OCTE 2011 – Elementary Conference Workshops

Grade 7 Biomimicry – "Laptop Cooling Stand"

Science and Technology Curriculum Expectations

Understanding Life Systems – Interactions in the Environment

Overall Expectations:

- 1. assess the impacts of human activities and technologies on the environment, and evaluate ways of controlling these impacts;
- 3. Demonstrate an understanding of interactions between and among biotic and abiotic elements in the environment.

Specific Expectations:

- 1.1 assess the impact of selected technologies on the environment;
- 3.2 identify biotic and abiotic elements in an ecosystem, and describe the interactions between them.

Understanding Earth and Space Systems – Heat In The Environment

Overall Expectations:

- 2. Investigate ways in which heat changes substances, and describe how heat is transferred.
- 3. Demonstrate an understanding of heat as a form of energy that is associated with the movement of particles and is essential to many processes within the Earth's systems.

Specific Expectations:

- 2.3 use technological problem-solving skills to identify ways to minimize heat loss *(please note that this unit reverses this process; however, managing heat loss is still the main goal)*;
- 2.4 use scientific inquiry/experimentation skills to investigate heat transfer through conduction, convection, and radiation
- 2.5 use appropriate science and technology vocabulary, including heat, temperature, conduction convection, and radiation, in oral and written communication;
- 2.6 use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes;
- 3.1 use the particle theory to compare how heat affects the motion of particles in a solid, a liquid, and a gas;
- 3.4 explain how heat is transmitted through conduction and describe natural processes that are affected by conduction;
- 3.5 explain how heat is transmitted through convection, and describe natural processes that depend on convection;
- 3.6 explain how heat is transmitted through radiation, and describe the effects of radiation from the sun on different kinds of surfaces.

Understanding Structures and Mechanisms – Form and Function

Overall Expectations:

- 1. Analyse personal, social, economic, and environmental factors that need to be considered in designing and building structures and devices.
- 2. Design and construct a variety of structures, and investigate the relationship

between the design and function of these structures and the forces that act on them.
- 3. Demonstrate an understanding of the relationship between structural forms and the forces that act on and within them.

Specific Expectations:
- evaluate the importance for individuals, society, the economy, and the environment of factors that should be considered in designing and building structures and devices to meet specific needs;
- 1.2 evaluate the impact of ergonomic design on the safety and efficiency of workplaces, tools, and everyday objects and describe changes that could be made in personal spaces and activities on the basis of this information;
- 2.1 follow established safety procedures for using tools and handling materials;
- 2.2 design, construct, and use physical models to investigate the effects of various forces on structures**;**
- 2.3 investigate the factors that determine the ability of a structure to support a load;
- 2.6 use appropriate science and technology vocabulary, including **truss, beam, ergonomics, shear,** and **torsion)**, in oral and written communication;
- 2.7 use a variety of forms to communicate with different audiences and for a variety of purposes;
- 3.4 distinguish between external forces and internal forces (tension, compression, shear, and torsion) acting on a structure.

Learning Goals

1. The student will investigate Biomimicry, and incorporate his/her findings (regarding heat transfer) into the design of a laptop-cooling stand.
2. The student will integrate heat transfer by conduction, convection and radiation into her/his design, and explain how each functions within the cooling system.
3. The student will design a structure that places a laptop in an ergonomic position, while withstanding the forces encountered during everyday use (e.g., tension, torsion, compression, and shear).
4. The student will address environmental, personal, and social factors in designing and building his/her laptop-cooling stand.

Assessment and Evaluation

Assessment as Learning

It is the goal of the OCTE Elementary Committee to support their members in the development of this skill. Assessment as learning is the second of three forms of assessment addressed in the Ministry of Education's Growing Success (2010) document. A summary of materials related to the three assessments is as follows:
- assessment for learning involves generating feedback about your students' progress that is shared with them before assessing for report card grades;
- assessment of learning is when you generate marks/levels for your report cards;
- assessment as learning, when developed fully, is when students provide their own feedback and assessment (peer and/or self) regarding their learning; students use this information to set learning goals, and to select appropriate learning strategies for their success.

