Animal Tlatoque: Attracting Middle School Students to Computing through Culturally-Relevant Themes *

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ABSTRACT

A popular approach to introducing students to computer science is to involve middle-school students in engaging programming activities. One challenge in such a program is attracting students who are not already positively predisposed to computing.

In order to attract a diverse audience, we developed a summer program based on culturally-relevant themes that appealed to our two target audiences, females and Latina/os. This paper describes our success in developing and implementing a computing curriculum and recruiting materials for a 2-week summer camp integrating two themes, animal conservation and Mayan culture. Scratch programming was used to engage students in creating animations about animals and Mayan culture, allowing them an interdisciplinary experience that combined programming, culture, biology, art, and storytelling.

Our recruiting efforts resulted in an application pool that was 73% female and 67% Latina/o, with only 6.5% in neither group. We had 34 students complete the program. Pre- and post- surveys showed that the number of students citing computer science as their top choice for a career doubled and interest in computer science as a career more than tripled.

Categories and Subject Descriptors

K.3.2 [**Computers and Education**]: Computer and Information Science Education; K.4.m [**Computers and Society**]: Miscellaneous—*Diversity and Outreach*

General Terms

Design, Human Factors

Keywords

diversity, K-12 education, outreach

*Tlatoque (Tlah-TOH-keh)—'speakers'—used as titles by Aztec rulers

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1. INTRODUCTION

The demand for computer scientists far outweighs the number of students pursuing computer science, and this gap is projected to grow[16]. To satisfy this demand, we must broaden participation in computer science to students who are not already predisposed to pursuing computing careers—and whose parents may not encourage them to choose computer science. This poses a two-fold challenge. First, how do we recruit students to an outreach activity they might not be interested in or aware of? Second, how do we keep their attention long enough to not only see that computer science is fun, but change negative impressions they may have about the field?

There has been a wealth of development of outreach activities designed to give students a taste of computer science without months of training. These range from simple programming with new programming languages like Scratch[14] and Alice[6], to learning about machine instructions by building LEGOs with instructions[10], to learning about different CS concepts through non-computer-based activities in CS Unplugged[5]. While these are all important pieces to solving the puzzle, a single outreach event is not sufficient to provide the transformative experience we want from students not already predisposed to computer science.

We chose two large pools of students who are not currently choosing computer science—females and Latina/os. We then designed a program that appeals to the target groups and their parents, both in recruitment and throughout participation, similar to UC Irvine's program[11], which is targeted at Native Americans. Culture and math have been paired in math tutoring via Wayan Outpost[4] and many projects in ethnomathematics.

The Animal Tlatoque Summer Camp is a 2-week summer camp for middle school students that combines two themes with computing: animal conservation and Mayan culture. We designed an interdisciplinary curriculum, including animals, culture, computing, art, and storytelling. Computing projects were carefully chosen to gradually build skills and confidence, culminating in capstone experiences of animating a story, implementing a virtual pet, and/or contributing to the simulation of a Mayan ball game. In addition, long-term academic assistance and tracking is being provided by Bridges to Pathways, an existing on-campus program that runs after-school study sessions, parent information sessions, and college preparedness assistance.

As part of the National Science Foundations's Broadening Participation in Computing program (bpcportal.org), the overarching goal of the Animal Tlatoque Summer Camp is

to increase the number of US students pursuing computer science, particularly among two underrepresented groups: females, and Latina/os. The project employs the following strategies:

- Providing positive exposure to computer science
- Increasing participants' skills and self-confidence in computing
- Increasing participants' openness to a career in Computer Science.

The rest of the paper is organized as follows. We begin with the motivation behind our themes in Section 2. We describe the curriculum in Section 3. Section 4 gives some logistics in how we ran the camp. Next, we present the results of our recruitment and camp implementation efforts in Section 5. Finally, Section 6 provides our conclusions and future directions.

2. MOTIVATION

Our summer camp has two specific goals: (1) to attract the target audience with themes that appeal to both parents and children[2, 12, 15], and (2) to engage participants in activities that allow them to experience many facets of computer science. We have integrated two themes that are intended to appeal to Latina/o and female children and their parents: Mesoamerican cultural history[1] and conservation of endangered species.

