INCREASING ENVIRONMENTAL LITERACY IN WORCESTER THROUGH STEM LEARNING MODULES

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Increasing Environmental Literacy In Worcester Through STEM Learning Modules

An Interactive Qualifying Project submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
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Report Submitted to:

Jacquelyn Burmeister
City of Worcester Lakes and Ponds Program

Laura Roberts
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ABSTRACT

Worcester has been experiencing an increase in cyanobacteria blooms in recent years. To counteract this, the Worcester Cyanobacteria Monitoring Collaborative (WCMC) has been releasing informational material to increase knowledge about this issue. Our team worked with the WCMC to create STEM learning modules that teach the youth different ways to identify cyanobacteria and measures they can take to prevent its growth. In addition to interviewing teachers, Scout leaders, and WCMC volunteers, we ran a pilot test with the Worcester Cub Scouts to develop modules that the WCMC can use internally or distribute to other organizations.

Executive Summary

Cyanobacteria is one of the main problems affecting the City of Worcester's lakes and ponds. The problem caused by this bacteria comes from its egress, which is aggravated by human impacts such as the usage of fertilizer or other substances. Those pollutants are taken to the lakes by rainwater, among other ways.

In Worcester, cyanobacteria is monitored by the WCMC. The Worcester Cyanobacteria Monitoring Collaborative (WCMC) is a volunteer group of community scientists. Community science, or citizen science, refers to the utilization of amateur scientists in scientific research. Overall, the most crucial finding is that participation in community science leads to an increase in environmental literacy.

Figure 2: Worcester Cyanobacteria Monitoring Collaborative logo

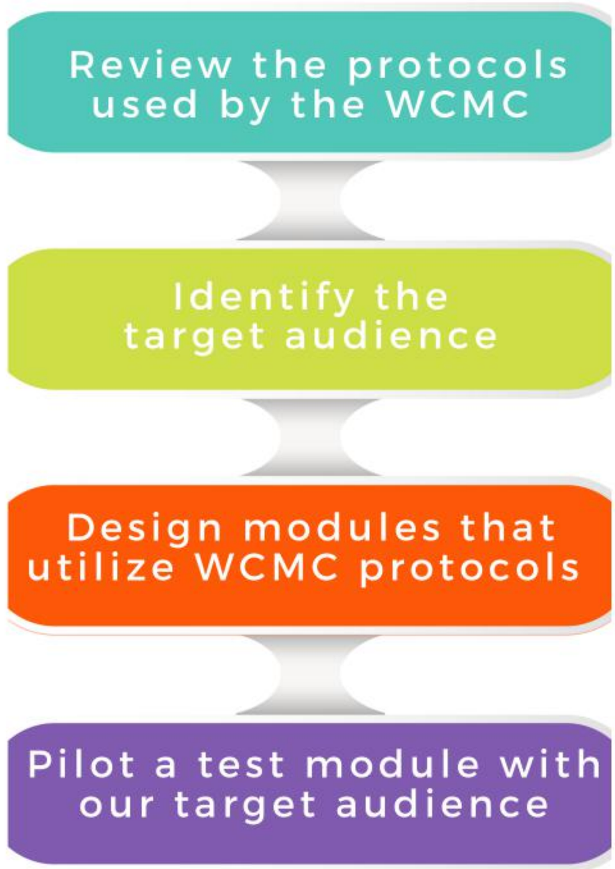
One of the main ways to prevent cyanobacteria blooms in local ecosystems is by educating the community about it, thus creating a more scientifically literate community of people who know how to better care for their local environment. Being scientifically literate can be expressed in multiple ways and is not limited to a particular set of skills or abilities.

Goals and Objectives

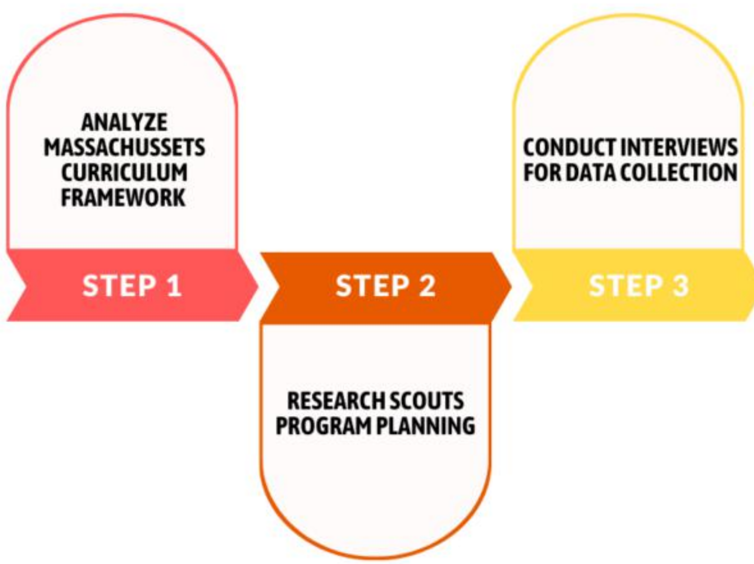
The goal of our project was to create STEM learning modules to increase environmental literacy in Worcester by incorporating the methods and procedures of the Worcester Cyanobacteria Monitoring Collaborative (WCMC).

To achieve this goal, we decided upon these four objectives:

Executive Summary



To address these objectives, the following methods were employed:



For our first objective, we conducted interviews with WCMC volunteers and leaders and cataloged various WCMC resources to find out what we could or could not use for the final deliverables.

For our second objective, We analyzed the Massachusetts Curriculum Frameworks, researched Scout merit badges and awards, and conducted interviews with teachers and Scout leaders.

5th Grade	6th Grade	7th Grade	8th Grade
Process by which plants use air, water, and energy from sunlight	Evidence that all organisms are made of cells	Characteristic animal behaviors and specialized plant structures	Environmental and genetic factors influence the growth of organisms
Matter moving throughout the ecosystem - producers, consumers, decomposers		Effects of periods of abundant and scarce resources on the growth of organisms	

Table 2: Life science educational objectives per grade (2022)

To accomplish our third objective, we interviewed Donna Taylor, Assistant Director of Professional Development at the STEM Education Center of WPI, to learn what format we should build the STEM learning modules in.

Lastly, in order to accomplish our fourth objective, we used two primary methods: Our own comments and notes made during the presentation of the STEM learning modules, and surveys administered to the parents or guardians of students.

Findings and Deliverables

After all the analysis and research done during the process of this project, we made three main findings. The first one was that the interactive activities for the STEM learning modules should be based on the water sampling and testing methods used by the WCMC. Our second finding is that the ideal audience for our project are middle schoolers. Lastly, our main finding from the pilot of the field trip learning module was that Scouts or students above the fourth-grade level were highly engaged by and enjoyed the activities.

Executive Summary

As for our deliverable, we created a handbook, the WCMC learning module handbook, which has all the learning modules included. There are four lesson plans for middle schoolers, two for scouts, and 2 for cub scouts.

	4TH GRADE	5TH GRADE	6TH GRADE	7TH GRADE	8TH GRADE
Expected to use microscopes	✗	✓	✓	✓	✓
Allowed to use lab equipment	✗	✓	✓	✓	✓
Allocated time for STE	3 hours	3 hours	4.5 hours	4.5 hours	4.5 hours
Field Trips	Instructor's discretion	Instructor's discretion	Instructor's discretion	Instructor's discretion	Instructor's discretion
Frameworks	Restrictive	Restrictive	Little restrictive	Flexible	Flexible
Scouts flexibility	Restrictive	Restrictive	Flexible	Flexible	Flexible

Table 4. Fourth to eighth-grade learning level and flexibility

ACKNOWLEDGMENTS

There are several people we would like to thank for helping us through the development of this project. More specifically our advisors, Laura Roberts and Steve McCauley for guiding and helping us create this report.

Special thanks to our sponsor Jacquelyn Burmeister and the City of Worcester for this incredible opportunity.

We are also very grateful to all the individuals we interviewed for lending us some of their time. As well as the Scoutmasters and Cub Scoutmasters for giving us a full morning to pilot our project.

Lastly, we would like to thank our fellow IQP groups and now friends for their company and support during this project.

OUR TEAM

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ECE Major

John Demedeiros is an Electrical and Computer Engineering major. He enjoys video games and Legos.

AUTHORSHIP

Given the complexity of our report and the many revisions we have had to make throughout the process, we found it more practical to give a written rough summary of every team member's role in contributing to the written report.

All team members contributed to all parts of the report to at least some degree. Eddie and John were the primary authors of most sections involving the Worcester Cyanobacteria Monitoring Collaborative, cyanobacteria, or the piloting of the STEM learning modules. Deborah and Ishayu were the primary authors of most sections involving identifying our target audience, schools, and the design of the STEM learning modules. John was the primary author for most sections on community science and environmental literacy.

During the later part of the project, Eddie and John were the primary authors of the findings, results, recommendations and conclusion and editors of the report as a whole, while Deborah and Ishayu focused their main efforts on the final design of the STEM learning modules.

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1 Introduction

Good water quality is an essential part of everyone's lives, especially for Worcester as it is surrounded by upwards of 25 lakes and ponds. However, due to global warming and the expansion of cities and towns, more and more contaminants are seeping into bodies of water every day, causing an influx of contaminants such as artificial nitrates from fertilizers, and triggering cyanobacterial blooms or huge cyanobacteria population increases in the water. Cyanobacteria or blue-green algae is a type of phytoplankton that can be found in Worcester and nearly every part of the world. Cyanobacterial blooms can threaten entire ecosystems and endanger any people or pets using the water (Centers for Disease Control and Prevention, 2022).

The increase in the frequency of cyanobacterial blooms is a symptom of a larger phenomenon with a lack of environmental literacy among residents in Worcester. The lack of environmental literacy can be attributed to a disconnect between what is taught in schools and what can actually be applied (Chepesiuk, R. 2007). Lack of context about the local fauna and waterbodies and misinformation regarding their own individual and collective impact on the environment all contribute to the deterioration of local ecosystems. Due to cyanobacteria blooms increasingly obstructing the use of blue spaces all over Worcester, our sponsor, the City of Worcester Lakes and Ponds Program, created the Worcester Cyanobacteria Monitoring Collaborative (WCMC).

The WCMC is a non-profit organization that uses volunteers to monitor the levels of cyanobacteria in lakes and ponds around the City of Worcester. They have been trying to implement educational modules to inform and alert the population of Worcester about cyanobacteria and its effects. They aimed to make educational modules that use their own practices in dealing with cyanobacteria to help increase environmental literacy in Worcester.

The goal of our project is to create STEM learning modules to increase environmental literacy in Worcester by incorporating the methods and procedures of the Worcester Cyanobacteria Monitoring

Collaborative (WCMC).

