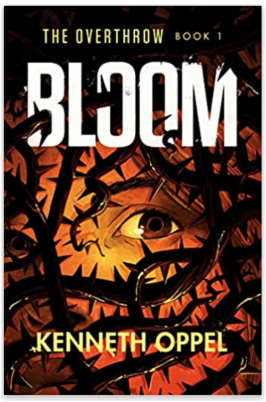
Title: Shining a Light on 'Plant Blindness': Using Kenneth Oppel's Young Adult Novel *Bloom* as a Motivating Tool for Teaching Plant Science to First-Year Undergraduate Students



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Total Amount Requested: $7000

Project Summary:

It has been over 20 years since the term "plant blindness" was coined to explain an overall educational apathy and lack of appreciation for plants, which often begins in early elementary school and persists into college[1]. Often, students find plants irrelevant or boring and carry misconceptions that they are physiologically inactive and unimportant in the environment[2]. The goal of this project is to make first-year college students interested in, knowledgeable about, and appreciate plants through the use of Young Adult (YA) Literature. We believe that the highly-exciting, intricately-plotted, and meticulously-researched novel, *Bloom* by Kenneth Oppel can be used as a literary tool to motivate students when learning about critical plant science topics such as photosynthesis, growth and development, and invasive species. In many ways, *Bloom* encourages students to envision plants as active participants in the ecosystem and not as unliving or uninteresting organisms. We outline several before, during, and after reading activities that task students with applying the botanical concepts learned in the book. Additionally, as the students read about the 3 main protagonists of the story, the literary topics of belonging, fitting in, and personal growth will be explored and discussed to help first-year students communicate their own anxieties about fitting in at college. To evaluate student understanding of plant concepts, we developed several assessment tools such as vocabulary-through-context flash cards, lab notebooks, lab report prompts with rubrics, a pre-and post student survey.

Project Description & Course Objectives:

All incoming freshmen at Fitchburg State University are required to take a First-Year Experience (FYE) seminar to develop the core skills of Self-Reflection, Active Reading and Listening, Information Literacy, Intentional Planning, and Effective Communication. The goal of this project is to design a FYE course that makes first-year college students (particularly secondary or middle school education students or science pre-majors) interested in, knowledgeable about, and appreciate plants through the use of Young Adult (YA) Literature, specifically, *Bloom,* by Kenneth Oppel. With a gripping plot and apocalyptic setting about invasive alien plants, *Bloom* captures readers' attention while also interjecting accurate botanical topics throughout. While students are engrossed in this thrilling novel, we hope to harness interest and excitement to engage students in active reading that makes them less "blind" to the importance of plants in the society and the environment. By the end of this FYE, students should be able to:

- *Define 20+ botanical/scientific terms.* Students will understand vocabulary such as photosynthesis, allomones, rhizomes, tendril, enzyme, invasive, differentiated, amino acids, DNA, and others. Before reading the book, students will be given the page number of each term and will have to use context clues from the text to define the words on flash cards. This helps students develop active reading skills and learn word meanings from context.

- *Dissect plant flowers & fruits*. Students will observe and draw features such as pollen (as seen under the microscope as wet mounts), reproductive organs, and seeds. While reading the novel, students learn about fantastical alien plants with large flowers that produce copious amounts of pollen and produce juicy, bright fruits that attract animals to them. Students can then compare the reproductive strategies of *Bloom's* alien plants to those in the lab. Student lab notebooks of drawings and with appropriate vocabulary labels will be graded on a scale of 1-3. (1=needs improvement, 2=developing skill & 3=proficient). This meets ASPB's Principal for Teaching Plant Biology's Standard on Heredity: Alternation of Generations.

- *Investigate photosynthesis*. One of the startling traits of the alien plants depicted in *Bloom* is their unusual color; they are black. According to one of the main characters in the book who is a plant biologist, "this means they can photosynthesize at any wavelength of light*"* (p. 48). To deepen students' understanding of the process of photosynthesis and to enable them to hypothesize which color light in the visible spectrum causes the fastest rate of photosynthesis in spinach, students will carry out a simple experiment using leaf disks with the air removed. Students place plant disks in a bicarbonate solution, expose them to different colors of light and count how quickly each of the disks floats to the surface. From these data, students can determine which is the best wavelength of light for photosynthesis. Questions that deepen their thinking about why the black, alien plants in *Bloom* have an advantage over Earth plants in their ability to utilize all the colors of the visible electromagnetic spectrum will be asked. Students will be assessed based on their answers to a scaffolded laboratory handout which can also serve as a template that prepares them to write a full lab report. This meets ASPB's Principal for Teaching Plant Biology's Standard on Molecules to Organisms: Photosynthesis. Additionally, this addresses Project Vision & Change's recommendations for pathways and transformations of energy and matter.