Here are some suggestions to support the implementation of "Assessment as Learning" in your program; they are as follows:

1. Provide your students with a copy of “Appendix C: Assessment As Learning, Student Self-Assessment Log” and refer to the appropriate “Learning Goal Statement” (for discussion) before each of these tasks is completed.
2. Ensure that the learning goal for each task is clearly understood by your students. Use student friendly language where ever possible.
3. Provide opportunities for self/peer assessment (move from structured to student directed as your students develop this skill).
4. Discuss or refer to successful and unsuccessful work (exemplars, or student generated materials) to provide benchmarks for your students’ self/peer assessments.
5. Collect and review the “… Self-Assessment Logs” make note of who needs additional support. Schedule time for these students into your next lesson (or provide opportunities for extra help, if possible).
6. Use your students’ self/peer assessments to determine if a task requires modification to support successful learning.
7. Refer to pp. 27-36 in the Growing Success document for complete details. Reference: Ontario. Ministry of Education. (2010). *Growing Success: Assessment, Evaluation, and Reporting in Ontario Schools, First Edition, Covering Grades 1-12.* Toronto: Author. ISBN 978-1-4435-2284-7 (Print), ISBN 978-1-4435-2285-4 (PDF) (Rev.), ISBN 978-1-4435-2286-1 (TXT), © Queen’s Printer for Ontario.

Success Criteria

- Check items you wish to evaluate during the completion of this unit.
- You may differentiate your assessment by offering your students a variety of these items as “choices”, while making other items mandatory.
- Please see Appendix A for this unit’s assessment rubric.
- Please see Appendix C for the Assessment As Learning, Student Self-Assessment Log.”

Knowledge and Understanding (K&U), please see attached “Assessment Rubric” for corresponding evaluation items:

O the student acquired a knowledge of facts and terminology related to Biomimicry, heat transfer, ergonomics, and structural strength (K&U, A);

O the student used tools and materials safely and appropriately in building her/his laptop cooling stand (K&U, B);

O the student demonstrated an understanding of ideas and principals involved in Biomimicry, heat transfer, and structural design by including them in the design of his/her final product (K&U, C);

O the student identified how biotic components in nature interact with abiotic components to transfer heat through conduction, convection, and radiation (K&U, D);

Thinking and Investigation (T&I), please see attached “Assessment Rubric” for corresponding evaluation items:

O the student identified appropriate items to research, and located resources that were relevant to her/his investigation (T&I, A);

- the student developed hypotheses, based on his/her research, about potential solutions to his/her design challenge (T&I, B);
- the student developed a suitable set of plans, based on the research and hypotheses noted above (T&I, C);
- the student fabricated and tested a prototype laptop cooling stand (T&I, D);
- where necessary, the student modified the design of her/his stand, to improve its performance (T&I, E);
- the student provided evidence of how his/her product has met the design challenge's requirements (T&I, F).

Communication (Com.), please see attached "Assessment Rubric" for corresponding evaluation items:

- the student completed an oral, visual, or written report on how she/he progressed through the Technological Problem-Solving process to create a final product that solved the design challenge (Com., A);
- the student's report was organized in a clear, logical manner, and included diagrams and models where appropriate (Com., B);
- the student's report accurately described the steps taken to solve the design challenge in oral, visual, and/or written forms (Com., C);
- the student's report used an appropriate oral, visual, and/or written form for the selected audience e.g., teacher, or teacher and classmates (Com., D);
- the student included the correct use of scientific vocabulary and terminology in his/her report (Com., E).

Application (App.), please see attached "Assessment Rubric" for corresponding evaluation items:

- the student identified how Biomimicry was incorporated into the design of her/his laptop cooling stand to transfer heat through conduction, convection, and radiation (App., A);
- the student has identified areas where heat energy is transferred away from the laptop by the movement of particles (App., B);
- the student identified which forces (tension, compression, torsion, and shear) acted on his/her stand during use, and how the structure was designed to withstand these forces (App., C);
- the student identified existing structures or devices that are cooled through conduction, convection, and/or radiation, by using a design that is based on Biomimicry (App., D);

O the student identified how her/his product impacts the environment favourably, when compared to similar products that are currently available for purchase (App., E);

O the student suggested ways in which his/her innovations could solve some of the problems faced by society and the environment (App., F).

Curriculum Connections and Additional Assessment Opportunities

Language:

- Oral Communication, Overall Expectations 2 and 3 (select from specific expectations 2.2 - 2.7, and 3.1);
- Reading, Overall Expectations 1 and 4 (select from specific expectations 1.2, 1.4, and 4.1);
- Writing, Overall Expectations 1, 2, 3, and 4 (select from specific expectations 1.3, 1.5 1.6, 2.1, 2.4, 2.6 - 2.8, 3.1 - 3.8, and 4.1);
- Media Literacy, Overall Expectations 3 and 4 (select from specific expectations 3.2 - 3.4, and 4.1).

