Enhancing learning in Primary Education with an Interactive Aquarium

Tomás Pinto dos Santos
tomas.d.santos@ist.utl.pt

ABSTRACT
Arts have been a vital part of education for years, as they can enhance multiple skills, promote creativity and be integrated with other subjects. Nowadays, with such a high number of computers, tablets and internet accesses at schools, there should be more of an incentive to innovate education with the use of digital art tools. This project aims to showcase the benefits of implementing digital art in the classroom, by creating an interactive art installation that serves as an educational resource. The proposed solution is an online aquarium that runs on a website, to which students can submit their drawings of fish. These drawings can be given certain feeding and social behaviours. Once submitted, the drawings inhabit the aquarium and become animated, interacting with their environment and other submitted sketches according to those behaviours. The result is an artistic experience that students can actively participate in and learn from.

Author Keywords
Digital Art; Interactive Art; Image Segmentation; Artificial Intelligence; Primary Education

INTRODUCTION
Arts have been part of primary and secondary education for decades now, and despite being cut at times (in terms of budget and time allocation), in favour of more STEM-oriented curricula, research has shown that children exposed to arts programs do better academically, and develop better social, emotional and cognitive skills than those who aren't [5] [11]. It is therefore imperative to maintain and find new ways of integrating arts in our school programs.

Arts have, however, undergone fundamental changes ever since computer and digital art broke into the scene. Artists now use graphics tablets for drawing, digital brushes for painting, and artificial instruments in music production. They're no longer limited by traditional tools or materials, and their works are more accessible than ever thanks to the internet. Movies, video games, and television shows can be entirely animated with computer-generated imagery, and new technologies and software are created every day with digital art in mind.

Interactive art installations (art projects in which the spectators actively influence the outcome) are some of the most innovative pieces to come out of this evolution, as they broke away from the norm of being site-specific, and now utilise a multitude of platforms such as the web, mobile devices and even virtual reality to create highly immersive experiences. Famous examples include teamLab's Sketch Aquarium [4], which inspired this project and Telegarden [1], which pioneered web-based installations.

With this rising number of new tools, mediums, artists and ideas, it would be a waste not to cross them over to fields that have integrated art in the past, like education. Especially when considering issues like educational stagnation and the need for distance learning. But how has education adapted to technology?

In this digital era, classrooms, much like art, have seen significant benefits from technological advancements. Digital schoolbooks, computers, tablets, and smart boards are available at high numbers [6], helping teachers create classes that are engaging and easy to comprehend, while also developing tech-savvy students.

Several disruptive innovations for education models have also started to gather support, making use of:

- Massive Online Open Courses (MOOCs) - to provide free online courses, materials, discussions and more, to any student;
- Artificial Intelligence - to automate tasks and provide personalised tutoring without human supervision (Intelligent Tutoring Systems);
- Gamification - to motivate students to study using game elements such as points, badges, leader-boards and more.

Unfortunately, despite all of this, education has been slow to adopt many of these ideas, with common barriers being the costs involved, and the need for training of staff and teachers. Due to this, digital art hasn't made many contributions to the field, so its influence on student learning remains a question mark. With successful experiments like [7] (which helped students better their understanding of the concept of light) growing in number, there should be more push to integrate digital art and study its effect on student learning.

METHODS
To measure digital art's value as an educational tool, a web aquarium where participants can submit their drawings of fish, define their feeding and social behaviours, and observe them interacting with their environment was created. This aquarium can be accessed through a website, and its teaching goals are the following:

- The diversity of sea creatures: in size, shape, colour, habitat;

- What an underwater habitat looks like - thanks to the aquarium and its underwater effects;
- Social behaviours, such as schooling and isolating, and how they affect the environment;
- Different feeding behaviours - carnivore, omnivore, and herbivore;
- Food chains - plants can be eaten, and so can herbivores, so small food chains are created;
- Life cycles - from birth to death, each creature has a cycle and changes its appearance and behaviour according to the stage it's in.

The intended demographic consists of third grade students or below, who are still unfamiliar with concepts such as feeding behaviours, food chains and life cycles.

Ideally, by allowing the student participants to play with web technology, actively influence the environment with their own creations and see their colleagues' drawings, they will be more attentive than normal and pick up the visual cues on display meant to be taught. Creativity, emotional and social skills, and the ability to work with computers are also meant to be fostered with this experience.

The results are afterwards measured through responses to a questionnaire.

Website

The website serves as the main user interface. It's a one-page website where all interactions take place, from submitting pictures to observing the aquarium.

The following features can be selected on the website and attributed to the drawing:

- Pelagic or Demersal.
- Carnivore, Herbivore or Omnivore;
- Social or Non-social;

Drawings are turned into digital images with an image segmentation script which uses an ImageMagick library [8].

Unity WebGL Aquarium

The aquarium itself consists of a Unity [3] WebGL application. It runs a 3D scene that represents the bottom of the ocean, decorated with multiple assets and underwater effects.

For there to be interactions between the users' drawings, such as eating one another, aspects of the Unity scene have to be synchronised across the network. This is achieved with an implementation of the framework Photon Unity Network [2].