The following chapters are the background chapter that delves deeper into the research we have conducted as a team to better establish the context behind our project goal and gain a better understanding of what has already been done by other research projects. The methodology chapter goes through what we planned to research to fill the holes left by the background and accomplish our established project goals. The findings and results chapter discusses what we found and the final results.

2 Background

The rise of climate change in our modern world has brought many challenges to the environment and our community, making it essential that citizens be aware of these issues and know how they can help address them. Citizen and community scientists are the people who drive the defense of the environment, finding solutions to issues in their immediate local environments to protect the community as a whole. Environmental and scientific literacy are critical abilities for a citizen or community scientist to aid their community. Education on environmental and scientific literacy is the foundation of a community's environmental well-being. In the following sections, we will elaborate more on scientific and environmental literacy, the impacts of community science on environmental literacy, and the efforts and impacts of the Worcester Cyanobacteria Monitoring Collaborative (WCMC).

2.1 Scientific and Environmental Literacy have been sidelined in Worcester

Scientific literacy can be defined by an individual's knowledge of scientific concepts, procedures, and the ability to use scientific tools. Being scientifically literate can be expressed in multiple ways and is not limited to a particular set of skills or abilities. The most crucial aspect of scientific literacy is understanding and applying the core principles of science and engineering such as the scientific method or the iterative design process.

Currently, for both public and private schools, increasing scientific literacy is accomplished by science classes or electives that fulfill state and national guidelines or frameworks such as the National Science Education Standards (NSES) or specifically for Massachusetts, the Science and Technology/Engineering (STE) framework. However, a lot of what is taught in classrooms is increasingly alienated from the local context necessary to have an impact on students. The pressure on teachers to prepare students for standardized testing heavily restricts what is taught and can deny the information necessary for students to properly contextualize what they have learned. While students may have learned concepts such as the scientific method, they simply use it to answer a question on a test as opposed to adapting it to their own critical thinking. This disconnect between what is taught and what is learned directly impacts the students' scientific literacy and in turn affects their environmental literacy (Chepesiuk, R., 2007).

Environmental literacy can be defined as the knowledge a person has in regard to their environment as well as the practical skills they may possess that affect the environment (Kamil, P. A., 2020). According to previous research, in order to effectively address and increase environmental literacy some key aspects to include are environmental perceptions, examples of environmentally friendly behavior, social perspective, and sustainability (Kaya, V.H., & Elster, D. 2019). Of course, what is important to note is that environmental literacy is rooted in local ecology and that while a person may have significant knowledge of the environment, the defining trait of being environmentally literate is understanding and applying that knowledge in how they themselves interact with the environment.

Environmental education has been sidelined and isn't properly integrated into public school curricula (Chepesiuk, R. 2007). Although increasing environmental literacy has not been prioritized by state or national frameworks, most of the knowledge on the environment and an individual's impact on the environment stems from classic environmental education, such as information gained in school, clubs, or community activism such as participating in community science.

2.2 Community Science can increase environmental literacy

Community science, or citizen science, refers to the utilization of amateur scientists in scientific research. Because of the reliance on local volunteers whose experiences and corresponding scientific and environmental literacy are varied, the success of a community science project relies on balancing the quality of data and ease of collection for volunteers. As such, community science works best when the local population has an

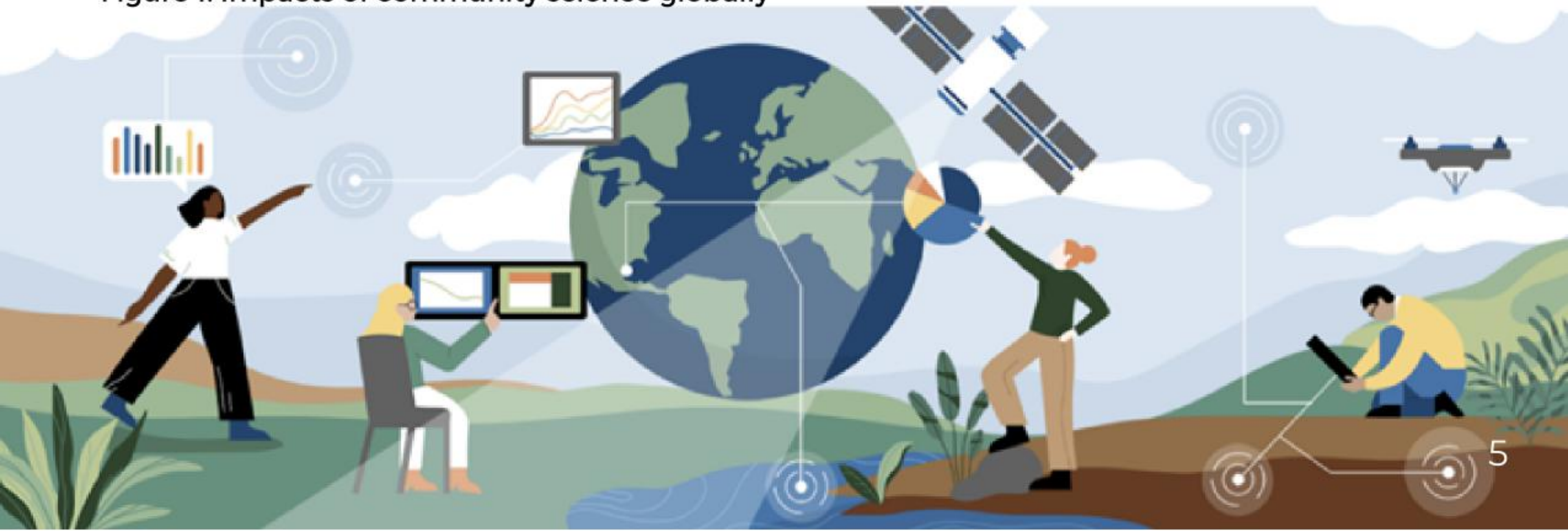
Background

in-depth knowledge of their surroundings and some experience with core scientific principles such as the ones found in the Massachusetts Science and Technology/Engineering (STE) Framework (Kamil, P. A., 2020).

From the perspective of researchers conducting a community science program, the most important aspects to keep in mind when conducting the program are ease of the research and activities, open communication, and assuring the volunteers that they're having an impact (Vohland et al., 2021; Rambonnet et al., 2019; Asingizwe et al., 2020). In addition, some aspects needed from the volunteers themselves to help facilitate the project are an understanding of scientific principles, knowledge of local ecology, and a willingness to go out and participate, all of which are essentially scientific and environmental literacy.

Overall, the most crucial finding is that participation in community science does lead to an increase in environmental literacy. It has been shown that as participants are exposed to the various aspects involved in community science such as actively exploring their local region, being made aware of the impacts that they and others have on the environment, and being taught methods to help in scientific research their corresponding environmental literacy increases (Cronje, R. 2011; Dean, A.J. 2018). It has been noted

Figure 1: Impacts of community science globally



that factual learning or book learning has limited positive effects and that building skills to increase engagement in nature has greater significance in increasing environmental literacy (Cronje, R. 2011; Dean, A.J. 2018). In the context of Worcester, one significant community science program that helps increase environmental literacy is the Worcester Cyanobacteria Monitoring Collaborative (WCMC).

2.3 The WCMC promotes environmental literacy in Worcester

The Worcester Cyanobacteria Monitoring Collaborative (WCMC) is a volunteer group of community scientists working to monitor the levels of cyanobacteria in Worcester's lakes and ponds while assessing the risk that these levels may pose to public health. Cyanobacteria has thrived to the point of overgrowth with the rise of climate change and pollution in water from stormwater runoff (Centers for Disease Control and Prevention, 2022). If allowed to overgrow, cyanobacteria can deprive aquatic life and vegetation of oxygen and sunlight and often can bring toxin levels in water bodies to a dangerous level for people and animals (Huisman et al., 2018; He et al., 2016). The WCMC volunteers test water samples one to two times a month, which they take from twenty-four different lakes and ponds in the Worcester area. The collected data is published and available to the public with records dating back to 2017 (City of Worcester, 2022). Based on the data provided by the WCMC, Worcester regularly treats its water sources for cyanobacteria by using chemical treatments approved by state environmental regulations (Turken et al., 2022).

