the oil spill:
- which shows the short- and long-term effects;
- which shows a reasonable sequence of events for each consequence; and
- which lists as many ideas as possible for each heading.

Note: You may use words, arrows, small pictures, symbols, and colour to clarify the relationships.
Dear editor of Youth Science Magazine,

I am writing to state that I don't agree with the statement made in your magazine.

I think it will cause long-term damage, it will act as a pesticide to the land and sea life. It will pollute the waters and kill off the sea life. It will also affect the wildlife because the animals drink the water and eat the fish. So it will definitely damage the food chain, population and may endanger different species.

Sincerely,

May 23, 2001

Here are some ways we can make sure this never happens again. Don’t take oil from around the Galapagos. Don’t transport oil under the airports. Get all bombs and sponges far from the islands. We need prevent this from happening again.

To summarise, this oil is a killer. This can be prevented and it should be.
Teacher’s Notes

Understanding of Basic Concepts
– The student identifies some relevant abiotic and biotic components of the ecosystem (e.g., Web Organizer: identifies three abiotic components but no aquatic plants and few marine animals; identifies general groups of animals, such as “snakes”, “insects”, “fish”, “birds”, “rodents”, rather than particular species).
– The student correctly depicts some interactions between components of the ecosystem (e.g., Web Organizer: shows some connections between biotic components and between biotic and abiotic components; shows no connections between abiotic components).

Inquiry Skills
– The student supports opinions with some use of scientific facts (e.g., Letter: “It will also effect the life on land because the animals drink the water and eat the fish. So it will definitely damage the food chain...”).

Communication of Required Knowledge
– The student communicates understanding of components and interactions within ecosystems with some clarity (e.g., Web Organizer: uses arrows to indicate some interactions that occur in nature: sun, soil, and water → plants → animals; water → fish).
– The student makes some use of appropriate science and technology vocabulary (e.g., “pollute, pestaside, food chain, species”).

Relating of Science and Technology to Each Other and to the World Outside the School
– The student makes simple predictions about the short-term and long-term effects of oil spills (e.g., Letter: “I think it will cause long term damage. It will act as a pestaside to the land and sea life... So it will definitely damage the food chain, population and may endanger different species.”).
– The student makes somewhat reasonable recommendations for reducing the risk of similar future events (e.g., Letter: “Don’t take oil from around the Galapagos. Don’t transport oil near the galapagos. Get oil from other areas.”).

Comments/Next Steps
– The student needs to improve understanding of short-term and long-term environmental effects and their relationship to economic and social effects.
– The student needs to use more information from previous learning and research to support opinions with facts and examples.
– The student should correct spelling errors by referring to resources such as wall charts and a dictionary.
Web Organizer: Abiotic and Biotic Interactions

Instructions
Use the space provided below or the back of this page to create a web organizer:
• which shows the specific abiotic and biotic components of the Galapagos Islands' ecosystems;
• which clearly shows the relationships between the abiotic and biotic components;
• which is organized in a way that is easy to understand; and
• which includes labels that explain the connections between components.

Note: You may use words, arrows, small pictures, symbols, and colour to clarify the relationships.

Flow Chart Organizer: Short- & Long-Term Effects

Instructions
Add to the template provided below to build a flow chart organizer of the environmental, social, and economic consequences of the oil spill:
• which shows the short- and long-term effects;
• which shows a reasonable sequence of events for each consequence; and
• which lists as many ideas as possible for each heading.

Note: You may use words, arrows, small pictures, symbols, and colour to clarify the relationships.
C

Supported Opinion – Letter to the Editor

Instructions

Using your planning sheet, point-form notes, and any posted information in your classroom, create a Letter to the Editor of Youth Science magazine which:

- states whether you agree or disagree with the expert’s statement about the oil spill;
- supports your opinion with scientific facts using the information from your graphic organizers;
- suggests some reasonable actions to reduce the chance of such situations happening again;
- summarizes your viewpoint; and
- uses proper letter format (complete sentences and paragraphs).

School
Ontario
May 3, 2001

The editor Youth Science Magazine

Dear Sir or Madam:

To whom it may concern I don’t agree with the letter that the editor wrote at all. I found it an out rage to me and several friends of mine.

I disagree with the letter that you wrote because I know that not all animals will adapt. Actually almost none (of) all of the animals on these (island) islands will die after a long time, some will die in shorter period of time. So you should take care of it now before something else dies, like plant life on the islands. I disagree with your letter because you guys are not taking the necessary precautions and they are not taking us (seriously). Seriously many animals are dying because there accidents.

To prevent this from happening again you can move the cargo area where the oil is being kept or you can get a better system in the boat. I got one more idea and it’s to make the caption and crew to take a special course where they become better in the area they working in.

Now that you know why I disagree with your letter I hope you take us seriously and take the necessary precautions in cleaning this mess up.
**Teacher’s Notes**

**Understanding of Basic Concepts**
- The student identifies some relevant abiotic and biotic components of the ecosystem (e.g., Web Organizer: identifies two abiotic and several biotic components of the Galapagos ecosystem; uses general names, such as “birds”, rather than species names such as “blue-footed booby”).
- The student correctly depicts some interactions between components of the ecosystem (e.g., Web Organizer: shows interactions between abiotic components and between biotic and abiotic components; shows interactions between a few biotic components but not all: dolphin and “Tortois” do not receive energy from any component).

**Inquiry Skills**
- The student supports opinions with some use of scientific facts (e.g., Flow Chart: shows that plants, animals, birds, and fish will die as a result of soil and water pollution).

**Communication of Required Knowledge**
- The student communicates understanding of components and interactions within ecosystems with some clarity (e.g., Letter: “I know that not all animals will adapt … So you should take care of it now before somthing else dies like plant life on the islands.”).
- The student makes some use of appropriate science and technology vocabulary (e.g., “polution, consumer, adapt”).

**Relating of Science and Technology to Each Other and to the World Outside the School**
- The student makes simple predictions about the short-term and long-term effects of oil spills (e.g., Letter: “… not all animals will adapt. Actually almost all of the animals on these islands will die after a long time, some will die in shorter period of time … take care of it now before somthing else dies like plant life on the islands.”).

- The student makes somewhat reasonable recommendations for reducing the risk of similar future events (e.g., Letter: “you can rean force [reinforce] the cargo area were the oil is being kept, or you can get a better system in the boat … make the captain and crew to take a special course were they become better in the area there working in.”).

**Comments/Next Steps**
- The student should select more pertinent information from previous learning and research in order to support opinions with facts and examples.
- The student should use science and technology vocabulary when making scientific explanations.
- The student should correct spelling errors by referring to resources such as wall charts and a dictionary.
The Galapagos Islands: Oil Spill Near the Coast

Level 3, Sample 1

A

Legend

- Biotic Factors in Galapagos
- Abiotic Factors in Galapagos
- Interactions between biotic factors (arrow pointing at the consumer)
- Interactions between abiotic and biotic factors (arrow pointing at the affected)
- Interactions between abiotic factors (arrow pointing at the affected)

Exception:
Air affects all animals except fishes, mollusks, squids, and sea invertebrates

Tips: Read one thing at a time. Take notes as you read it.
Flow Chart Organizer – Short- & Long-Term Effects

Instructions
Add to the template provided below to build a flow chart organizer of the environmental, social, and economic consequences of the oil spill:
- which shows the short- and long-term effects;
- which shows a reasonable sequence of events for each consequence; and
- which lists as many ideas as possible for each heading.

Note: You may use words, arrows, small pictures, symbols, and colour to clarify the relationships.

Supported Opinion – Letter to the Editor

Instructions
Using your planning sheet, point-form notes, and any posted information in your classroom, create a Letter to the Editor of Youth Science magazine which:
- states whether you agree or disagree with the expert’s statement about the oil spill;
- supports your opinion with scientific facts using the information from your graphic organizers;
- suggests some reasonable actions to reduce the chance of such situations happening again;
- summarizes your viewpoint; and
- uses proper letter format (complete sentences and paragraphs).

Dear Editor of Youth Science,

I strongly disagree with the oil expert’s comments on the Galapagos Oil Spill. If the oil spills, it will not cause any significant long-term effects on the environment because the components of the ecosystem will be able to cope with any changes created by the oil spill.

According to my research, the water would be contaminated, causing many marine lives to die. The animals that feed on nothing but marine lives will starve and decrease in number. Some species could become extinct because they cannot get enough food. The animals that eat land organisms as well as marine ones may soon or very soon go extinct. The land organisms that are preyed on can become rare or extinct because the predators rely on them as food more than usual. Furthermore, Galapagos Islands ecosystem is extremely delicate. Both kinds of predators...
Understanding of Basic Concepts
- The student identifies a considerable number of relevant abiotic and biotic components of the ecosystem (e.g., Web Organizer: lists five abiotic components, two aquatic plants, a variety of land and marine animal species, and several bird species; does not list any land plants).
- The student correctly depicts a considerable number of interactions between components of the ecosystem (e.g., Web Organizer: relates the warmth of the sun and sand to the hatching of tortoise eggs; relates the role of air, soil, water, and sun to the growth of mangrove trees; in explanation of “Legend” on back of Web Organizer, relates the role of air to “all animals except fishes, mollusks, squids, and sea invertebrates”).

Inquiry Skills
- The student supports opinions with adequate use of scientific facts (e.g., Flow Chart: “The foodchains would be unbalanced”; Letter: “... the water would be contaminated, causing many marine lives to die. The animals that feed on nothing but marine lives will starve and decrease in number/become extinct ...”).

Communication of Required Knowledge
- The student clearly communicates understanding of components and interactions within ecosystems (e.g., Web Organizer: uses labels to specify types of interactions between abiotic and biotic components; uses colour codes to differentiate abiotic and biotic components and interactions and explains codes in “Legend” on back of Web Organizer).
- The student makes general use of appropriate science and technology vocabulary (e.g., “ecologist, herbivorous, carnivorous, invertebrates, phytoplankton”).

Some preventive measures can be taken to prevent the crisis from repeating itself. For example, more severe and painful punishments can be used. For another, they can use stronger materials to make containers. A third suggestion is to reduce the number of ships sailing through the area to cut down the risk. If the Ecuadorian government thinks this last suggestion is too hard to do, it can prohibit non-resident fishing, and people who own fishing boats have to buy a license for fishing in the area. To conclude, there will be a long-term effect on the ecosystem. If people are not careful, history won’t repeat itself. Next time you want comments on ecosystems, please ask a ecologist instead of an oil expert.

With due respect,
A reader
Relating of Science and Technology to Each Other
and to the World Outside the School
- The student makes reasonable predictions about the short-term and long-
term effects of oil spills (e.g., Flow Chart: “Short Term Affects: The water
would be polluted/the foodchains would be unbalanced ...”; “Long Term
Affects: Take long time or never to recover”).
- The student makes reasonable recommendations for reducing the risk of
similar future events (e.g., Letter: “… use stronger materials to make con-
tainers ... reduce the number of ships sailing through the area to cut down
the risk.”).

Comments/Next Steps
- The student’s complex organizer is supported by a clear legend.
- The student should group items in graphic organizers to clarify connections.
- The student should explore in more detail the connections between short-
term and long-term effects of environmental accidents.
The Galapagos Islands: Oil Spill Near the Coast  
Level 3, Sample 2

A  
Web Organizer - Abiotic and Biotic Interactions

Instructions
Use the space provided below or the back of this page to create a web organizer:
- which shows the specific abiotic and biotic components of the Galapagos Islands’ ecosystems;
- which clearly shows the relationships between the abiotic and biotic components;
- which is organized in a way that is easy to understand; and
- which includes labels that explain the connections between components.

Note: You may use words, arrows, small pictures, symbols, and colour to clarify the relationships.

B  
Flow Chart Organizer - Short- & Long-Term Effects

Instructions
Add to the template provided below to build a flow chart organizer of the environmental, social, and economic consequences of the oil spill:
- which shows the short- and long-term effects;
- which shows a reasonable sequence of events for each consequence; and
- which lists as many ideas as possible for each heading.

Note: You may use words, arrows, small pictures, symbols, and colour to clarify the relationships.
C

Supported Opinion – Letter to the Editor

Instructions

Using your planning sheet, point-form notes, and any posted information in your classroom,
create a Letter to the Editor of Youth Science magazine which:

• states whether you agree or disagree with the expert’s statement about the oil spill;
• supports your opinion with scientific facts using the information from your graphic organizers;
• suggests some reasonable actions to reduce the chance of such situations happening again;
• summarizes your viewpoint; and
• uses proper letter format (complete sentences and paragraphs).

I disagree with the expert’s statement regarding the oil spill near the Galapagos Islands and how he said that there will be no long term effects because the animals can cope. There is no doubt that the oil will poison the water which destroys habitats and poisons animals. Oil harms animals in three different ways: poisoning by ingestion (the animals eating it), direct contact and destroying habitats, and it is impossible for the oil to not be at least one of these three. The oil could wipe out an entire species and damage the food web. It could wipe out a type of animal only found in the Galapagos. The marine environment will be definitely contaminated, some lines

D

Beaches and parks. The oil gets carried by the waves and completely covers beaches in oil and then another animal eats the bird and is now affected. The animals do not know what oil is so that it can harm them therefore, we will not be cautious. In order to prevent this problem from recurring, we could take more oil on each trip, which means there would be less trips, let a clean up crew know the exact route and the fastest way there. We could also have some clean up equipment on the tanker (enough to clean it down) but we have to definitely get a crew there soon because the longer it stays the longer the effects will be. These small efforts are a small price to pay to save the lives and beautiful animals on the coasts. I think that we should all make an effort to prevent a totally harmful and preventable situation.
Teacher’s Notes

Understanding of Basic Concepts
– The student identifies a considerable number of relevant abiotic and biotic components of the ecosystem (e.g., Web Organizer: lists three abiotic components and a considerable range of biotic components, including several species of land and sea animals, plants, and birds).
– The student correctly depicts a considerable number of interactions between components of the ecosystem (e.g., Web Organizer: outlines relationships among water, soil, decomposers, plants, plant eaters, and meat eaters).

Inquiry Skills
– The student supports opinions with adequate use of scientific facts (e.g., Letter: “Oil harms animals in three different ways, poisoning by ingestion [by animal eating it], direct contact and destroying habitats ... The oil gets carried by the waves and completely covers birds in oil ... ”).

