



Teacher's Corner Lesson Plans

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their Outdoor Classroom*

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Conducting an Ecological Inquiry Investigation

Sandra McEwan

Grade level: Grade 10 and 11.

Provincial curriculum links: Ontario and Pan-Canadian.

Subject: Science.

Keywords: independent inquiry, research method, research design, ecology, variable, independent variable, dependent variable, control group, analysis, presentation, group work.

Description

This lesson gives students the opportunity to develop skills of scientific inquiry, design and communication. Students will plan, conduct and analyze a scientific investigation for a question they have formulated on an observable and/or measurable ecological relationship, problem or idea in the school grounds.

Curriculum Framework

This lesson is linked directly to the learning expectations described in the Ontario Curriculum for Grade 10 and 11 Science.

The learning expectations are also broadly applicable to other Canadian curricula, including the Pan-Canadian Science Curriculum.

A: Ontario Curriculum Grade 10 Science, Academic (SNC 2D)

Strand: Biology

Specific Lesson Goals:

Through investigations and applications of basic concepts:

- formulate scientific questions about observed ecological relationships, ideas, problems and issues (e.g., “What impact will supplying an excess of food for a particular organism have on an ecosystem?”);
- demonstrate the skills to plan and conduct an inquiry into ecological relationships, using instruments, apparatus, and materials safely and accurately, and controlling major variables and adapting or extending procedures where required;

- select and integrate information from various sources including electronic and print resources, community resources and personally collected data to answer the questions chosen;
- analyze data and information and evaluate evidence and sources of information, identifying flaws such as errors and bias;
- select and use appropriate vocabulary and numeric, symbolic, graphic and linguistic modes of representation to communicate scientific ideas, plans, results, and conclusions (e.g., use terms such as *biotic*, *abiotic*, *biomass*, *biome*, *ecosystem*, *chemical concentration* and *biodiversity* when making presentations).

B: Grade 11 Biology, University Preparation (SBI 3U)

Strand: Plants: Anatomy, Growth and Functions

Specific Lesson Goals:

- design and carry out an experiment to determine the factors that affect the growth of a population of plants, identifying and controlling major variables.

C: Pan-Canadian Curriculum

Knowledge:

- 331-7 describe how soil composition and fertility can be altered and how these changes could affect an ecosystem

Skills:

- 212-1 identify questions to investigate that arise from practical problems and issues.
- 212-3 design an experiment identifying and controlling major variables.
- 212-4 state a prediction and a hypothesis based on available evidence and background information.
- 212-8 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making.
- 212-9 develop appropriate sampling procedures.
- 213-2 carry out procedures controlling the major variables and adapting or extending procedures where required.
- 213-3 use instruments effectively and accurately for collecting data.
- 213-5 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data.
- 213-6 use library and electronic research tools to collect information on a given topic.

- 213-7 select and integrate information from various print and electronic sources or from several parts of the same source.
- 213-8 select and use apparatus and materials safely.
- 214-9 identify and apply criteria, including presence of bias, for evaluating evidence and sources of information.
- 214-10 identify and explain sources of errors and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty.
- 214-11 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion.
- 214-12 explain how data support or refute the hypothesis or prediction.
- 215-2 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results.

Preparation

Preparation time: Approximately 25 minutes to collect materials, prepare student worksheets, read educator notes (provided) and review references/resources (as noted below).

Length of lesson: Approximately 375 minutes for class discussions, scientific investigation and reporting.

Resources required: Student worksheets. Other resources will depend on the inquiry being undertaken.

Procedure

1. Model the steps of a scientific inquiry investigation in the school ground using a sample researchable question.
2. Distinguish between a controlled experiment and a correlational study.
3. Review the terminology and guiding principles for the design and analysis of an experiment or investigation as summarized in the Educator Notes.
4. Organize students into research teams of two to four members. Assign tasks to each member (e.g., group leader, equipment manager, data collector, safety officer and on-task monitor).
5. Provide time for the teams to brainstorm topics to investigate and share ideas with the class.
6. Approve and sign off on each team's study topic, research question, materials list and investigation design. Make sure students know that they need to have these approved (see Teacher Approval sheet, attached) before they can go ahead with the investigation.

7. Engage teams in the investigation and report write-up.

NOTE: This lesson allows students to think independently and creatively when designing an investigation, but keep in mind that Grade 10 and 11 students will need quite a bit of direction. Check students' progress periodically, and encourage them to check in with you to make sure they stay focused.

