TED ANKARA COLLEGE FOUNDATION HIGH SCHOOL

BIOLOGY EXTENDED ESSAY
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Investigating the effect of distance between obstacles on *Poecilia reticulate* memory.

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ABSTRACT

The aim of the extended essay is to investigate the memory of fishes, especially a special kind, *Poecilia reticulate.* So it is an extended essay about fish behavior and ability to memorize. Additionally, this experiment investigates the relation between the obstacles and the time for *Poecilia reticulate* to reach the source of food.

My research question for this extended essay was: 'Is *Poecilia reticulate* memory powerful enough to reuse acquired knowledge when the distance between obstacles increase through the way to source of food?'

My hypothesis for the essay is: '*Poecilia reticulate* will be able to swim faster as they adapt the environment, although the distances between obstacles increase, so they have ability to learn and memorize what they learnt for finding their food.'

In order to answer the research question I have designed my own method. In this experiment, I have used two obstacles with wholes, one of them is in the top, and one of them is in the bottom of the plates. The path was designed and the distance between the obstacles increased in every 5 days. There are also varieties in every species. So, I have used 5 *Poecilia reticulate* to obtain more precise data. In addition, a video camera is placed to obtain most accurate and precise data. So, I was able to watch step by step, which *Poecilia reticulate* swim across the obstacles. At the end of the experiment, these data have compared to each other. The experiment was successful to end up a conclusion.

Results show that as the distance between obstacles increase, the time for *Poecilia reticulate* to reach their food also increases. Moreover, according to ANOVA test there was a significant mean difference between the increasing distances between obstacles.

In this extended essay, I have used fishes, and it was important to keep up their life standards. It was also important to design an environment, which they can live in good conditions. I have done many researches about this in the beginning of the experiment. And in the end, all *Poecilia reticulate* was able to survive and still they are healthy.

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INTRODUCTION

When I pet fish in an aquarium, I laughed the way they seem while swimming like absent-minded. They look like they are unaware of what they are doing, or even forgetting. I started thinking, every time when a person forgets something that has been told many times, others say he or she has a fish like memory. Even Disney's children film, 'Finding Nemo' there is a fish, Dora, who has difficulties about remembering things. While I was watching them to swim, I came up with some questions on my mind. Do fishes really forget? Can they even learn? Is it a myth, fishes having a three second memory or they can actually use their brains to keep something in mind?

To start with, it should be understood what is memory and learning. Learning means the acquisition of knowledge or skills through experience, practice or study, or being taught. The power to remember things is called memory. As a result, memory is about remembering what is learnt. With practice or repetition, every skill can be memorized by brain.

Researchers showed that there are many ways of learning for different species. A vertebrate that has a brain must learn and memorize the action, and keep doing it unless there are external misfortunes. It seems nonsense to not memorizing as brains are functioning. However, a person may also forget information that is not learnt well. Forgetting is reverse for learning, remembering or memorizing. So do we really forget our memories or just need to refresh them? If we can adapt to a doctored memory, is it because of our developed brains, or just a standing function for brain? Can a primitive living thing, like fish, also memorize something and then reuse it?

Our brains are the authoritative centers of our bodies. What we think, what we feel or what we have done depends on our brains. A brain is important because it allows us to behave. Our behaviors are based on our brains. Is it true for only humans? Human brain authorizes being aware of environment, reasoning and remembering. Most importantly, brain functions for combining incoming data.

A human brain has many parts that are functioning in different ways. There are lobes control reasoning, somatic sensing. Hearing, vision, movement and many other functions. For example, frontal lobes enable to decide while parietal lobes are for sensory reception or temporal lobes are responsible for hearing. Also optical lobes are the most posterior lobes responsible for visual information coming from eyes. Another part of human brain, cerebellum, receives sensory input from muscles, eyes and ears. Motor outputs about human's body positions and movements received from cerebellum, too. It maintains all voluntary movements. There are medulla oblongata controlling heartbeat, breathing, blood pressure, swallowing and some involuntary reflexes. Hypothalamus regulates hunger, thirst, body temperature or sleep whereas, thalamus combine information and send them appropriate parts of body. Because of that, thalamus is called 'gatekeeper' of human brain. The thalamus participates in higher mental functions like memory and emotions. Human brain is complex and functioning all day long.