Communication of Required Knowledge
– The student clearly communicates understanding of components and interactions within ecosystems (e.g., Flow Chart: “Pollutes water ➔ kills biotic elements in water ... ➔ less/no food for animals that depend on plants/fish (marine iguana) ➔ will mess up food chain/web by killing species ➔ animal eats a poisoned animal ... ➔ other anial [animal]/flamingo is now effected”).
– The student makes general use of appropriate science and technology vocabulary (e.g., “pollutes, biotic, food chain, species, habitat, algae, decompose”).

Relating of Science and Technology to Each Other and to the World Outside the School
– The student makes reasonable predictions about the short-term and long-term effects of oil spills (e.g., Flow Chart, Social effects: “will effect people living on the islands ➔ will effect studies being done ➔ less people want to visit the islands ... ➔ no work for tour guides”).

– The student makes reasonable recommendations for reducing the risk of similar future events (e.g., Letter: “... take more oil on each trip, which means there would be less trips. Let a clean up crew know the exact route and the fastest way there. We could also have some clean up equipment on the tanker ... ”).

Comments/Next Steps
– The student needs to improve understanding of the technology used in clean-up operations and its limitations for dealing with the effects of oil spills.
– The student should investigate further the economic implications of environmental disasters.
– The student should use proper letter format, including a salutation and closing, in his or her letter to the editor.
The Galapagos Islands: Oil Spill Near the Coast

Web Organizer: Abiotic and Biotic Interactions

Instructions:
Use the space provided below or the back of this page to create a web organizer:
- which shows the specific abiotic and biotic components of the Galapagos Islands’ ecosystems;
- which clearly shows the relationships between the abiotic and biotic components;
- which is organized in a way that is easy to understand; and
- which includes labels that explain the connections between components.

Note: You may use words, arrows, small pictures, symbols, and colour to clarify the relationships.

Flow Chart Organizer – Short- & Long-Term Effects

Instructions:
Add to the template provided below to build a flow chart organizer of the environmental, social, and economic consequences of the oil spill:
- which shows the short and long term effects;
- which shows a reasonable sequence of events for each consequence; and
- which lists as many ideas as possible for each heading.

Note: You may use words, arrows, small pictures, symbols and colour to clarify the relationships.
Dear Editor of Youth Science Magazine,

I am totally opposed to the statement in which the oil company denies the long-term effects of the oil spills on the Galapagos Islands.

Certainly, the oil can be cleaned up but parts of the oil may be trapped in place we have no way of recovering them. The sound of the dwellers would never come like a Marine iguana. Sea lions, fur seals, Galapagos Penguins, and Blue-footed Boobies may spread the oil to lands. The oil could affect the vegetation like Dutch Peak cactus and mangrove trees. Well die from the oil affecting the nutrient in the soil. The oil may be trapped in coral's brains, contaminating the food habitat of fish like the Threatened Blue-Footed Booby, First Wala and Tapa. And because of the process of

biological amplification, the animals that eat these fish, like sea eagles, Green sea turtles, sea lions, fur seals, Galapagos Penguins, and boobies. The oil would also stick to rocks & sand, effecting the habitat of all these animals.

There are many ways we could use to try and avoid this problem in the future. We could use alternative routes and totally bypass the Galapagos Islands. We could thoroughly check the tanks’ hull to make sure there are no leaks as well as make the hulls with two layers made on courses. The tankers should know how to handle oil spills. We should also use less oil. That means the less oil used, the less oil we have to ship.

I happen wanted to speak out about my opinion about this important subject so another tragedy like the one in the Galapagos never happens again. But remember, the oil will effect the environment so don’t think it won’t. We should also have better transport methods and be careful with our oil.

A Concerned Reader.
**Teacher’s Notes**

**Understanding of Basic Concepts**
- The student identifies many relevant abiotic and biotic components of the ecosystem (e.g., Web Organizer: identifies abiotic components of sun, water, and soil; identifies a variety of biotic components including several species of land and water plants, animals, and birds such as seaweed, prickly pear, mangrove, lava lizard, parrot fish, booby, frigate bird).
- The student correctly depicts many interactions between components of the ecosystem (e.g., Web Organizer: abiotic to biotic – soil to mangrove tree; abiotic to abiotic – water to soil; biotic to biotic – milk fish to green sea turtle).

**Inquiry Skills**
- The student supports opinions with significant use of scientific facts (e.g., Letter: “The oil could effect the vegetation like Prickly Pear Cactus and Mangrove Trees, and will die from the oil effecting the nutrients in the soil.”; “The oil would also stick to rocks and sand effecting the habitat of all these animals.”).

**Communication of Required Knowledge**
- The student clearly and precisely communicates understanding of components and interactions within ecosystems (e.g., Flow Chart: “Oil would cause immediate danger for the infection of fish ... as well as animals that depend on fish ...”; “The pollutants would cause ... higher pH levels in precipitation do [due] to the evaporation of the oil into the atmosphere.”).
- The student makes extensive use of appropriate science and technology vocabulary (e.g., “process, biological amplification, nutrients, habitat, contaminating”).

**Relating of Science and Technology to Each Other and to the World Outside the School**
- The student makes sophisticated predictions about the short-term and long-term effects of oil spills (e.g., Flow Chart, Economic effects: “The oil company would ... use new, more expensive transportation route”; Social effects: “Protests & boycotts would occur for oil spills”; “Funds & Projects would be created to help the Galapagos”).

- The student makes insightful and reasonable recommendations for reducing the risk of similar future events (e.g., Letter: “… use alternative routes of transport and totally bypass the ... Islands”; “… thoroughly check the boat’s hull to make sure there are no leaks as well as make the hulls with two layers incase of breaks ... We should also use less oil ...”).

**Comments/Next Steps**
- The student should improve skills in presenting information in graphic organizers to make the information easier to read.
- The student should provide more extensive explanations when supporting opinions.
**The Galapagos Islands: Oil Spill Near the Coast**

**Web Organizer—Abiotic and Biotic Interactions**

**Instructions**
- Use the space provided below or the back of this page to create a web organizer:
  - which shows the specific abiotic and biotic components of the Galapagos Islands' ecosystems;
  - which clearly shows the relationships between the abiotic and biotic components;
  - which is organized in a way that is easy to understand; and
  - which includes labels that explain the connections between components.

*Note:* You may use words, arrows, small pictures, symbols, and colour to clarify the relationships.

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**Flow Chart Organizer—Short- & Long-Term Effects**

**Instructions**
- Add to the template provided below to build a flow chart organizer of the environmental, social, and economic consequences of the oil spill:
  - which shows the short- and long-term effects;
  - which shows a reasonable sequence of events for each consequence; and
  - which lists as many ideas as possible for each heading.

*Note:* You may use words, arrows, small pictures, symbols, and colour to clarify the relationships.
Understanding of Basic Concepts

- The student identifies many relevant abiotic and biotic components of the ecosystem (e.g., Web Organizer: abiotic – soil, rocks, sun, water; biotic – several species of land and water plants, animals, and birds, such as sea turtle, plankton, giant tortoise, bat, king angel).

- The student correctly depicts many interactions between components of the ecosystem (e.g., Web Organizer: abiotic to abiotic – sun to soil and rocks, sun to water; abiotic to biotic – sun to plankton, water to sea plants, sun to soil and rocks; biotic to biotic – plankton to whale, king angel, and sea turtle; bat to fruit tree and insects).

Inquiry Skills

- The student supports opinions with significant use of scientific facts (e.g., Letter: “The islands contain as many as 85 different species of birds …”; “… countless fish species may go extinct for the reason that the oil may block the fish’s gills. This would limit the amount of food obtained by carnivores/omnivores …”).

Communication of Required Knowledge

- The student clearly and precisely communicates understanding of components and interactions within ecosystems (e.g., Letter: “… the islands are bursting with living creatures, especially around the shoreline. Now, the oil spill itself occurred on the shoreline. This would not only contaminate the water, but also the soil near the shoreline … countless fish species may go extinct … this would limit the amount of food obtained by carnivores/omnivores …”).

- The student makes extensive use of appropriate science and technology vocabulary (e.g., “species, subspecies, archipelago”).

Teacher’s Notes

The Ontario Curriculum – Exemplars, Grades 7 and 8: Science and Technology
Relating of Science and Technology to Each Other and to the World Outside the School

- The student makes sophisticated predictions about the short-term and long-term effects of oil spills (e.g., Flow Chart, Economic effects: “Tourists won’t want to go to the island → Islands will lose one of the two main sources of income – tourism”; “Fish industries will suffer → Islands will lose its second main source of income”; “Oil company may lose money → Cleaning up … and monitoring selected sites and species won’t be possible due to lack of money.”).
- The student makes insightful and reasonable recommendations for reducing the risk of similar future events (e.g., Letter: “We can prohibit [prohibit] ships from travelling near environmentally sensitive areas, and make sure that all tankers are double-hulls along with a captain only being licensed if he or she meets strict international standards for piloting ships.”).

Comments/Next Steps

- The student should use a variety of reliable resources to ensure that all scientific facts used are accurate.
- The student should continue to develop and use appropriate science and technology vocabulary.
Teacher Package

Science and Technology Exemplar Task
Grade 7

Title: The Galapagos Islands: Oil Spill Near the Coast

Time Requirements: 320 minutes (over several class periods)

- Introductory activities
  - Pre-task 1: 60 minutes
  - Pre-task 2: 40 minutes
  - Pre-task 3: 60 minutes

- Exemplar task
  - Part 1: 40 minutes
  - Part 2: 40 minutes
  - Part 3: 40 minutes
  - Part 4: 40 minutes

Description of the Task
Students will research and examine environmental issues related to an oil spill near the coast of the Galapagos Islands. They will present their findings in graphic and written formats for submission to a youth science magazine.

Students will complete the worksheets provided in this package and submit selected worksheets for assessment.

Scenario and Instructions for Students
Students should be presented with the following scenario and set of instructions:

Your science class regularly receives the science magazine Youth Science, which is aimed at teenagers and young adults. In the most recent issue, there is an article about an oil spill near the coast of the Galapagos Islands. In the article, an oil industry expert makes the following statement:

The recent oil spill off the coast of the Galapagos Islands will not cause any significant long-term damage to the environment because the components of the ecosystem will be able to cope with any changes caused by the spill.

Since your class has just finished studying ecosystems, your teacher has asked you to use information recently learned in class, as well as information gathered through your own research, to prepare a submission to Youth Science magazine in response to the expert’s statement.

Your response is to include:
1. a graphic organizer in the form of a web that will inform readers about the abiotic and biotic components of the Galapagos Islands as well as show how they interact;
2. a flow chart depicting the potential short-term and long-term effects of the spill on the components of the ecosystem;
3. a letter to the editor of Youth Science magazine, supported with scientific facts, expressing your agreement or disagreement with the expert’s statement, and suggesting ways of reducing the risk of such a spill in the future.

Curriculum Expectations Addressed in the Task
Note that the codes that follow the expectations relate to the Ministry of Education’s Curriculum Unit Planner (CD-ROM).

Students will:
1. demonstrate an understanding of the interactions of plants, animals, fungi, and microorganisms in an ecosystem (7s1);
2. investigate the interactions in an ecosystem, and identify factors that affect the balance among the components of an ecosystem (e.g., forest fires, parasites) (7s2);
3. demonstrate an understanding of the effects of human activities and technological innovations, as well as the effects of changes that take place naturally, on the sustainability of ecosystems (7s3);
4. identify living (biotic) and non-living (abiotic) elements in an ecosystem (7s4);
5. interpret food webs that show the transfer of energy among several food chains, and evaluate the effects of the elimination or weakening of any part of the food web (7s9);
6. investigate ways in which natural communities within ecosystems can change, and explain how such changes can affect animal and plant populations (e.g., changes affecting their life span, their gestation periods, or their ability to compete successfully) (7s11);
7. use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (e.g., use scientific terms such as biosphere, biome, ecosystem, species) (7s15);
8. communicate the procedures and results of investigations for specific purposes and to specific audiences, using media works, oral presentations, written notes and descriptions, charts, graphs, and drawings (e.g., design a multimedia presentation explaining the interrelationships of biotic and abiotic elements in a specific ecosystem) (7s17);
9. investigate the impact of the use of technology on the environment (7s18);
10. identify and explain economic, environmental, and social factors that should be 
    considered in the management and preservation of habitats (e.g., the need for 
    recycling; the need for people to have employment) (7s24).

“Big Ideas”
Based on the above expectations, the following “big ideas” for this task have been identified:
• Ecosystems are composed of abiotic and biotic components that interact dynamically with 
  one another.
• Natural and human-induced changes affect the health of an ecosystem.

Teacher Instructions
Prior Knowledge and Skills Required
Before attempting the task, students should have had experience with the following:
• investigating the interactions of components within an ecosystem
• using research materials to create point-form notes
• developing and using graphic organizers such as mind maps, webs, chains, and flow charts
• developing and creating a supported opinion piece (e.g., in the form of a paragraph or letter)

The Rubric
The rubric* provided with this exemplar task is to be used to assess students’ work. The rubric is 
based on the achievement levels outlined on page 13 of The Ontario Curriculum, Grades 1-8: 

Introduce the task-specific rubric to students at least one day before administering the task. Copy 
the rubric for students or create a transparency to use with the class. You may find it useful to 
rephrase the rubric for students to help them in their work.

Review the elements of the rubric with students to ensure that they understand the criteria and 
the descriptions for achievement at each level. Allow ample class time for a thorough reading and 
discussion of the assessment criteria outlined in the rubric. You may also find it beneficial to 
create assessment criteria collaboratively with your students.

Accommodations
Accommodations that are normally provided in the regular classroom for students with special 
needs should be provided in the administration of the exemplar task.

Classroom Set-up
A method of storing and sharing collected pictures and associated reference material will be 
needed (e.g., a table display, bulletin board, wall display).

Materials Needed
- writing instruments
- chart paper
- markers
- pencil crayons
- a variety of resource materials including pictures and other visuals related to the Galapagos 
  Islands and to oil spills (e.g., books, list of websites, magazines)
- access to the library and the Internet

Safety Considerations
There are no additional safety considerations beyond normal classroom safety practices required 
for these tasks.

Task Instructions
Introductory Activities
The pre-tasks are designed to review and reinforce the skills that students will require for the 
exemplar task. Although the exemplar task is to be completed in its entirety at school, some 
research for the pre-tasks is to be completed at home.

Pre-task 1: Introducing the Scenario
This activity provides students with experiences paralleling those required in the exemplar task.

1. Present the following scenario to your class:
   A tanker truck is transporting a toxic chemical along Highway 60 through Algonquin Park. 
   The truck is involved in an accident and spills its load of toxic chemicals beside the road. You 
   are to decide whether or not this would be harmful to the ecosystem in the short or long term.