Figure 2: Worcester Cyanobacteria Monitoring Collaborative logo

Background

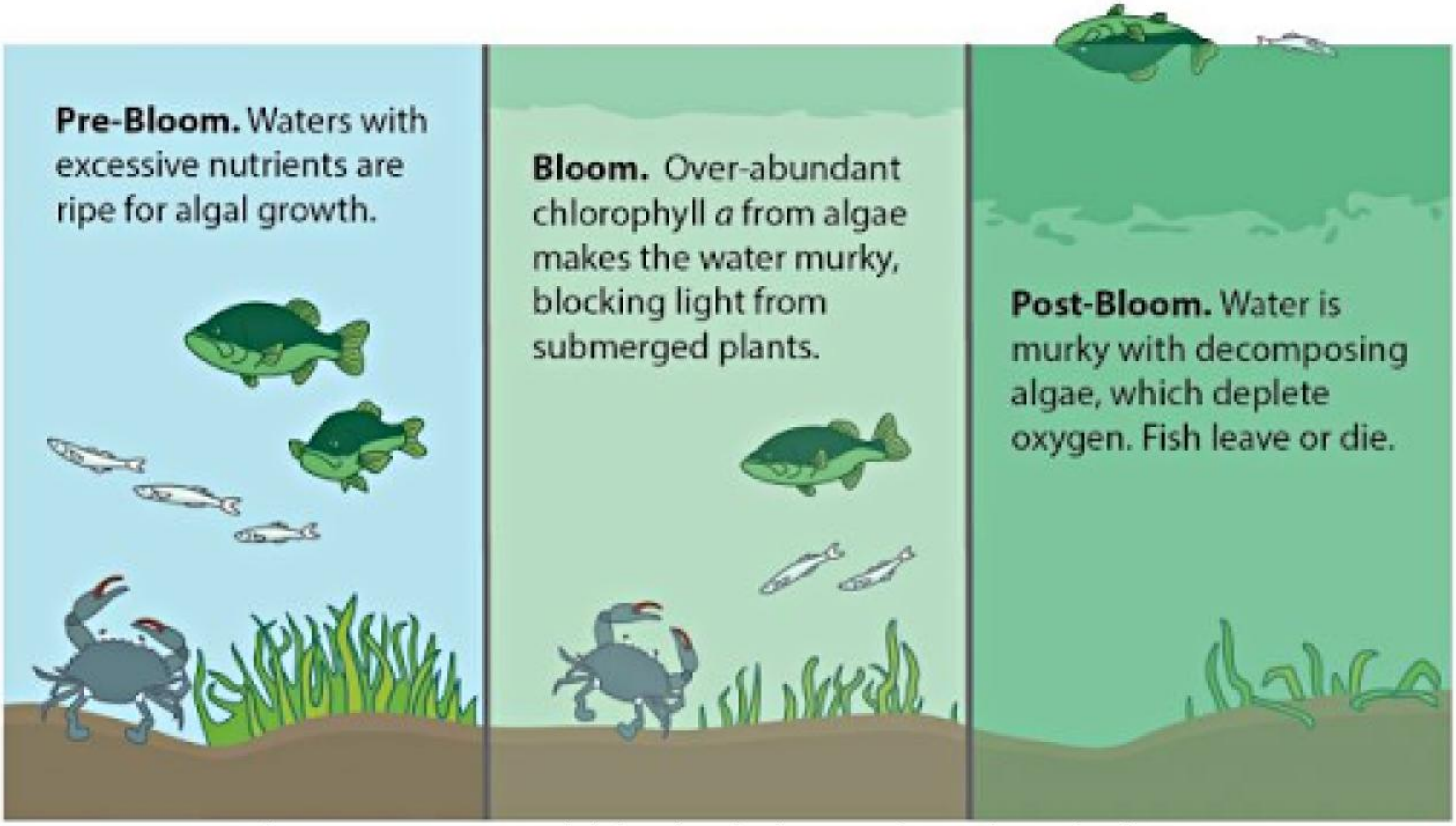


Figure 3: Ecosystem Model showing the impact of Cyanobacteria Blooms

By monitoring the cyanobacteria levels in Worcester's water to keep the community safe, the WCMC volunteers work as community scientists. Despite many of them having no scientific background, they all take time to care for their local environment by simply collecting data and sharing their knowledge with their neighbors. Their example shows that anyone can help protect the environment and can be a community scientist. Jacquelyn Burmeister, one of the founders of the WCMC, and other volunteers have regularly talked to students and other youth organizations about the WCMC, promoting environmental and scientific literacy by teaching youth about critical environmental issues within their own community (personal communication, September 24, 2022).

2.4 Flexible learning modules are key to keeping up with the ever-changing state of STEM education

To continue the efforts of the WCMC, we believed learning modules would be a key aspect to this end. In order to achieve this, it became important to develop learning modules that can embed themselves into the current STEM pedagogy while allowing flexibility to alter materials as needed. One of the best practices to implement while developing these learning modules was the backward-design process (Bowen, 2017).

Traditional courses are designed with the idea of teaching students pre-determined materials and assessing them on what they remember. A backward-design approach on the other hand derives its materials from learning objectives that are prepared before the course, and are often the outcomes at the end of it (Hall, 2018). This student-centric design is effective in considering the content of the course and allowing for changes in it as assessments are based not on the content, but on the learning objectives (Hall, 2018).

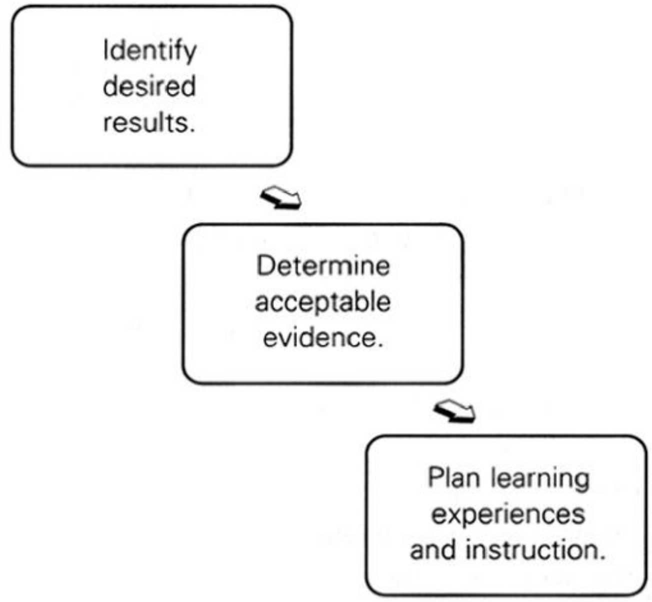


Figure 4: Backward Design Process

In conjunction with the backward-design approach, Bloom's Taxonomy is often used to order the modules created. Bloom's Taxonomy is a categorization system used to distinguish between different levels of human cognition (Edge Glossary, 2013). By using verbs that classify stages of learning such as knowledge, skills, and behaviors, learning objectives can be created that target a higher level of learning. By utilizing this taxonomy, courses can be created that ensure students will reach the stages of evaluation and creation by building on the previous materials they have learned. The criteria for this organization can be

Background

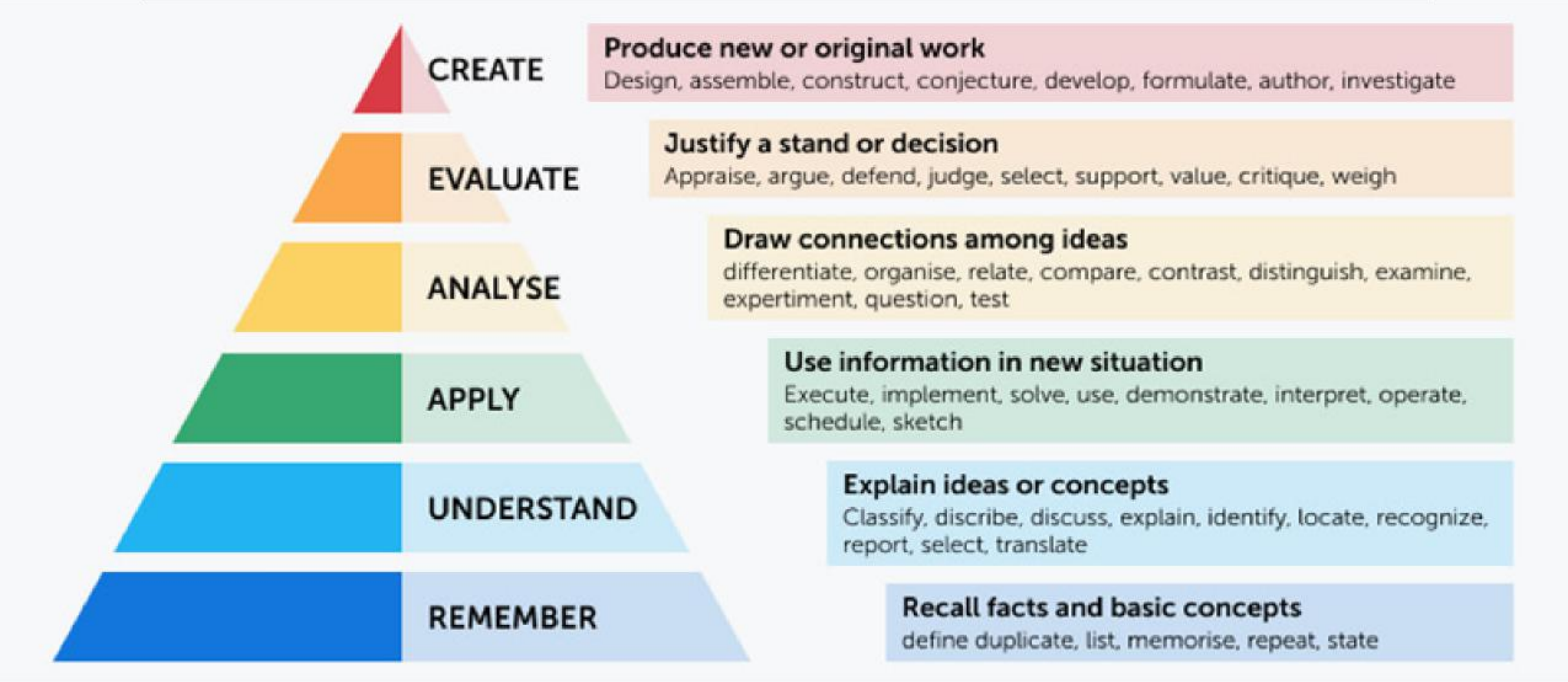


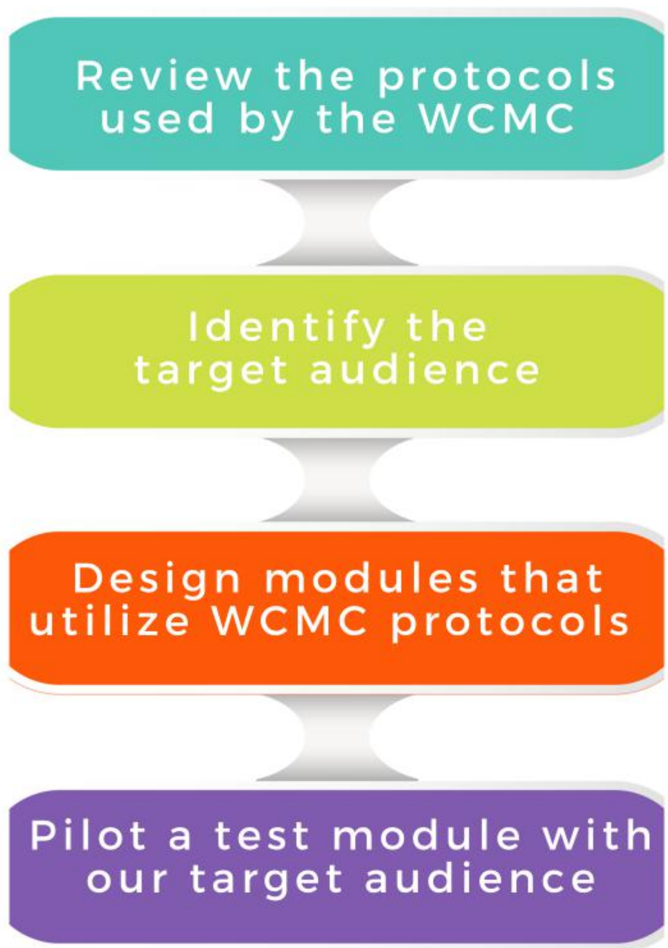
Figure 5: Bloom's Taxonomy

seen in Figure 5. Almost 95% of exam questions test students on their memory and not on their critical thinking (IAASC, 2011). This problem can be solved by implementing Bloom's Taxonomy in the curriculum design process as it necessitates students to gain higher-order thinking skills of evaluation and creation. This allows for greater cross-curricular learning as subjects complement each other while maintaining the overall learning experience (Jelle Boeve-de Pauw et al., 2022).

Based on the information collected in the background we created four main project objectives to guide the progression of the project and accomplish the final project goal of increasing environmental literacy in Worcester. Each project objective serves a purpose in defining what our final deliverables look like and are explained in the methodology.