The Arts:

- Drama, Overall Expectation B1 and B2 (select from specific expectations B1.1 - B1.3, and B2.3);
- Visual Arts, Overall Expectations D1 and D2 (select from specific expectations D1.3, D1.4, and D2.4).

Materials and Tools List

Materials:

- 1/2" x 24" basswood strips (about five pieces per project);
- 1/4" x 24" basswood (about five pieces per project);
- 1/8" x 12" x 30 Baltic Birch Plywood (one 10" x 12" piece per “flapper” styled project);
- low heat glue sticks (three - four sticks per project);
- balsa wood airplane propellers, with mounts (one propeller per “fan” styled project);
- rubber bands (two - three elastics per project);
- ¼” - ½” width fabric elastic (12” of length per “flapper styled project);
- gear racks 100 mm (two each for advanced students who wish to design a quick wind system for their fans), *use gear racks in conjunction with red plastic gears*;
- red plastic gears,10 tooth, with inserts (1 each for advanced students who wish to design a quick wind system for their fans);
- 2 boxes of 100, large paperclips (to be used in a variety of creative way when making the projects e.g., elastic hooks, hinges, etc.);
- 1 box of 1" finishing nails, can be either ardox or regular (use as needed for hinges, strengthening joints, and small drill bits by clipping off the heads so the shaft can be clamped securely in the chuck);
- 1 box of 1 1/2" finishing nails, can be either ardox or regular (use as needed for hinges, strengthening joints, and small drill bits by clipping off the heads so the shaft can be clamped securely in the chuck);
- tinfoil (approx. 1 foot per laptop stand);
- rubberized or heavy fabric (e.g., an old raincoat or pants, old jeans, etc.), this will be cut into strips that are glued along the sealed edge of the flapper to act as a hinge, and to prevent air from escaping out its back when used.

Tools - please note that this list is designed for classroom projects where the use of powered tools is prohibited:

- CSA approved safety glasses/goggles, one pair per person (parent volunteers included);
- 2 eyewash bottles (check expiry durations for decanted fluid) or an eyewash sink;
- 1 first aid kit (consult your Board's health and safety policy for required size/ contents);
- work gloves, 1 pair per low heat glue gun;
- aprons, 1 per glue gun;
- 1 bucket of cool water per glue gun station (place beyond the reach of a student who is still holding a glue gun that is plugged in);
- 1 low heat (10-15) watt, glue gun for every 3 students;
- 1 fine tooth saw (e.g., coping saw, backsaw, hacksaw, junior hacksaw, etc.) for every 2-3 students,
- 1 fine tooth hand saw (24 tpi minimum), to cut Baltic birch plywood, for every 6 "flapper" styled projects;
- 1 egg beater or pistol grip hand drill for every 5 students;
- 1 pair of long nose pliers, with side cutter, for every 5 students;
- 1 set of Robertson screwdrivers for every 10 students;
- 1 claw hammer for every 5 students;
- 1 C-clamp for every 2-3 students;
- 1 bench hook for every 2-3 students;
- 1 file (8" or longer) for every 5 students;
- sand paper, 1/6 sheet per pair of students (sanding blocks may be used as well);
- 1 pair of scissors for every 5 students (they may use their if available);
- 4 instant read (digital) cooking thermometers.

Resources

Electronic Resources:

- Video CBS News, 3:18 "The Fast Draw: Biomimicry" (http://www.cbsnews.com/8301-502623_162-5577007-502623.html)
- Video Ted, 17:39 "Janine Benyus: Biomimicry in action" Search "Janine Benyus" to find a number of good videos, of varying lengths, for researching and understanding biomimicry. (http://www.ted.com/talks/janine_benyus_biomimicry_in_action.html)
- "Ask Nature" This website allows the user to search its database for answers to questions that begin with "How would nature …?" It is designed for people who wish to solve design problems by mimicking nature, and starting points to work from (http://www.asknature.org/)
- "Biomimicry Institute" This is the main website for biomimicry based material (http://www.biomimicryinstitute.org/)
- Video TED, 13:47 "Michael Pawlyn: Using nature's genius in architecture" This one is a little advanced for students; however, there are some good examples and very interesting facts that can be shared from it. http://www.ted.com/talks/michael_pawlyn_using_nature_s_genius_in_architecture.html
- "designboom's 'biomimicry' article now online" (http://www.designboom.com/contemporary/biomimicry.html) Warning – do not allow use of links; stay on this page.