2. A sk students to brainstorm a list of abiotic and biotic components found in the Algonquin 
   Park forest ecosystem. Record these components on the board or on chart paper.

3. Review with students different types of graphic organizers such as webs, pyramids, and flow 
   charts and discuss how they can be used to represent relationships visually. Then use a web to 
   illustrate the interrelationships among the listed components, emphasizing features such as 
   words, arrows, small pictures, symbols, and color that can be used to show connections 
   within the web (see Appendix 1).

4. Discuss with students some of the possible short-term and long-term environmental, social, 
   and economic consequences of this spill. Model the use of a flow chart to show the possible 
   sequence of events (see Appendix 2).

5. Review the features of a supported opinion letter (see Appendix 3). Encourage students to 
   support their opinions about the consequences of the spill with as many reasonable and 
   factual scientific ideas as possible. Students are expected to use specific information from 
   their webs and flow charts to develop their arguments and support their opinions.

*The rubric is reproduced on page 14 of this document.
6. Explain to students that they will be going through this same process in a more formalized way in the exemplar task about the effects of an oil spill off the coast of the Galapagos Islands.

7. Give each student a copy of the student scenario. Go over the components of the task (a graphic organizer such as a web or flow chart, and a letter to the editor).

8. Copy the rubric for students or create a transparency to use with the class. Explain the features of the rubric. Allow time for students to ask questions for clarification.

9. Do not allow students to keep a copy of the student scenario or the rubric at this time. They will be provided with these when completing the exemplar task.

Pre-task 2: Conducting the Research

The research conducted by students for Pre-tasks 2 and 3 will be used for the exemplar task.

1. Divide the class into two groups. Have one group research the abiotic and biotic components of the Galapagos Islands, while the other group researches the transportation of oil by water and the effects that oil has on the environment when it is spilled into an ocean. Tell students that they will be responsible for reporting back to the whole class. Ask each student to bring some information (including pictures, if possible) about his or her topic to class for use the next day.

2. Have students carry out research in the library and/or in the computer lab. Spend some time with each of the two groups to focus the research and make sure that each student is making point-form notes on his or her topic. Try to collect as many pictures about the topic as possible.

3. Tell students that they are expected to continue with their research at school or at home, using the resources they have collected. They may collect their own notes on both topics if they wish, but they are responsible for reporting to the class only on their assigned topic. Tell them that they may bring only their point-form notes to class.

4. Since students will not be evaluated on their research skills during the exemplar task, it is recommended that you also collect as much supporting data for the topics as possible to assist students.

Pre-task 3: Collating and Displaying Research Results

1. Have students sit in groups of three or four with others who have researched the same topic. Ask them to share their data, recording it in large print on chart paper so that it can be easily read by other students in the room. (20 minutes)

2. Have the students post their chart paper around the room. Go over the information with the class to explain and expand on the concepts related to the Galapagos Islands (20 minutes). Then review the information posted by students dealing with oil and oil spills (20 minutes). Teachers should add to or clarify the information presented at this time.

3. Remind students that, when they begin the exemplar task next day, they will be using these charts, their personal point-form notes, and the collection of pictures acquired to assist them in this process.

Exemplar Task

The completed student worksheets “Web Organizer – A biotic and Biotic Interactions”, “Flow Chart Organizer – Short- & Long-Term Effects”, and “Supported Opinion – Letter to the Editor” (see Appendices 4, 5, and 7) are to be submitted for marking.

Part 1: Web Organizer – A biotic and Biotic Interactions

1. Distribute a copy of the Student Package and the assessment rubric to each student. Refer students to the scenario and the web organizer (see Appendix 4).

2. Remind students of the type of thinking they did during the introductory activity on the toxic chemical spill in Algonquin Park. Review with them the expectations for web organizers.

3. Clearly state the time parameters (40 minutes) for completing the task outlined on the worksheet “Web Organizer – A biotic and Biotic Interactions”. Ensure that students work individually and that they use only the point-form notes on the chart paper or from their own research.

Part 2: Flow Chart Organizer – Short- & Long-Term Effects

1. Refer students to the flow chart organizer (see Appendix 5).

2. Review the components of effective flow charts, emphasizing the possibility of multiple branches within the flow of events. (Show students the diagram in Appendix 2)

3. Clearly state the time parameters (40 minutes) for completing the task outlined on the flow chart worksheet reproduced in Appendix 5. Ensure that students work individually and that they use only the point-form notes on the chart paper or from their own research.

Part 3: Planning the Supported Opinion – Letter to the Editor

Note: This section has been included to help guide students in the organization of their ideas. It will not be part of the evaluation of the exemplar task.

1. Review the components for a supported opinion such as a letter to the editor (see Appendix 3). Refer also to the introductory activity on the toxic chemical spill in Algonquin Park.

2. Have students use the “Supported Opinion – Letter to the Editor” planning sheet (see Appendix 6) to help them plan their letters. Students are expected to use information from their graphic organizers and the data related to the task posted within the classroom to support their ideas for their letters.
Part 4: Writing the Supported Opinion - Letter to the Editor
1. Refer students to the worksheet “Supported Opinion - Letter to the Editor” (see Appendix 7).
2. Review the instructions with students, emphasizing the requirements of the letter.
3. Remind students to use their letter to the editor planning sheets (see Appendix 6) to help create their letters.
4. Clearly state the time parameters (40 minutes) for completing the task outlined on the worksheet, and ensure that students work individually.

Appendix 1

Teacher Guidelines: Web Organizer

- Ensure that students are aware that directional arrows may indicate the dependence of one item on another and the flow of materials in an ecosystem: for example, food chains/webs, energy pyramids, abiotic cycles (water cycle, carbon cycle).
- Emphasize the importance of including some of the connections between abiotic and biotic components within an ecosystem: for example, water ➔ insects; soil ➔ plants.
- Remind students that producers are the initial source of energy in any ecosystem. For example, in the case of the Algonquin Park ecosystem, the primary producers are the trees.
- Inform students that words are as appropriate to use as pictures with their webs.
- Recommend that colour be used to highlight visually the different types of connections and interactions in students' webs (e.g., purple for food relationships, green for shelter).
- Encourage students to keep their webs clearly organized and easy to read.
- Encourage students to provide descriptions on their arrows that clarify the reasons for their connections.
- Remind students to refer to the resources available in the classroom whenever they are needed.

A Sample Representation of the Algonquin Web

```
Soil
  | (anchor, nutrients)
  v (warmth)
Balsam fir tree
  | (food)
  v
Sun
  | (nutrients)
  v
Cattails
  | (food)
  v
Water
  | (food)
  v
Blueberries
  | (nutrients)
  v
Black bear
  v
Moose
```
Appendix 2

Teacher Guidelines: Flow Chart Organizer

- Explain to students that flow charts and webs are commonly used to show cause-and-effect relationships or sequences of events.
- Encourage students to include multiple branching in their flow charts to indicate various consequences of an event or action. (See the flow chart below.)
- Stress that the vocabulary included in the flow chart should be specific (e.g., cattails) rather than general (e.g., plants).

Effects of the Algonquin Chemical Spill
(Only a few economic examples are noted.)

- Chemical spill in Algonquin Park
- Economic effects
- Environmental effects
- Social effects

The company cannot recover the chemicals or the cost of the chemicals.

The value of the company’s stock decreases.

Consumers stop buying this product.

The cost of the chemicals will increase to cover the loss.

Media reports provide negative publicity.

The company’s transportation costs will increase.

Effects of the Algonquin Chemical Spill

Environmental effects

Economiceffects

The company cannot recover the chemicals or the cost of the chemicals.

The value of the company’s stock decreases.

Consumers stop buying this product.

The cost of the chemicals will increase to cover the loss.

Media reports provide negative publicity.

The company’s transportation costs will increase.

Appendix 3

Teacher Guidelines Planning Sheet for a Letter to the Editor

Paragraph 1: Opinion and introduction (agree or disagree)
- Disagree with the statement.
- There are many changes that will affect the ecosystem.

Paragraph 2: Scientific facts and supporting arguments
- Fact: The soil along the roadside will absorb the chemicals and will become contaminated.
- Argument: This may cause a decrease in local plant populations, such as the cattails and grasses, as they depend on the soil.
- Fact: The chemicals will pollute the water in the ditches.
- Argument: This may affect the green frogs, as they rely on this water for their basic needs, such as food, drink, and habitat.

Paragraph 3: Suggested actions to reduce the chance that such spills will occur again
- Plan alternative routes around environmentally sensitive areas for trucks transporting toxic chemicals to limit the opportunity for a spill to occur in these areas.
- Decrease the speed limit for transportation through parkland to decrease the number or severity of accidents occurring within the area.

Paragraph 4: Summary of your viewpoint
- It is felt that the local ecosystem in the Algonquin Park area has been compromised by this spill.
Appendix 4

Web Organizer - A Biotic and Biotic Interactions

Use the space provided below or the back of this page to create a web organizer:
- which shows the specific abiotic and biotic components of the Galapagos Islands’ ecosystems;
- which clearly shows the relationships between the abiotic and biotic components;
- which is organized in a way that is easy to understand; and
- which includes labels that explain the connections between components.

Note: You may use words, arrows, small pictures, symbols, and colour to clarify the relationships.

Appendix 5

Flow Chart Organizer - Short- & Long-Term Effects

Add to the template provided below to build a flow chart organizer of the environmental, social, and economic consequences of the oil spill:
- which shows the short- and long-term effects;
- which shows a reasonable sequence of events for each consequence; and
- which lists as many ideas as possible for each heading.

Note: You may use words, arrows, small pictures, symbols, and colour to clarify the relationships.
Appendix 6

Supported Opinion – Letter to the Editor

(Planning Sheet)

Using only your point-form notes and any information posted in the classroom, create an outline of the points you will use in your Letter to the Editor of Youth Science magazine that:
- states whether you agree or disagree with the expert’s statement about the oil spill;
- supports your opinion with scientific facts using the information from your graphic organizers;
- suggests some reasonable actions to reduce the chance of such situations happening again;
- summarizes your viewpoint.

Paragraph 1: Opinion and introduction (agree or disagree)

Paragraph 2: Scientific facts and supporting arguments

Paragraph 3: Preventative actions to reduce this event in the future

Paragraph 4: Summary of your viewpoint

Appendix 7

Supported Opinion – Letter to the Editor

Instructions

Using your planning sheet, point-form notes, and any posted information in your classroom, create a Letter to the Editor of Youth Science magazine which:
- states whether you agree or disagree with the expert’s statement about the oil spill;
- supports your opinion with scientific facts using the information from your graphic organizers;
- suggests some reasonable actions to reduce the chance of such situations happening again;
- summarizes your viewpoint; and
- uses proper letter format (complete sentences and paragraphs).
Grade 8
Structures and Mechanisms
Rescuing Whales

The Task

Students were asked to use their knowledge and understanding of simple machines and mechanical advantage to design and construct a lifting mechanism that would achieve a mechanical advantage of at least 4 to facilitate the rescue and release of stranded whales. Specifically, they were to:

- rephrase the problem;
- record several different ideas as sketches with suggested dimensions;
- choose one of the ideas as the best solution and explain the reason for the choice;
- gather appropriate materials to execute their plan;
- construct the lifting mechanism;
- test their mechanism and make necessary revisions;
- observe results and record data and observations in a written reflection;
- prepare and deliver a four-minute oral presentation about their design processes and the results.

Expectations

This task gave students the opportunity to demonstrate achievement of all or part of each of the following selected overall and specific expectations from the strand Structures and Mechanisms: Grade 8 – Mechanical Efficiency. (The codes that follow the expectations are from the Ministry of Education’s Curriculum Unit Planner.)

Students will:
1. demonstrate an understanding of the factors that contribute to the efficient operation of mechanisms and systems (8s87);
2. design and make systems of structures and mechanisms, and investigate the efficiency of the mechanical devices within them (8s88);
3. determine the velocity ratio of devices with pulleys and gears (8s97);
4. formulate questions about and identify needs and problems related to the efficient operation of mechanical systems, and explore possible answers and solutions (8s99);
5. produce technical drawings and layout diagrams of a structure or a mechanical system that they are designing, using a variety of resources (8s106);
6. describe how the components and subsystems of a product used by humans enable the product to function (8s109);
7. evaluate their own designs against the original need, and propose modifications to improve the quality of the products (8s118).
Prior Knowledge and Skills

To complete this task, students were expected to have some knowledge and/or skills related to the following:

- the design process
- the functions of simple machines (e.g., levers, pulleys, gears)
- calculations involving mechanical advantage
- ways of combining various structural components to create structures and mechanisms
- the safe and appropriate use of tools

In the teacher’s notes and comments accompanying the student samples that follow, the examples cited are either from the student worksheets (indicated by a “P”, for “print”) or from the videotape (indicated by a “V”).

