Ecology at Work: The Biodome Challenge

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Abstract

This article describes a challenge given to students completing a senior high school biology course. The scenario described encourages students to apply their knowledge, understanding, and appreciation of scientific and commercial principles. It permits them the opportunity to develop skills in research, collaboration, cooperation, delegation, and reliability, as well as monitoring, evaluation, and reflection. The assessment strategy described ensures that the individual and the group understand the evaluation criteria being used and, by using peer evaluation protocols and independent reviewers, the overall project mark is seen to be fair and valid.

Introduction

An understanding of ecological principles enables scientists to predetermine the requirements necessary to establish a balanced ecosystem. The abiotic components of an ecosystem determine the type, quality, and quantity of living tissue that the system can support. It is, however, the interrelationships between the biotic components that dictate the complexity of the biome. To establish a biome, several parameters have to be considered. For example, inter and intra species relationships, symbiotic associations, migration patterns, succession sequences, biogeochemical cycles, and climatic conditions.

In Ontario, Canada, ecology is studied in greater depth at the senior level than in previous courses. There is greater focus in areas such as dynamic influences of energy transformation and transfer, complex interactions between and within species, climatic influences, and the biogeochemical cycles. Further, because of the complexity of the systems being considered, the material is typically broken down into logical components. This often results in the fragmentation of students' knowledge, impairing their appreciation of the system as a whole.

Moreover, in the Ontario secondary school system, students aged 17-19 who are completing university entrance courses are expected to complete an independent study product (ISP). This usually involves some working alone in an area allied to, but outside of, the main course curriculum.

This activity addresses the above concerns by taking a holistic approach and presenting a challenge to students that requires the development and application of a wide variety of skill sets. By fostering cooperation and collaboration among individuals, it also permits students to operate in a way more attuned to scientists in the field. Further, it provides opportunities for independent and group research, problem solving, time management, delegation, and technological and presentation skills, as well as a consideration toward building an effective business plan. As this is an ISP, no class time is allocated except for the final evaluation. This occurs in a science fair format using faculty and senior science students as independent evaluators.

The Challenge

An entertainment consortium has put out a tender to build a zoological and botanical biodome. The biodome must be unique in design and self-contained; it must permit observation from within without disturbing the inhabitants. The biodome does not actually have to be built, however, a model of the design should be constructed. The proposal must consider the following major areas:

- Soil profiles
- Weather patterns
- Temperature fluctuations
- Abiotic and biotic parameters
- Symbiotic relationships
- Energy transformations
- Succession parameters.

Other areas that must be addressed include:

- Business plan
- Technical plan
- Maintenance
- Personnel requirements
- Environmental systems
- Meeting deadlines.

The primary considerations for evaluation are that students present the results of their research of the major parameters and demonstrate how these will be incorporated into the biodome.

Evaluation

The allocation of marks for this project is at the discretion of the instructor. However, it is suggested that the three major areas shown in Table 1 be considered.

Table 1
Possible Mark Allocations for the Project

Part	Area for evaluation	Evaluation protocol	Suggested mark distribution (%)
A	Individual work Peer review	Appendix A Appendix B	40 10
B	Project presentation - Peer evaluation	Appendix C	15
C	Project presentation - Independent evaluation	Appendix D	35

In order to make the independent evaluation as objective as possible, evaluators are requested to focus in the following areas: the presentation, presentation board, written proposal, model, and answers to questions posed by the evaluators.

Guidelines

Students have 6 weeks to complete the project. The only class time allocated is for the formal evaluation. Students work in groups of 6-8 as they compete to win the contract. They choose the habitat, ecosystem, or biome they wish to investigate and the area where the biodome will be situated. They are required to construct a freestanding display of the biodome, to be presented to the consortium for consideration. Grading of the display is undertaken by peer evaluators (15%) and independent reviewers (35%).