Print Resources (Biomimicry):

- Biomimicry: Innovation Inspired by Nature. Janine Benyus.
- 1997Design and Nature II. Ed M. W. Collins et. Al. 2004

Print Resources (Grade 7 Science):

- Any Grade 7 Science textbook that is found on the Ministry Approved “Trillium List” will contain resources that will assist teachers and students in completing this unit.

Activity Description

Design Challenge:
What is Biomimicry? According to “The Biomimicry Group”, it is the study and imitation of nature's remarkably efficient designs, and the use of these models to create sustainable technologies (http://www.biomimicry.net/).

Students will investigate how heat is transferred through conduction, convection and radiation. Using this knowledge, the materials and tools provided, as well as, teacher approved “found items”, students will create a laptop-cooling stand that includes Biomimicry in the design of its cooling system. The cooling system cannot use any electrical power to operate, and must transfer heat away from a laptop by conduction, convection, and radiation. Please see “Appendix B” for the students' design challenge black line master.

Minds On/Hands On

1. Show high interest segments from one or more videos listed in the Electronic Resources section
2. Read Aloud: if a projector is available show pictures and read text from “designboom's ‘biomimicry’ article now online” (see Electronic Resources).
3. Pass around some Velcro so students can investigate what was imitated in nature to make this product.

Action – with the exception of safety, teachers may skip items that do not support the learning/assessment they wish to address during this unit.

1. Teacher, introduces and provides design challenge to individuals, partners, or small groups, discusses all items with the class, and ensures students understand what must be done.
2. Teacher and students, co-construct success criteria based on curriculum expectations and prior learning (recommended teacher suggestions are listed in this document).
3. Teacher, displays tools and materials available for the design challenge.
4. Teacher, reviews Learning Skills related to this type of task (e.g., safety [safe use of tools and materials], research, problem solving, collaboration, responsibility).
5. Students, perform research on cooling systems found in Nature, then apply this knowledge to the design of their stands.
6. Students, perform research on ergonomic laptop positioning, then apply this knowledge to the design of their stands.
7. Teacher and/or students, review or complete a lesson(s) on how heat is transferred, and vocabulary that is related to these processes (e.g., conduction, convection, and radiation), then apply this knowledge to the design of their stands.
8. Teacher and/or students, review or complete a lesson(s) on particle theory, and particle movement during the transfer of heat energy, then apply this knowledge to the design of their stands.

9. Teacher and/or students, review or complete a lesson(s) on structural designs and forces that act on them (tension, compression, torsion, and sheer), then apply this knowledge to the design of their stands.
10. Students, research the terms biotic and abiotic, and determine how interactions between and/or among these elements function when a cooling system operates in nature, then apply this knowledge to the design of their stands.
11. Students list their top ideas for solving the design challenge, sketch out the two that seem the most promising, then submit them to their teacher for approval.
12. Teacher, reviews sketches for safety and feasibility. Students with approved sketches move on to the next step.
13. Students, create plans for building their stands, and submit them to their teacher for approval.
14. Teacher, reviews plans for safety, and feasibility. Students with approved plans move on to the next step.
15. Students build a laptop-cooling stand using provided materials and tools. Students who wish to use found materials must have them approved by their teacher.
16. Students, test the cooling stand by operating the laptop in its normal position until it is warm. Once warm, students take the temperature between its base and the desktop using the instant read thermometer (leave in place for 2 minutes to ensure an accurate reading). Record the temperature.
17. Students, take a second temperature reading after the computer has been used on the stand for half an hour. During this time, the stand must be operated as intended, by the student. To record the temperature place probe against the base, and read after it has been in place for 2 minutes.
18. Students, change their design (if necessary) based on observations, peer feedback and teacher feedback (test again if time permits).
19. Students, record all final data and observations, then begin working on their reports using this material and applicable content from items 5-18 listed above.
20. Students, research and discuss other devices/systems that control temperature using biomimicry. This material should be added to the students' reports.
21. Students, complete and hand in/present a written/oral report that addresses all the design challenge's requirements selected by their teacher.