For information on the process used to prepare students for the exemplar task and on the materials and equipment required, see the Teacher Package reproduced on pages 88–99 of this document.
## Task Rubric – Grade 8: Rescuing Whales

<table>
<thead>
<tr>
<th>Expectations*</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Understanding of Basic Concepts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1, 3</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>The student:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- demonstrates limited understanding in applying, calculating, and explaining mechanical advantage</td>
<td>- demonstrates some understanding in applying, calculating, and explaining mechanical advantage</td>
<td>- demonstrates general understanding in applying, calculating, and explaining mechanical advantage</td>
<td>- demonstrates thorough understanding in applying, calculating, and explaining mechanical advantage</td>
<td></td>
</tr>
<tr>
<td><strong>Design Skills</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2</td>
<td></td>
<td></td>
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<tr>
<td>The student:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- identifying the problem/need</td>
<td>- rephrases the problem/need with limited clarity</td>
<td>- rephrases the problem/need with some clarity</td>
<td>- rephrases the problem/need clearly</td>
<td>- rephrases the problem/need clearly and precisely</td>
</tr>
<tr>
<td>- making the plan</td>
<td>- explores potential solutions in a limited way</td>
<td>- explores potential solutions in a somewhat appropriate way</td>
<td>- explores potential solutions in an appropriate way</td>
<td>- explores potential solutions in an insightful way</td>
</tr>
<tr>
<td>4</td>
<td>- selects a solution and provides a limited explanation for the choice</td>
<td>- selects a solution and provides some explanation for the choice</td>
<td>- selects a solution and provides a clear explanation for the choice</td>
<td>- selects a solution and provides an in-depth explanation for the choice</td>
</tr>
<tr>
<td></td>
<td>- creates a simple design sketch</td>
<td>- creates a somewhat organized and labelled design sketch</td>
<td>- creates an organized and labelled design sketch</td>
<td>- creates a highly organized and fully labelled design sketch (e.g., orthographic or isometric)</td>
</tr>
<tr>
<td>- executing and evaluating the plan</td>
<td>- outlines a few steps of the construction plan</td>
<td>- outlines some steps of the construction plan</td>
<td>- outlines most steps of the construction plan</td>
<td>- outlines all or almost all steps of the construction plan</td>
</tr>
<tr>
<td>2, 7</td>
<td>- constructs a solution that meets the task criteria to a limited extent</td>
<td>- constructs a solution that meets the task criteria to some extent</td>
<td>- constructs a solution that meets the task criteria</td>
<td>- constructs a solution that meets the task criteria in insightful ways</td>
</tr>
<tr>
<td><strong>Communication of Required Knowledge</strong></td>
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<tr>
<td>5, 6</td>
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<tr>
<td>The student:</td>
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</tr>
<tr>
<td>- presents the solution with limited clarity</td>
<td>- presents the solution with some clarity</td>
<td>- presents the solution with clarity and accuracy</td>
<td>- presents the solution concisely and with clarity and accuracy</td>
<td></td>
</tr>
<tr>
<td>- demonstrates with limited supporting evidence how the solution meets the task criteria</td>
<td>- demonstrates with some supporting evidence how the solution meets the task criteria</td>
<td>- demonstrates with considerable supporting evidence how the solution meets the task criteria</td>
<td>- demonstrates with extensive supporting evidence how the solution meets the task criteria</td>
<td></td>
</tr>
<tr>
<td>Expectations*</td>
<td>Level 1</td>
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<tr>
<td>6, 7</td>
<td>- provides a limited reflection on the strengths and weaknesses of the model</td>
<td></td>
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<tr>
<td></td>
<td>- suggests minimally appropriate improvements</td>
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<tr>
<td>Level 2</td>
<td>- provides a somewhat reasonable reflection on the strengths and weaknesses of the model</td>
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<tr>
<td></td>
<td>- suggests somewhat appropriate improvements</td>
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<td></td>
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</tr>
<tr>
<td>Level 3</td>
<td>- provides a reasonable and balanced reflection on the strengths and weaknesses of the model</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>- suggests appropriate improvements</td>
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<tr>
<td>Level 4</td>
<td>- provides a detailed and extensive reflection on the strengths and weaknesses of the model</td>
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<tr>
<td></td>
<td>- suggests insightful improvements</td>
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</tbody>
</table>

*The expectations that correspond to the numbers given in this chart are listed on page 50.

Note: This rubric does not include criteria for assessing student performance that falls below level 1.
Scenario: “Whales Forever” Design Competition

Throughout the world, whales get stranded on seaside beaches from time to time. Whales Forever, an environmental group, is concerned about the low survival rate of beached whales. They know that beached whales must be able to swim in open water within a short time or they will perish. Whales Forever has announced a design competition for students to create a prototype device that can safely lift a stranded whale onto a hovercraft to allow for both medical attention and release.

In your role as a designer, you are challenged to design and construct a lifting mechanism that:

- achieves a mechanical advantage (MA) of at least 4;
- uses one of the types of simple machines (e.g., lever, pulley, gear) or a system combining two or more simple machines.

You will make a four-minute presentation to the Whales Forever board of directors demonstrating your model’s effectiveness in lifting the “whale” (simulated by a resealable plastic bag filled with sand) a height of 10 cm and lowering it 5 cm onto a simulated hovercraft platform. Since only the lifting mechanism is involved in the design competition, you may hand-position your “whale” in whatever harness you decide to use. It is recommended that, wherever possible, you use readily available materials (e.g., desks, tables, stools, retort stands) as the supports for your lifting device. If time and your skill level permit, you may be given permission to create a support structure that works best with your solution.

Your presentation must also include the following:

- exploratory sketches and a labelled sketch of your chosen design, with measurements, indicating the critical components
- mechanical advantage measurements, calculations, estimations, explanations, and verifications
- a written reflection on the strengths and weaknesses of your design
- suggestions for improving your solution
Rescuing Whales  Level 1, Sample 1

Appendix 6
Making the Plan

1. Restate the Need
   To rescue beached whales

2. Exploring Ideas: (Use the space below to illustrate your ideas.)

   Wood
   Hooks

3. Select your preferred solution and explain why you've made your choice.
   
   I selected solution #2 because I like to use pulleys.

4. Design Sketch (draw a clearly labelled design sketch of your solution on the back of this sheet or on graph paper).
   On graph paper

5. Outline the design process steps followed in constructing, testing, and revising your solution. These steps should only include the lifting mechanism construction, not the supporting structure.

   1) I took one of the pulleys that had a hook glued to the top of my s.s.
   2) I took a piece of wood and glued it onto the base so it was aligned with the other pulley that I glued onto it.
   3) I glued 2 pulleys onto the shaft of the support s.s. I higher that the other.
   4) Then I simply just threaded some string through all of the pulleys.
Appendix 7
Executing / Evaluating the Plan

Observe and record data that show that your mechanism generates a mechanical advantage (MA) of at least 4. Show how you have applied MA calculations with an explanation. Show evidence verifying your results.

Palleys

4 pulleys therefore a mechanical advantage of 4.
Appendix 8
Reflection

1. Provide an evaluation of the strengths and weaknesses of your mechanism.
   a) Strengths: My device is able to lift 500g's.

   b) Weaknesses: The string falls off of the fixed pulley's a lot of the time.

2. Explain how your design could be improved.

   The main way I can improved it is by taking more time to construct it. And by thinking of a way to make a device that would keep the string on track.

Reflection

My lift aid complete the job that it was designed to do. It was able to lift the 500g's, (whole) and even a little more, even though the string fell off of the track a few times. Over all I am fairly happy with the way it all turned out.
Teacher’s Notes

Understanding of Basic Concepts
- The student demonstrates limited understanding in applying, calculating, and explaining mechanical advantage (e.g., [V] states that there is a mechanical advantage of 4; incorrectly bases the estimate of mechanical advantage on the fact that there are four pulleys in the mechanism).

Design Skills
- The student rephrases the problem/need with limited clarity (e.g., [P] Making the Plan [1]: “To rescue beached whales”; [V] in the presentation, expands on the need recorded in the written task: “… we need to be able to lift it 10 cm off the ground and then lower it 5 cm onto a hovercraft”).
- The student explores potential solutions in a limited way (e.g., [P] Making the Plan [2]: provides one clear design sketch of a pulley system and one that is unclear).
- The student selects a solution and provides a limited explanation for the choice (e.g., [P] Making the Plan [3]: “I selected solution #2 because I like to use pulleys.”).
- The student creates a simple design sketch (e.g., [P] Making the Plan [4]: creates a sketch that shows the structure and dimensions of the device and provides measurements but no labels).
- The student outlines a few steps of the construction plan (e.g., [P] Making the Plan [5]: lists four steps but supplies few explanatory details: “I took one of the pulley’s that had a hook at [and] glued the hook to the top of my s.s. [supporting structure]”).
- The student constructs a solution that meets the task criteria to a limited extent (e.g., [V] constructs a mechanism that partially performs the required work – lifts the prescribed weight only some of the time and not the required distance).

Communication of Required Knowledge
- The student presents the solution with limited clarity (e.g., [V] becomes distracted when the string comes off the pulley during the presentation; makes comments such as “I just thought of …”).

Relating of Science and Technology to Each Other and to the World Outside the School
- The student provides a limited reflection on the strengths and weaknesses of the model (e.g., [P] Reflection [1a]: “My device is able to lift 500 g’s”; [1b]: “The string falls off of the fixed pully’s a lot of the time.”).
- The student suggests minimally appropriate improvements (e.g., [P] Reflection [2]: recognizes the need “to make a device that would keep the string on track.”).

Comments/Next Steps
- The student creates a clear and simple design sketch.
- The student should expand the restatement of the problem/need to include the design/construction challenge.
- The student should address all the criteria outlined in the task.
- The student should add explanatory detail when describing construction processes.
- The student should correct spelling errors by referring to resources such as wall charts and a dictionary.
Rescuing Whales  Level 1, Sample 2

Appendix 6
Making the Plan

1. Re state the Need

To move beached whales

2. Exploring Ideas: (Use the space below to illustrate your ideas.)

| ![Diagram 1] | ![Diagram 2] |
| ![Diagram 3] | ![Diagram 4] |

3. Select your preferred solution and explain why you have made your choice.

I chose No. 3 because it is the only one that has a MA of 4.

4. Design Sketch (draw a clearly labelled design sketch of your solution on the back of this sheet or on graph paper).

5. Outline the design process steps followed in constructing, testing, and revising your solution. These steps should only include the lifting mechanism construction, not the supporting structure.

   The first thing I did was try and build a pulley system lifted by a crank. I found the string wasn’t strong enough and the pulleys wouldn’t stay in place. Then I realized that levers work the best so I glued and duct taped a structure made it slip so I changed it.
Appendix 7
Executing / Evaluating the Plan

Observe and record data that show that your mechanism generates a mechanical advantage (MA) of at least 4. Show how you have applied MA calculations with an explanation. Show evidence verifying your results.

The effort arm is 4 times bigger than the load arm.

Since the effort arm is 4 times longer than the load arm you only need to put in \( \frac{1}{4} \) of the load arm to lift it.

\[
MA = \frac{LF}{EF}
\]

\[
MA = \frac{1000N}{250N}
\]

\[
MA = 4N
\]
Appendix 8
Reflection

1. Provide an evaluation of the strengths and weaknesses of your mechanism.
   
   a) Strengths:
   The strength is it uses 4 or more mechanical advantage.
   
   b) Weaknesses:
   The arms could be a little stronger.

2. Explain how your design could be improved.
   I could use a triangle shape base instead of a square
   and I could make the arms stronger. I might
   want to get wheels that work on it. That's how

Teacher’s Notes

Understanding of Basic Concepts

- The student demonstrates limited understanding in applying, calculating, and explaining mechanical advantage (e.g., [P] Executing/Evaluating the Plan: applies concepts incorrectly: “Since the effort arm is 4 times longer than the load arm you only need to put in 1/4 of the load arm to lift it.”).

Design Skills

- The student rephrases the problem/need with limited clarity (e.g., [P] Making the Plan [1]: “To move beached whales”).
- The student explores potential solutions in a limited way (e.g., [P] Making the Plan [2]: provides design sketches that deal only with pulleys, and two examples lack sufficient clarity; provides few and inadequate labels).
- The student selects a solution and provides a limited explanation for the choice (e.g., [P] Making the Plan [3]: “I chose No. 3 because it is the only one that has a MA [mechanical advantage] of 4.”).
- The student creates a simple design sketch (e.g., [P] Making the Plan [4]: gives misleading title “Tree Picker” to the diagram, showing confusion about the mechanism’s purpose).
- The student outlines a few steps of the construction plan (e.g., [P] Making the Plan [5]: provides only general statements rather than a detailed description of steps: “...I realized that levers work the best so I glued and duck [duct] taped a structure together. I started with wheels but found that made it slip so I changed it.”).
- The student constructs a solution that meets the task criteria to a limited extent (e.g., [V] constructs a mechanism with an unstable fulcrum and lever).

Communication of Required Knowledge

- The student presents the solution with limited clarity (e.g., [V] uses the word “thing” to refer to the whole mechanism and its parts).
- The student demonstrates with limited supporting evidence how the solution meets the task criteria (e.g., [V] demonstrates how the lever should work, but the position of the student’s hand on the lever in the video makes it unclear whether the load is raised 10 cm).
Relating of Science and Technology to Each Other
and to the World Outside the School
– The student provides a limited reflection on the strengths and weaknesses of the model (e.g., [P] Reflection [1b]: states that “The arms could be a little stronger”).
– The student suggests minimally appropriate improvements (e.g., [P] Reflection [2]: proposes a triangular shape rather than a square shape for the base but does not explain the purpose of the change; also suggests “I could make the arms stronger” to solve the problem identified in [1b]).

Comments/Next Steps
– The student’s choice of a lever is a simple, sensible solution to the problem.
– The student should expand the restatement of the problem/need to include the design/construction challenge.
– The student should outline the design/construction steps in more detail.
– The student should review the steps in applying, calculating, and explaining mechanical advantage.
Rescuing Whales

Level 2, Sample 1

Appendix 6
Making the Plan

1. Restate the Need: Make a mechanism that lifts a 500 g “whale” 10 cm high and back down 5 cm.

2. Exploring Ideas: (Use the space below to illustrate your ideas.)

[Diagram of a pulley system with labels: driver, idler, roller, input force, output force, 3 gear system, effort force, load force, distinct work, pulleys, etc.]
3. Select your preferred solution and explain why you've made your choice.

I chose plan #2. The four-pulley system didn't work out as planned. I then used a 2-pulley system with a 3-gear system. It had a mechanical advantage of 10. I succeeded in all areas.

4. Design Sketch (draw a clearly labelled design sketch of your solution on the back of this sheet or on graph paper).

5. Outline the design process steps followed in constructing, testing, and revising your solution. These steps should only include the lifting mechanism construction, not the supporting structure:

1. Make the wall for the gears. Attach it to base.
   - Make stand for lower pulley.
   - Make stand for higher pulley
   - Collapsed
   - Make base
   - Make pulley system (3 gears) and attached to base.
   - Make pulley (2 pulley) attached to base
   - Attach dowel rod to follower gear (50)
   - Attach crank to driver (10)
   - Attach string under pulley
   - Glue into follower rod
   - Calculate M = 5
Appendix 7
Executing / Evaluating the Plan

Observe and record data that show that your mechanism generates a mechanical advantage (MA) of at least 4. Show how you have applied MA calculations with an explanation. Show evidence verifying your results.

\[
\text{MA} = \frac{\text{number of teeth on follower}}{\text{number of teeth on follower}}
\]

\[
\text{MA} = \frac{50}{10} = 5
\]

I tried to use the ruler, but it didn't quite work out because I couldn't figure out how to attach it to the

Appendix 8
Reflection

1. Provide an evaluation of the strengths and weaknesses of your mechanism.
   a) Strengths: Pulling or attached, could lift easily 500g, easy to use, pulleys provide easier lift.

   b) Weaknesses: base is not sturdy, takes a lot of hands to hold, crank is not easy to turn, falls apart, the follower gear does not stick to the wall.