Attracting Parents: Studies have found that foreign-born parents are concerned that their children will lose their ethnic identity and culture[15, 20, 19]. In the outreach programs we have been associated with, we have found this sentiment to be corroborated anecdotally. At UCSB outreach events, the authors have often heard parents voice their gratitude for programs that teach their children about their home countries in ways that are not taught in public schools.

Santa Barbara is also an ideal test-bed for attracting parental interest based on conservation. Some in Santa Barbara consider their community as the "birthplace of the environmental movement," which gathered steam after a devastating oil disaster caused by an offshore drilling accident in January 1969[8].

Attracting Students: A 1996 national study on Latino Youth found that YLA (Young Latino Americans) are "extremely interested in maintaining a connection with their culture; 67% agree that this is something that is important to them and nearly half of YLA have the desire to form a stronger connection to their Latino culture."[1] Again, such opinions are borne out by current outreach programs in local junior high schools. A program directed by Aldana was introduced into Santa Barbara Junior High School in 2008. That program combined Mayan hieroglyphic writing with ceramic art and the chemistry of the ceramic firing process. By the end of the calendar year, the voluntary, not-for-credit class grew from 18 students to 35.

The theme of endangered species was chosen to tap into two interests of young females—having a positive impact on the world and working with animals. Females tend to choose majors that have a positive impact[21, 7, 18], and we want to attract those females in order to show them how computing can be used to help solve problems with high social impact. In addition, young females have a strong attraction to animals. In Canada and the United States, women constitute approximately 80% of the veterinary college student population[13]. In fact, our theme was inspired by a current stuffed animal-based web phenomenon called Webkinz^{TM}, an interactive web environment tied to small stuffed animals that experienced 1.9 million unique visitors in December 2006[9].

[1]Mesoamerica extends from Central Mexico to parts of Honduras, including Olmec, Teotihuacan, Maya, and Aztec cultures.

3. CURRICULUM

Our curriculum has five components: Mayan culture, art, Scratch programming, CS unplugged activities, tours, and guest speakers. The first three areas are integrated, allowing animations to be created that directly related to the art and Mayan culture lessons. The CS unplugged activities are used to introduce concepts of computer science that the Scratch projects do not cover, and tours and guest speakers are provided to inspire students and introduce academic preparation programs. The remainder of this section provides more detail about each of these components.

On the first day of class, each pair of students is assigned an endangered animal from the Mesoamerican geographical region. They then research basic information about that animal. All of the projects for the rest of the camp are in the context of their animal.

3.1 Mayan culture

Two principles guided the determination of the Mayan cultural activities integrated into the program. First, the activities provided material that would be used in the Scratch programming activities, including drawings and narratives. Second, activities highlighted STEM fields within ancient Mayan culture to demonstrate a relevance of science and technology across cultures and across time.

Mayan counting: Mayan numeration is vigesimal, or base 20, evidenced in records of Mayan hieroglyphic writing. We introduce beans, toothpicks, and shells to provide a manipulable version of calculation using the hieroglyphic bar-and-dot notation. This activity is linked to a binary numbers CS Unplugged activity to provide students exposure to non-decimal computation.

Mayan glyphs: The ancient Mayan writing system is hieroglyphic in which individual glyphs represent vowels or syllables and are combined within glyph blocks and grids of blocks to compose words and sentences. In Mayan books, or codices, glyphic texts often accompanied illustrations to which they were related. Students learn to write the name of their animal in Mayan hieroglyphs and then imitate codex images in their Scratch animations.

Mayan ballgame: One version of the ancient Mayan ball game included elevated rings through which the ball infrequently passed. Students learned about the ball game and then focused on the physics of projectile motion. The next part of this activity involved the launching of water balloons of the same weight and with the same velocity at different angles. Students graphed the measurements of several launches.

Mayan stories: Students participate in a "scavenger hunt" in the library to find Mesoamerican or Native North American myths that made reference to their animals. These stories are summarized and transformed into storyboards as the basis of their second required Scratch animation.