How about fishes? Do they have complex brains like humans'? Generally, fishes have smaller brains in ratio with their bodies. For fishes, brain is control center both for automatic and higher behaviors. A fish brain consists of three major parts; forebrain, midbrain and hindbrain. Forebrain receives and relays impulses from olfactory organs. In forebrain, there is cerebrum like structure called telencephalon. Forebrain is mainly related to sense smell for fishes where midbrain does the same for eyes. Midbrain has two optic lobes responsible for sight. Diencephalon connects these two parts, forebrain and midbrain in fishes, related to maintaining homeostasis. Other main part of fish brain, hindbrain, is responsible for movement, taste and pressure sense, which is hearing for fishes. Hindbrain has cerebellum, the biggest part in fish brain, responsible for balance. However, both human brain and fish brain have brainstem, cerebrum, cerebellum, pituitary gland and olfactory bulb.

When compared to human brain, fishes' have less complexity. When more developed human brain can face difficulties while remembering something in memory, how can a primitive brain have strong memory? Actually what is learning and memorizing works on human brain?

Memory is the ability to keep something learnt in mind, from a word told or our own experiences. Learning takes place when we reuse past memories. It is essential in our daily lives. For a moment to be called memory, it should be sensed by one or more senses. For example, if we found a path to go home, we reuse that memory every time we want to get back to home. People cannot do anything without relying their memories. Once a process is done, it is stored in short-term memory, if we continue doing that; it goes into our long-term memory. Short-term memories transferred to long-term memory through repetition. When we temporarily use an information, prefrontal lobe in our brains become active. On the other hand, long-term memory is a mixture of sematic memory and episodic memory.

Sematic memory is mostly about common knowledge, such as remembering numbers or words, or how to use a knife and fork. Episodic memory is more about a person's own collections of moments. With episodic memory, people are able to remember how they felt about events, people or places. Skill memory, or procedural memory, is being able to perform a learnt activity or knowing how to do things. Some examples for skill memory can be, taking a step, swimming, climbing stairs.

From these questions in mind, I wondered whether those primitive creatures, fishes, could learn a simple path and keep that in mind despite there are some changes about the path. My experiment is about searching are fishes really learn or swim irrelevantly; if they can, how they learn their way to food? After this experiment, I am planning to find out how developed brains and frontal lobes have. Memorizing is about frontal lobe in brains. This experiment will also teach me about similarities and differences between human brain and fish brain. I will also learn more about fish brains.

All above, my significant aim to do this experiment is answering the question 'Is *Poecilia reticulate* memory powerful enough to reuse acquired

knowledge when the distance between obstacles increase through the way to source of food?'

HYPOTHESIS

Scientists believe that fishes can remember prey types or they can learn to avoid predators after being attacked once, by their memories. It shows that fishes can learn from their past experiences and change behaviors according them. There are many experiments about fishes learning music or playing or feeding. Many researchers believe fishes are smarter than scientists think.[1]

Whenever its time to feed my fishes, they start to swim near the surface of water. They know that I am going to feed them and it is time to eat something. It is fairly surprising that they know what I am going to do. When it comes cleaning the aquarium, again, they start to swim in the surface so that it becomes easier to take them on another container. Also they are able to swim same paths over and over again.

From these previews, it can be hypothesized that as '*Poecilia reticulate* will be able to swim faster as they adapt the environment, although the distances between obstacles increase, so they have ability to learn and memorize what they learnt for finding their food.' It is expected that the *Poecilia reticulate* to memorize where they have fed before.

METHOD DEVELOPMENT AND PLANNING

While designing an appropriate method in order to justify the hypothesis and answer the research question, there are some points to consider. One of them was which type of fish I will use in this experiment. First of all, I have done a research on different types of fishes. I have found the best type of fish to feed on an aquarium, *Poecilia reticulate.* They are easier to care and easy to feed. Because of these, it is believed that *Poecilia reticulate* is best for this experiment.