2. Explain how your design could be improved.
   - The base could have been sturdier.
   - Gear could have been put on ground instead of in air.
   - Crank should be small enough to fit in hole without falling out.
   - Pulley stands could have been sturdier.
Teacher’s Notes

Understanding of Basic Concepts
− The student demonstrates some understanding in applying, calculating, and explaining mechanical advantage (e.g., [P] Executing/Evaluating the Plan: calculates mechanical advantage by applying gear-ratio formulas; experiences technical difficulties in verifying with Newton force meter: “… I couldn’t figure out how to attach [the Newton scale] to the gears.”).

Design Skills
− The student rephrases the problem/need with some clarity (e.g., [P] Making the Plan [1]: focuses on the need to design/construct a mechanism as well as on the goal of lifting a whale, and states some of the design criteria such as load force, height, and distance, but does not mention the required mechanical advantage of 4).
− The student explores potential solutions in a somewhat appropriate way (e.g., [P] Making the Plan [2]: explores two potential ideas in labelled drawings).
− The student selects a solution and provides some explanation for the choice (e.g., [P] Making the Plan [3]: explains that design 2 was chosen because “It had a mechanical advantage of 6.”; elsewhere calculates a mechanical advantage of 5).
− The student creates a somewhat organized and labelled design sketch (e.g., [P] Making the Plan [4]: includes some detail such as driver and follower gears in the first design sketch, and numbers of teeth in the gears in the second sketch).
− The student outlines some steps of the construction plan (e.g., [P] Making the Plan [5]: lists twelve steps, but includes several relating to the supporting structure that was not included as part of the task).
− The student constructs a solution that meets the task criteria to some extent (e.g., [P] Making the Plan [5]: determines a mechanical advantage of 5 using gear ratio, but does not recognize that fixed pulleys do not increase mechanical advantage).

Communication of Required Knowledge
− The student presents the solution with some clarity (e.g., [P] Executing/Evaluating the Plan: makes a correct numerical calculation of MA based on formula for gears but mislabels the written components on which the calculation is based: both gears are identified as “follower”).
− The student demonstrates with some supporting evidence how the solution meets the task criteria (e.g., [V] demonstrates the mechanism’s lifting capacity but needs to use manual force to drive the follower gear).

Relating of Science and Technology to Each Other and to the World Outside the School
− The student provides a somewhat reasonable reflection on the strengths and weaknesses of the model (e.g., [P] Reflection [1a]: notes that pulley system works well: “could lift easily 500g”; [1b]: notes that gear system is unstable and difficult to operate: “takes a lot of hands to hold, crank is not easy to turn …”).
− The student suggests somewhat appropriate improvements (e.g., [P] Reflection [2]: suggests two improvements to avoid instability: “gears could have been put on ground …” and “create dowel rods small enough to fit in hole without falling out”, but does not clearly explain the function of the second improvement).

Comments/Next Steps
− The student should include measurements in the design sketch.
− The student should become more familiar with mechanical advantage calculations.
− The student should use the design process to explore a greater variety of possible solutions.
Rescuing Whales

Level 2, Sample 2

Appendix 6
Making the Plan

1. Restate the Need
   - To lift a whale 10m and then drop it 5m
   - Have a mechanical advantage of 4.

2. Exploring Ideas: (Use the space below to illustrate your ideas.)

3. Select your preferred solution and explain why you’ve made your choice.
   - My number 2 design is my preferred because I feel I will have a greater mechanical advantage. I also have triangles supporting everything.

4. Design Sketch (draw a clearly labelled design sketch of your solution on the back of this sheet or on graph paper).

5. Outline the design process steps followed in constructing, testing, and revising your solution. These steps should only include the lifting mechanism construction, not the supporting structure.
Steps: First thing I did was draw my plan. Then I started building my fulcrum out of:
- wood
- hot glue
- paper triangles

After this I built my lever (arm) with wood and hot glue. Through this process I stuck the wood together and sawed. The next thing I did was build my harness. I built it out of wood, glue, tape, string. I had to stick wood together and drill holes for string. After this procedure I tested it. It worked and it has a mechanical advantage of 5.

Appendix 7
Executing / Evaluating the Plan

Observe and record data that show that your mechanism generates a mechanical advantage (MA) of at least 4. Show how you have applied MA calculations with an explanation. Show evidence verifying your results.

My lever is a meter long so that is how I get a mechanical advantage of more than 4. 

\[
\text{MA} = \frac{LE}{EF} = \frac{10\text{N}}{2\text{N}} = 5\text{N}.
\]

Their mechanical advantage is 5N.
Appendix 8
Reflection

1. Provide an evaluation of the strengths and weaknesses of your mechanism.
   a) Strengths:
      • It has a long arm to lift 10N.
      • Has triangles to hold the fulcrum up and the lever.
   b) Weaknesses:
      • It is possible the string will break because it is weak.

2. Explain how your design could be improved.
   • I could use another material instead of string so it could be easier to lift.

Teacher’s Notes

Understanding of Basic Concepts

– The student demonstrates some understanding in applying, calculating, and explaining mechanical advantage (e.g., [P] Executing/Evaluating the Plan: cites data from which calculation for mechanical advantage was made – “LF = 10N; EF = 2N” – and makes correct calculation, but includes other information without explaining its relevance: “My lever is a meter long so that is how I get a mechanical advantage of more than 4”).

Design Skills

– The student rephrases the problem/need with some clarity (e.g., [P] Making the Plan [1]: “To lift a whale 10 cm and then drop it 5 cm” and “Have a mechanical advantage of 4”; leaves out reference to constructing a mechanism to perform the lifting).
– The student explores potential solutions in a somewhat appropriate way (e.g., [P] Making the Plan [2]: provides one moderately clear design sketch and one that is less clear, out of a possible four).
– The student selects a solution and provides some explanation for the choice (e.g., [P] Making the Plan [3]: states reasons but does not explain them clearly: “it will have a greater mechanical advantage. I also have triangles supporting everything.”).
– The student creates a somewhat organized and labelled design sketch (e.g., [P] Making the Plan [4]: provides an enlarged and labelled version of exploratory sketch showing structure and materials, but without measurements).
– The student outlines some steps of the construction plan (e.g., [P] Making the Plan [5]: lists materials and main steps but omits detailed explanations of substeps: “Built my lever [arm] with wood an [and] hot glue. Through this process I stuck the wood together and sawed.”).
– The student constructs a solution that meets the task criteria to some extent (e.g., [V] constructs a lever-based mechanism that lifts the required load; [P] Executing/Evaluating the Plan: correctly calculates MA but explains calculation in relation to the length of the whole lever rather than the ratio between load force and effort force).
Communication of Required Knowledge
- The student presents the solution with some clarity (e.g., [V] presents con-
cclusions but does not support them with specific calculations: “An advan-
tage of this is that because of having a long effort arm my lever has a great
mechanical advantage.”).
- The student demonstrates with some supporting evidence how the solution
meets the task criteria (e.g., [P] Executing/Evaluating the Plan: states that
the mechanism has a mechanical advantage of more than 4 and shows the
calculation, but does not explain the process used to determine the elements
[load force and effort force] used in the calculation or the construction).

Relating of Science and Technology to Each Other
and to the World Outside the School
- The student provides a somewhat reasonable reflection on the strengths
and weaknesses of the model (e.g., [P] Reflection [1a]: “… a long arm to lift
…” and “… triangles to hold the fulcrum up ...”; [1b]: “It is possible the
string will break because it is weak.”).
- The student suggests somewhat appropriate improvements (e.g., [P] Reflec-
tion [2]: suggests an improvement in the materials not the design:
“… another material instead of string”).

Comments/Next Steps
- The student needs to review units of measurement and how to use them to
calculate mechanical advantage.
- The student should include substeps when describing the construction
process and provide a fuller explanation of how this process produced a
working lever system.
Appendix 6
Making the Plan

1. Restate the Need
The need is to create a lifting mechanism using simple machines. It must lift the whale a height of 10 cm. and lower it 5 cm on to a hovercraft platform. It must also have a mechanical advantage of at least 4.

2. Exploring Ideas: (Use the space below to illustrate your ideas.)

3. Select your preferred solution and explain why you’ve made your choice.
   I chose to do the Four Pulley System as my preferred solution. I chose to do this method because I feel it is the most efficient way of solving the problem. It will give me a mechanical advantage of 8. It will not require a lot of effort to lift it and it will lift 10 cm and lower 5 cm.

4. Design Sketch (draw a clearly labelled design sketch of your solution on the back of this sheet or on graph paper).

5. Outline the design process steps followed in constructing, testing, and revising your solution. These steps should only include the lifting mechanism construction, not the supporting structure.
   1. Drill two holes in the wood approximately 7.5 cm apart and put two dowels in the holes.
   2. Attach one pulley onto each of the dowels.
   3. Attach two pulleys together using a glue gun.
   4. Attach a piece of wood on the original piece of wood on a 90° angle.
   5. Drill hole on the second piece of wood for the spool.
   6. Thread fishing wire through the pulleys to make a Four Pulley System.
   7. Add weight and test the mechanism.
   8. Test again.
Appendix 7
Executing/Evaluating the Plan

Observe and record data that show that your mechanism generates a mechanical advantage (MA) of at least 4. Show how you have applied MA calculations with an explanation. Show evidence verifying your results.

The mechanism I used to lift the whale was the pulley system. My mechanism has a mechanical advantage of 5.

Formula for Mechanical Advantage for Pulleys

\[
\text{Mechanical Advantage} = \frac{\text{load force}}{\text{effort force}}
\]

Load force: 500g (5N)
Effort force: 100g (1N)

\[
\text{MA} = \frac{5N}{1N} = 5 
\]

Mechanical Advantage = 5

I found the mechanical advantage for my four-pulley system by placing the Newton Spring Scale on the fishing wire and pulling it upwards. The Newton Spring Scale gave me a reading of 1N. I tried it several other times to make sure it was correct.
Appendix 8
Reflection

1. Provide an evaluation of the strengths and weaknesses of your mechanism.
   a) Strengths:
      The strengths of my mechanism are that it can raise the provided weight a height of 10 cm and it can lower it 5 cm. In addition, my mechanism has a mechanical advantage of 5. It is also very strong and can support the weight.
   b) Weaknesses:
      The weaknesses of my mechanism are that the pulleys come off the dowels a lot and the fishing wire that I used comes out of the pulleys. I continually must place the fishing wire into the pulleys in order for it to stay.

2. Explain how your design could be improved.
   My design could be improved by putting the second piece of wood on a 50° angle. I would have been much easier to find the mechanical advantage if it wasn’t like that. Also, I could’ve used different string instead of fishing wire. It most likely would have stayed in the pulleys better.
   
   • whale: 500 g
   • bring raw material from home to use for catcher
   • whale must be raised 10 cm and lowered 5 cm
   • M.A. = 4
   •

Teacher’s Notes

Understanding of Basic Concepts
- The student demonstrates general understanding in applying, calculating, and explaining mechanical advantage (e.g., [P] Executing/Evaluating the Plan: uses the Newton force meter to determine the effort force, verifies the results, and accurately calculates the mechanical advantage).

Design Skills
- The student rephrases the problem/need clearly (e.g., [P] Making the Plan [1]: notes the need “to create a lifting mechanism using simple machines ...” that can lift “the whale” 10 cm, lower it 5 cm, and that has “a mechanical advantage of at least 4.”).
- The student explores potential solutions in an appropriate way (e.g., [P] Making the Plan [2]: illustrates four possible mechanisms: a lever, a lever-and-pulley combination, a single fixed pulley, and a four-pulley system).
- The student selects a solution and provides a clear explanation for the choice (e.g., [P] Making the Plan [3]: selects a four-pulley system; gives as reason that mechanism meets the mechanical advantage criterion of 4 set for the task).
- The student creates an organized and labelled design sketch (e.g., [P] Making the Plan [4], sketch on graph paper: presents a clear drawing with most parts labelled).
- The student outlines most steps of the construction plan (e.g., [P] Making the Plan [5]: lists eight steps, including two for testing the mechanism).
- The student constructs a solution that meets the task criteria (e.g., [V] demonstrates that the mechanism can lift and lower the specified weight the required distances and has the required mechanical advantage).

Communication of Required Knowledge
- The student presents the solution with clarity and accuracy (e.g., [P] Executing/Evaluating the Plan: clearly explains the process for finding mechanical advantage “by placing the Newton Spring Scale on the fishing wire and pulling it upwards” and shows the calculation).
The student demonstrates with considerable supporting evidence how the solution meets the task criteria (e.g., [V] differentiates between appropriate terms such as crank and spool; [P] Making the Plan [4]: explains that when spool is turned “counterclockwise”, “it pulls on the fishing wire. The fishing wire then pull the moveable pulleys up ...”).

Relating of Science and Technology to Each Other and to the World Outside the School
- The student provides a reasonable and balanced reflection on the strengths and weaknesses of the model (e.g., [P] Reflection [1a]: “... it can raise the provided weight ... and it can lower it”; [1b]: “The weaknesses ... are that the pulleys come off the dowels a lot ... the fishing wire ... comes out of the pulleys ...”).
- The student suggests appropriate improvements (e.g., [P] Reflection [2]: hypothesizes that “different string instead of fishing wire ... most likely would have stayed in the pulleys better” but doesn’t specify what type of string would work better).

Comments/Next Steps
- The student made a clear presentation.
- The student should include greater detail in technical drawings (e.g., by supplying dimensions and specific labels for all parts of the model).
Rescuing Whales  
Level 3, Sample 2

Appendix 6
Making the Plan

1. Restate the Need
   The need is to build a simple machine like a lever, pulley, gear system that is able to support a 500 g weight. It must raise the entire load 10 cm and lower it 5 cm. It must have a mechanical advantage of 4 or more.

2. Exploring Ideas: (Use the space below to illustrate your ideas.)

3. Select your preferred solution and explain why you’ve made your choice.
   I chose my fourth solution, because it was simple, logical, and had a 500 g weight, which had a mechanical advantage of 5. That was the ideal goal when I started the task. Plus, the mechanical advantage is actually higher than necessary.

4. Design Sketch (draw a clearly labelled design sketch of your solution on the back of this sheet or on graph paper.)

5. Outline the design process steps followed in constructing, testing, and revising your solution. These steps should only include the lifting mechanism construction, not the supporting structure.