3.2 Scratch Programming

Scratch programming projects are chosen to provide concrete milestones while gradually introducing more programming concepts. The first three projects involve their assigned animal (name poem, story, virtual pet), and are completed by all students. For the fourth project, students are offered a choice between implementing a virtual pet in Scratch, or helping to design a game based on the Mayan Ball game. In all cases, students are encouraged to integrate Mayan art and culture into their projects. culture lessons.

Name Poem: Students write a name poem for their animal and implemented this as a Scratch animation (an idea adapted from[22])–providing an opportunity to learn sequential instructions and event-driven programming. For example, "fish" might become Friendly, Intelligent, Shy, Hairless. When each letter is clicked, the adjective appears. In addition, the fish might swim across the screen in response to pressing the space bar.

Animal Information: Students completed an animation to teach others about their animal. This involves placing many pictures of their animal in two different scenes, one the natural habitat and another of their choice. They record the animal's sounds, narrated information, and add buttons to switch between scenes. All action is in response to user input. This project reinforces the lessons from the name poem and adds control flow (to control the scenes) and audio.

Animating a Story: Students then animate a story about their animal. First, students are taught about Mayan codices, the folded books in which Mayan stories were recorded. The students are also given an opportunity to research Mayan mythology and stories connected with their assigned animal. Finally, the students are invited to animate a story about their animal using the Scratch skills learned so far. These animations are posted on a website to share with friends and family.

Virtual Pet: For the virtual pet project, we teach the students how to make a finite state diagram illustrating the emotional states of their animal as well as how actions transition the pet from state to state, building on a clever virtual pest assignment[17]. Students are then given a simple virtual pet implemented in Scratch in order to demonstrate the additional skills needed for this project. Students then replace the pictures with their own animal pictures and add states and transitions to the code. This is a very challenging project in if-else if statements because the next state depends on both the current state and the action.

Mayan Ballgame: Students work with an undergraduate programmer to design the next steps in a Mayan ballgame. A skeleton program was provided, and students brainstorm with the programmer to decide what they should add to the game. This helps to show how design decisions and creativity are an important part of software development.

3.3 Art

The purpose of the art lessons was to directly support the Scratch animation projects as well as to show that programming projects are creative not only in their design, but also in their implementation.

Drawing animal heads: Students begin by looking at the outlines of different animal heads and identifying what specific shapes identify those animals. They then look at examples of Mayan depictions of animals. Finally, they draw examples of their own animal's head for use in the name poem.

Drawing animal bodies: In order to expand the artwork for the animal information project, students look at the shapes that are used to draw different types of animal bodies.

Drawing landscapes: Next, students work on the backgrounds of their projects, choosing appropriate habitats in which to place their animals. They look at perspectives and vegetation. They can then substitute their own drawings for the "stock" backgrounds chosen in their Scratch projects.

Drawing emotions: Finally, students are given 20 facial expressions of a cartoon fish and asked to identify which emotion goes with each one. They analyzed how simple differences in the eyebrows, eyes, and mouth make major differences in the emotions. They are then given the opportunity to draw their own animal with the same facial characteristics–this is incorporated into the various scratch animations. This is especially relevant to the virtual pet project. where the animal's expression changes to indicate its mood.

3.4 Extras

In addition to the main lessons, we schedule a CS unplugged activity, tour, and/or guest speaker at least once a day. The purpose is to show a broader view of computer science, to educate about careers, and to introduce students to academic preparation programs.

CS Unplugged: Our curriculum incorporates many CS unplugged activities, including counting to 31 on one hand (binary), KidFax (pictures as numbers), Secret messages (writing with numbers), sorting weights, parallel sorting, Muddy Roads (shortest path), and the Routing and Deadlock game (networking).

Guest Speakers / Tours: During the 2010 camp, we had two guest speakers. One was a female graduate student in electrical engineering who develops underwater sensors and communication. The second was from the UCSB program Bridges to Pathways a program that gives students academic advice and invites students to participate in their academic counseling and college preparation program. The students also went on tours of , the Allosphere[3], an immersive interactive environment utilizing 3-d glasses that allows the user to interact with touch, sound, and a video game controller, the Santa Barbara Zoo, and the Marine Science Institute.