3 Methodology

The goal of our project was to create STEM learning modules to increase environmental literacy in Worcester by incorporating the methods and procedures of the Worcester Cyanobacteria Monitoring Collaborative (WCMC). While the WCMC had some existing materials already for educating the general community and youth on Worcester's struggles with the environment and cyanobacteria, we intended to help the WCMC by taking their existing materials and protocols and finding ways to integrate them with already existing curricula and programs in schools and youth organizations to promote environmental literacy and interest in STEM. To achieve this end we split the project into four distinct objectives:



We outline these objectives and our methods for achieving them below.

Methodology

3.1 Objective 1: Review the protocols used by the WCMC

For our first objective, we reviewed and cataloged any potential educational lessons and resources available for the STEM learning modules from the WCMC. To better increase environmental literacy and to teach others about cyanobacteria pollution in Worcester and the WCMC, it is essential that we are very familiar with the protocols that the WCMC uses and what they have done in the past for educating the community. To accomplish this we conducted interviews with WCMC volunteers and leaders and cataloged various WCMC resources to find out what we could or could not use for the final deliverables.

3.1.1 Interviewing WCMC Volunteers and Leaders

Knowing and understanding the people who made and execute the protocols that we wish to turn into STEM learning modules for youth was a necessity in order to avoid overlooking important details. The people who volunteer for the WCMC identify themselves as "community scientists," regular people who collect scientific data for the environmental benefit of the community (Metcalfe et. al., 2022). Many of these people are involved with their local lake associations in Worcester and started volunteering with the WCMC to help with keeping their local lakes clean (City of Worcester, 2022) (personal communication, September 24, 2022). We reached out to and interviewed some of these individuals to learn more about them, why they volunteer for the WCMC, and what the WCMC does. In addition to Jacquelyn, we found three volunteers who were willing to participate in an interview, including a student at a local university, a retired scientist, and a retired engineer. Three of the four interviews were virtual over Zoom, and one was in person at one of the local lakes. An example of the types of questions we asked can be found in Appendix A for the volunteers and Jacquelyn respectively.

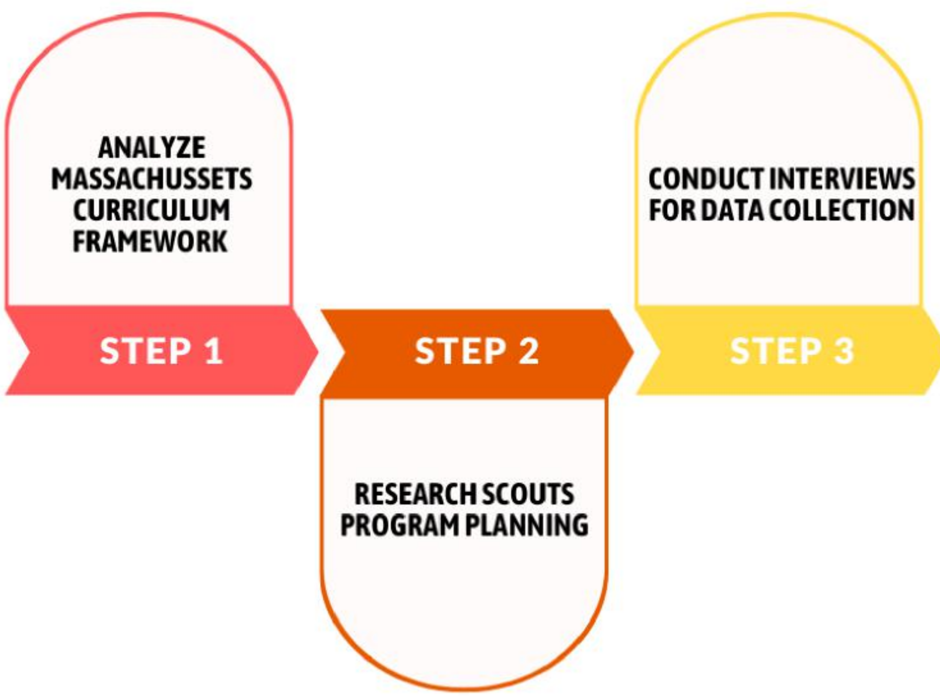
We investigated what the WCMC has done with youth in the past for education on cyanobacteria pollution in Worcester through these interviews, particularly with WCMC leadership and those who have taught youth about cyanobacteria or the environment before. Our sponsor has told us of several informal educational activities that she has done with schools, such as going to talk about the WCMC and cyanobacteria in Worcester in classrooms at schools for a day. These interviews gave us some useful insight on how we should structure our STEM learning modules for schools and other organizations.

3.1.2 Cataloging WCMC Resources

Over the years, the WCMC has collected a substantial quantity of data on cyanobacteria in Worcester and created highly effective methods of collecting and testing water samples as well as detailed educational training modules for its volunteers. We inspected and cataloged a significant portion of WCMC resources primarily the volunteer training slides as they are already in an educational format and the monthly water quality reports since they could be used as a resource in the STEM learning modules.

3.2 Objective 2: Identify the target audience

The second objective was to identify the ideal target audience for the STEM learning modules in order to better focus our efforts. We mainly did this to find out which audience would benefit the most from the development of STEM learning modules. The steps we followed were:



Methodology

3.2.1 Framework Analysis

We analyzed and researched the 2016 Science and Technology Engineering (STE) Massachusetts Curriculum Framework. We looked through the Frameworks to find out which educational disciplines would align the best with WCMC resources. Based on the disciplines that applied, we further clarified what specific educational areas of study and

5th Grade	6th Grade	7th Grade	8th Grade
From Molecules to Organisms: Structures and Processes	From Molecules to Organisms: Structures and Processes	From Molecules to Organisms: Structures and Processes	From Molecules to Organisms: Structures and Processes
Ecosystems: Interactions, Energy, and Dynamics	Biological Evolution: Unity and Diversity	Ecosystems: Interactions, Energy, and Dynamics	Heredity: Inheritance and Variation of Traits
			Biological Evolution: Unity and Diversity

Table 1: Life science areas of study per grade 2022

5th Grade	6th Grade	7th Grade	8th Grade
Process by which plants use air, water, and energy from sunlight	Evidence that all organisms are made of cells	Characteristic animal behaviors and specialized plant structures	Environmental and genetic factors influence the growth of organisms
Matter moving throughout the ecosystem - producers, consumers, decomposers		Effects of periods of abundant and scarce resources on the growth of organisms	

Table 2: Life science educational objectives per grade (2022)

educational objectives we could attempt to satisfy with the STEM learning modules. An example of the information that we extracted in our initial analysis of the Frameworks can be found in Tables 1 & 2. In addition to the Massachusetts Frameworks, we also analyzed the requirements for Scout merit badges and certificates and aligned the respective awards to the corresponding grade.

3.2.2 Interview Data Collection

The last method we used was to prepare and run a short interview for public school teachers in Worcester. We had one interview with Stacey Hill, the Science Department Head at Doherty HS. We also interviewed a Scout leader, Robert Belin, the Scoutmaster for Troop 37, Worcester, and a Cub Scout leader, Nicholas Cantrell from Pack 37, Worcester. The type of questions we asked can be found in Appendix B. The main goal of the interviews was to help clarify aspects of the classroom or the field that can't be found through written frameworks or standards. The most important aspects being what type of equipment can be considered age-appropriate, and the logistics of setting up field trips.

3.3 Objective 3: Design modules that utilize WCMC protocols

The third objective we accomplished, while working with the WCMC, was creating the STEM learning modules for schools and Scout groups. Keeping in mind that the goal of this project was to increase overall environmental literacy among the youth, we focused the STEM learning modules on hands-on scientific processes and tools. Cyanobacteria were used as a means to get to that point. There were two significant steps in order to create the STEM learning modules. The first was to learn about lesson plan formats used most commonly in public schools and Scout programs, and the second was to gather information on what types of activities or assessments we should include in the STEM learning modules.

3.3.1 STEM Education Center

To better understand the requirements for making lesson plans for the STEM learning modules, we interviewed Donna Taylor, Assistant Director of Professional Development at the

STEM Education Center of WPI (Appendix C). With her help, we received two potential lesson plan formats geared toward public schools in Massachusetts: Integrated STEM Lesson Template and I am STEM Lesson Template. The first was heavily reliant on the English Learning and Arts (ELA) standards, which would require us to specify books in order to fulfill the format requirements. The I am STEM template, on the other hand, was structured in a way that allowed for greater flexibility while choosing materials and each task was more learning objective focused. An example can be seen in Appendix D.

3.3.2 Developing the STEM learning modules

After learning what format we should build the STEM learning modules in, we looked at their contents. For middle school students, the STEM learning modules were broken up into four topics: Introduction to Community Science, Introduction to Ecological Relationships, Introduction to Scientific Analysis, and Analysis of Microorganisms. Each topic follows an STE Standard and has its own assessment criteria. Look in Appendix E for more details. For the Scouts, the STEM learning modules require them to visit a local lake or pond and conduct sample collection followed by viewing microorganisms through a microscope. Additional information was provided depending on the age of the Scouts. The Cub Scouts would be given activities that made them look at the environment and ask questions regarding their surroundings. For Scouts, a more detailed explanation of community science and environmental literacy was provided. An example of a Scout lesson plan can be seen in Appendix F. To validate that the models would work well with the target audience, we conducted pilot tests.

3.4 Objective 4: Pilot a test module with our target audience

In order to accomplish the fourth project objective we used two primary methods: Our own comments and notes made during the presentation of the STEM learning modules, and surveys to be administered to the parents or guardians of students. The notes we took while piloting the STEM learning modules served as a more qualitative data source that helped tweak any minor issues in the modules and keep track of any major issues that needed to be addressed. The surveys aided in establishing a baseline of expectations for students and helped in expressing the success of the STEM learning modules.

Due to overlap in our target audience, the STEM learning modules could be applied to various locations including schools, and organizations like the Boys and Girls Club, and the Scouts. As a result of the climate during the project term, we ultimately focussed on piloting the interactive field trip with the Scouts as they had the most flexible schedule, and the age ranges lined up with the corresponding grades we intended to apply to the STEM learning modules as well. We conducted the pilot at Green Hill Pond in Worcester, MA, on the morning of Saturday, December 10th, 2022.

3.4.1 Qualitative data collection

To ensure that the STEM learning modules were effective we piloted the draft module with both the Scouts and Cub Scouts. We took notes and observations during and after the lesson to make our own qualitative remarks on the successes and problems with the module. We used these comments to improve the module and the style of presentation and to continuously tweak any minor issues as we went through the session. Also, towards the end of piloting the modules and the project itself, we compiled the comments to act as a guide for any future groups or organizations who seek to emulate the STEM learning modules.

3.4.2 Surveys with parents

We used surveys to help establish the demand for STEM learning modules and field trip activities. The data collected from the surveys helped establish a baseline for what can be expected of the students. In addition, we also used the surveys as evidence of the demand for more STEM-related activities which can be used later on for our recommendations. An example of the type of questions we asked can be found in Appendix G.