   1. Get a piece of wood, and drill two holes in the middle of the wood, approximately 3 cm apart from each other.
   2. Get a piece of dowel and cut into two pieces. Each approximately 11 cm in length.
   3. Get a 10 teeth gear and a 50 teeth gear. Sand the end of a piece of dowel and put the 10 teeth gear on it. Sand the end of the other dowel, and put the 50 teeth gear on it. (Glue the gears to the middle of the doweling.)
   4. Place both dowels through each of the two holes in the wood.
   5. Glue in place on one side.
   6. Attach a wooden spool to the 50 teeth gear with glue.
   7. Attach fishing wire to wooden spool, and wrap it around. (Attach weight to wire.)
   8. Once this has been completed, test the mechanism with the 500 g weight, to achieve the mechanical advantage of 5.
Appendix 7
Executing / Evaluating the Plan

Observe and record data that show that your mechanism generates a mechanical advantage (MA) of at least 4. Show how you have applied MA calculations with an explanation. Show evidence verifying your results.

Simple mechanism: gears

Mechanical Advantage Formula (for gears):
follow gear / driver gear

Gear system: 10 teeth driver gear
(includes) 50 teeth follower gear

Mechanical Advantage = 50 teeth / 10 teeth
= 5

* When driver gear is turned clockwise, the follower is automatically turned counter-clockwise. This mechanism allows to lift the whale.

To lower the whale, the driver is turned counter-clockwise, and the follower automatically turns clockwise.
Appendix 8
Reflection

1. Provide an evaluation of the strengths and weaknesses of your mechanism.
   a) Strengths:
   Some of this mechanism’s strengths are that it is able to support 500 g of weight, it has a mechanical advantage of 5, and is simple yet logical. It is only a two-gear system, but is capable of raising a 500 g whale 10 cm and lowering it 5 cm.
   b) Weaknesses:
   Some of this mechanism’s weaknesses are that it is not too strong, it is able to support the weight of 500 g, but may be improved if I added another piece of wood to the side of the one I already have. By adding a piece of wood to the already existing one, I would strengthen it, which would make it more reliable. Also, I would probably use a stronger sort of dowelling next time, because it would make it easier to turn the gears. As well, I might add a crank if possible.

2. Explain how your design could be improved.

* Whale = 500 g (sand)
* Catcher may be made of any raw material!
* Whale must be raised 10 cm, and lower it 5 cm!

\[\text{[single-fixed pulley system]}\]

* Keep the system simple!
* Assume that the whale is already harnessed! (But make the harness!) You have to have a MA of 4! (or more.)
* Use either: lever, pulley, gears.
*
Teacher’s Notes

Understanding of Basic Concepts
- The student demonstrates general understanding in applying, calculating, and explaining mechanical advantage (e.g., [P] Executing/Evaluating the Plan: states the mechanical advantage formula for gears, uses it to calculate the mechanism’s MA of 5, and explains how the mechanism works).

Design Skills
- The student rephrases the problem/need clearly (e.g., [P] Making the Plan [1]: “The need is to build a simple machine [lever, pulley, gear] system that is able to support a 500 g whale ... It must have a mechanical advantage of 4 or more.”).
- The student explores potential solutions in an appropriate way (e.g., [P] Making the Plan [2]: illustrates four mechanisms: a lever, a lever and pulley, and two gear mechanisms).
- The student selects a solution and provides a clear explanation for the choice (e.g., [P] Making the Plan [3]: “I chose my fourth solution because it was simple, logical, able to support 500 g of weight, and had a mechanical advantage of 5.”).
- The student creates an organized and labelled design sketch (e.g., [P] Making the Plan [4]: sketch on graph paper: illustrates and labels all parts of mechanism but omits dimensions and title).
- The student outlines most steps of the construction plan (e.g., [P] Making the Plan [5]: lists eight detailed steps in construction, including measurements, but does not mention procedures for testing using the Newton force meter).
- The student constructs a solution that meets the task criteria (e.g., [V] demonstrates that mechanism can lift and lower weight the specified distances and has the required mechanical advantage).

Communication of Required Knowledge
- The student presents the solution with clarity and accuracy (e.g., [P] Executing/Evaluating the Plan: explains the direction of movement of the gears during both the lifting and the lowering of the weight).
- The student demonstrates with considerable supporting evidence how the solution meets the task criteria (e.g., [P] Executing/Evaluating the Plan: includes a close-up diagram of the gear mechanism with an explanation of how it works).

Relating of Science and Technology to Each Other and to the World Outside the School
- The student provides a reasonable and balanced reflection on the strengths and weaknesses of the model (e.g., [V] strength: “It’s capable of lifting the 500 gram weight”; weakness: “It’s not that strong” and “It’s not as efficient as it could be”).
- The student suggests appropriate improvements (e.g. [P] Reflection [2]: “add a crank”; “use a stronger sort of dowelling next time, because it would make it easier to turn the gears.”).

Comments/Next Steps
- The student should provide distinct alternative ideas (e.g., two of the design sketches are identical).
- The student needs to explore alternative means of deriving the mechanical advantage (e.g., use of a Newton force meter, in addition to counting the teeth on a gear system).
- The student should investigate the use of appropriate tools (e.g., a ruler) to help improve estimates and calculations.
3. Select your preferred solution and explain why you've made your choice.

    I personally favor my fourth design as it appears to be the strongest and most durable structure on paper. In addition, the design complies with the criteria and uses pulleys, which I like working with. The solution appears to be creative and can be used in real life for an inexpensive cost.

4. Design Sketch (draw a clearly labelled design sketch of your solution on the back of this sheet or on graph paper).

5. Outline the design process steps followed in constructing, testing, and revising your solution. These steps should only include the lifting mechanism construction, not the supporting structure.

The four pulley system I have chosen will presumably achieve a mechanical advantage of at least 4 and will successfully lift a weight of 500 g, 10 cm, and then lower it 5 cm on to a hovercraft. The steps necessary for constructing my lifting mechanism are as follows:

**Step 1**: Cut approx. 200 cm of string for the 4-pulley system

**Step 2**: Collect and assemble a triple moveable pulley system

**Step 3**: Fasten 2 pulleys approx. 2-3 cm from the top of my supporting structure with a glue gun or a clasp

**Step 4**: Fasten a third and fourth pulley with string securing it from the first and second pulley with a glue gun or a clasp

**Step 5**: Cut 2 pieces of 12 x 1 cm paper and secure it to the two pulleys on the double pulley

**Step 6**: Weave the appropriate 330 cm of string through the moveable pulley system and test it using a Newton scale.
Initial design extra fixed ply

*Please refer to isometric drawing for more detailed design.
Appendix 7
Executing / Evaluating the Plan

Observe and record data that show that your mechanism generates a mechanical advantage (MA) of at least 4. Show how you have applied MA calculations with an explanation. Show evidence verifying your results.

Mechanical Advantage (M.A.) = \( \frac{\text{load force}}{\text{effort force}} \)

1) "Load force" - whole (100g, 9.8N)
2) In reference to the isometric drawing, the string is pulled at approximately 60\(^\circ\) therefore concluding that the larger the angle the string is pulled at, increases the mechanical advantage.

\* Applying my effort and load force to the formula above:

\[
\text{5N (whole)} \div 0.84 \text{N (energy used to pull string)} = 6.25 \text{ (mechanical advantage)}
\]

1) In reference to #1 above, if I were to reduce the angle at which the string was pulled, for example 30\(^\circ\) (approx. half that of the current angle), it would reduce the Mechanical Adv. by half.

2) Mechanical Adv. of #1 is 3.13

3) Important to note that to measure the effort and load force I used a Newton spring scale

4) Alternately, the position at which I placed the Newton scale on the remaining string also affects the Mechanical Adv. to a certain extent

5) Finally, refer to the rough drawing (right) to observe the length of string and the order in which the pulleys are placed.

Appendix 8
Reflection

1. Provide an evaluation of the strengths and weaknesses of your mechanism.
   a) Strengths:
      - could be easily operated
      - stronger string replaced for ordinary fishing string (originally attached)
      - possible to lift 1500g with ease, exceeds 500g requirement
      - possible to lift whole 50cm with ease, exceeds 10cm requirement
      - achieves mechanical advantage of 4 or more on a consistent basis (MA = 4)
   b) Weaknesses:
      - structure exceeds the size criteria and is adaptable to other
      - sturdy, well supported structure, true design situation
      - angle at which string is pulled results too large
      - occasionally string lost grip on pulley
      - mechanical advantage exceeds size work is lifted (5x10 cm)

2. Explain how your design could be improved.
   - slight possibility another design might be the simpler and easier to construct in real life.

   Following the construction of my triple-pulley, I realized:
   - I identified multiple strengths and weaknesses, outlined above.
   - In the event, I was given an opportunity to re-design and examine my design, the first improvement to be made to my lifting mechanism would possibly be to decrease the angle at which the string is pulled to initiate the lifting of the whole.
   - Currently the angle of the pulley to the string is approximately 60\(^\circ\).
   - To improve this design, I would propose to install a crank which would be secured to the structure and vertex wooden post. This structure would probably work in cooperation with a helicopter to rescue a stranded whale.

   Although considering that this is a prototype, this model could be improved by adding wheels or racks. To the bottom of the structure for added mobility and convenience in air or on water. Instead of my structure being installed on a helicopter, major proxema and a motor could be added to the structure, therefore not depending on anything else.
Teacher’s Notes

Understanding of Basic Concepts
- The student demonstrates thorough understanding in applying, calculating, and explaining mechanical advantage (e.g., [V] explains the mechanical advantage calculations in more than one way and provides a thorough explanation of the effect on mechanical advantage of changing the angle of the applied effort; [P] Executing/Evaluating the Plan: “... the larger the angle the string is pulled at, increases the Mechanical Advantage.”).

Design Skills
- The student rephrases the problem/need clearly and precisely (e.g., [V] outlines the requirements then describes how he met the criteria: “I found out through process of elimination and experimentation ... more distance in return for less force being used ...”).
- The student explores potential solutions in an insightful way (e.g., [V] describes combinations of pulleys with a lever and a lever with an inclined plane: “I’ve used pulleys called a triple movable pulley ...”).
- The student selects a solution and provides an in-depth explanation for the choice (e.g., [P] Making the Plan [3]: “I personally favour my fourth design as it appears to be the strongest and most durable structure on paper ... complies with the criteria ... uses pulleys ... can be used in real life ... inexpensive”).
- The student creates a highly organized and fully labelled design sketch (e.g., [P] Making the Plan [4], sketch on graph paper: provides an “Isometric Drawing”, including dimensions and scale, and displays all necessary information).
- The student outlines all or almost all steps of the construction plan (e.g., [P] Making the Plan [5]: lists main steps with some dimensions and includes a step for testing with a Newton scale).
- The student constructs a solution that meets the task criteria in insightful ways (e.g., [P] Executing/Evaluating the Plan: includes force/angle considerations in the solution as well as a truss design).

Communication of Required Knowledge
- The student presents the solution concisely and with clarity and accuracy (e.g., [V] outlines an in-depth, effective manner the challenge, the steps followed to solve it, and the problems encountered and solved during construction).
- The student demonstrates with extensive supporting evidence how the solution meets the task criteria (e.g., [P] Executing/Evaluating the Plan, and Reflection, and [V] provides a thorough, accurate explanation of the design considerations and the functioning of the device).

Relating of Science and Technology to Each Other and to the World Outside the School
- The student provides a detailed and extensive reflection on the strengths and weaknesses of the model (e.g., Reflection [1a]: strengths: “exceeds the task criteria and is adaptable to other operations”; [1b]: weaknesses: “angle at which string is pulled may be too large”; “lot of string is used – 330 cm”).
- The student suggests insightful improvements (e.g., [V] “The angle is approximately sixty-eight degrees”; implies that the angle would have to be reduced for greater efficiency).

Comments/Next Steps
- The student expresses interesting insights, such as the impact of changing the position and angle of the applied effort force.
- The student should study technical drawings in order to learn to differentiate between 2-D and 3-D drawings.
1. **APPENDIX B (Making the Plan)**

In order to complete this project we had to create a prototype that has a Mechanical Advantage of at least four, and the machine must be capable of lifting 4 kg. We cannot use the ground. We can only use simple machines to build this prototype and each student gets only 2 hours of building time.

2. Design #2
5) The design process steps I followed in order to construct my machine were as follows. First I constructed my box like frame, so that once it was good and strong I could then begin building my gear and pulley systems which would lift the weight.

When I finally had my frame the way I liked it I began building my gear and pulley systems. I started out by making my pulley system, which was made of movable pulleys. I needed five pulleys on each side in order to get my pulley system to work properly. Once I got those pulleys all strung up and working I had to get four more pulleys so that I could get the strings from each pulley system into the center of my frame. When this task was completed and I had both strings from both systems in the center of my frame I tied the strings off so that the whole thing would not fall apart. I could then begin building my gear system.

I had to build a type of frame, which would hook up to my large frame, which I could hook, my gear system up on. When I had the frame finally built and securely fastened to my large frame I began assembling my gear system. What I did for this was I got the four gears I would need to complete the system and then I made a crank. When I had the stuff I needed I drilled the holes which the dowel would go threw and the gears would hook onto. Then I slipped both pieces of dowel threw each hole and I put my small drivers and big followers on so that they rotated perfectly. Then I put my crank on so that my gear system worked.

Once I had both systems working I hooked everything up so that the whole machine worked properly. When you cranked the crank the gears turned which coiled the string around the dowel so that my pulley systems would rise up at exactly the same time and lift the 1-kilogram mass.
Appendix 7 (Executing / Evaluating the Plan)

Then came the process of calculating the Mechanical Advantage. In my prototype I used movable pulleys and a combination of a small driver gear and a large follower gear, which made my Mechanical Advantage very high. I used a Nuton spring scale to calculate the Mechanical Advantage of the pulley systems, which turned out to be 5. This is because it took 10 Nutons to lift 1 kg without any pulleys attached. When I put the kilogram on my machine, with my pulley system, it took only 2 Nutons to lift 1 kg, 10 divided by 2 = 5. Therefore the Mechanical Advantage of my pulley system is 5.

Next I calculated the Mechanical Advantage of my gear system. To do this I counted the teeth on each of my gears, the small driver gear had 10 teeth, and the big follower gear had 50 teeth. So to find the Mechanical Advantage of the gears you do 50 divided by 10, which equals 5. So the Mechanical Advantage of my gear system is 5.

Then to get the Mechanical Advantage of my whole machine you add the Mechanical Advantage of my pulley systems and the Mechanical Advantage of my gear system, which is 5 plus 5, which is equivalent to 10. Therefore my machine had a total Mechanical Advantage of 10.