4. CAMP DESIGN

During Summer 2010, Animal Tlatoque was offered as a full-day, 2-week camp with free bussing. The full fee was $200. Most students qualified for free or reduced school lunches and had their tuition waived. All other students requesting a scholarship paid $100. This included 10 days with full lunches, breakfast bar, mid-morning snack, and a field trip to the zoo.

Thirty-six students started the camp, and 34 finished the camp. The remainder of the statistics in this paper cover the 32 students whose parents gave informed consent for their children's information to be used for research purposes. The students sometimes worked as a single group, and other times were split into two groups of about 16-18 students each. Each group was led by a graduate student with expertise in Mayan culture and experience with outreach in the

	Applied		Participated	
Ethnicity	Elementary	Middle	Elementary	Middle
Males				
African Am	0	0	0	0
Asian	0	0	0	0
Caucasian	2	1	2	0
Latino	5	4	4	3
Native Am	0	1	0	1
Females				
African Am	1	0	1	0
Asian	1	2	1	2
Caucasian	7	4	4	4
Latina	19	3	12	3
Native Am	2	0	2	0

Table 1: Demographics of Applicants and Participants. Some participants have multiple ethnicities.

Latina/o community. The graduate students were assisted by six undergraduates—one Chicana/o studies major and five computer science majors. All of the CS majors were not yet in upper-division courses; thus the camp provided an internship opportunity at a point in their academic program where it is difficult for them to compete for CS-related summer internships and research projects.

Students used pair programming for all computer-based projects and had individual supplies for paper-based tasks. We attempted, whenever possible, to pair students with similar academic backgrounds and ages. The least successful pairings were when we were unable to do so.

Conversations between the students and the undergraduate staff indicate that the students were very satisfied with the camp. Many students asked if they could attend next year. The next section presents our survey results.

5. RESULTS

In this section, we evaluate how well we achieved our two specific goals: (1) attracting underrepresented minorities to our camp (specifically, females and Latina/os), (2) increasing the chances that participants will pursue computer science as a career.

5.1 Recruiting

We recruited in two ways. For 7th graders and older, UCSB has direct access to school records. So, to recruit 7th graders (future 8th graders), we sent fliers to all females and Latina/os with GPAs of at least 3.0. For the elementary schools, we distributed fliers to all 5th and 6th graders at many elementary schools, specifically targeting those with high Latina/o populations and high percentages of students who were at or above grade level in math and science.

Table 1 shows the demographics of the participants. Some students are counted twice if they are of mixed heritage. Out of 46 applicants, only 3 are outside of our target population, even though a large majority of the applications were distributed to elementary schools with students of both genders and several ethnicities.

On the application, we had an open-ended question asking why the student wanted to attend our camp. Some students cited one or more of our themes as the reason. Figures 1 and 2 show the breakdown between three themes—computer science, animals, and Mayan culture.

As we had expected, interest in computer science was

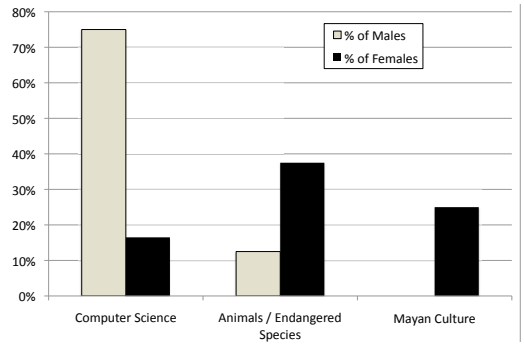

Figure 1: Reasons for choosing Animal Tlatoque camp, broken down by gender

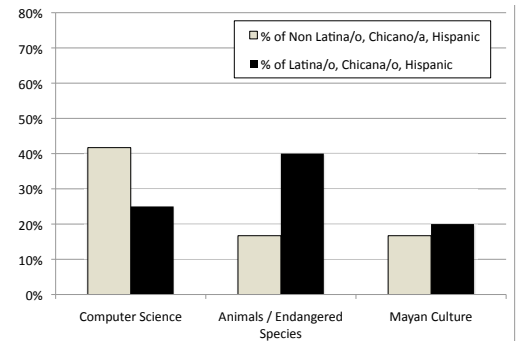

Figure 2: Reasons for choosing Animal Tlatoque camp, broken down by ethnicity

dominated by males, and interest in animals and endangered species was dominated by females. Females were also much more interested in Mayan culture than in computer science. Therefore, our non-computing themes were very successful in attracting females into our program. The data showed nearly the same level of interest in Mayan culture among the Latina/o and non-Latina/o students in our program—though our sample size is too small to draw any strong conclusions,