4 Findings and Deliverables

4.1 Findings

Throughout the project, we made three main findings that eventually led to the creation of the STEM learning modules. We found that the interactive activities for the STEM learning modules should be based on the water sampling and testing methods used by the WCMC, using the recommendations of Jacquelyn and WCMC volunteers as a guide. We also found the ideal target audience with the information gathered from interviews with teachers and Scout leaders and analysis of the Frameworks. Furthermore, we found tools to aid in the creation of the lesson plans which included existing templates and information gathered through surveying the local lakes and ponds.

4.1.1 WCMC water sampling methods are a perfect introduction to environmental science and STEM

From the review of the WCMC volunteer training materials, we found that the step-by-step instructions for the water sample collecting and testing were an easy process for even those without any scientific background to understand and learn from (Appendix H). We also concluded from the interviews with Jacquelyn and other volunteers that giving students hands-on experience to help them understand an environmental issue in their local environment from a scientific approach would be a beneficial introduction to STEM for youth. Jaquelyn and the volunteers all agreed that education on issues in students' local environments would help increase students' interest and involvement in protecting their local ecosystems through science.

Many of the supplementary ideas for the STEM learning modules were provided by the WCMC volunteers in the individual interviews. In the interview with the local university student, we were given the idea of creating simpler activities that could introduce elementary students, who might be too young to understand water sampling and microorganisms, to a simplified scientific method of approaching and solving environmental problems. She gave us some examples even from her own experiences as a field teacher for elementary students, such as looking at mud samples from water and identifying the bugs that live there. From the interview with the retired scientist, we concluded that we should ensure that students get hands-on experience with microscopes in our field trip plan so they could learn how to operate them properly. He shared his experience with teaching some students at his local lake how to use microscopes to test the water and even a detailed instructional document that he wrote on how to operate a microscope and use it to identify cyanobacteria and other microorganisms (Appendix I). In the interview with the retired engineer, we discovered an ideal field trip location for the pilot phase of the STEM learning modules, which we decided to use. He showed us the lake area and informed us of the efforts he has done with the WCMC to care for the lake, which regularly undergoes cyanobacterial blooms. Lastly, from our interview with Jacquelyn, we found that we should have students complete field sheets as they note how certain conditions in the weather, the surrounding environment, and the water itself may affect the results found in water samples to give them practice with collecting testing data for scientific processes. Jacquelyn gave us a copy of the actual field sheets used by WCMC volunteers when collecting water samples, which we chose to replicate with simpler wording for students (Appendix J).

4.1.2 Middle schoolers are the ideal target audience

Our second finding is that the ideal audience is sixth to eighth-grade (middle schoolers). Through an analysis of the Massachusetts STE Framework and interviews with teachers and Scout leaders, we collected information regarding the restrictions from the Frameworks, allocated time for STEM, the feasibility of field trips, and what could be expected of the students. Our initial step was to mimic the organization of the Massachusetts STE Framework and grouped up all the grades into three main grade ranges. The grade ranges also doubled as age ranges since the Frameworks are already made with age appropriateness in mind.

We found that the scientific tools such as the microscopes the WCMC uses are not considered age appropriate until fifth-grade or when students are eleven years old.

Findings and Deliverables

The anecdotal evidence from our interviews with Donna Taylor (she/her), the associate director of the STEM Education Center at WPI, and Stacey Hill, the Science Department Head at Doherty High School corroborated what we found in our analysis of the Frameworks. An interesting point is that after Covid-19 a lot of the laboratory experience has been diminished if not eliminated, so the STEM learning modules potentially stand as one of the first introductions to microscopes for many students.

Another factor we paid attention to was the expected time allocated for STEM. Middle schoolers have in comparison to both younger grades and ages a lot more time allocated for STEM and stand in a unique position where more serious scientific thought is introduced. In addition, we found that field trips are usually up to the discretion of teachers and principals for middle schoolers, making middle schoolers an ideal target audience as field trips would be easier to coordinate with schools.

The last factor we looked into was the flexibility of the Frameworks for both schools and Scouts. When we analyzed the Massachusetts STE Framework we looked for standards that correlated with scientific tools, scientific analysis, and data collection. Out of all the disciplines covered in the Framework, we decided that the life sciences discipline aligned the best with WCMC resources and focused on it for the STEM learning

Topic: Life Science	Grades K - 3	Grades 4 - 5	Grades 6 - 8
From Molecules to Organisms: Structures and Processes		5.3.5.ETS3.2(MA). 4-LS1-1. 5-LS1-1.	6.MS-LS1-1. 8.MS-LS1-5.
Ecosystems: Interactions, Energy, and Dynamics		5-LS2-1.	7.MS-LS2-1. 7.MS-LS2-2.
Heredity: Inheritance and Variation of Traits	1-LS3-1.		
Biological Evolution: Unity and Diversity			

Table 3. STE Massachusetts Framework

modules. In the Life Science discipline, there are several topics that we could focus on and the standards that matched were 5.3.5.ETS3.2, 4-LS1-1, 5-LS1-1, 5-LS2-1, 6.MS-LS1-1, 8.MS-LS1-5, 7.MS-LS2-2 and 7.MS-LS2-2 which can be seen in Table 3.

Scouts and Cub Scouts are both ideal target audiences. For the Scouts, we looked into the requirements for merit badges and certifications which in comparison to schools are the most flexible between varying age ranges. Our interviews with Nicholas Cantrell, Pack 37 Cubmaster, and Robert Belin, Troop 37 Scoutmaster, confirmed what we had understood about the possibility of the STEM learning modules satisfying the requirements for both Scouts and Cub Scouts since the merit badges and certificates have different difficulties depending on the age of the Scout.

With all the factors we looked at, we came to the final conclusion that sixth to eighth-graders are the optimal audience since the STEM learning modules would be the most beneficial to them. Sixth to eighth-graders can be expected to either know or learn how to use the

	4TH GRADE	5TH GRADE	6TH GRADE	7TH GRADE	8TH GRADE
Expected to use microscopes	✗	✓	✓	✓	✓
Allowed to use lab equipment	✗	✓	✓	✓	✓
Allocated time for STE	3 hours	3 hours	4.5 hours	4.5 hours	4.5 hours
Field Trips	Instructor's discretion	Instructor's discretion	Instructor's discretion	Instructor's discretion	Instructor's discretion
Frameworks	Restrictive	Restrictive	Little restrictive	Flexible	Flexible
Scouts flexibility	Restrictive	Restrictive	Flexible	Flexible	Flexible

Table 4. Fourth to eighth-grade learning level and flexibility

tools used in our interactive activities. More time is allocated for STEM, which means the teachers might be more flexible with adopting the modules, and the Frameworks are more flexible which allows us greater freedom in creating the STEM learning modules.

4.1.3 Flexible Frameworks that can be used in the field or classroom are needed

Across all of the interviews we conducted, one point that recurred several times was the STEM learning modules we created should be focused on Worcester. From the interview with Stacey Hill, the Science Department Head at Doherty HS, we learned that students often do not learn much about their local environment. So including information that teaches them about their city's lakes and ponds would be a first for them and very interesting. Similarly, the Scouts also wanted to have any field trips conducted within Worcester as they usually reserve going outside Worcester for summer camps and overnight camping trips. Within the same finding, there were some areas that we had to change to accommodate the schools' and the Scouts' restrictions. School students and teachers do not get much time to include additional lesson plans into their already time-constrictive curriculum. Having a short module of about thirty minutes would be ideal for both. Additionally, not all schools may be able to go on a sample collection field trip or have access to water bodies. Instead, having exercises where students can analyze data and identify patterns should also be included in the STEM learning modules. As for the Scouts, since they spend a lot of time outdoors and on hands-on activities, they became our main priority.

The second thing we learned that is related to module development is that our target audience has very little experience with microscopes or scientific laboratory procedures. Not just middle and high schoolers, but the Scouts too had a similar response. Since most of their activities are in outdoor areas observing the environment, they do not have many opportunities to use microscopes. Being able to use them on-field and even in their laboratories would be a great experience for those considering going into STEM or who want an introduction to it.

One of the most important aspects of developing our lesson plans was to ensure they could be universally used by the schools and Scout groups in Worcester. To make this happen, we needed to follow a template that was recognized by every public school teacher. This is where Donna Taylor came in to assist us. With her help, we discovered two lesson plan formats from the STEM Education Center's library that meet our requirements and chose to use one of them, the I am STEM Lesson Template (Appendix D). As for the Scouts, each Scout group follows its own, unique template when building activities. Since one of our future goals is to have our lesson plans be a requirement Scouts can meet to get the Environmental Science merit badge, we thought of moving forward with the Mississippi Valley Council (MVC) Merit Badge Lesson Plan (Appendix K). It is freely available and in use by some Scout groups. The MVC lesson plan is similar to the template used by schools and ensures cross-compatibility and reproducibility in the future.

4.1.4 Field Trip was effective for students in fourth-grade and above

The main finding from the pilot of the field trip learning module was that Scouts or students above the fourth-grade level were highly engaged by and enjoyed the activities. While, unfortunately, no Scouts were able to attend the event, the Cub Scouts who attended were highly enthusiastic to complete the field sheets we provided them and engaged by the questions we asked regarding why the field sheet data was important in regards to the water sampling. The Cub Scouts also found the water sampling and the equipment we used to be interesting and were especially intrigued by the microscopes and what they found with them in the water samples. They loved looking in the microscopes and operating them to look at the many varieties of molecules that we could see, and they were very engaged with identifying the different cyanobacteria and other microorganisms found using the images on the posters that we had of some of them. Projecting the view of one of the microscopes on a laptop was particularly helpful in allowing the Cub Scouts to observe everything under the microscope together as a group. While all the Cub Scouts seemed to enjoy the activities, the older Cub Scouts, the ones in fourth and fifth-grade, were definitely getting more out of the activities than the younger ones, who seemed less interested in the microscopes as they had a harder time understanding the concepts surrounding microorganisms, which we explained as simply as we could. All the Cub Scouts enjoyed running around outside at the very least which was great, but overall for all the activities the fourth and fifth-graders were more understanding of and engaged by the material.

4.2 Deliverables

4.2.1 WCMC Learning Modules Handbook

The main deliverable for our project is the WCMC Learning Modules Handbook. The handbook contains lesson plans for middle schoolers, Scouts, and Cub Scouts and can also be used for general public education. The middle school section of the Handbook has four different lesson plans that incorporate different Massachusetts STE Framework curriculum requirements. The lesson plans in this section are Introduction to Community Science, Introduction to Ecological Relationships, Introduction to Scientific Analysis, and Analysis of Microorganisms. The lesson plans aim to provide middle school teachers with the material they can use for the classroom, a lab, or a field trip.