Discussion and Questions

Provide a full class period for the research teams to analyze their data and to work on the report write-up. The report and presentation are due the following class. Facilitate a class discussion around the Analysis and Write-up requirements outlined on the student worksheet. Introduce these questions as well:

1. What is the significance of these inquiry results? That is, why do the results matter? Could they be applied to school ground maintenance or school ground gardening?
2. Do the results of these inquiries suggest the need for further research? Suggest research questions for future inquiries.
3. Why is it important to ensure that your inquiry could be replicated by another researcher?
4. Could you have conducted these inquiries in the classroom or laboratory, instead of outdoors? What would be the advantages and disadvantages of such an approach?

Student Evaluation

- Completion of written report
- Observations
- Peer and self-evaluation
- Presentation Rating Scale and Written Report Rating Scale (provided)

Enrichment and Extension Activities

If time permits, teams may deliver a short (5-8 min.) oral presentation to their peers on their inquiry investigations. You may want to allow these presentations to take place outdoors, so that students can show where their study sites were.

Connections to the Outdoor Environment

All inquiries should take place outdoors in the school grounds.

Educator Notes

- In the most general sense, inquiry centers around the desire to answer a question or to know more about a situation. Scientific inquiry refers to the process of developing testable hypotheses and constructing understandings of real-world scientific ideas. This inquiry process involves the following basic steps:
 1. identifying a worthwhile and researchable question
 2. planning the investigation
 3. executing the research plan
 4. preparing the research report
 5. assessing the inquiry process.
- Students should have prior knowledge of the scientific method and the scientific inquiry process.
- Students should be aware of the following terminology and principles for the design and analysis of an experiment or investigation:
 - *Variable* - any factor or condition that affects the results of a scientific investigation.
 - *Controlled Variable* - the factor or condition that affects the results of a scientific investigation.
 - *Independent Variable* - the factor or condition being tested.
 - *Dependent Variable* - the factor that responds to the change in the independent variable. Its response is measured as data.
- Two groups of subjects are used in most experiments. Design the experiment so all factors except the one being tested are kept the same for both groups:
 - The experimental group is the group being tested by having the independent variable changed.
 - The control group is the group in which the independent variable is not changed but treated as a controlled variable.
- Use the same type of subject for both the experimental and controlled groups.
- Be certain that each group is a representative sample and large enough to give validity to the results.
- The inquiry investigations may involve a controlled experiment in which one variable is changed, or a correlational study in which change in variables are compared.
- **SAFETY NOTE:** Consult your school board's policy regarding safety precautions for outdoor excursions and plan your trip accordingly. Be aware of any students with allergies to insect bites and plants and ensure they carry the required medications. Students should wash their hands after handling soil, plants and equipment. Encourage students to wear sunscreen and appropriate clothing (e.g. hat, long-sleeved shirt) to minimize the damaging effects of sun exposure.

References

- Etheredge, S. and Rudnitsky, A. *Introducing Students to Scientific Inquiry. How Do We Know What We Know?* MA: Allyn and Bacon. 2003.
- Martin, R. et al. *Teaching Science For All Children. Lessons for Constructing Understanding, (2nd Ed).* MA: Allyn and Bacon. 2002.

Worksheets

Student Worksheet

In this scientific study, you will plan and conduct an investigation to answer a question that you have formulated on an observable and/or measurable ecological relationship, problem or idea in the school ground. You will prepare a formal report of your inquiry investigation.

Part 1: Before Going Outdoors

1. Decide on a study topic. Brainstorm a list of variables - that is, what differs from one area to another. Once you have a list of variables, work together to come up with several possible relationships among them. For example:
 - Soil pH and tree species
 - Soil temperature and depth profile
 - Soil compaction and percolation rate
 - Plant species and location/plant adaptations
 - Species diversity and proximity to the parking lot
 - Slope and species distribution or abundance
 - Hours of sun per day and plant adaptation
 - Foot traffic level and soil compaction
2. Research Question - Select one topic to investigate and write a research question. For example:
 - What is the relationship between soil pH and tree species?
 - How does soil temperature change with depth?
 - Is there a relationship between soil compaction and percolation rate?
 - Why do dandelions grow more abundantly on the south side of the school compared to the north side?
 - How does species diversity change with proximity to the parking lot?
 - What is the relationship between the slope of the ground and the distribution/abundance of species?
 - Is there a relationship between the number of hours of sun exposure per day and plant adaptation?
 - What effect does foot traffic have on soil compaction?

3. Background Research - Use the library, internet and other media to collect information on the topic to be investigated and the factors that might affect the design of the investigation.
4. Hypothesis - Make a hypothesis or testable prediction about the possible outcome of the investigation.
5. Materials and Equipment - List everything you need for the investigation.
6. Procedure - Design and record the step-by-step instructions. These instructions must be specific enough to allow others to repeat the investigation in exactly the same way each time. Specify the type of evidence or data to be collected. Set up any required data tables.
7. Ask your teacher to check your work before providing you with the necessary equipment to complete your investigation.