5.2 Interest in Activities

During the camp, we polled the students as to what activities they had enjoyed so far. We also used pre- and post-surveys to measure students self-perceived learning and interest in overall camp activities.

Prior to the camp, students were asked what specific camp activities interested them. Post camp they were asked to choose what would interest them now they know what each camp component entailed. Figure 3 shows the results of this survey. We can see that before the camp, many of the activities were fairly evenly identified, with creating computer games and learning about animals being the top activities. After the camp, the absolute level of interest increased significantly, and the top choices became much more even with the rest. Learning about animals remained the top choice. We were happy to find that the students were even more satisfied with the activities after having experienced them, and that the non-game computing tasks (as well as others) became more important to the students.

On days three, five and seven of camp participants were asked to select their two favorite and one least favorite activities from a given list. Scratch programming was a favorite

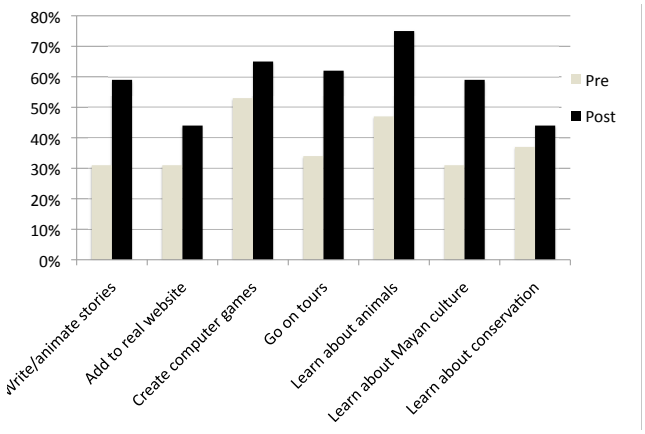

Figure 3: Interest in camp activities, before and after camp

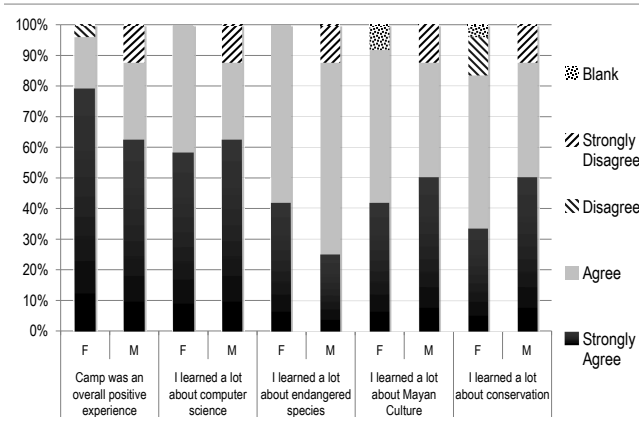

Figure 4: Student self-reported learning, broken down by gender

activity for the most participants (13), even beating out a water balloon slingshot activity (10). Their least favorite activities were learning the binary and Maya number systems (10) and a linear graphing activity (3) (because they were "too hard" and "too much like school"). Further examination found no correlation between their success in learning the Mayan and binary systems. Many students had no least favorite activity.

5.3 Student Learning

At the end of the camp, students were asked whether the camp was an overall positive experience, as well as how much they felt they learned about various subjects. Figure 4 shows the results. All but two students agreed or strongly agreed that the overall experience of the camp was a positive one. Thirty-one of the participants agreed or strongly agreed that they learned a lot about computer science. Overall, students felt they learned about all of the subjects. Students felt they learned they learned the least about conservation and endangered species, which were not as developed this first year.