The Scouts Lesson Plan is a lesson plan designed for a field trip that will provide Scouts with hands-on experience practicing a scientific method toward research on a local environmental issue in the outdoors. The Cub Scout Lesson is a. simplified version of the Scouts Lesson Plan.

4.2.2 List of potential field trip sites in Worcester

Lastly, we created a qualitative chart of data collected from several potential field trip sites in Worcester for teachers and others to reference when searching for a field trip location for the STEM learning modules. The direct observation method was used when we visited different parks around the City of Worcester cataloging and characterizing them depending on parking, pavilion, geography, restrooms, and accessibility. We also noted the water quality based on data given to us by Jacquelyn.

5 Recommendations

In this chapter, we present below a set of recommendations aimed at making this project more effective. It should be noted that the recommendations presented here do not cover all possible improvements that a more comprehensive future work could indicate, but only those most important areas that offer immediate prospects for improvement and that have come to our attention in the course of our work. With that said we have three main recommendations aimed at increasing the scope of our deliverables including the creation of a mobile STEM laboratory, collaboration with the Worcester Public Library, and collaboration with the Girl Scouts of Central & Western Massachusetts.

5.1 Implement WCMC Mobile Laboratory

A recommendation we have is to use the lesson and field trip plan as a justification for the implementation of a mobile laboratory. Our sponsor had shared her intentions of getting a big blue bus that's equipped with all the scientific tools necessary to bring the WCMC to others. The STEM learning modules currently rely a lot on WCMC resources like the field kit, so having the capability to bring those same resources to schools or Scouts can increase the flexibility of the modules. Overall, the modules and the mobile laboratory would complement each other so it is highly recommended to proceed with the creation of the big blue bus for the WCMC.

5.2 Collaborate with Worcester Public Library

We recommend pursuing a relationship with the Worcester Public Library so that WCMC field kits can be kept in the library's system. Currently, to acquire a WCMC field kit an individual would need to get into contact with the WCMC itself which could potentially lead to conflict during the cyanobacteria bloom season as the kits may not be readily available. By collaborating with the public library system we can ensure that any educator can acquire the field kits when needed.

Recommendations

5.3 Implement STEM Learning Modules at Girl Scouts Summer Camp

Another recommendation we have is to further pursue a collaboration with the Girl Scouts of Central & Western Massachusetts. Due to time constraints, we were unable to interview them and potentially apply the STEM learning modules to them. However, they have a summer camp program that already has some water-based interactive activities and is currently developing a STEM room where the STEM learning modules could potentially be utilized. The next steps would be to further elaborate with the Girl Scouts themselves and potentially work to set up a pilot in their summer camp as they have shown some interest in including the STEM learning modules in their STEM room.

6 Conclusion

Over a period of two terms, our group learned, explored, and discovered new information about the City of Worcester. We came to understand the impact of cyanobacteria blooms in Worcester and the importance of the work our sponsor, the WCMC, does. Based on our earlier research we understood the deficit in environmental literacy caused by the disconnect between what's required to teach in educational standards and the actual local context. Because of this disconnect, the WCMC stands in a unique position since their use of community scientists can help give local context about the environment and science.

That of course is what led to our project goal of creating STEM learning modules that integrate the methods and procedures of the WCMC. The procedures of the WCMC stand as an ideal vehicle to teach and introduce the core principles of STEM and provide more context to the environment. All of which can contribute to increasing the environmental literacy of Worcester residents.

We created learning modules focused on increasing environmental literacy in the City of Worcester for different audiences mainly around the same age range as middle schoolers. These learning modules were made available to anyone who felt interested at present or in the future.

We hope that the STEM Learning Modules we have made will prove to be a useful and dynamic tool that the WCMC and Worcester community can rely on and that our recommendations may also prove to be effective in further accomplishing the goal of this project. Working with the Worcester community to create these modules has been an immense pleasure and honor, and the experiences and connections we have made rewarded us in more ways than we could ever imagine.

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Appendices

Appendix A: Interview questions for the WCMC volunteers/leaders

Oral Consent Form:

We are the Worcester Green Modules Team from Worcester Polytechnic Institute in Massachusetts. We are conducting interviews with WCMC volunteers to gather data for our learning modules. The data we collect will be used to improve the learning modules and contribute to making a more complete deliverable.

Your participation in this study is completely voluntary and you may withdraw at any time. Your answers will remain anonymous and no names or identifying information will appear on the questionnaires, project reports, or publications.

This is a collaborative effort between the City of Worcester Lakes and Ponds Program and Worcester Polytechnic Institute, and your participation is greatly appreciated. If interested, a copy of our learning modules and/or final report will be provided through email.

If you have any questions regarding our research, you can contact our team at gr-worcesterlakesandponds-b22@wpi.edu. If you have any questions regarding your rights as a research subject, please contact Worcester polytechnic institute's Institutional Review Board at irb@wpi.edu.

Thank you for your help.

Appendix A: Interview questions for the WCMC volunteers/leaders

Examples of semi-structured interview questions for volunteers

1. If you don't mind, what is your regular, daily occupation or job?
2. How did you hear about and become involved with the WCMC?
3. What do you do for the WCMC?
4. Have you ever done anything involving community or youth education on environmental literacy for the WCMC?
5. What parts of the WCMC do you feel could be turned into lessons or activities for youth?
    a. Any ideas for good activities?
6. How do you feel that youth education on environmental science literacy could make an impact?
    a. Do you have any ideas for our learning modules or anything in particular that you feel should be included in them?

Appendix B: Interview Questions for teachers and Scout leaders

Oral Consent Form:

We are the Worcester Green Modules Team from Worcester Polytechnic Institute in Massachusetts. We are conducting interviews with teachers and Scout instructors to gather data regarding the creation of learning modules. The data we collect will be used to create cyanobacteria learning modules and lesson plans for students and Scouts.

Your participation in this study is completely voluntary and you may withdraw at any time. Your answers will remain anonymous and no names or identifying information will appear on the questionnaires, project reports, or publications.

This is a collaborative effort between the City of Worcester Lakes and Ponds Program and Worcester Polytechnic Institute, and your participation is greatly appreciated. If interested, a copy of our learning modules and/or final report will be provided through email.

If you have any questions regarding our research, you can contact our team at gr-worcesterlakesandponds-b22@wpi.edu. If you have any questions regarding your rights as a research subject, please contact Worcester polytechnic institute's Institutional Review Board at irb@wpi.edu.
Thank you for your help.

Appendix B: Interview Questions for teachers and Scout leaders

Questions we asked teachers:

1. Would you be interested in a lesson on environmental science related to Healthy Ecosystems that aligns with the MA Curriculum framework?
2. In your opinion, which grades/age would benefit the most from a lesson on environmental literacy?
3. Are there any current lessons about environmental literacy/education in your school?
    a. If there are, could our environment literacy modules mesh well with the existing lessons?
4. How do we incorporate more hands-on experience inside the classroom?
5. Would it be possible to fit a field trip to a nearby lake into their schedule?
    a. What standards would need to be met for a field trip?
    b. Is a field trip a feasible or good idea?
6. Are there any specific items or thoughts we should keep in mind when making the modules?
    a. Are there any curriculum restrictions or potential obstacles that we should be aware of?

Questions we asked Scout and Cub leaders:

1. What are some appropriate field activities for scouts?
    a. Are our planned field activities appropriate?
2. What is the size of your troop/pack?
    a. What is the average age range of the scouts?
3. What are some environmental awards for the scouts that we might be able to integrate into this?
    a. Can we integrate some of these activities into the requirements for the Environmental Science merit badge? If so, how?
4. Are the scouts able to visit Worcester lakes for field trips?
5. What equipment are the scouts allowed to use due to their age?
6. Do we need any authorizations & training from the parents to work with the scouts?
7. When might be a good time for the field trip(s) to take place and what would be an appropriate length of time for a field trip?

Appendix C: Interview Questions for STEM Education Center

Ask about the lesson plan format

1. What are the most important things to be aware of when developing a formal lesson plan?
2. Are there any tools/websites that you recommend?
3. What exactly are the guidelines that we should use?
4. What would you say is essential when creating modules? (Ex. Time management).

Ask about resources to build a lesson plan

1. Do you have resources on environmental education?
2. Do you have previous similar modules?

Piloting modules

1. What is more effective: us presenting / the instructors?
2. How to make good informative instructions - get the point across?

Extra

1. At what grade/age would it be ok to use a microscope?

Appendix D: I am STEM and Integrated STEM Framework

I am STEM Lesson Plan:

<table>
<tr><th>Monday</th><th>
</th></tr>
<tr><td>Teacher Preparation:</td><td></td></tr>
<tr><td>Student Preparation:</td><td></td></tr>
<tr><td>Problem Solving:</td><td>

- Read the book.
- **Identify the problem(s)** in the story.
- Define criteria and constraints.
- **Brainstorm** possible solutions

</td></tr>
<tr><td>CRT Strategies</td><td>

- Connect the content of the book to your students' cultural and linguistic backgrounds.
- Ask relevant and inclusive questions that connect to all students from various backgrounds (e.g. Asking what kind of instruments and music they like or hear in their homes, rather than what instruments they play).
- Connect the problems in the stories to all students' home and community experiences.
- Scaffold students' learning using their family and home funds of knowledge (e.g. connect the problem to the students' family/community expertise).

</td></tr>
</table>

Duration	Activity	Instructions	Product

Appendix D: I am STEM and Integrated STEM Framework

Integrated STEMLesson Plan:

Standards and Learning Targets

STE/M Standard 1:			
Vocabulary	**Tier 1**	**Tier 2**	**Tier 3**
What do students need to **KNOW**?	1. Students will use the following vocabulary words in context: 2. 3.		
What do students need to **DO**?	1. 2. 3.		
What will students **CREATE**?	1. 2.		

STE/M Standard 2 OR STE/M Practice: (optional)			
Vocabulary	**Tier 1**	**Tier 2**	**Tier 3**
What do students need to **KNOW**?	1. Students will use the following vocabulary words in context: 2. 3.		
What do students need to **DO**?	1. 2. 3.		
What will students **CREATE**?	1. 2.		

Appendix E: Middle School Lesson Plan Example

LESSON PLAN 3

INTRODUCTION TO SCIENTIFIC ANALYSIS

This module should take approximately **30 minutes**

Objective:

By the end of this lesson, students will be able to understand how to do scientific analysis using datasheets or fieldsheets.

STE Standards

7.MS-LS2-1. Analyze and interpret data to provide evidence for the effects of periods of abundant and scarce resources on the growth of organisms.
8.MS-LS1-5. Construct an argument based on evidence for how environmental and genetic factors influence the growth of organisms.