Consolidation

1. In groups, students discuss what went well with their designs, what changes were made to their designs, why they were needed, and what they would do differently if given another opportunity. This material should be added to the students' reports.
2. In groups, students share and discuss the how the cooling systems of their stands achieved biomimicry in their designs and functions. New discoveries should be added to the students' reports.
3. Talk about the ideas they used in their stand that were based on natural cooling systems; new discoveries should also be addressed in the students' reports
4. Research and discuss what other kinds of devices control temperature using biomimicry. This material should be added to the students' reports.

Complete and hand in or present a written, oral, and/or media report that addresses the design challenge's content requirements.

Appendix A: Assessment Rubric

This rubric was developed from the Ontario Curriculum Grades 1-8 Science and Technology, Revised 2007 document.

	Level 1	Level 2	Level 3	Level 4
Knowledge and Understanding (K&U) – Subject-specific content acquired in each grade (knowledge), and the comprehension of its meaning and significance (understanding)				
	The Student:			
A) Knowledge of content (e.g., facts and terminology related to Biomimicry, heat transfer, and structural design)	demonstrates limited knowledge of content	demonstrates some knowledge of content	demonstrates considerable knowledge of content	demonstrates thorough knowledge of content
B) Knowledge of content (tools and materials are used safely and appropriately in building the laptop cooling stand)	demonstrates limited knowledge of content	demonstrates some knowledge of content	demonstrates considerable knowledge of content	demonstrates thorough knowledge of content
C) Understanding of content (understand ideas and principals involved in Biomimicry, heat transfer, and structural design; demonstrate by addressing these items effectively in the design of the final product)	demonstrates limited understanding of content	demonstrates some understanding of content	demonstrates considerable understanding of content	demonstrates thorough understanding of content
D) Understanding of content (identify how biotic components in nature interact with abiotic components to transfer heat through conduction, convection, and radiation)	demonstrates limited understanding of content	demonstrates some understanding of content	demonstrates considerable understanding of content	demonstrates thorough understanding of content
Thinking and Investigation (T&I) – The use of critical and creative thinking skills and inquiry problem solving skills and/or processes				
	The Student:			
A) Use of initiating and planning skills and strategies (identify appropriate items to research, and locate resources that are relevant to the investigation)	uses initiating and planning skills and strategies with limited effectiveness	uses initiating and planning skills and strategies with some effectiveness	uses initiating and planning skills and strategies with considerable effectiveness	uses initiating and planning skills and strategies with a high degree of effectiveness
B) Use of initiating and planning skills and strategies (developed hypotheses, based on research, about potential solutions to the laptop cooling stand design challenge)	uses initiating and planning skills and strategies with limited effectiveness	uses initiating and planning skills and strategies with some effectiveness	uses initiating and planning skills and strategies with considerable effectiveness	uses initiating and planning skills and strategies with a high degree of effectiveness
C) Use of initiating and planning skills and strategies (develop a suitable set of plans, based on the research and hypotheses noted above)	uses initiating and planning skills and strategies with limited effectiveness	uses initiating and planning skills and strategies with some effectiveness	uses initiating and planning skills and strategies with considerable effectiveness	uses initiating and planning skills and strategies with a high degree of effectiveness
D) Use of processing skills and Strategies (fabricate and test a prototype laptop cooling stand)	uses processing skills and strategies with limited effectiveness	uses processing skills and strategies with some effectiveness	uses processing skills and strategies with considerable effectiveness	uses processing skills and strategies with a high degree of effectiveness