Appendix 8 (Reflections)

Strengths:
My machine has a couple really good strengths. I think that one of the strengths in my machine is my frame, which is good and solid so that it does the job effectively. I think that my pulley systems are another strength. This is because I have the same pulley systems on each side of my machine so that both systems share the work.

Weaknesses:
I think that one weakness is the frame that I have my gear system on. If I would have had more time I would have used the same would throughout my whole machine so that it would be a lot stronger. Another weakness is the speed of which the machine cranks at. It's too slow. If I played around with the gear ratio I could make it go faster.

Improvements:
To improve my prototype I would have put wheels on it so that it could roll back over the load, get the harness placed under it, and lift it off of the ground. Then it could easily be place wherever it has to go. This would make the model better because if it had to place a beached whale back into the water, it would make the job a lot easier.
Teacher’s Notes

Understanding of Basic Concepts
- The student demonstrates thorough understanding in applying, calculating, and explaining mechanical advantage (e.g., [V] “I used a Newton spring scale and I put it right here”; [P] Executing/Evaluating the Plan: “... the Mechanical Advantage of the pulley systems ... turned out to be 5 ... the Mechanical Advantage of my gear system is 5 ... Therefore my machine has a total Mechanical Advantage of 10.”).

Design Skills
- The student rephrases the problem/need clearly and precisely (e.g., [P] Making the Plan [1]: “... we had to create a prototype that has a Mechanical Advantage of at least four, and ... capable of lifting 1 Kg ... We can only use simple machines to build this prototype and each student gets only 2 hours of building time.”).
- The student explores potential solutions in an insightful way (e.g., [P] Making the Plan [2]: provides three clear design sketches showing combined gear-and-pulley mechanisms mounted on different types of frames).
- The student selects a solution and provides an in-depth explanation for the choice (e.g., [P] Making the Plan [3]: “I figured that the frame would hold well and the gear and pulley systems would do a good job and have a high mechanical advantage.”).
- The student creates a highly organized and fully labelled design sketch (e.g., [P] Making the Plan [4]: includes an enlarged sketch showing details of the pulley mechanism and the gear mechanism with labels, measurements, and an explanation of the scale of the sketch relative to the model).
- The student outlines all or almost all steps of the construction plan (e.g., [P] Making the Plan [5]: provides a detailed, clear explanation of a logical sequence of steps, including tests at various stages of construction).
- The student constructs a solution that meets the task criteria in insightful ways (e.g., [P] Making the Plan [5]: constructs a double gear system to operate the double pulley system, thus distributing the load over a broader area and reducing the strain on the individual parts of the mechanism).

Communication of Required Knowledge
- The student presents the solution concisely and with clarity and accuracy (e.g., [V] with prompting, provides a full explanation of the system and the reasons for the design).
- The student demonstrates with extensive supporting evidence how the solution meets the task criteria (e.g., [P] Executing/Evaluating the Plan: explains in detail the two methods used to calculate the mechanical advantage of the linked gear-and-pulley mechanisms).

Relating of Science and Technology to Each Other and to the World Outside the School
- The student provides a detailed and extensive reflection on the strengths and weaknesses of the model (e.g., [V] states that the frame is “good and solid”, and that the pulleys have “the same design on each side so they share the work”; [P] Reflection [1b]: “… the speed of which the machine cranks at ... [is] too slow.”).
- The student suggests insightful improvements (e.g., [P] Reflection [2]: “put wheels on it so that it could role back over the load ... Then it could easily be place wherever it has to go.”; [V] “… mess around with the gear ratios and make it quicker”).

Comments/Next Steps
- The student’s solution shows a thorough understanding of applications of simple machines and calculation/verification of mechanical advantage.
- The student should practice isometric and orthographic drawings.
- The student should include dimensions and labels in exploratory drawings.
Title: Rescuing Whales

Time Requirements: 245 minutes (over several class periods)

Introductory activities
- Pre-task 1: 40 minutes
- Pre-task 2: 45 minutes
- Pre-task 3: 40 minutes

Exemplar task: 120 minutes (the amount of time needed for each of the five parts to be determined by the individual teacher, depending on the particular needs of each class)

Description of the Task
Students will use their knowledge and understanding of simple machines and mechanical advantage (MA) to design and construct a lifting mechanism that will achieve a mechanical advantage of at least 4 to facilitate the rescue and release of stranded whales.

Students will complete the worksheets provided in this package and submit selected worksheets for assessment. Each student will also make a four-minute oral presentation describing and demonstrating how his/her model works, and these presentations will be videotaped. The videotapes will also be used for assessment purposes.

Scenario and Instructions for Students
For the scenario and instructions that should be presented to students, see Appendix 5: “Scenario: ‘Whales Forever’ Design Competition”.

Curriculum Expectations Addressed in the Task

Note that the codes that follow the expectations relate to the Ministry of Education’s Curriculum Unit Planner (CD-ROM).

Students will:
1. demonstrate an understanding of the factors that contribute to the efficient operation of mechanisms and systems (8s87);
2. design and make systems of structures and mechanisms, and investigate the efficiency of the mechanical devices within them (8s88);
3. determine the velocity ratio of devices with pulleys and gears (i.e., divide the distance that a load moves by the distance covered by the force [effort] required to move it) (8s97);
4. formulate questions about and identify needs and problems related to the efficient operation of mechanical systems, and explore possible answers and solutions (e.g., test a device at each stage of its development and evaluate its performance in relation to specific criteria) (8s99);
5. produce technical drawings and layout diagrams of a structure or a mechanical system that they are designing, using a variety of resources (8s106);
6. describe how the components and subsystems of a product used by humans enable the product to function (8s109);
7. evaluate their own designs against the original need, and propose modifications to improve the quality of the products (8s118).

“Big Ideas”
Based on the expectations being assessed, the following “big ideas” have been identified for this task:
• Machines are a way to transfer energy.
• Design influences the efficiency of machines.
• Designs for machines arise from a need to solve problems.

Teacher Instructions

Prior Knowledge and Skills Required
Before attempting the task, students should have had experience related to the following:
• the design process (see Appendix 4): identifying the problem/need, making the plan, executing and evaluating the plan, and communicating the solution
• the functions of simple machines (e.g., levers, pulleys, gears)
• calculations involving mechanical advantage
• ways of combining various structural components to create structures and mechanisms
• the safe and appropriate use of tools
The Rubric*
The rubric provided with this exemplar task is to be used to assess students' work. The rubric is based on the achievement levels outlined on page 13 of The Ontario Curriculum, Grades 1-8: Science and Technology, 1998.

I introduce the task-specific rubric to students at least one day before administering the task. Copy the rubric for students or create a transparency to use with the class. You may find it useful to rephrase the rubric for students to help them in their work.

Review the elements of the rubric with students to ensure that they understand the criteria and the descriptions for achievement at each level. Allow ample class time for a thorough reading and discussion of the assessment criteria outlined in the rubric.

Accommodations

Accommodations that are normally provided in the regular classroom for students with special needs should be provided in the administration of the exemplar task.

Classroom Set-up

• Ensure that students have a suitable work space for their design processes.
• Review the safe use of tools with all students.
• Keep low-temperature glue guns away from the regular flow of student traffic.
• Allow students easy access to materials (although you should emphasize the economical use of the materials) and tools (with safe storage provided).
• Provide students with a generic support device for their mechanisms, such as a retort stand and ring, a metre stick placed across an open space between chairs or tables, or some other method of supporting their lifting device.
• Consider providing a suitable location for the lift test (one for the class).

Materials Needed

• pulleys (hooked on both ends): a single axle/single wheel; double axle/double wheel
• 4 mm (1/8 in.) dowels (to be used for axles and levers)
• gears (assorted sizes: 50, 40, 30, 20, and 10), all bevel-toothed
• cranks (to fit on gears)
• 1 cm x 1 cm x 60 cm wood (to be used for levers or gear-and-pulley frames)
• low-temperature glue guns (10 W)
• low-temperature glue sticks
• paper gussets (for reinforcing corners of structures; these could be cut from file folders)
• 4 mm (1/8 in.) drill bits (to create snug axle holes)
• 5 mm (9/64 in.) drill bits (to create loose axle holes)
• Newton meter spring scales (0 – 10 N)
• sandpaper
• miter box
• clamps (to hold material to be drilled or glued)
• carpenter's glue
• miscellaneous wood scraps (to be used for levers and other components)
• 300 m of string, fishing line, or thread appropriate to students' mechanisms
• resealable plastic bag (to be used for the skin of the "whale")
• sand to represent at least 500 g of whale mass (only one "whale" is required per class)
• hand saw
• hand drill or an electric drill (See the safety considerations that follow.)
• selection of hooked masses (1 kg, 500 g)
• other found materials (e.g., cardboard, empty spools, small pieces of cloth)

Note: Many of these materials (e.g., pulleys, gears) can be reused after the presentations have been shared and assessed.

Safety Considerations

Before attempting this task, it is important for both you and your students to be familiar with the following safety considerations:

• Students should use only those tools for which they have been given instructions for safe use.
• The work area should be kept neat and well organized.
• The floor and walkways should be kept clear of debris.
• Students should use only mini- or low-temperature glue guns to reduce the risk of burns.
• Students should be aware that most burns result not from the glue guns themselves but from contact with melted glue. If hot glue comes in contact with skin, it should be removed as quickly as possible by immersing the affected area in cold water. A bucket of water should be available for this purpose.
• Students must wear closed-toe shoes to reduce the possibility of injury from dropped materials.
• Students should wear protective aprons to protect synthetic clothing from heat, as this type of material will melt when subjected to intense heat such as that generated by glue guns.
• Extension cords and power-tool cords must be situated in such a way that they do not pose a tripping hazard.
• When students use power tools such as drills, they must clamp their work securely in place.
• When working with hand tools, power tools, and glue guns, students must use CSA-approved eye protection.
• When using power tools, students must tie back any long hair that could be caught or tangled in a machine and should remove jewellery and long scarves and roll up their sleeves to avoid the risk of entanglement.

Note: Check your board regulations regarding the need for any additional qualifications when using power tools with students.

*The rubric is reproduced on pages 52–53 of this document.
Task Instructions

Introductory Activities

The pre-tasks are designed to ensure that students have the prior knowledge and skills required to complete the exemplar task. These activities review and reinforce the skills and concepts that students will be using in the exemplar task, but are not assessed on the rubric.

Pre-task 1: Setting the Scene

1. Introduce and discuss the student scenario with the class. Discuss and clarify the task-specific assessment rubric, perhaps displaying it on an overhead as you discuss it. (This will take about 15 minutes.)

2. Review with students the types of simple machines (e.g., levers, gears, pulleys) through discussions or using a video such as Eureka (TVO, No. 60164). (This will take about 25 minutes.)

Pre-task 2: Calculating Mechanical Advantage

1. Have students work at centres (with partners or in groups) using gears, pulleys, and levers to experience and review how to calculate the mechanical advantage of various systems in more than one way. Set up the centres as follows:

   - **Gear centre.** Set up the three gear combinations shown in Appendix 1 on Styrofoam, cardboard, or wooden bases. See also “Set-up for Gear Centre” in Appendix 9.
   - **Pulley centre.** Set up the pulley combinations shown in Appendix 2 by suspending them on string from the ceiling or from a pre-made support. See also “Set-up for Pulley Centre” in Appendix 9.
   - **Lever centre.** Set up levers as outlined in “Set-up for Lever Centre” at the end of Appendix 9.

2. Distribute the student worksheets “Gears”, “Pulleys”, and “Levers” (see Appendices 1-3) and have students move through each of the three centres. Ask them to spend fifteen minutes at each centre measuring and recording the effort and load forces for three different circumstances. The forces measured will be used to calculate mechanical advantage. The worksheets also show students how to estimate mechanical advantage in a variety of ways. If time allows, the use of wheels and axles can also be discussed.

3. With the class, consolidate students’ understanding of calculating and estimating mechanical advantage. Clarify any misunderstandings.

Pre-task 3: Understanding the Design Process

1. Spend about fifteen minutes reviewing the design process with the class using the student worksheet (see Appendix 4).

2. Challenge students to work through the design process with the following task: Support one science and technology textbook 10 cm above the desk using only two sheets of letter-size paper. With the class, consolidate students’ understanding of the design process as they have applied it to this challenge. Clarify any misunderstandings.

Exemplar Task

The completed student worksheets “Making the Plan”, “Executing/Evaluating the Plan”, and “Reflection” (see Appendices 6-8) are to be submitted for marking.

Part 1: Identifying and Rephrasing Design Needs

1. Distribute the student scenario (see Appendix 5) to students and review it with the class. Clarify that only the lifting mechanism is to be constructed; classroom materials can be used for a supporting structure. For example, a metre stick between two desks or a retort stand with a clamp can be used to support a lifting device. If their time and skill level permit, students may choose to create an appropriate alternative support structure, but this will add considerably to the time required for the task and is not assessed in the rubric.

2. Give students a chance to discuss possible solutions as a group and to ask questions for clarification.

Part 2: Making the Plan

1. Distribute the student worksheet “Making the Plan” (see Appendix 6) to students.

2. Have students individually rephrase the need in part 1 of the worksheet.

3. Ask students individually to record several different ideas as sketches with suggested dimensions in part 2 of the worksheet.

4. Have each student complete part 3 of the worksheet, choosing one of the possible solutions from part 2 of the worksheet and explaining the reasons for his or her choice.

5. Ask students to create a design sketch in part 4 of the worksheet, labelling the dimensions, the materials, the simple machines used, and the location of the load and effort forces.

6. Have students outline the steps necessary to complete their plans in part 5 of the worksheet. These steps should include the construction only of the lifting mechanism, not the supporting structure. If you like, allow students to construct the supporting device, but this is not required or assessed in the rubric.

Part 3: Executing and Evaluating the Plan

1. Have students gather the materials they will require to follow their plans.

2. Instruct them to construct their lifting mechanisms safely and within the allotted time.

3. Have students test their mechanisms to meet the task criteria.

4. Ask students to observe and record data and make the necessary calculations on their worksheets (see Appendix 7) to verify that their mechanisms are able to generate a mechanical advantage of at least 4.
Part 4: Reflection
Have students evaluate the strengths and weaknesses of their models and suggest possible improvements using the “Reflection” worksheet (see Appendix 8).

Part 5: Presentation to the Board of Directors of Whales Forever
1. Have each student prepare a four-minute oral presentation that communicates a summary of his or her design process and demonstrates clearly how his or her mechanism meets the task criteria. Students can use their completed Appendices 6, 7, and 8 to plan their oral presentations.
2. Ask students to demonstrate the effectiveness of their mechanisms (in lifting the “whale” 10 cm and lowering it 5 cm) to the “board of directors” (portrayed by peers sitting around a board table, other classes, outside experts, or parent volunteers).