Materials

- WCMC data sheets

Presentation link can be found in appendix A

Key Vocabulary Words

Tier 1
Lake
Park
Data
Surveys

Tier 2
Hypothesis
Evidence
Experiment

Tier 3
Data sheet
Scientific analysis
Scientific method
Cyanobacteria

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Appendix E: Middle School Lesson Plan Example

Topic	Introduction to Scientific Analysis
Teacher Preparation	Verify Slides Presentation Print WCMC data sheets
Student Preparation	None
Problem Solving	• Brainstorm possible solutions • Share your work • Communicate your revised solution to an audience
CRT Strategies	• Ask relevant and inclusive questions that connect to all students from various backgrounds. • Encourage students to express and communicate their knowledge and ideas using multiple modes and modalities, including students' home language. • Give students plenty of opportunities to discuss and share various stages and possibilities of the design.

Duration	Activity	Brief Instructions	Product
10 min	Slides Lecture	Use a presentation to explain the concept of scientific analysis	
10 min	Individual Analysis	Distribute the WCMC datasheets and ask students to compare datasheets	
10 min	Group Activity	Form groups based on the lake/park data sheets from activity 2 and create a hypothesis	

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Appendix F: Scout Lesson Plan Example

LESSON PLAN I

FIELD SAMPLING

Field Trip Plan: ______________		Date: ___/___/_____	
Activity	**Description**	**Run By**	**Time**
Welcome/ Briefing	Introduction and Safety Briefing		5 minutes
Skills Instructions	Explain the activities and safety measures		
Breakout Groups	Form groups of 5		
Activity			55-75 minutes
Activity 1	**Surveying the area:** Scouts will be given a map and a field sheet for recording data that may impact the water sampling		15-20 minutes
Activity 2	**Collecting water samples:** Scouts will collect water samples from the lake at a designated spot. The tools to collect water samples will be provided by the WCMC.		20-25 minutes
Activity 3	**Microscope Skills:** Scouts will use the samples collected to view under microscopes provided by the WCMC.		20-25 minutes
Closing	Snacks		
Total 60 minutes of activities			
After the Activities	Post-Survey		5 minutes

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Appendix F: Scout Lesson Plan Example

ACTIVITY 1
SURVEYING THE AREA
GENERAL INFO

THEME

Investigating the area around the waterbody and collecting data that may affect the results of the water samples

ENGINEERING PRACTICES

- Asking questions (for science) and defining problems (for engineering)
- Planning and carrying out investigations
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in an argument from evidence
- Obtaining, evaluating, and communicating information

TAKEAWAY

- Scouts should become more aware of the local ecology around the park and start to establish the relationships between animal and plant life.
- Be able to develop an argument about whether certain conditions may affect the results of a water sample or not based on evidence.

MATERIALS NEEDED

- Field sheet
- Lake map
- Trash bag (optional)

SKILLS LEARNED

- Understanding ecosystems
- Field identification skills

MATERIALS INFO

Field sheet can be found at the appendix C
Lake map can be found at the appendix D

Appendix G: Field Trip Surveys for Students/Scouts/ Parents

Survey for Scout Leaders:

Location Questions

- How would you rate this location's parking facility (1 being the lowest rating and 5 being the highest)?

1	2	3	4	5
○	○	○	○	○

- How would you rate this location's activity/rest areas (1 being the lowest rating and 5 being the highest)?

1	2	3	4	5
○	○	○	○	○

- How would you rate this location's restroom access (1 being the lowest rating and 5 being the highest)?

1	2	3	4	5
○	○	○	○	○

- Please include some other thoughts you have regarding the location of today's activity including whether it was suitable for the scout.

Appendix G: Field Trip Surveys for Students/Scouts/Parents

Survey for Scout Leaders:

Activity Questions Part 1

- Did you think there was sufficient time for Activity 1?
  - ◯ Yes
  - ◯ No, there was too much time allotted
  - ◯ No, there wasn't enough time allotted
- Did you think there was sufficient time for Activity 2?
  - ◯ Yes
  - ◯ No, there was too much time allotted
  - ◯ No, there wasn't enough time allotted
- Did you think there was sufficient time for Activity 3?
  - ◯ Yes
  - ◯ No, there was too much time allotted
  - ◯ No, there wasn't enough time allotted
- Please add any comment you have on the set of previous question.

Appendix G: Field Trip Surveys for Students/Scouts/ Parents

Survey for Scout Leaders:

Activity Questions Part 2

- Did you think the contents of Activity 1 were appropriate for the scouts' age range?
  - ◯ It was appropriate
  - ◯ It mostly targeted the younger scouts
  - ◯ It mostly targeted the older scouts
  - ◯ It was too advanced/basic for the scouts
- Did you think the contents of Activity 2 were appropriate for the scouts' age range?
  - ◯ It was appropriate
  - ◯ It mostly targeted the younger scouts
  - ◯ It mostly targeted the older scouts
  - ◯ It was too advanced/basic for the scouts
- Did you think the contents of Activity 2 were appropriate for the scouts' age range?
  - ◯ It was appropriate
  - ◯ It mostly targeted the younger scouts
  - ◯ It mostly targeted the older scouts
  - ◯ It was too advanced/basic for the scouts
- If you answered with "It was too advanced/basic for the scouts" in any of the questions above, please provide some details.

Appendix G: Field Trip Surveys for Students/Scouts/ Parents

Survey for Scout Leaders:

Additional Questions

- Do you think this event could be done in the future with the resources provided today?
  - ○ Yes
  - ○ Yes, with minor changes
  - ○ No, a lot needs to be changed
- If you answered with either the second or third option in the previous question, please provide some details.

- Please mention any additional comments you have.

Appendix G: Field Trip Surveys for Students/Scouts/ Parents

Survey for Parents:

General Questions

- Has your child used a microscope before?
  - ◯ Yes
  - ◯ No, it was his/her first time
- If yes, please mention where and when?
- Does your child get enough opportunities to participate in STEM-related activities?
  - ◯ Yes
  - ◯ Not as often as I would like
- Would you like to see more STEM activities being introduced in schools or scouts? Please choose the statement you agree with the most.
  - ◯ I am content with how many there are currently
  - ◯ I would like to see more STEM activities being introduced

Appendix G: Field Trip Surveys for Students/Scouts/ Parents

Survey for Parents:

Location Questions

- How difficult was it to find this location?

	1	2	3	4	5	
Very difficult	○	○	○	○	○	Very easy

- How would you rate this location's parking facility (1 being the lowest rating and 5 being the highest)?

1	2	3	4	5
○	○	○	○	○

- How would you rate this location's accessibility (1 being the lowest rating and 5 being the highest)?

1	2	3	4	5
○	○	○	○	○

- Please mention any additional comments you have.

Appendix G: Field Trip Surveys for Students/Scouts/ Parents

Scouts Pre-Activity Survey

- How do people affect the environment? List a few ways you can think of.

- Have you used a microscope before?
  - ◯ Yes
  - ◯ No
- What do you think microscopes are used for?

- What do you think cyanobacteria are? (Hint: it is very similar to algae)

- Why do you think cyanobacteria are bad for the environment?
  - ◯ They release toxins into the water
  - ◯ They block sunlight from entering the lake
  - ◯ They use up oxygen meant for aquatic organisms
  - ◯ All of the above
- How would you describe a scientist?

- Would you consider yourself to be a scientist?
  - ◯ Yes
  - ◯ No
  - ◯ Maybe

Appendix G: Field Trip Surveys for Students/Scouts/ Parents

Scouts Post-Activity Survey

- How do people affect the environment? List a few ways you can think of.
- Did you have difficulty using the microscope?

	1	2	3	4	5	
Very Difficult	○	○	○	○	○	Very Easy

- Did you see anything interesting through the microscope?
- Can you explain what cyanobacteria are?
- What makes a cyanobacterial bloom bad for the environment?
  - ○ They release toxins into the water
  - ○ They block sunlight from entering the lake
  - ○ They use up oxygen meant for aquatic organisms
  - ○ All of the above
- How would you describe a community scientist?
- Would you consider yourself to be a community scientist now?
  - ○ Yes
  - ○ No

Appendix H: WCMC Volunteer Training Modules

WCMC Volunteer Training:
https://drive.google.com/drive/folders/1K_WPty1tLOpAhMLLT4MdeVVubqJ_K82v

Appendix I: WCMC Volunteer Training Modules

HCB Identifications using the Microscope:
https://docs.google.com/document/d/1MrzoD6-D6ByTeDKfmEpdaHIV8xOsXGdUXab4jiaIOtI/edit

Appendix J: Student Field Sheet

Your Name	
Name of Lake	
Weather	
Date of Last Rainfall	
Water Temperature	
Is the Water Calm or Rough?	
How Clear is the Water on a Scale of 1-10?10=crystal clear1=not clear at all	
Animal Life	
Vegetation	
Are there many people and pets in the area?(None, Few, Some, Many)	

Appendix H: Appendix K: Mississippi Valley Council (MVC) Merit Badge Lesson Plan

Merit Badge Name Program Area:
https://www.mississippivalleybsa.org/mvc-merit-badge-lesson-plan-blank-template/

Merit Badge Name

Program Area

Mississippi Valley Council - 2021 Summer Camp

Day of Week:
Duration: 50 Minutes
Counselor:
Date Written/Updated:

Resources

- Merit Badge Pamphlet
-

Materials Needed

-

Learning Objectives/Requirements Covered (2 Minute)

- *Requirement Covered & one sentence about what you want them to learn.*
-

Discovery (5 Minutes)
Ask the group 3-5 questions to see how much they know about what you're about to teach

Skill Instruction (36 Minutes)

Appendix L: Potential groups where we can pilot the learning modules

The locations are all based in the Worcester area:

- Troop 54, Worcester
- Troop 9, Worcester
- Troop 37, Worcester
- Girl Scout Leadership Center, Worcester
- Worcester Technical High School
- North High School
- Doherty Memorial High School
- Burncoat Senior High School
- Abby Kelley Foster Charter Public School
- Burncoat Middle School
- Forest Grove Middle School
- Dr. Arthur F. Sullivan Middle School
- Worcester East Middle School

Appendix M: Parental Consent Form

Hello, we are students at Worcester Polytechnic Institute who are developing educational modules for Worcester Lakes and Ponds in Worcester, MA. This fall, the City of Worcester's Lakes and Ponds Program wishes to create learning modules to increase environmental literacy among youth in Worcester by utilizing the methods and procedures of the Worcester Cyanobacteria Monitoring Collaborative (WCMC).

We would like to conduct a study involving your child to help improve the module design. We will be conducting a pre-survey to gain an initial understanding of the participants. We will then conduct a pilot test of the hands-on learning modules about cyanobacteria (blue-green algae).

In the pilot learning modules, students will engage in a hands-on learning experience about cyanobacteria. While conducting this activity we will consider how students will be most engaged with the learning material so that they can receive an optimal, fun learning experience about the environment. We hope to also introduce students to a real-life STEM experience that has a direct impact on their community.