Animation

The life cycle transformations, biting motions, and camouflage effect are all done with frame-by-frame animations. The swimming cycle is done with vertex shader animation, applying a modified sine wave function, similarly to what is done in the game ABZÛ [9].

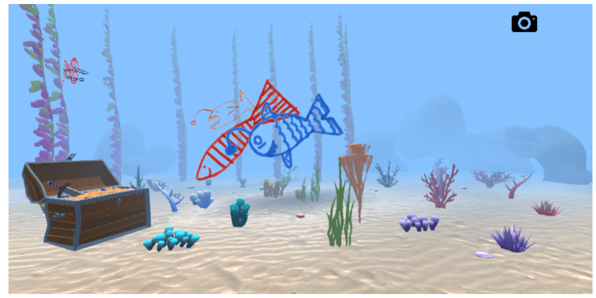

Figure 1. Fish schooling in the interactive aquarium.

Behaviours

Swimming

The drawn fish are able to swim, with random directions and speed, within the bounds of the aquarium. Pelagic fish are inherently faster, and can freely swim in the aquarium, whereas demersal fish are limited to the bottom area and slower, just like in nature. When deciding how to move, turning back from the bounds of the aquarium takes highest precedence, then chasing a target when hungry, and lastly schooling if the fish is social.

Feeding

Upon reaching maturity, the fish is ready to feed itself. Carnivore and omnivore fish are able to hunt other fish drawings, but have a chance of failing. This chance increases if those fish are in a school. Eaten fish disappear from the aquarium. Herbivores, on the other hand, feed themselves with algae. Hunger increases over time until the fish feed themselves, if they're not able to do it in time, the fish can die from hunger as well.

Schooling

Schooling behaviour is based on Craig Reynolds' Boids [10], but neighbour detection is implemented differently: two invisible lead fish are present in the aquarium (one for demersal, and another for pelagic fish) and the only possible neighbours.

RESULTS

Conditions

The tests were conducted at a local school, with a class of 23 students in 3rd grade. They took place over the course of three days, and students had to be divided into small groups (2-6 students) so that classes weren't disrupted.

To speed up the process, students were asked to prepare their drawings before the days of testing, not knowing what would happen to them. They were asked to draw a single fish in a white background and to colour the fish at their own discretion. The drawings were then scanned by their classroom teacher and sent out to be reviewed.

On the days of testing, a room would be prepared with multiple laptops with two pages loaded: one with the website, and another with a collection of all the submitted drawings, so students could pick theirs.

Groups of students would then be called and given instructions on how to use the website and run the application. Most students were able to do it on their own, as they had obtained experience with computers either at home or in their programming and robotics classes. There were, however, some students who still struggled with reading and writing. For those students, individual assistance was given.

Analysis

The questionnaire measured the following aspects:

- Usability of the website - 91.30% of students found it easy to use;
- Students' emotional response to their drawings turned digital - 21 loved it, 1 felt indifferent, and another hated it;
- Learning of concepts - approximately 86% of the theoretical answers were correct;
- Aesthetics of the aquarium - All but one of the students found it visually appealing.

Despite how positive the results were, this small of a sample size makes the data unreliable, so general statements cannot be made regarding the effectiveness of interactive digital art when used for teaching. Is it as effective as watching a video or reading a manual? Did the students retain what they learnt weeks or months after? For more conclusive analysis on this topic, more tests would have to be made in the future, at different schools, along with periodic re-tests.

There were, however, clear takeaways from the experiment, which successfully highlighted the benefits of implementing digital art in class:

- Students were able to express themselves creatively;
- Students became more tech-savvy while using the website;
- Students enjoyed the social aspect of the activity, something that is easily implemented in digital art projects;
- Students were highly immersed during the activity, meaning it's suitable for learning;
- Students with learning difficulties were still able to enjoy and learn from the experience;
- Students expressed interest in revisiting the web aquarium from home;
- Students expressed strong emotional responses to what happened on screen.

CONCLUSION

This work has discussed how digital art is currently unappreciated and underused in the field of education, and how its integration can bring innovation to classrooms and multiple benefits to students.

In order to showcase this, an interactive digital art solution was created with the intent of teaching primary school students about sea life, and a questionnaire was handed out to them afterwards to measure their experience.

Students were very engaged throughout the entire experience, and the questionnaire's results were very promising for a first sample.

The most notable achievements of this work were:

- Successfully creating an engaging interactive art installation, which can be used as an educational resource, or for artistic purposes;
- Combining knowledge of web design, game design, artificial intelligence and animation into a single project;
- Successfully teaching the majority of students who participated in the experience;
- Showcasing some of the benefits of digital art implementation in classrooms.

In terms of future work, most of the behaviours have room for improvement, and a different network implementation could be done. The notions of libido and fear, present in [12], for example, are not present in this project. Their addition, along with corresponding mating behaviours and self-defence mechanisms, would significantly improve realism and allow students to learn more about reproduction.

The project could also be expanded in order to include other aquatic animals besides fish, such as turtles or jellyfish, or even a different habitat altogether.

As mentioned before, more testing should be done in the future to ensure proper statistical analysis and the ability to generalise the project's findings.

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