A further problem is that *Poecilia reticulate* are tropical fishes. Their origin is from tropical climate. In this point, I needed to research for aquarium conditions. To make them live longer and harmless, the medium they are kept is curial. As tropics benefit from sunlight at least 12 hours a day, the aquarium should be lighted at least 10 hours a day[3]. So, for this reason, it must be kept somewhere where it can see sunlight and in nights there should be a light source. The optimum temperature for them to stay alive is between 17.8 and 27.5°C. Moreover the pH for the water must be kept between 5.5 and 8.0[2]. These are also a curial point for fishes not to harm. As this is an experiment done on the animals, the life conditions must be double checked instead of not giving harm to animals and protect their lives in ethical ways.

Now it came to how they will be fed? As they are herbivores, their diet needs to contain herbal products. I have asked a local pet shop for fish-feed, and they are easy to obtain. When all these variables controlled, it comes to designing the path, there are many points to consider. Because, the path should be challenging when it allows the fishes reach the other side. In this point I needed to design a mechanism that is complex and safe for fishes. This problem could be solved with imagination. A hole on each two plates of glass will cut from different places. The holes must be big enough for *Poecilia reticulate* to swim through. And they will be placed vertically inside the aquarium. By this way the aquarium split up three places. One side of the aquarium will be used to cast and the other side is the place for fished to stay. The distance between the plates will be changed in a period of time so that the ability of memorizing and the relation between distance and memorizing will be estimated. First the distance will be 25cm and in every trial it will be 5cm closer. Without a well-designed path, their ability to memory won't be calculated precisely, so the experiment. For further information about the mechanism, see Method.

In the end of the experiment, I expect the *Poecilia reticulate* to remember the path I have designed, although the distance between the plates changed. It is expected that as the distance gets smaller, the time for fishes to complete the path will be quicker.

METHOD

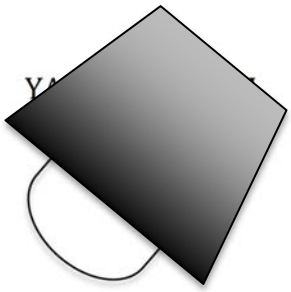
Materials and Apparatus

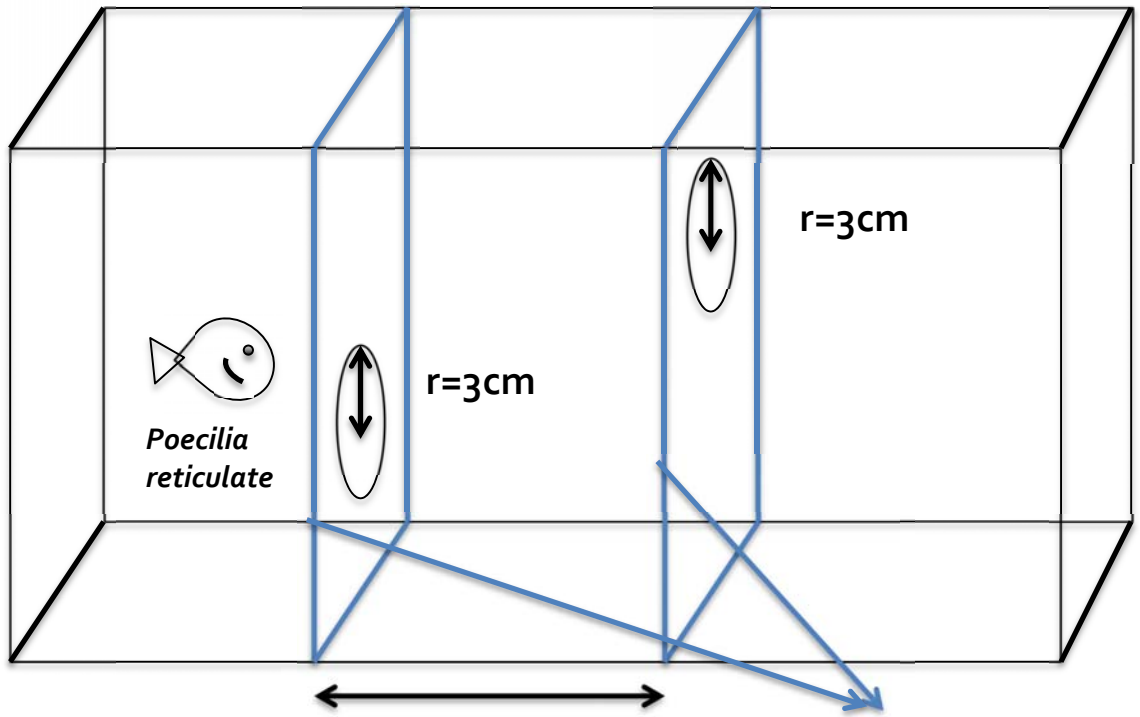
- At least 100 x 40 x 50 cm 200 liter aquarium
- 5 *Poecilia reticulate*- they must be in the same gender and similar physical characteristics to obtain accurate and precise data.
- Fish feed-the product need to be herbal.
- Two plates made of glass- two holes should be cut and the diameters of the holes need to be at least 3cm.
- Ruler- for estimating distance between plates.
- A light source
- Water- pH between 5.5 and 8.0.
- Sea salt- for cleaner and better aquarium conditions
- Timer- to calculate the time for fishes to reach the other side and find their food.
- Aquarium motor- for clearance of the aquarium.
- Video camera- better understanding on fishes' movements.