This activity will take a total of two hours and depending on circumstances we would like to include a field trip to nearby lakes such as the Coes Reservoir or Indian Lake. As both these locations are where the WCMC operates, we will have pre-determined their safety. The content of this activity is currently in development and will be further developed by the Worcester Lakes and Ponds group.

After testing the modules, we will have a post-survey to analyze the effectiveness of our activity, in hopes of improving the learning modules.

Appendix M: Parental Consent Form

Child Information

Full name:____________________ Age:____ Current Grade:_______________

Consent

TO WHOM IT MAY CONCERN:

Filling out all the below spaces does hereby give consent for our (my) child, ______________, to attend and participate in a focus group. This study and activities will be sponsored by the Worcester Polytechnic Institute and the City of Worcester Lakes and Ponds Program from October 24, 2022, to December 16, 2022.

For any questions or concerns about the research, please contact us at gr-worcesterlakesandponds-b22@wpi.edu.

By checking this box and typing my name below, I am electronically signing this consent form.

Parent / Guardian Signature:________________________

Relation to student:_____________ Date:___________

Appendix N: Survey questions for teachers post-classroom pilot of STEM learning modules

Oral Consent Form:

We are the Worcester Green Modules Team from Worcester Polytechnic Institute in Massachusetts. We are conducting interviews with teachers to gather feedback on our learning modules. The data we collect will be used to improve the learning modules and contribute to making a more complete deliverable.

Your participation in this study is completely voluntary and you may withdraw at any time. Your answers will remain anonymous and no names or identifying information will appear on the questionnaires, project reports, or publications.

This is a collaborative effort between the City of Worcester Lakes and Ponds Program and Worcester Polytechnic Institute, and your participation is greatly appreciated. If interested, a copy of our learning modules and/or final report will be provided through email.

If you have any questions regarding our research, you can contact our team at gr-worcesterlakesandponds-b22@wpi.edu. If you have any questions regarding your rights as a research subject, please contact Worcester polytechnic institute's Institutional Review Board at irb@wpi.edu.

Thank you for your help.

Appendix N: Survey questions for teachers post-classroom pilot of STEM learning modules

Examples of semi-structured interview questions for teachers:

1. How would you describe the attentiveness of the class?
   a. Were there any points that significantly impacted the attentiveness of the students?
2. What did you think of the content in the module?
   a. Were there any subjects that might've been better left out
3. How was our teaching? (*if we presented the module)
   a. Did anything stand out as good or bad?
   b. What could improve how we present the material?
4. How did you feel about presenting the module? (*if the teacher presented the module)
   a. Did anything stand out as good or bad?
   b. What could've been changed to better facilitate teaching the module?
      i. More interactive activities?
      ii. More comprehensive teaching plan?

Appendix N: Survey questions for teachers post-classroom pilot of STEM learning modules

Examples of semi-structured interview questions for teachers:

1. How would you describe the attentiveness of the class?
    a. Were there any points that significantly impacted the attentiveness of the students?
2. What did you think of the content in the module?
    a. Were there any subjects that might've been better left out
3. How was our teaching? (*if we presented the module)
    a. Did anything stand out as good or bad?
    b. What could improve how we present the material?
4. How did you feel about presenting the module? (*if the teacher presented the module)
    a. Did anything stand out as good or bad?
    b. What could've been changed to better facilitate teaching the module?
        i. More interactive activities?
        ii. More comprehensive teaching plan?

Appendix O: Graphs and Images

Figure 1: Impacts of community science globally

Figure 2: Worcester Cyanobacteria Monitoring Collaborative logo

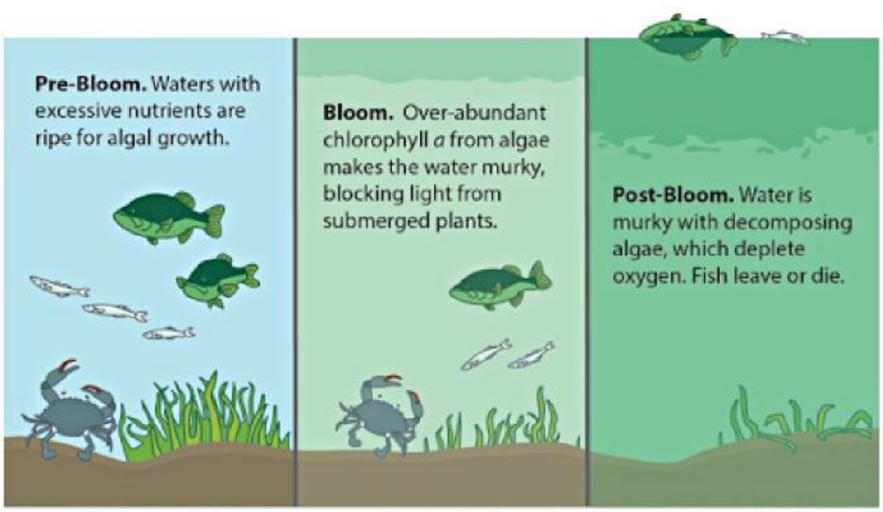

Figure 3: Ecosystem Model showing the impact of Cyanobacteria Blooms

Appendix O: Graphs and Images

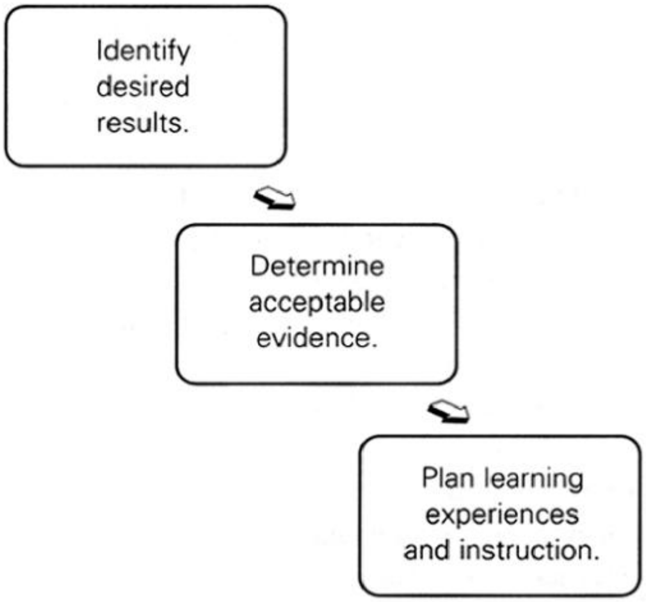

Figure 4: Backward Design Process

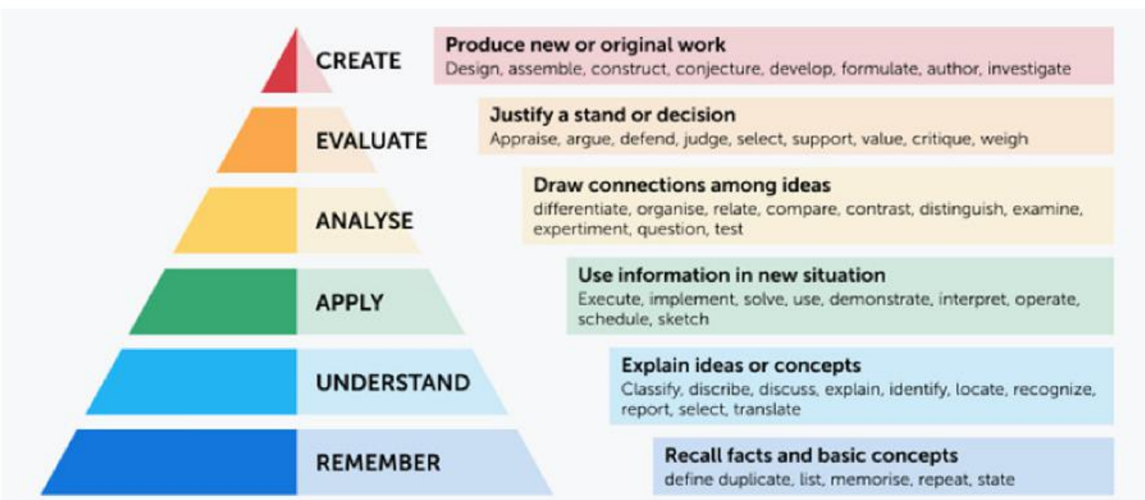

Figure 5: Bloom's Taxonomy

Appendix O: Graphs and Images

5th Grade	6th Grade	7th Grade	8th Grade
From Molecules to Organisms: Structures and Processes	From Molecules to Organisms: Structures and Processes	From Molecules to Organisms: Structures and Processes	From Molecules to Organisms: Structures and Processes
Ecosystems: Interactions, Energy, and Dynamics	Biological Evolution: Unity and Diversity	Ecosystems: Interactions, Energy, and Dynamics	Heredity: Inheritance and Variation of Traits
			Biological Evolution: Unity and Diversity

Table 1: Life science areas of study per grade 2022

5th Grade	6th Grade	7th Grade	8th Grade
Process by which plants use air, water, and energy from sunlight	Evidence that all organisms are made of cells	Characteristic animal behaviors and specialized plant structures	Environmental and genetic factors influence the growth of organisms
Matter moving throughout the ecosystem - producers, consumers, decomposers		Effects of periods of abundant and scarce resources on the growth of organisms	

Table 2: Life science educational objectives per grade (2022)

Topic: Life Science	Grades K - 3	Grades 4 - 5	Grades 6 - 8
From Molecules to Organisms: Structures and Processes		5.3.5.ETS3.2(MA). 4-LS1-1. 5-LS1-1.	6.MS-LS1-1. 8.MS-LS1-5.
Ecosystems: Interactions, Energy, and Dynamics		5-LS2-1.	7.MS-LS2-1. 7.MS-LS2-2.
Heredity: Inheritance and Variation of Traits	1-LS3-1.		
Biological Evolution: Unity and Diversity			

Table 3. STE Massachusetts Framework

Appendix O: Graphs and Images

	4TH GRADE	5TH GRADE	6TH GRADE	7TH GRADE	8TH GRADE
Expected to use microscopes	✗	✓	✓	✓	✓
Allowed to use lab equipment	✗	✓	✓	✓	✓
Allocated time for STE	3 hours	3 hours	4.5 hours	4.5 hours	4.5 hours
Field Trips	Instructor's discretion	Instructor's discretion	Instructor's discretion	Instructor's discretion	Instructor's discretion
Frameworks	Restrictive	Restrictive	Little restrictive	Flexible	Flexible
Scouts flexibility	Restrictive	Restrictive	Flexible	Flexible	Flexible

Table 4. Fourth to eighth-grade learning level and flexibility