E) Use of critical/creative thinking processes, skills, and strategies (if needed, the design is modified to improve the stand's performance)	uses critical/creative thinking with limited effectiveness	uses critical/creative thinking with some effectiveness	uses critical/creative thinking with considerable effectiveness	uses critical/creative thinking with a high degree of effectiveness
F) Use of critical/creative thinking processes, skills, and strategies (provide evidence to show that the laptop cooling stand has met the design challenge requirements)	uses critical/creative thinking processes, skills, and strategies with limited effectiveness	uses critical/creative thinking processes, skills, and strategies with some effectiveness	uses critical/creative thinking processes, skills, and strategies with considerable effectiveness	uses critical/creative thinking processes, skills, and strategies with a high degree of effectiveness
Communication (Com.) – The conveying of meaning through various forms				
	The student:			
A) Expression and organization of ideas and information in oral, visual, and/or written forms (complete a report that is organized in a clear, logical manner)	expresses and organizes ideas and information with limited effectiveness	expresses and organizes ideas and information with some effectiveness	expresses and organizes ideas and information with considerable effectiveness	expresses and organizes ideas and information with a high degree of effectiveness
B) Expression and organization of ideas and information in oral, visual, and/or written forms (include diagrams and models where appropriate)	expresses and organizes ideas and information with limited effectiveness	expresses and organizes ideas and information with some effectiveness	expresses and organizes ideas and information with considerable effectiveness	expresses and organizes ideas and information with a high degree of effectiveness
C) Communication for different audiences and purposes in oral, visual, and/or written forms (accurately describe the steps taken to solve the design challenge)	communicates for different audiences and purposes with limited effectiveness	communicates for different audiences and purposes with some effectiveness	communicates for different audiences and purposes with considerable effectiveness	communicates for different audiences and purposes with a high degree of effectiveness
D) Communication for different audiences and purposes in oral, visual, and/or written forms (use an appropriate form for the selected audience, e.g., teacher or teacher and classmates)	communicates for different audiences and purposes with limited effectiveness	communicates for different audiences and purposes with some effectiveness	communicates for different audiences and purposes with considerable effectiveness	communicates for different audiences and purposes with a high degree of effectiveness
E) Use of conventions, vocabulary, and terminology of the discipline in oral, visual, and/or written forms (use vocabulary such as conduction, convection, radiation, biomimicry, torsion, tension, compression, sheer, particle theory, biotic, and abiotic correctly in the report)	uses conventions, vocabulary, and terminology with limited effectiveness	uses conventions, vocabulary, and terminology with some effectiveness	uses conventions, vocabulary, and terminology with considerable effectiveness	uses conventions, vocabulary, and terminology with a high degree of effectiveness
Application (App.) – The use of knowledge and skills to make connections within and between various contexts				
	The student:			

A) Application of knowledge and skills in familiar contexts (identify how biomimicry is incorporated into the design of the stand, to transfer heat through conduction, convection, and radiation)	applies knowledge and skills in familiar contexts with limited effectiveness	applies knowledge and skills in familiar contexts with some effectiveness	applies knowledge and skills in familiar contexts with considerable effectiveness	applies knowledge and skills in familiar contexts with a high degree of effectiveness
B) Application of knowledge and skills in familiar contexts (identify how heat energy is transferred away from the laptop by the movement of particles)	applies knowledge and skills in familiar contexts with limited effectiveness	applies knowledge and skills in familiar contexts with some effectiveness	applies knowledge and skills in familiar contexts with considerable effectiveness	applies knowledge and skills in familiar contexts with a high degree of effectiveness
C) Application of knowledge and skills in familiar contexts (identify where tension, compression, torsion, and shear act on the stand during use, and how the stand is designed to withstand these forces)	applies knowledge and skills in familiar contexts with limited effectiveness	applies knowledge and skills in familiar contexts with some effectiveness	applies knowledge and skills in familiar contexts with considerable effectiveness	applies knowledge and skills in familiar contexts with a high degree of effectiveness
D) Transfer of knowledge and skills to unfamiliar contexts (identify other existing structures or devices that are cooled through conduction, convection, and/or radiation, by using a design that is based on Biomimicry)	transfers knowledge and skills to unfamiliar contexts with limited effectiveness	transfers knowledge and skills to unfamiliar contexts with some effectiveness	transfers knowledge and skills to unfamiliar contexts with considerable effectiveness	transfers knowledge and skills to unfamiliar contexts with a high degree of effectiveness
E) Making connections between science, technology, society, and the environment (identify how the stand impacts the environment favourably, when compared to similar products currently available for purchase)	connects science, technology, society, and the environment with limited effectiveness	connects science, technology, society, and the environment with some effectiveness	connects science, technology, society, and the environment with considerable effectiveness	connects science, technology, society, and the environment with a high degree of effectiveness
F) Proposing courses of practical action to deal with problems relating to science, technology, society, and the environment (suggest ways in which your innovations could solve some of the problems faced by society and the environment)	proposes courses of practical action of limited effectiveness	proposes courses of practical action of some effectiveness	proposes courses of practical action of considerable effectiveness	proposes highly effective courses of practical action

Notes: ____________________

Appendix B: Student Design Challenge

Name:_______________________ Teacher:______________________ Class: ______

You were recently promoted to the Biomimicry division of the product development team at InvestiGreen Solutions Inc. Your skills are being put to the test because you have been given the lead position on the laptop cooling stand project. This stand must be environmentally friendly. It must also mimic designs found in Nature that solve cooling problems for living organisms.