Each group is responsible for researching, evaluating, collating, and presenting the specified aspects of the habitat, ecosystem, or biome being studied. The work needs to be distributed equally between group members, with each having responsibility for a portion of the work that they will present to the group for peer evaluation before independent evaluation by the instructor.

The following areas are to be considered:

- The monthly temperature fluctuations and precipitation rates for a year. This information should be expressed in the form of a climatogram, with temperature as a line graph and precipitation as a bar graph.
- Soil profile containing a list of the flora and fauna. The relationship between these two groups should be represented as food webs.
- Energy relationships. These should be presented as pyramids of number and biomass, and the flow of energy through the organisms should be represented diagrammatically.
- Symbiotic relationships. Examples of such relationships that are key to the establishment of the biodome should be presented and explained in depth.
- Technical requirements: An explanation of how the biodome will be constructed to permit a relatively unobstructed view of the inhabitants by visitors, while maintaining an undisturbed system.
- Energy requirements: An explanation of how the system will be maintained using environmentally friendly systems for energy generation.

Each component will be handed in for individual assessment and returned for upgrading if necessary before being used for the group display and presentation. The final grading could be in a science fair forum and, rather than using a formal test, the grades utilized for a portion of the course mark.

Evaluation Criteria

Evaluation criteria include the following:

- Presentation: Board arrangement - logical sequence, clear, and coherent with relevant information included.
- Model: Plans and scale drawings of the system are logically organized and arranged.
- Technical: Explanation of technical parameters, including use of alternative energy sources and control systems, is presented.
- Biological: Incorporation of sound ecological principles. Examples of the native fauna and flora, important symbiotic relationships, and decomposers are identified. Inclusion of the pyramids of energy/numbers and the consideration for biogeochemical cycles.
- Abiotic: Include a graphical summary of climate changes, temperature fluctuations, and diurnal cycles.
- Written proposal: Must contain all relevant information, research, page numbers, table of contents, introduction, and references. It should be organized logically and coherently, with figures and graphs included in the text and raw data, if applicable, attached as appendices.

Summary

This activity was used for 3 years, with different senior biology classes, by the author. The skills students developed were more numerous than would be required for a typical ecological investigation. These included research skills, planning, organization, conferencing, and consensus building.

In order to develop the protocols necessary for establishing a successful arena, students needed an in-depth understanding of the structure of the biome and the interaction of the biotic and abiotic components. Setting up the project in this form, where more than science is stressed, presented a tangible challenge to students. Further, it permitted the contribution of all group members, drawing on a wide variety of skills and interests. The display and peer group and independent review processes accommodated for several learning styles and ways of expressing the learning objectives. Moreover, it reduced or eliminated the need for more formal testing protocols.

Based on direct observations by the author and other independent evaluators, the excitement the participants exhibited in the science fair presentations supports the conclusion that, overall, the activity was worthwhile. Observations of students who had previously shown marginal interest in ecology found that within the scope of this project, they were able to contribute positively. Others found that the allocation of a specific area for research that was peer assessed helped to keep them focused. In addition, the experience of independent research combined with group collaboration, cooperation, and discussion to produce a novel product was exciting.

The value of this approach to ecological study is not so much in ensuring a profound understanding of all the underlying principles, although this may be realized in some students. Rather, it is more in providing students with a task that requires them to develop and exercise other important life skills.

Appendix A

Assessment Tool for Individual Profiles

Name: …………………………………. Date: ……………….
Biome: ………………………………… Area considered: ……………………

Criteria		Yes	No	0	1	2
Content	a) Is the material complete?					
	b) Has the material been fully analysed?					
	c) Is the analysis credible?					
	d) Any suggestions for dome structure/form?					
Presentation	a) Is the information well organized?					
	b) Are there headings and sub-headings?					
	c) Are the pictorial representations applicable?					
	d) Are their significance explained?					
	e) Is the document word processed?					
Logistics	a) Were the timelines met?					
	b) Was the material handed in early?					
	c) Was the material late?					
Preview	a) Was document previewed by group, teacher?					
	b) Is there verification?					
	c) Were suggestions from preview used?					
References	a) Are all sources included & correctly presented?					
Peer review	a) Was the material reviewed by peer group?					
	b) Is there verification?					
Comments:						

Note. If the answer to a question is *yes*, then full marks should be given. If the answer is *no*, part marks may be given, together with an indication of the deficiency.