Appendix 1

**Steps**
1. Note the names of each gear in the above diagram.
2. Using the gear sample with only two gears, turn the driver and record the direction that the follower turns.
3. Using the gear sample with three gears (as in the above diagram), turn the driver and record the direction that the follower turns.
4. What effect does adding an idler gear have on the direction that the follower turns?
5. When a small driver gear turns a larger follower gear a mechanical advantage is gained. The mechanical advantage can be found by completing the following steps:
   - Find the force required to lift a mass straight up (load force), using a Newton spring scale (N).
   - Using something like tape, string, or a dowel, fasten the mass to the outside edge of the follower gear.
   - Now fasten a Newton spring scale to the driver gear and note the force required to move the mass (effort force).
   - Calculate the mechanical advantage by using the formula MA = load force ÷ effort force.
     For example: It requires 20 N to raise a mass unaided (the load force). When the mass is connected to a gear system, the force required to raise it is 5 N (the effort force).
     \[ MA = \frac{\text{load force}}{\text{effort force}} = \frac{20 \text{ N}}{5 \text{ N}} = 4 \]
   - To estimate the mechanical advantage for gears:
     \[ MA = \frac{\text{number of teeth on follower}}{\text{number of teeth on driver}} \]
For example, a gear of 10 teeth driving a follower of 30 teeth produces an MA of 3:

\[
\text{MA} = \frac{30 \text{ teeth}}{10 \text{ teeth}} = 3
\]

- Another way of estimating mechanical advantage is by using the radius of the gears:

\[
\text{MA} = \frac{\text{radius of the follower}}{\text{radius of the driver}}
\]

6. Determine the MA for each of the gear systems shown in the photograph below or for gear systems provided by your teacher.

Appendix 2

Pulleys

Using the pulleys set up by your teacher, investigate the changing effort required when the number of pulleys is changed. Use the Newton meter for observation and record the effort required to lift the load. Calculate the mechanical advantage of each pulley system.

Single Fixed Pulley – Set-up 1

Single Movable Pulley – Set-up 2

Single Fixed Double Movable Pulley – Set-up 3

Four-Pulley System – Set-up 4
Appendix 3

Levers

Steps
1. Study the diagram and note the parts of a lever.
2. Using the Newton spring scale, measure the force required to lift the mass provided.
3. For each of the three lever set-ups provided by your teacher:
   a) measure and record the force required to lift the mass without using the lever (load force);
   b) measure and record the force required to lift the mass using the lever (effort force).
   Note that the load force does not change; it is the same for each lever set-up.
4. Calculate the mechanical advantage (MA) for each of the three lever set-ups by dividing the load force by the effort force:
   \[ MA = \frac{\text{load force}}{\text{effort force}} \]
5. Measure and record the length of the load arm (the arm extending from the load to the fulcrum) and that of the effort arm (the arm extending from the effort force to the fulcrum) for each of the levers.
6. Based on your data from step 5, propose a relationship between the ratio of the effort arm to the load arm and mechanical advantage.

Show your work in the space below and on the back of this page.

Appendix 4

The Design Process

Identifying the Problem/Need
- Provide a description of the problem/need.
- Ask questions to clarify the criteria for developing a plan.
- Brainstorm a variety of solutions to the problem/need.

Making the Plan
- Select a solution from the alternative solutions while considering criteria.
- Outline the steps to be followed using appropriate vocabulary and units of measurement (and labelled sketches if required).
- Select and record the materials, equipment, and tools that you will require.
- Make a reasonable timeline for completion.

Executing and Evaluating the Plan
- Construct a solution that represents the plan and meets the design criteria.
- Demonstrate appropriate construction techniques.
- Use the most appropriate materials, equipment, and tools.
- Test the solution and make the revisions necessary to meet the design criteria.
- Follow the timeline and meet the deadline.

Communicating the Solution
- Communicate the solution concisely and accurately.
- Communicate the solution using the appropriate method/format.
- Use appropriate vocabulary.
Appendix 5

Scenario: “Whales Forever” Design Competition

Throughout the world, whales get stranded on seaside beaches from time to time. Whales Forever, an environmental group, is concerned about the low survival rate of beached whales. They know that beached whales must be able to swim in open water within a short time or they will perish. Whales Forever has announced a design competition for students to create a prototype device that can safely lift a stranded whale onto a hovercraft to allow for both medical attention and release.

In your role as a designer, you are challenged to design and construct a lifting mechanism that:
- achieves a mechanical advantage (MA) of at least 4;
- uses one of the types of simple machines (e.g., lever, pulley, gear) or a system combining two or more simple machines.

You will make a four-minute presentation to the Whales Forever board of directors demonstrating your model’s effectiveness in lifting the “whale” (simulated by a resealable plastic bag filled with sand) a height of 10 cm and lowering it 5 cm onto a simulated hovercraft platform. Since only the lifting mechanism is involved in the design competition, you may hand-position your “whale” in whatever harness you decide to use. It is recommended that, wherever possible, you use readily available materials (e.g., desks, tables, stools, retort stands) as the supports for your lifting device. If time and your skill level permit, you may be given permission to create a support structure that works best with your solution.

Your presentation must also include the following:
- exploratory sketches and a labelled sketch of your chosen design, with measurements, indicating the critical components
- mechanical advantage measurements, calculations, estimations, explanations, and verifications
- a written reflection on the strengths and weaknesses of your design
- suggestions for improving your solution

Appendix 6

Making the Plan

1. Restate the Need.

2. Exploring Ideas. (Use the space below to illustrate your ideas.)
3. Select your preferred solution and explain why you've made your choice.

4. Design Sketch (draw a clearly labelled design sketch of your solution on the back of this sheet or on graph paper).

5. Outline the design process steps followed in constructing, testing, and revising your solution. These steps should only include the lifting mechanism construction, not the supporting structure.

Appendix 7

Executing/Evaluating the Plan

Observe and record data that show that your mechanism generates a mechanical advantage (MA) of at least 4. Show how you have applied MA calculations with an explanation. Show evidence verifying your results.
Appendix 8

Reflection

1. Provide an evaluation of the strengths and weaknesses of your mechanism.
   a) Strengths:
   b) Weaknesses:

2. Explain how your design could be improved.

Appendix 9

Teacher's Background Information

Gears

A gear is a toothed-wheel device. A group of two or more gears in contact with each other is called a gear train. The driver gear is the part of the mechanism that is turned by an external force such as a crank or a motor. The follower gear turns as a result of its contact with the driver gear. When the driver gear is turned, the follower gear will turn in the opposite direction. Adding an idler gear in between the two gears has the effect of making the driver gear and the follower gear turn in the same direction.

A small gear driving a larger follower gear produces more force (mechanical advantage is gained) but decreases the speed. A large gear driving a smaller follower gear produces less force but increases the speed. The relationship of the amount of force involved with gears can be used to calculate mechanical advantage (MA).*

There are two ways to determine mechanical advantage (MA) for gears.

1. Experimentally
   - Use a Newton spring scale to find the force required to lift a mass straight up (load force).
   - Using something like tape, string, or a dowel, fasten the mass to the outside edge of the follower gear.
   - Fasten the Newton spring scale to the driver gear and note the force required to move the mass (effort force).
   - Calculate mechanical advantage by using the formula
   \[
   MA = \frac{\text{load force}}{\text{effort force}}
   \]

   For example, it requires 20 N to raise a mass unaided (load force). When the mass is connected to a gear system, the force required to raise it is 5 N (effort force):
   \[
   MA = \frac{20 \text{ N}}{5 \text{ N}} = 4
   \]

*Note: Mechanical advantage is numerical and does not involve any units of measurement. The greater the number, the greater the mechanical advantage.
2. Using a Formula
   - To estimate mechanical advantage for gears:
     \[ MA = \frac{\text{number of teeth on follower}}{\text{number of teeth on driver}} \]
   
   For example, a gear of 10 teeth driving a follower of 50 teeth produces an approximate
   \[ MA = \frac{50}{10} = 5 \]

   - Mechanical advantage can also be estimated using the radius of the gears:
     \[ MA = \frac{\text{radius of the follower}}{\text{radius of the driver}} \]

Set-up for Gear Centre (for Pre-task 2)
Set up gears as outlined in Appendix 1. Styrofoam provides a good, easy-to-work-with base or
background for the gears. Nails or wooden skewers can be used to fasten the gears to the
Styrofoam. Alternatively, you may prefer to make more permanent samples by using nails for
shafts and scraps of wood for the base. Use a marker or pen to identify which gears are the driver
and follower gears. Driver gears are on the left of the illustrations at the end of Appendix 1.

Answers to Student Questions (see Appendix 1)
Question 2. The driver and follower turn in opposite directions.
Question 3. The idler gear makes the driver and follower gears turn in the same direction.
Question 4. Adding an idler gear causes the follower gear to turn in the same direction as the
driver gear.
Question 6. Answers will vary depending on the gear system used. If the gear systems shown in
the photograph are used, the answers are as noted in the following table:

<table>
<thead>
<tr>
<th>Set-up</th>
<th>Mechanical Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30 ÷ 12 = 2.5</td>
</tr>
<tr>
<td>2</td>
<td>30 ÷ 20 = 1.5</td>
</tr>
<tr>
<td>3</td>
<td>40 ÷ 12 = 3.3</td>
</tr>
</tbody>
</table>

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Pulleys
A pulley is a wheel with a grooved outer rim with a string or rope running in the groove around
the rim. It is similar to a lever.

<table>
<thead>
<tr>
<th>Lever</th>
<th>Pulley</th>
</tr>
</thead>
<tbody>
<tr>
<td>bar</td>
<td>rope</td>
</tr>
<tr>
<td>fulcrum</td>
<td>axle</td>
</tr>
<tr>
<td>effort and load arms</td>
<td>sides of the pulley</td>
</tr>
</tbody>
</table>

Pulleys can be positioned so that they are attached (fixed) or so that they move as the rope or
string is pulled (movable).

A single fixed pulley does not give a mechanical advantage. It simply changes the direction of the
motion and can make the movement more convenient (e.g., a fixed pulley at the top of a flagpole
used to raise and lower the flag).

When fixed and movable pulleys are combined to form a pulley system, they form a block and
tackle, which can provide a significant mechanical advantage.

There are two ways to determine mechanical advantage for pulleys.

1. Experimentally
   - Use a Newton spring scale to find the force required to lift a mass (load force).
   - Fasten the mass to the pulley system.
   - Attach the Newton spring scale to the pulley system and record the force required to raise
     the mass.
   - Calculate the MA, which is \( \frac{\text{load force}}{\text{effort force}} \)

   For example, with a load force of 6 N and an effort force of 3 N:
   \[ MA = \frac{6 \text{ N}}{3 \text{ N}} = 2 \]

2. By Estimation
   The MA for pulleys can also be estimated by counting the number of rope sections supporting
the load. A pulley with two rope sections supporting the load has a mechanical advantage of
approximately 2, and a pulley system with three rope sections supporting the load has a
mechanical advantage of approximately 3, and so on.
Set-up for Pulley Centre (for Pre-task 2)

Set up the pulley arrangements as shown in Appendix 2. To support the pulley arrangements, use metre sticks with table or desk supports, retort stands, or strings attached to the ceiling.

Answers to Pulley Questions (see Appendix 2)

Set-up 1: MA = 1 (with one rope supporting the load)
Set-up 2: MA = 2 (with two ropes supporting the load)
Set-up 3: MA = 3 (with three ropes supporting the load)
Set-up 4: MA = 4 (with four ropes supporting the load)

Levers

There are two ways to determine mechanical advantage (MA) for levers.

1. Experimentally
   • Attach a Newton spring scale to a mass and record the force required to lift the mass straight up (load force).
   • Place the same mass on the load end of the lever and place the Newton spring scale on the effort end of the lever. Exert force on the Newton spring scale and record the force required to lift the mass using the lever (effort force).
   • Calculate the mechanical advantage by dividing the load force by the effort force.
   • For example, to lift a sample mass straight up requires a force of 10 N. Using a lever, the force required is 5 N.

   \[
   MA = \frac{\text{load force}}{\text{effort force}} = \frac{10\,\text{N}}{5\,\text{N}} = 2
   \]

2. Using a Formula
   The MA for levers can be estimated by comparing the length of the effort arm to the length of the load arm. Thus,

   \[
   MA = \frac{\text{length of effort arm}}{\text{length of load arm}}
   \]

   For example, for a length of effort arm of 50 cm and a length of load arm of 10 cm:

   \[
   MA = \frac{50\,\text{cm}}{10\,\text{cm}} = 5
   \]

   To have a mechanical advantage of 5 with a lever, the effort arm must be five times longer than the load arm. (Note: If students add harnesses or similar devices to hold the “whale” on the ends of their levers, they will be adding more mass to the load arm, which will affect their MA calculations.)

Set-up for Lever Centre (for Pre-task 2)

To facilitate the use of the lever centre for Pre-task 2, the six to nine levers (two or three sets of levers with three set-ups in each set) should already have been constructed and be available for student use. This will focus student time on concept exploration rather than on lever construction. To create the levers for this centre, use metre sticks (as levers), pencils (as fulcrums), and tape to secure the pencils to the metre sticks. Since the levers must be somewhat above the desk to work, the lever mechanisms can be supported on a pile of textbooks. You will require the following set-ups:

- Set-up 1: with the fulcrum at the 50 cm mark on the metre stick, halfway between the load and the effort
- Set-up 2: with the fulcrum at 25 cm from the load
- Set-up 3: with the fulcrum at 75 cm from the load

Answers to Lever Activities (see Appendix 3)

Question 2. A newers will vary depending on the mass used.
Question 3. A newers will vary depending on the mass used.
Question 4. A newers will vary depending on the mass used, but final answers will be close to those in number 5.
Question 5.
Set-up 1: \[ MA = \frac{50 \text{ cm}}{50 \text{ cm}} = 1 \]
Set-up 2: \[ MA = \frac{75 \text{ cm}}{25 \text{ cm}} = 3 \]
Set-up 3: \[ MA = \frac{25 \text{ cm}}{75 \text{ cm}} = 0.33 \]

Question 6. Students should generalize that the approximate mechanical advantage for a lever is obtained by dividing the length of the effort arm by the length of the load arm.
The Ministry of Education wishes to acknowledge the contribution of the many individuals, groups, and organizations that participated in the development and refinement of this resource document.