To the aquarium 200dm^3, the water, which has a pH between 5.5 and 8.0, is poured. For better conditions, sea salt is also added. To make sure the aquarium is clean, start the motor and leave the aquarium for at least one day. Make sure that the light source is placed where the fishes can benefit and the temperature of water is stabilized at between 17.8 and 27.5°C. Two holes should be cut in different places, which have a diameter 3cm. One hole should be on the top, where the other one is in the bottom of the aquarium. For better understanding, see the diagrams below. Two plates should be placed in particular distance. In this experiment the distances between plates are measured as 25cm, 20cm, 15cm, 10cm, 5cm. For measuring the distances, the ruler will be used. When these conditions are stabilized, the fishes will be placed on one side of the aquarium.

Using a method, which I have designed myself, the time for fishes to swim across the holes will be estimated. To estimate the time, I used a video camera and timer. Because it is a limitation to watch them all the time, a video camera will be placed in front of the aquarium. By this way it was easier to distinguish between the fishes. For different distances, 25, 20, 15, 10, 5cm, same method will be done 5 days to in order to understand fishes' habits. And in order to minimize any error, 5 *Poecilia reticulate* will be used in this experiment. After the experiment end, the video will be watched and the time for them to swim through is measured with a timer.

Diagram;





The dependent, independent and controlled variables are given in the following table.

Independent Variables	Dependent Variables	Controlled Variables
• The distance between plates.	• Time for *Poecilia reticulate* to swim through holes across the aquarium.	• Temperature of water • pH of water • Fish feeds • Light source • The power of cleaning motor • Number of *Poecilia reticulate*

Table 1: represents the variables in the experiment.

RESULTS

DISTANCE MEASURED 5CM BETWEEN PLATES- EXPERIMENT 1

	DAYS	TIME (sec) (±0.05 s)
Poecilia reticulate 1	1	753
	2	492
	3	525
	4	531
	5	472
Poecilia reticulate 2	1	617
	2	487
	3	533
	4	523
	5	520
Poecilia reticulate 3	1	1040
	2	753
	3	576
	4	544
	5	567
Poecilia reticulate 4	1	774
	2	785
	3	739
	4	734
	5	629
Poecilia reticulate 5	1	662
	2	634
	3	504
	4	520
	5	432

Table 2: represents time for *Poecilia reticulate* to swim across to holes, where there are 5cm difference between them, and reach their source of food. The results collected for 5 days to understand if they can remember the path for following days. Uncertainties of the experiment are calculated as ±0.05s.

DISTANCE MEASURED BETWEEN PLATES10CM- EXPERIMENT 2

	DAYS	TIME (sec) (±0.05 s)
Poecilia reticulate 1	1	942
	2	837
	3	842
	4	797
	5	814
Poecilia reticulate 2	1	1022
	2	769
	3	729
	4	735
	5	876
Poecilia reticulate 3	1	1142
	2	1097
	3	1069
	4	1082
	5	921
Poecilia reticulate 4	1	981
	2	907
	3	896
	4	782
	5	805
Poecilia reticulate 5	1	980
	2	897
	3	903
	4	909
	5	792

Table 3: represents the time for *Poecilia reticulate* to swim across to holes, where there are 10cm between the plates, and reach their source of food. The results collected for 5 days to understand if they can remember the path for following days. Uncertainties of the experiment are calculated as ±0.05s.