Appendix B

Peer Assessment Sheet

Name: ………………………………………. Date: …………………..
Biome: ……………………………………… Area: ………………………………..

Technical information	Yes	No	Presentation	Yes	No
a) Is the content covered?			a) Was the presenter concise?		
b) Are the graphs drawn correctly?			b) Does the presenter know the material?		
c) Is there an introduction?			c) Is the presentation clear?		
d) Is the work properly referenced?			d) Were the key facts presented clearly?		
e) Is the presentation acceptable?			e) Did the key information assist in the arena design?		
f) Were the timelines met?					
Comments:					

These comments should be aimed at helping the presenter improve this work in time for the independent evaluation and group presentation. A signed copy of the peer evaluation sheet will be included with each portion of the work that is handed in for teacher evaluation.

Appendix C

Group Assessment Sheet

Group #: ………… Date: …………………. Biome: …………………………………..

Area	Criteria	
Booklet	a) Overall presentation	0 1 2 3
	b) Headings clear	0 1 2 3
	c) Introduction complete	0 1 2 3
	d) Contents list included with page numbers	0 1 2 3
	e) Reference list in alphabetical order	0 1 2 3
	f) Graphs, figures, photos clearly organized and labelled	0 1 2 3
Presentation board	a) Overall impression	0 1 2 3
	b) Essential information clear	0 1 2 3
	c) All design elements included	0 1 2 3
Model	a) Overall impression	0 1 2 3
	b) Design clear and pleasing	0 1 2 3
	c) Inclusion of all design elements	0 1 2 3
Presentation	a) Contribution of all participants	0 1 2 3
	b) Feasibility of concept	0 1 2 3
	c) Informative and captivating	0 1 2 3
	d) Clarity of explanation of design elements that make arena unique	0 1 2 3
	e) Utilization of alternative energy sources explained	0 1 2 3
	f) Overall impression	0 1 2 3
Questions	a) Responses to questions	0 1 2 3
	b) Creatively in answering applied/extension questions	0 1 2 3
Total:		
Comments:		

Appendix D

Independent Evaluation Sheet

Group #: …… Name of Arena: …………………… Evaluator name: ……………………...

Area	Criteria	
Presentation	a) Effective board arrangement	0 1 2 3
	b) Parameters arranged in logical sequence	0 1 2 3
	c) Information clear, coherent, and relevant	0 1 2 3
Model	a) Model to scale, and scale indicated	0 1 2 3
	b) Plans and drawing presented or included	0 1 2 3
	c) Logical design of systems in the arena	0 1 2 3
Technical	a) Explanation of technical parameters provided	0 1 2 3
	b) Alternative energy sources incorporated in design	0 1 2 3
	c) Control systems described	0 1 2 3
	d) Internal observation of arena included in design	0 1 2 3
	e) Uniqueness and creative arena that is self contained	0 1 2 3
Biotic	Reflection of the arena with the natural system with respect to:	
	a) soil and water conditions	0 1 2 3
	b) fauna and flora	0 1 2 3
	c) symbiotic relationships	0 1 2 3
	d) succession parameters	0 1 2 3
Abiotic	Reflection of the arena with the natural system with respect to:	
	a) climatic conditions	0 1 2 3
	b) temperature fluctuations	0 1 2 3
	c) diurnal patterns	0 1 2 3
	d) biogeochemical cycles	0 1 2 3
Booklet	a) Booklet complete and logically arranged	0 1 2 3
	b) Contents page, numbered pages, headings present	0 1 2 3
	c) Self-explanatory introduction	0 1 2 3
	d) References included	0 1 2 3
	e) Appendices included	0 1 2 3
Mark		
Comments		