InvestiGreen requires that you complete the following actions in designing and developing your prototype:

- review the list of materials your department has been given to accomplish this task;
- research and record how non-human life forms cool themselves using conduction, convection, and radiation as a means of heat transfer;
- apply this knowledge to the design of a laptop cooling stand that does not use electrical power to operate its system;
- incorporate ergonomics into the stand's design, so the keyboard will be positioned comfortably for the user;
- design a structure that will withstand the forces generated under normal use;
- 95% of the materials used must fall under at least one of the following classifications, renewable, recyclable, reclaimed, or biodegradable;
- determine if additional "found" materials may be needed; before you bring in your own materials, request approval from the upper management (your teacher) to see if they are safe for use in a school setting;
- submit your plans to the upper management (your teacher) for approval;
- build and test a prototype of your design;
- if necessary, modify your prototype to improve its performance.

Following this process, you will be required to submit or present a report to InvestiGreen Solution's upper management (your teacher). Your report must include all the items you teacher has checked off for this task.

O Use vocabulary that includes the correct use of the terms radiation, conduction, and convection.

O Use vocabulary that includes the correct use of the terms tension, compression, torsion and shear.

O Identify and discuss the examples you copied from nature, to make your cooling system (Biomimicry); explain how your device mimics your choices.

O Identify where forces of torsion, tension, and shear act on your stand, and explain how your design is made to handle these forces, without breaking, during normal use.

O Identify how ergonomic positioning is demonstrated by your stand.

O Identify how biotic components in nature interact with abiotic components to transfer heat through conduction, convection, and radiation.

- O Identify areas where heat energy is transferred away from the laptop by the movement of particles (apply what you have learned about heat and the particle theory).
- O Prove that your stand is better for the environment than some of the other laptop cooling stands that are currently available for people to buy.
- O Explain how your design can solve some current problems faced by society and the environment.
- O Explain how you tested your device, and what your results were.
- O Describe any improvements you made, or would make, based on your testing results.
- O Prove that your product has met the design challenge's requirements.
- O Identify other structures or devices that use biomimicry in their design, to provide cooling through conduction, convection, and/or radiation.
- O If you are writing a report, your audience is your teacher. If you are presenting a report, your audience is your teacher and other students. Complete a report that does not include material that is beyond the understanding of your audience.
- O Check to make sure that your report is organized in a clear, logical manner, and includes diagrams and models where appropriate.
- O Revise your report to make sure that it communicates all your information clearly and accurately.

Notes:

Appendix C: Assessment As Learning, Student Self-Assessment Log

Name:______________________ Teacher:_____________________ Class: ______

Self-assessment is an important skill for learning. As you work through this unit, these pages will help you take ownership of your achievement and progress. Here are some simple suggestions that will help you with this process:

A. Be honest and accurate in recording your results.
B. Make sure you understand each goal clearly, **before** you begin working on it.
C. Your teacher will be looking for specific items related to each goal. If you are not sure what these are, ask. When you clearly understand what you need to do, keep these instructions and guidelines in mind as you complete each task.
D. You may use feedback from your teacher to help with your self-assessment.
E. You may use feedback from your peers (other students) to help with your self-assessment.
F. Compare your efforts to the samples of successful and unsuccessful work your teacher has provided.
G. Compare your efforts to what is expected for each learning goal.
H. Select one or more "Responsibility for Learning" strategies, if needed.
I. Record new learning in your notebook, or design challenge logbook.
J. Leave the blank beside "Date Achieved" empty, until are confident you have achieved that learning goal.

<table>
<tr><td>Self-Assessment (SA):
1. I have reached this goal.
2. I am getting there.
3. Help! I am struggling with this.</td><td>Peer-Assessment (PA):
1. You have reached this goal.
2. You are getting there.
3. You have not reached this goal.</td></tr>
<tr><td colspan="2">Responsibility For Learning (RFL).
0. No assistance is needed. I have achieved what this task requires.
1. I will reach this goal by asking for direct support from my teacher.
2. I will reach this goal by asking for support from my peers.
3. I will reach this goal by asking for support from my caregiver(s).
4. I will reach this goal by working on it independently.</td></tr>
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Learning Goal Statements:

1. I understand what Biomimicry is and can discuss some examples of how this science is solving problems faced by our society.