DISTANCE MEASURED BETWEEN PLATES15CM- EXPERIMENT 3

	DAYS	TIME (sec) (±0.05 s)
Poecilia reticulate 1	1	1236
	2	1182
	3	1189
	4	1193
	5	1150
Poecilia reticulate 2	1	1431
	2	1242
	3	1272
	4	1394
	5	1182
Poecilia reticulate 3	1	1626
	2	1531
	3	1409
	4	1492
	5	1452
Poecilia reticulate 4	1	1390
	2	1314
	3	1342
	4	1322
	5	1272
Poecilia reticulate 5	1	1389
	2	1257
	3	1203
	4	1209
	5	1174

Table 4: represents the time for *Poecilia reticulate* to swim across to holes, where there are 15cm between the plates, and reach their source of food. The results collected for 5 days to understand if they can remember the path for following days. Uncertainties of the experiment are calculated as ±0.05s.

DISTANCE MEASURED BETWEEN PLATES 20CM- EXPERIMENT 4

	DAYS	TIME (sec) (±0.05 s)
Poecilia reticulate 1	1	1482
	2	1394
	3	1427
	4	1341
	5	1299
Poecilia reticulate 2	1	2188
	2	1331
	3	1647
	4	1613
	5	1525
Poecilia reticulate 3	1	2065
	2	1957
	3	1942
	4	1981
	5	1928
Poecilia reticulate 4	1	1634
	2	1411
	3	1517
	4	1536
	5	1284
Poecilia reticulate 5	1	1800
	2	1752
	3	1672
	4	1797
	5	1752

Table 5: represents the time for *Poecilia reticulate* to swim across to holes, where there are 20cm between the plates, and reach their source of food. The results collected for 5 days to understand if they can remember the path for following days. Uncertainties of the experiment are calculated as ±0.05s.

DISTANCE MEASURED BETWEEN PLATES 25CM- EXPERIMENT 5

	DAYS	TIME (sec) (±0.05 s)
Poecilia reticulate 1	1	1821
	2	1777
	3	1632
	4	1704
	5	1628
Poecilia reticulate 2	1	1943
	2	1870
	3	1757
	4	1842
	5	1632
Poecilia reticulate 3	1	2479
	2	2264
	3	2242
	4	2304
	5	2232
Poecilia reticulate 4	1	2229
	2	1942
	3	2015
	4	2066
	5	2218
Poecilia reticulate 5	1	2344
	2	2286
	3	2003
	4	2176
	5	1956

Table 6: represents the time for *Poecilia reticulate* to swim across to holes, where there are 25cm between the plates, and reach their source of food. The results collected for 5 days to understand if they can remember the path for following days. Uncertainties of the experiment are calculated as ±0.05s.

DATA ANALYSIS

For 5cm and 1st day, the average time is calculated as shown below;

