The Aqua-Labyrinth

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Abstract

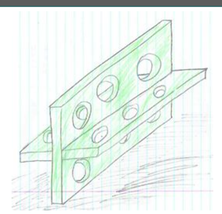
In the field of laboratory animals, there have been considerable improvements in environmental enrichment procedures for mammalian species but little is available for aquatic species, in particular for fish. Recent publications have shown benefits in providing laboratory zebrafish (*Danio rerio*) certain types of enrichments, such as substrate and plants. In the presentation, we will propose a novel **tank enrichment for zebrafish** that will help add complexity to the aquatic life in laboratory setting. The main goal of our product is to help to mimic a natural aquatic environment to provide the fish with a place to explore, hide, and a safe environment to breed and to **reduce stress, anxiety, and unnecessary euthanasia due to fighting wounds. The design is considering some important specifications** that allow for ease of manufacturing, assembly and low cost of the product.

While the project recently won the 3rd place at the 2020 Janet Wood Innovation Award (JWIA) competition, a manufacturer is still needed tfor this novel enrichment product to reach commercial accessibility.

Product Design

Preliminary Sketches

The design consists of two plates that are in different configurations, and they are meant to have a good support against the wall of the tank. Each plate has many holes to help the fish to move freely throughout the tank. The whole purpose of this design is to enrich the environment of Zebrafish to relieve their stress and pain by **offering a coral-like environment.**



Quadrilateral hole-shapes was selected. This shape takes the maximum thickness of the fish with more space on the sides as well as taking consideration of its length. To prevent accumulation of dirt and cause erosion to the plates and hurts the fish when it gets closer to the edges, holes with fillets in the inner edges was designed. In addition, the panels sliding into each other permit modular options that can be of interest depending on the size of the tank. The latter allow to use either, a single panel or the two panels into a **larger tank creating an interesting object for the fish to explore (similar to a wreckage in the ocean)**.

Design for Manufacturing and Assembly (DFMA)

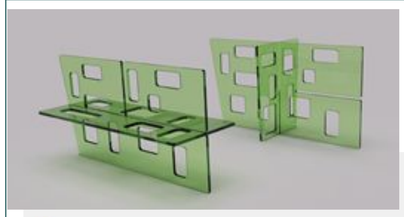
Product was analyzed using this technique to minimize production cost through design and process improvements.*

Main principles of DFMA implemented in our design :

Simple Design	• Geometry of parts is simplified and unnecessary features are avoided
Ease of manufacture & Ease of Assembly	• Minimise the number of components therefore, reducing assembly and ordering costs
Few Parts	• Reduction in the total number of parts. • Reducing work in process and simplifying automation
Eliminate or reduce required adjustments	• Reducing tight tolerance or unnecessary part finishes
No environmental impact	• Using safe material that has no environmental impact and it can be recycled and reused.

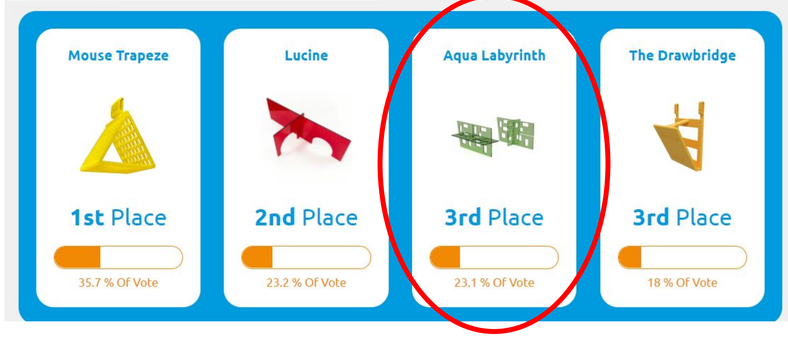
**The full report of this analysis can be obtained if requested.*

The competition



In February 2020, the completed final design was submitted to the 2020 Janet Wood Innovation Award and won 3rd place. Prototypes were sent for testing.