   SA:_________ PA:________ RFL:_______ Date Achieved:__________

2. I understand what the design challenge is, and what I need to do to be successful.

   SA:_________ PA:________ RFL:_______ Date Achieved:__________

3. I know which tools and materials available for the design challenge, and I understand how to use these safely.

   SA:_________ PA:________ RFL:_______ Date Achieved:__________

Name:_______________________ Teacher:______________________ Class: ______

4. I have the learning skills needed for this design challenge (e.g., research, problem solving, collaboration, responsibility, safety).

   SA:_________ PA:________ RFL:_______ Date Achieved:__________

5. I have researched how creatures and structures are cooled in nature, and I have found examples that I can use in the design of my stand.

   SA:_________ PA:________ RFL:_______ Date Achieved:__________

6. I understand what ergonomic positioning is, and I can apply knowledge to the design of my stand.

   SA:_________ PA:________ RFL:_______ Date Achieved:__________

7. I understand how heat is transferred by conduction, convection, and radiation, I can use this vocabulary correctly, and I can apply this knowledge to the design of my stand.
8. SA:_________ PA:________ RFL:_______ Date Achieved:__________

9. I understand what particle theory is, and I can apply the transfer heat energy through the movement of particles to the design of my stand.

   SA:_________ PA:________ RFL:_______ Date Achieved:__________

10. I understand the terms tension, compression, torsion, and sheer and I can use this vocabulary correctly. I know how these forces act on structures, how structures are designed to withstand these forces, and how I can apply this knowledge to the design of my stand.

    SA:_________ PA:________ RFL:_______ Date Achieved:__________

11. I understand the terms biotic and abiotic. I can use this vocabulary correctly, and I can explain how biotic elements and abiotic elements work (either together or separately) to cool a creature or structure found in Nature. I can also apply this knowledge to the design of my stand.

    SA:_________ PA:________ RFL:_______ Date Achieved:__________

12. I have listed my top ideas, sketched out the best two, handed them in, and received approval to create a set of plans.

    SA:_________ PA:________ RFL:_______ Date Achieved:__________

13. My set of plans includes diagrams, measurements, instructions, and a list of necessary tools and materials. I have handed them in and my teacher has approved them.

    SA:_________ PA:________ RFL:_______ Date Achieved:__________

14. I have finished building my stand, and it is ready for testing.

    SA:_________ PA:________ RFL:_______ Date Achieved:__________

15. I understand how to test my stand, and how to record my results and observations.

    SA:_________ PA:________ RFL:_______ Date Achieved:__________

Name:________________________ Teacher:______________________ Class: ______

16. I have tested my stand and have recorded the required data and observations accurately.

    SA:_________ PA:________ RFL:_______ Date Achieved:__________

17. I have changed my design (if necessary) based on my observations, peer feedback and teacher feedback.

    SA:_________ PA:________ RFL:_______ Date Achieved:__________

18. I understand what needs to be included in my report (up to testing, and improving my design). I have been told what form it will be (oral, or written) and which audience to write for (teacher only, or teacher and students). I have the information and materials needed to complete my report.

    SA:_________ PA:________ RFL:_______ Date Achieved:__________

19. Through research, I have found other man made devices/systems that use biomimicry in the design of their temperature control systems. I have added this information to my report.

    SA:_________ PA:________ RFL:_______ Date Achieved:__________

20. I have discussed the following items with a group of my peers: what went well with our designs, what changes could be made (or were made) to improve our designs, why these changes were needed, and what we would do differently if given another opportunity. I have added key materials from these discussions to my report.

    SA:_________ PA:________ RFL:_______ Date Achieved:__________

21. I have discussed and confirmed, with a group of my peers, that my stand's cooling system includes biomimicry in its design. I have made corrections and/or added new information from these discussions to my report.

    SA:_________ PA:________ RFL:_______ Date Achieved:__________

22. I am able to and hand in/present a written/oral report that includes all the required information listed and checked off in the design challenge.

    SA:_________ PA:________ RFL:_______ Date Achieved:__________

Notes: ____

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