5.4 Career Aspirations

We asked several questions on our surveys to find out students' views of whether specific groups could or should become computer scientists, as well as whether they themselves would be interested in becoming a computer scientist.

Question	Pre-Camp	Post-Camp
CS possible career	7	21
CS first choice	3	6
Not capable of being CS	3	0
CS inappropriate for girls	2	0
Boys better at CS	7	5
Girls better at CS	7	0

Table 2: CS attitudes surveys summary

In the pre-survey, females were less likely to think females could or should become computer scientists, as well as less likely to want to become one. Post-camp, most of these attitudes had disappeared. Table 2 summarizes the results of these questions, and we give more details on the responses below.

One item on the Pre and Post Animal Tlatoque Survey asked participants to select all of the careers that they had considered for themselves from a list of options. Pre camp, 7 (22%) of the 32 participants chose computer science as a possible career option from a list. Asked which was their first choice from the options they selected, 3 (9%) of the participants selected computer science. Post camp, 21 (65%) participants selected computer science as a career choice with 6 (18%) of these participants choosing it as a first choice. Of the 21 interested participants, 11 had originally given their reason for coming to camp as other than related to computers.

All six of the participants who chose computer science as their first choice of career option expressed an interest in signing up for the Pathways program. Ten of the 21 participants who chose CS as a possible career choice will be first-generation college graduates. All but one of these participants had not thought of CS as an option for them before attending this camp.

Another indicator of participant interest in computer science was a Likert item that asked them to rate the extent to which they agree with the statement: I am excited about taking computer science classes in high school. Not much pre-post change occurred on this variable. Pre camp 27 participants agreed or strongly agreed with the statement: I am looking forward to taking computer science classes in high school. Post camp, 3 participants changed their disagree to agree, and one of the participants who originally chose strongly agree changed their response to disagree.

Finally, three of the Likert items on the Pre and Post Animal Tlatoque Survey were designed to assess participant attitudes about self in relationship to computer science by indicating the extent to which they agreed with the following statements:

1. I think that I could become a good computer scientist if I chose that goal for myself.

2. Who do you think is better at computer science—boys, girls, or neither?

3. Computer science/learning about computers is an appropriate subject for both boys and girls to pursue.

Pre camp, 3 female participants didn't think that they would be able to be a computer scientist. By the end of camp 2 of these girls had decided that they could and 1 decided that she would become a computer scientist.

Pre camp, 3 boys and 4 girls believed that boys were better than girls at computer science. Post camp, one of these boys and one of these girls changed their beliefs to neither. Pre camp, 7 girls believed that girls were better than boys at computer science. Pre camp, 2 of these girls indicated that they didn't think computer science was an appropriate career choice for girls. Post camp, these beliefs changed.

These survey questions show that the Animal Tlatoque Summer Camp had a large impact on students' views of computer science. Many students who had never never considered a career in computing were now interested in computing, and several students who had gender-based stereotypes about their skills or the suitability of computer science found that they could, and wanted, to pursue such a career. In addition, we were successful at interesting students in the Pathways campus advising program. The major factor we did not change was interest in taking computer science courses in high school. This shows a tremendous success in both the recruitment strategies and the implementation of our program.

6. CONCLUSIONS AND FUTURE WORK

Our approach, to mix culturally-relevant themes and computing, was very successful in both attracting students in target populations and improving their opinions of computer science as a career. Our recruiting efforts resulted in an application pool that was 73% female and 67% Latina/o, with only 6.5% in neither group. We had 34 students complete the program. Pre- and post-surveys showed that the number of students citing computer science as their top choice for a career doubled and interest in computer science as a career more than tripled. This impact is significant considering how few of our students were initially interested in pursuing computer science. Our surveys show that students ended the camp more confident in their computing skills, more positive about computer science as a field, and much more likely to pursue a computer science career.

We have funding to continue the camp for at least two more summers ('11, '12). Our plans for next year include expanding the conservation and endangered species component.

A logical extension to this work would be a program for high school students focused on engaging applications such as social networking or cell phone applications. Such a program could bridge the gap between our success with middle school students, and the college years, inspiring a new generation of computer scientists.

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