the Janet Wood Innovation Award



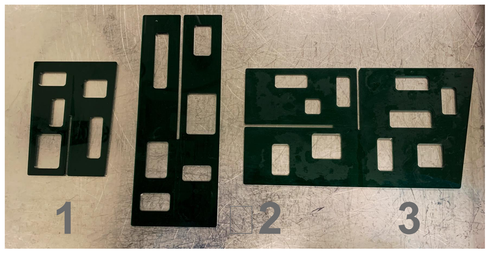
Experimental Design

To provide evidence of the fish' interaction with the enrichment, a simple test was designed. The fish involved in the experience were housed in Aquaneering 2.8 liter tanks in a balanced salt and bicarbonate water at 27° Celcius with Light:Dark cycle 14:10h. Each tank held 3 fish. **The tanks contained 3 Aqua-Labyrinth variations and were compared to an enrichment option that is recommended for zebrafish: the Mouse Igloo.**

The 3 different modules of the Aqua-Labyrinth were:

- **Module 1**: horizontal panel (2) + vertical panel (3)
- **Module 2:** vertical panel (3) + vertical panel (1)
- **Module 3**: horizontal panel (2) only.

The fish were acclimated to their novel object for 5 days prior to the recording of the data. The fish were filmed for 2,5 minutes periods and the number of travels through the enrichment were counted on 30 seconds periods. *Average counts for each Enrichments are found in the Table 1.*



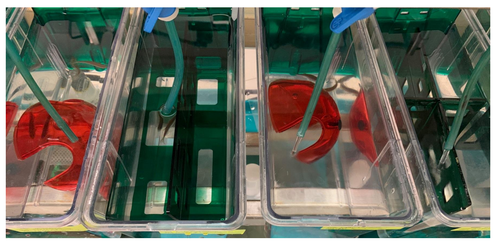


Table 1: Results of the Counts of each 30 Second Window

Testing Enrichment	Average Counts
Vertical Large + Vertical Small Panels	16.5
Vertical Large + Horizontal Panels	10
Horizontal Panel	8.5
Mouse Igloo	11

Discussion

Enrichment options in zebrafish husbandry are very few. The Aqua-Labyrinth was designed to **offer a modular enrichment that is easy to clean and assemble, and adds complexity to the environment of the zebrafish**. When comparing interaction numbers with other recommended enrichment for aquatics such as the Mouse Igloo, the Aqua-labyrinth in all its different modular options, offers as much interaction opportunities for the fish. However, it is interesting to note the difference in terms of space and shape they take. Igloos do not allow multiple ways to use it (either up or upside down). Aqua-Labyrinth on its side can be very versatile and can fit in different angles and size. As shown in the methodology section, with only 3 different types of panel, the Laboratory facility **can easily create at least 5 different configurations and with those configurations, the different size of tanks also makes a different way of looking at the enrichment and how the fish will behave with it. In addition, the concept can easily be manufactured for any type of Zebrafish Laboratory Tank**. The Aqua-Labyrinth, in comparison to the Igloo, can prevent circling behavior as the configurations are multiple so the fish can get new patterns to explore when the enrichment gets changed. Both the Igloo and the Aqua-Labyrinth allow proper monitoring of the health of the fish with the semi-transparent finish, but the cleaning of the Igloo is more labour intensive due to the black rubber material and the dome-shaped. Indeed, the rubber may increase dirt and algea accumulation and the dome shape can be tricky to clean on the concave side. **Aqua-Labyrinth design is flat and has only acrylic which makes it easy to clean and handle.**

To experiment the potential effect on the fighting, longer studies should be performed. However, it was seen in Zebrafish tanks used in personal aquariums that, when using the Aqua-Labyrinth, no more figthing was recorded *(The Aqua-Labyrinth was used in the aquarium of Dorothée Therrien, the author of this article)*. Therefore, it can be concluded that fighting reduction can be possible thanks to this enrichment, but to confirm this statement, more investigation should be done.

Finally, the experiment was done with tanks of 3 fish. With more fish in a single tank, proper selection of the configuration to use will be important as if the enrichment takes up all the space, it may lead to compartmentalisation of the space and negatively impact the tank environment.

Videos:

Wreck Video:
https://youtu.be/Ja5U1_VL8hA

Large Vertical Panel + Small Vertical Panel vs. Mouse Igloo Video:
https://youtu.be/tiUkr-kGetk

Large Vertical Panel + Horizontal Panel Video:
https://youtu.be/uPJ-ZHcATM4

Acknowledgements

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Thank you for the ARD Team of the RI-MUHC and the helping and participating in the testing of the Zebrafish Aqua-Labyrinth.