Part 2: Outdoors

1. Experiment - Select the study area(s) and conduct the investigation.
2. Results - Collect data in the form of observations and/or quantitative measurements. Use data tables to organize data as it is collected.

Part 3: Analysis and Write-Up

1. Analyze Data - Evaluate the data to identify patterns. When organizing data for analysis, use such visual tools as graphs, diagrams and flow charts.
2. Prepare Report - Your report should include the following sections:
 - Introduction: describing your research question and your predictions or hypothesis. Use your background research to describe why the question is important, and the reasoning behind your hypothesis. In this section, indicate what was the independent variable and dependent variable, and list the controlled variables. Describe the experimental and control group.
 - Equipment: provide a detailed list of required materials.
 - Procedure: outline your research method, step by step. Include notes about advance preparation and safety.
 - Results: include your 'raw' data - that is, the data you recorded in the field - as well as data analysis results (e.g. using graphs and charts). Remember to indicate your measurement units.
 - Discussion: provide a detailed discussion of the inquiry, including your conclusions, as well as arguments to defend your conclusions and the merits of your hypothesis. Drawing on your background research, theorize how one variable might affect another. Comment on whether the research question or problem was testable, and whether the results strengthen your confidence of your hypothesis or, instead, require that the hypothesis be modified or discarded (a hypothesis is never proven to be true; it is just supported by a greater amount

of evidence). Are there any weaknesses in the design of the investigation? List those weaknesses. How would you change the design of the experiment to correct those weaknesses?

- Conclusion: summarize what was learned from the investigation

Conducting an Ecological Inquiry Investigation

Research Summary and Teacher Approval

Date: _____

Group Members: _____

Study Topic: _____

Research Question: _____

Materials List:

Investigation Design (briefly describe your research method):

Teacher Approval: _____

Date: _____

Inquiry Investigation: Written Report Rating Scale

Date Submitted:.....

Group Members:

Topic:.....

CRITERIA	DESCRIPTION OF CRITERIA	GRADE					
		FX	D	C	B	A	E
Title	Title is valid, concise and clearly identifies the problem/topic of the investigation.	0	1	2	3	4	5
Introduction and Focus of Project	The introduction clearly and concisely describes the focus question/problem; the focus is novel; predictions and hypothesis are stated with logical reasoning; background research is summarized.	0	1	2	3	4	5
Materials and Equipment	A detailed list of required materials and equipment is provided.	0	1	2	3	4	5
Procedure	Valid safety notes are included; advanced preparation needs are noted; the procedures are clearly, concisely and sequentially written; variables are effectively controlled; measured a wide range of possible cause and result variables; tests duplicated; tests valid and reliable.	0	1	2	3	4	5
Results	Data is complete on which to base a thorough analysis; includes qualitative descriptions and quantitative data presented in tables and/or graphs and/or figures; includes repeat measurements and descriptions; measurements include SI units.	0	2	4	6	8	10
Analysis and Discussion	A detailed discussion features data and arguments in defending all conclusions and about the merits of the predictions and hypothesis; the conclusions are logical; conclusions appropriately relate theory to evidence; the results and conclusions are addressed with conviction; related result variables are compared; describes possible cause and result variables; summarizes any concerns about how well designed the actual project was compared to the initial plans.	0	2	4	6	8	10
Creativity/Originality	This is an original, scientific inquiry investigation; displays creativity in design.	0	1	2	3	4	5
Appearance	Layout is impressive; well organized with headings; lacks spelling and grammatical errors; professional in appearance.	0	1	2	3	4	5
Total		/50 points					

Inquiry Investigation: Presentation Rating Scale

Date:.....

Presenters:.....

Topic:.....

CRITERIA	DESCRIPTION OF CRITERIA	GRADE					
		FX	D	C	B	A	E
Planning	The presentation was clear and well organized; the sequence was logical and well timed; the introduction was interesting.	0	1	2	3	4	5
Communication	Presenters were enthusiastic; ideas were expressed clearly and concisely; the use of English was excellent; AV aids were used effectively; a valid and professional discussion was generated.	0	1	2	3	4	5
Questioning	Clear, concise questions were asked, as deemed appropriate during the presentation.	0	1	2	3	4	5
Involvement	All group members participated in meaningful ways and the class was involved mentally and physically in the presentation and topic.	0	1	2	3	4	5
Creativity and Style	The presentation exhibited a high level of creativity; relevance was stressed; presentation was elegant yet comprehensive, integration and unification were demonstrated.	0	1	2	3	4	5
Scholarship and Project Summary	A mastery of the content of the project was exhibited; problem was posed; empirical tests and results and conclusions are summarized.	0	1	2	3	4	5
Overall Impression	The presentation was of high quality and left peers with a very positive impression.	0	1	2	3	4	5
Total		/35 points					

COMMENTS: