CyanoHABIT: A Novel Game to Identify Harmful Freshwater Algae

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Abstract. CyanoHABIT (Cyanobacterial Harmful Algal Bloom Identifying Technology) is a proposed learning technology designed to give the general public the ability to self-teach identification of potentially harmful bloom-forming algae (HABs) in freshwater lakes. The primary users will be adults who are interested in helping government agencies distinguish potentially toxic algae blooms from other non-toxic blooms. Toxic algae in freshwater lakes present a serious threat to public safety, and while many algal blooms are not toxic, confirming toxicity can be time consuming and expensive. Many states have only one agency that is able to monitor, sample, and test water for HABs, and some states have no resources for this task [1]. Fortunately, relatively few freshwater algae are capable of forming toxins, and distinguishing between benign algae blooms and potentially toxic ones is a task that can be learned in a short time by most adults. With a better educated public, the time and resources of the professional public services can be concentrated on the cases where they are needed most. We developed a gamified trainer for use on smartphones and personal computers to teach this skill to the general public. Our focus was on education, enabling the user to learn the distinguishing features of toxic algae, and not provide a flip-book of pictures of algae. Preliminary testing indicates that the software is enjoyable to use, and that the users do acquire a valuable skill from its use.

Keywords: Cyanobacteria · Learning technology · Games
Algal blooms

1 Introduction

Freshwater algae can be found in almost any damp environment, including lakes and ponds, but also streams, wet soil, rocky areas in the spray zone of waterfalls, and standing water in birdbaths, fountains, livestock troughs, etc. Most

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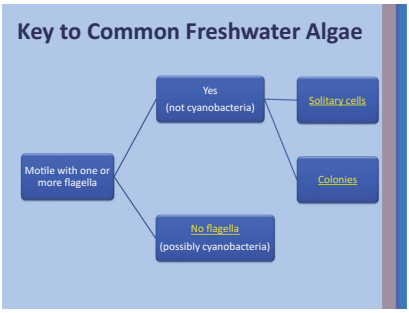
freshwater algae are harmless, but one group, the cyanobacteria, have species that can release toxins that are harmful to humans, pets, and wildlife. Harmful cyanobacteria blooms (often called "CyanoHABS") are increasing in frequency and duration [2], partly in response to climate change [3,4]. The only definitive way to identify toxic cyanobacteria blooms is through chemical testing, but with training and access to an inexpensive microscope, most people can learn to separate the potentially toxic species from "all others."



(a) Example of typical choices in algal identification.

(b) Typical colony of cyanobacteria (*Microcystis wesenbergii*).

Fig. 1. Examples of a typical keying approach to algal identification.

The CyanoHABIT (Cyanobacterial Harmful Algal Bloom Identifying Technology) game will provide a novel approach to learning how to recognize toxic cyanobacteria by incorporating the training into a game. Games have been considered ideal for visual scanning task training, given the game is selected to deliberately train the skills necessary for the task [5]. Identification of toxic cyanobacteria is typically presented in high-academic settings that present a steep learning curve for non-academics. Current work is in progress to increase the accessibility of this information, such as cyanoScope [6], but most of these efforts still rely on experts for the final identification. However, due to the limited number of features needed to identify toxic cyanobacteria, this process is ideal for gamification.

The CyanoHABIT game will use simple choices, with beginner, intermediate, and advanced settings, that allow the user to learn to identify potentially toxic species using clearly visible features described in nontechnical terms. Currently, the resources available for algal identification ask yes/no (dichotomous) choices for classification. For example, from "No flagella" (Fig. 1a), selecting "Colony" will bring up images of a typical colony of toxic cyanobacteria (Fig. 1b). As a learning technology, CyanoHABIT instead aims to train the user for a visual scanning task that will eventually be independent of the application. Users will be able to identify algae based on visual attributes and classification categories learned from the technology. The use of CyanoHABIT will provide the skills for

citizen scientists to be able to identify a subset of "could be toxic," "definitely not toxic," and "too difficult to identify." In all cases, if there is concern about the health effects of an algal bloom, the identification should be confirmed by contacting a professional or the appropriate testing agency. But the ability to identify the first two categories may lessen the workload for state-based testing facilities, and can be used to contribute cyanoHAB citings to projects like cyanoScope, thus providing important information about the occurrence of algae blooms in the USA [6].

2 Proposed Learning Technology

The learning technology will use an instructional approach for the identification of toxic cyanobacteria. Our target user base will be people who are invested in the presence of toxic algal blooms in their freshwater lakes, ponds, and reservoirs, including, but not limited to, fishermen, swimmers, and citizen scientists. The design will focus on accessibility and limiting academic word barriers. Whenever possible, easy to understand descriptors will be used rather than technical terms. The app will be available on both mobile devices and desktop computers to increase accessibility.

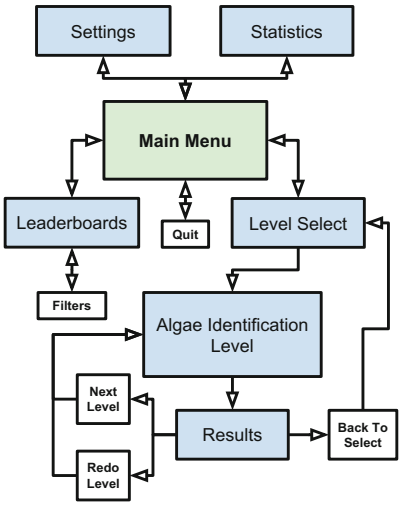


Fig. 2. The taskflow of the learning technology.

2.1 Design

Figure 2 shows the internal layout of the gaming system. The user starts on the Main Menu and can select from information about their progress, or continue learning about toxic cyanobacteria. The Level Select provides options between categories of identifiable process of elimination. For example, "Flagella and Cilia" are easily determined features of a microscopic organism; if present, they will disqualify the organism from being a toxic cyanobacteria. Figure 3 shows the workflow thought process involved in navigating CyanoHABIT.

Figure 4 shows a working example of the simple, clean design that will be used for the interface. When scientific wording must be used, such as "flagella" or "flagellum", simple definitions will be provided. Some examples of other screens as they may appear on the mobile version can be seen in Fig. 5 which displays wireframe mockups.

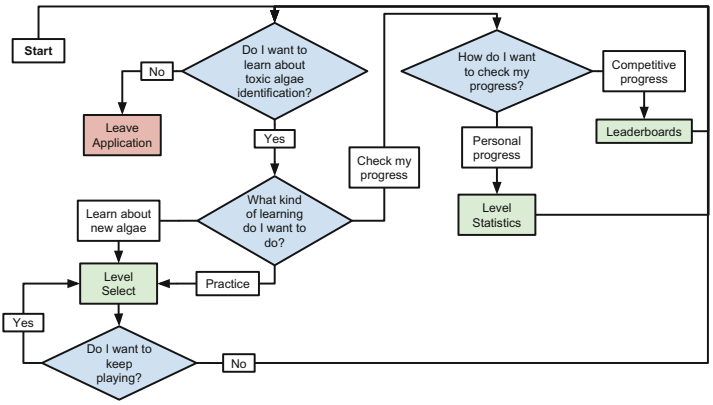


Fig. 3. The workflow of the learning technology.

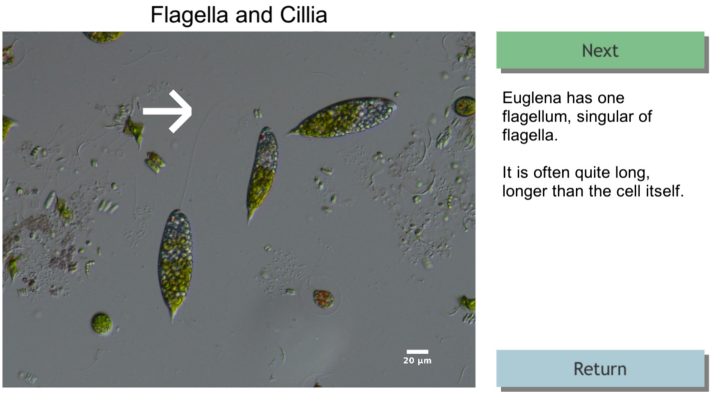


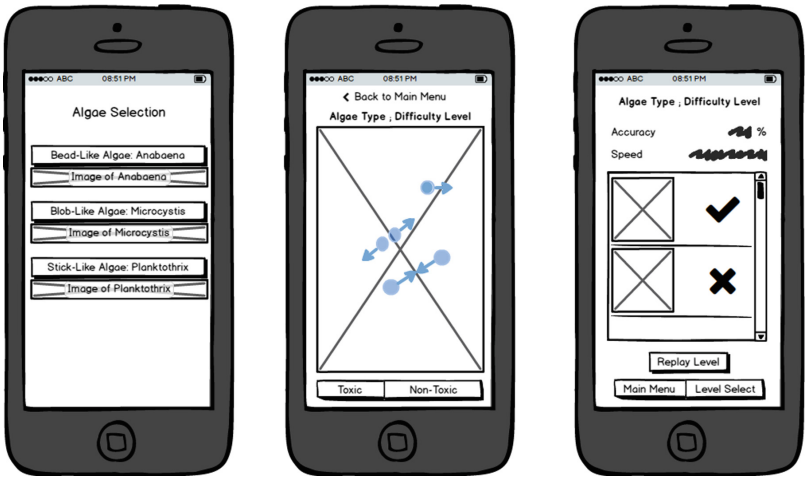
Fig. 4. A picture of the demo tutorial level on PC.

2.2 Personas

Primary Persona: Brandon Waters
Occupation: Fisherman; Technological Use: Expert

Brandon is a fisherman and spends 90% of his day either on or in the water. Brandon has recently taken a couple of different families out fishing on Lake Pine. He heard that some members of the family got sick after eating the fish they caught from the lake. Brandon was also informed one of the dogs got extremely sick after playing in the lake. He decided to take a trip to the lake where he noticed a macro-visible change in the water's appearance. He knew that the greenish color didn't necessarily mean a toxic algal bloom was occurring, but Brandon wanted to check whether there were cyanobacteria present in the lake.

Brandon had been using the CyanoHABIT game for some time now, so he collected a sample of the algae and took it to his local university's free-use



(a) Algae type menu selection.

(b) Active level controls.

(c) Level results.

Fig. 5. Wireframe mockups for the mobile version.

laboratory, which provided inexpensive microscopes for public use. Thanks to Brandon's experience with the learning technology, he was able to identify the type of algae he saw in the microscope as one of the common toxic algae, and determined it was the likely to have caused the illnesses. He informed his other fishermen buddies to avoid the lake until the bloom cleared up and reported the bloom to his state monitoring agency so that they could follow up with confirmatory chemical test and post a notice for the public indicating that fishing, swimming, or playing in the water was hazardous.

Secondary Persona: Rachel Keller
Occupation: Day Care Worker; Technological Use: Novice

Rachel works at Kiddie Cove, a daycare center promoted by the nearby elementary school. Kiddie Cove is located next to a popular lake where the kids love to wade and splash. Rachel grew up on a lake and loves taking the kids out to enjoy the lake. Often, the children's afternoon consisted of supervised, water-based activities.

Some of Rachel's coworkers mentioned that several children developed rashes while attending a weekend camping even at the lake. In addition to her concern for the daycare children, Rachel is a mother, and her son spends time at Kiddie Cove. One evening, at home, Rachel noticed a rash appearing on her son's leg. He had spent his afternoon playing in the lake, she began to wonder if it had something to do with the greenish water that she saw. Rachel spent some time online and learned that her son's rash might be caused by exposure to toxic

algal. While looking into toxic algal blooms, Rachel came across a fun, algal identification game. This game could easily teach her how to conduct her own research on this issue. After playing a few rounds of the game she felt like this could be a great asset to have at the daycare.

2.3 Use-Case Scenarios

Task: Check Progress. Persona: Brandon
Brandon has been practicing most levels on CyanoHABIT and wants to check his learning progress. He opens the game and selects an option for "progress and statistics." The game shows Brandon a screen that lists his general progress and statistics for the entire game, such as accuracy and average time taken per image, as well as options to see statistics for individual levels.

Brandon clicks on the "*Anabaena* Statistics" option to see how well he can identify that particular type of algae. The algal-specific statistics page displays similarly to the general page, with accuracy and speed for the entire *Anabaena* category, along with the accuracy and speed listed for each of the various difficulty levels of easy, medium, and hard. He sees that, on average, for *Anabaena* he has a 95% accuracy rating.

After checking his personal statistics, Brandon wonders how his score compares to other people in his local area. Back on the main menu, Brandon remembers seeing a "Leaderboards" option, so he goes back and selects that option. The leaderboard, by default, lists all the scores available. Brandon wants to only see the local area, so he selects the local filter option. He had previously filled in his location for CyanoHABIT so the program knows where to list statistics from. Brandon's average accuracy lists him at 10th in his area, but his speed puts him in 2nd place. Satisfied with his progress, Brandon closes the game.

Task: Learn About Toxic *Anabaena* Persona: Rachel
Rachel is just beginning to learn the visual differences between the toxic algae types. In the evening, after dinner, and she has some free time to spare. Rachel wants to become sufficiently proficient with visually identifying cyanoHABs so that she can check the water samples herself, rather than sending out the samples for testing, which requires more money that her workplace, Kiddie Cove, can afford on a regular basis.

Rachel starts up CyanoHABIT and looks over her options. She wants to keep learning so she selects "Level Select." Rachel previously completed the "easy" level for algae that looked like beads on a string, but couldn't remember what the name for that type of algae. The menu for level select listed three different types of algae, using both the scientific names as well as a visual descriptors and images, with an option for "All types." Rachel selects the "Bead-Like Algae: *Anabaena*" section after recognizing the algae image. However, feeling confident from last time, she then selects the "medium" difficulty level.

The medium levels provide fewer hints to Rachel while she plays the game, selecting "toxic" or "non-toxic" on a series of algae images. After each selection,

CyanoHABIT provides the correct answer along with a list of the identifying features that Rachel should have used for identification.

After 10 randomly selected images, the level concludes with a results screen. The results show Rachel that while she was fairly accurate, her speed was slow. Rachel clicks on the one image she failed to identify correctly to review the identifying features again. Once she is satisfied with her ability to recognize that type of algae, Rachel closes the game.

3 Conclusion and Further Work

To test the efficacy of CyanoHABIT, several user studies will need to be completed. Expert opinions will be gathered from an algal identification workshop at Western Washington University to inform the design and scope of information covered in CyanoHABIT. The final development stages will use a traditional user study with between-subjects data collection measuring information retention.

Once CyanoHABIT is fully verified and developed, we want to work cooperatively with public outreach projects, such as cyanoScope, to increase awareness and access to our application. We are confident that CyanoHABIT will provide a means for citizens to contribute to improving watershed quality and public safety.

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