- *Conduct a scientific experiment on seed dispersal*. The plants that Oppel depicts in *Bloom* also stand out for their ability to disperse their seeds in a hyper-aggressive way; ejecting seeds by spitting them out like acidic bullets from a large flower head. To learn about seed dispersal, students gather maple samaras and measure their weight and total "wing" (pericarp) area. Next, from a roof, stairwell, or balcony, students then drop the samaras and measure dispersal as the distance from a plumb bob at different heights. Students make hypotheses, collect data in a lab notebook, graphing weight against height and area, and analyze the role that seed characteristics have in successful dispersal. A final lab report would be required of the students using a template similar to that used earlier but with fewer prompts (scaffolded approach). This report would demonstrate students' growing knowledge of seed dispersal patterns and how this evolutionary adaptation helps with genetic diversity and propagation. This meets ASPB's Principal for Teaching Plant Biology's Standard on Heredity: Population & Quantitative Genetics. Additionally, this addresses Project Vision & Change's recommendations for scientific inquiry and the ability to apply the process of science.

- *Observe & discuss carnivorous plants & secondary metabolites.* As students discover fairly early on in *Bloom*, the invasive alien species of plants are carnivorous, luring animals (and people) into their digestive sacs using juicy berries as bait. Once inside, the plants put their prey to sleep using a special "perfume metabolite" and then slowly digest it with acids & digestive enzymes. Observing & experimenting with Venus Fly Traps can give students an in-depth look at the process by which plants lure, capture, and digest their prey over several days. We will then have a lecture & discussion on plant chemicals that can induce sleep, be used in the manufacturing of perfumes, dyes, or serve as drugs. This meets ASPB's Principal for Teaching Plant Biology's Standard on Molecules to Organisms: Specialized Metabolites.

- *Visualize plant growth using time-lapse photography*. In *Bloom*, the plants grow so quickly, their vines seem snake-like. There are many earth plants that grow quickly, but in this activity, students will use time-lapse photography to visualize plant growth. This will be followed by a "film festival" of videos and a discussion on perceptions of time & plant lifespans.

- *Create a Podcast on "Plant Intelligence".* The denouement of the novel reveals the extent to which the alien plants are both intelligent and sentient because they understand their environment, have strategies to take on their opponents, and are able to communicate. This after-reading activity asks students to explore the ways Earth plants could be considered "intelligent" in how they adapt to their environments. Plants have unique abilities and outward characteristics that make them seem "intelligent and sentient" - in some cases more like slow moving animals[3]. For example, there is evidence that plants can respond to both the sound of caterpillars feeding on them[4] and react to the smell of airborne chemicals from nearby insect-attacked plants[5]. Students will become scientific thinkers for this project as they create and share a podcast investigating these central issues. Serving as expert witnesses and drawing from their growing mastery of plant biology topics, students will use evidence from the book, scientific digests, primary references, and other library resources to contend that plants are intelligent beings. Students are graded based on a quantitative rubric with standards for effort, source selection, communication, and accuracy of content. This meets ASPB's Principal for Teaching Plant Biology's Standard on Evolution: Environmental Responses.

- *"Terraform" the classroom*. After reading Bloom, students will recreate the alien plant world that they visualized in the book and create life-sized artwork versions of the different alien plants (pit vines, water lilies, and black grass).

- *Design Invasive Species "Warning Posters"*. A logical and fun extension activity that can follow the book is a field trip or nature walk in search for invasive plants, which can be identified using photos, field guides, or internet resources. Students then create a "WARNING" poster on a specific plant using Google Slides or Canva. Students must research their invasive plant using vetted websites and describe its origin, life cycle, problems, and potential treatments. Posters will be assessed using a qualitative rubric (1-5) that accurately addresses all the features listed above. This meets ASPB's Principal for Teaching Plant Biology's Standard on Ecosystems: Biodiversity.

Project Details:
The above activities will be completed in a 15-week fall or spring college semester 3-credit course with a class of approximately 25 college freshmen. Each activity above (except vocabulary) is expected to take 2 weeks (4, 75-minute classes) to complete. The expected outcomes for participants are for them to be more aware of plants in the environment while having developed a general understanding of plant biology. Students will be evaluated through the use of various assessments that are specific to each objective or activity. Furthemore, by participating in active book discussions, we hope to teach students active reading techniques that can be applied to additional texts during their college experience.

Expected Outcomes and Evaluation:
Assessments for each specific objective/activity are included in the descriptions above. Briefly, during this course, student's learning of plant biology will be based on their growing ability to

- Apply vocabulary from context
- Draw and dissect plant features in a lab notebook
- Conduct lab experiments on photosynthesis and seed dispersal
- Write thorough and logical lab reports using a scaffolded technique
- Analyze and synthesize scientific literature to create a mock podcast on plant intelligence
- Create and share accurate posters on invasive species
- Develop an awareness of the plants around them and appreciate plants in society

Data collected from student artifacts will inform us whether the first 6 objectives of the course were met or not. We would like students to meet all objectives with 75% accuracy or higher. Assessment tools such as rubrics and handouts will be created by the project leaders when more detailed lesson plans for each activity are drafted. Using a backwards design, we will ensure that the lessons are specifically designed to meet the specific objectives of the course. Finally, to assess overall learning outcomes and objective 7, we have designed a pre-and post-course survey. The final pre-post survey can be found here.

Teaching Philosophy:
We are Associate Professors with 20+ years of college teaching experience and are members (Co-Chair - Covino, Instructor - Rehrig) of Fitchburg State University's PASM program (Program Area of Study in Secondary and Middle School Education) where we prepare future educators. The activities described in this proposal are based on constructivist learning models; students are actively engaged in their own learning process through many different types of hands-on activities. Several of the lessons are also inquiry-based and have students learning the process of science through the testing of hypotheses, collecting and analyzing data, interpreting results and communicating those results in a written lab report. We are excited about this project because of its cross-curricular themes in science and language arts. By combining active reading techniques with learning scientific content, we hope that students will have a more meaningful learning experience than if this were taught in a traditionally siloed 1-subject classroom. While English and History teachers have long seen YA literature as a way of connecting to and supporting content-area teaching and learning, other subject areas, including science, are embracing this resource at a slower pace. The use of YA is highly motivating, especially when it involves a high-interest and exciting text with apocalyptic themes, dynamic characters, and a fast-paced story line. We are capitalizing on the accurate scientific topics woven throughout *Bloom* to teach students about plants, a subject they are often disinterested in and blind about. Some of the labs have been taught before in non-majors courses (like the photosynthesis and seed dispersal labs), however, by grounding these activities with passages in the book, we hope that they are more engaging, contextual, and relevant. By also incorporating STEAM (STEM + ART) activities such as the one described in the "terraforming" a classroom to look like the alien setting of the book, we hope to tap into students' different talents and foster creativity in the classroom. Finally, we are excited to provide modeling for female students as experts in a STEM field.

Budget:

Item	COST estimate (Amazon)	Activity where funds are to be used
30 copies of Bloom (to be reused)	$540	Whole course
10 Plant grow lamps (with colored bulbs)	$240	Photosynthesis
Brinno Time Lapse Camera	$150	Plant Growth
6 Plumb Bobs & nylon rope	$70	Seed Dispersal
Art supplies (paper, sharpies, paint, scissors)	$100	Terraformed classroom
Carnivorous plants, seeds, pots, supplies	$400	Carnivory observation
Faculty Stipends for co-teaching a 3-credit course (110 hours each), includes prep time	$5500	

Budget Justification:

We would like to provide some justification for the faculty stipends. In order for this course to be taught properly, we believe that both project leaders from Biology and English should co-teach the course. This provides students with the opportunity to discuss the book from a critical literary point of view as well as have the expertise of a plant biologist as an instructor. However, FYEs on our campus are only 3 credits and co-teaching gives each instructor only 1.5 course credits. Thus, we are justifying prep time, grading time, and teaching time for one 3-credit course for 1 instructor. However, if the full amount is not available or granted, we are willing to accept partial funding and are grateful for any compensation.

References:

1. Wandersee, J.H., & Schussler, E.E. (1999). Preventing Plant Blindness. *American Biology Teacher,* 61(2):82–86.

2. Senchina, D. (2008). The Students Were Right All Along…Plants Really Are B.O.R.I.N.G., *Plant Science Bulletin*, 54(2):50-55

3. Schulz, J. (2002). How Plants Fight Dirty. *Nature* (416) 267

4. Appel, H.M., Cocroft, R.B. Plants respond to leaf vibrations caused by insect herbivore chewing. *Oecologia* 175, 1257–1266 (2014).

5. Heil, M., (2014) Herbivore-induced plant volatiles: targets, perception and unanswered questions, *New Phytologist* 204 (2) 297-306.