$$753 + 617 + 1040 + 774 + 662 = 3846$$

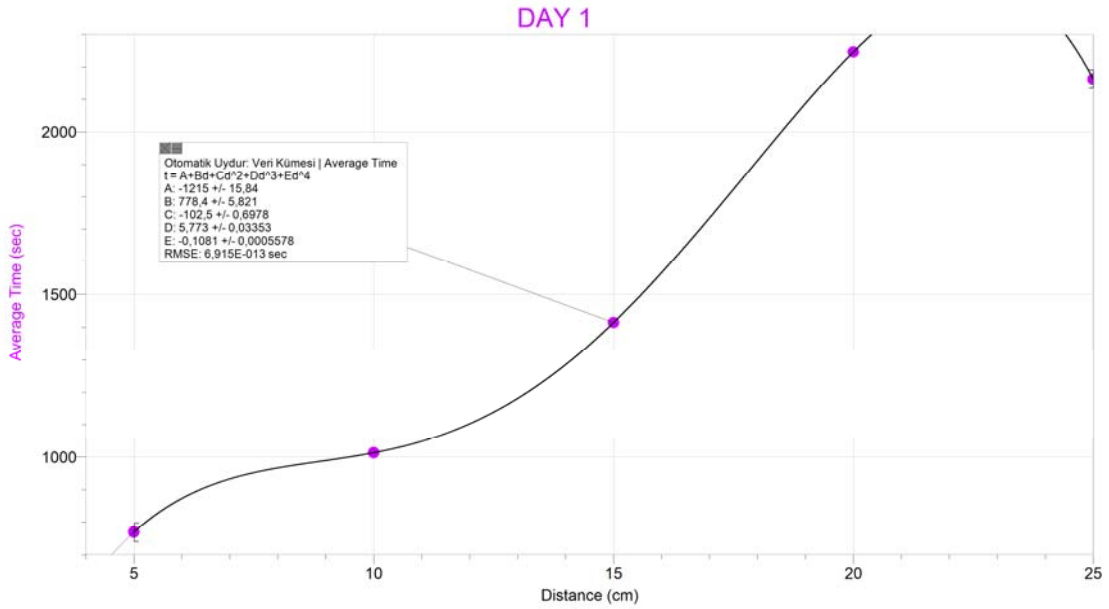
$$3846 \div 5 = 769.2$$

And the other measurements are done with respect to these equations. Each day, the mean of results for each *Poecilia reticulate* is calculated and shown in the following table.

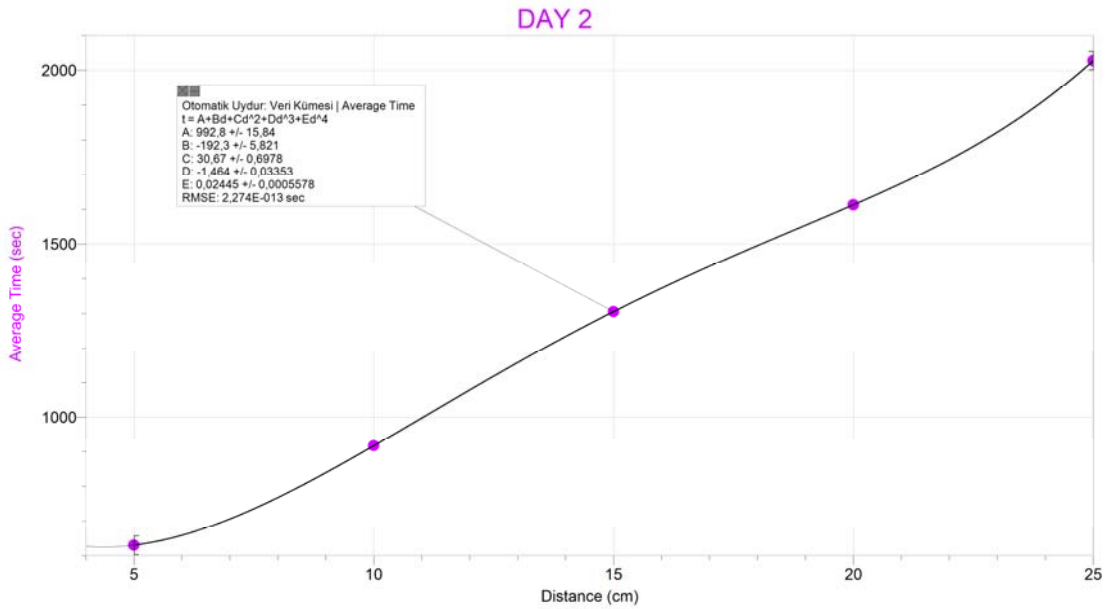
DISTANCES BETWEEN OBSTACLES (cm)	DAYS	AVARAGE TIME (sec) (±0.05 s)
5cm	1	769.2
	2	630.2
	3	575.4
	4	570.4
	5	524
10cm	1	1013.4
	2	917
	3	887.8
	4	861
	5	841.6
15cm	1	1414.4
	2	1305.2
	3	1283
	4	1322
	5	1246
20cm	1	2246.8
	2	1613.6
	3	1641
	4	1653.6
	5	1550.4
25cm	1	2163
	2	2027.8
	3	1929.8
	4	2018.4
	5	1933.2

Table 7: presents the average time for *Poecilia reticulate* to swim through the obstacles in particular distances. The uncertainty is measured as ±0.05s.

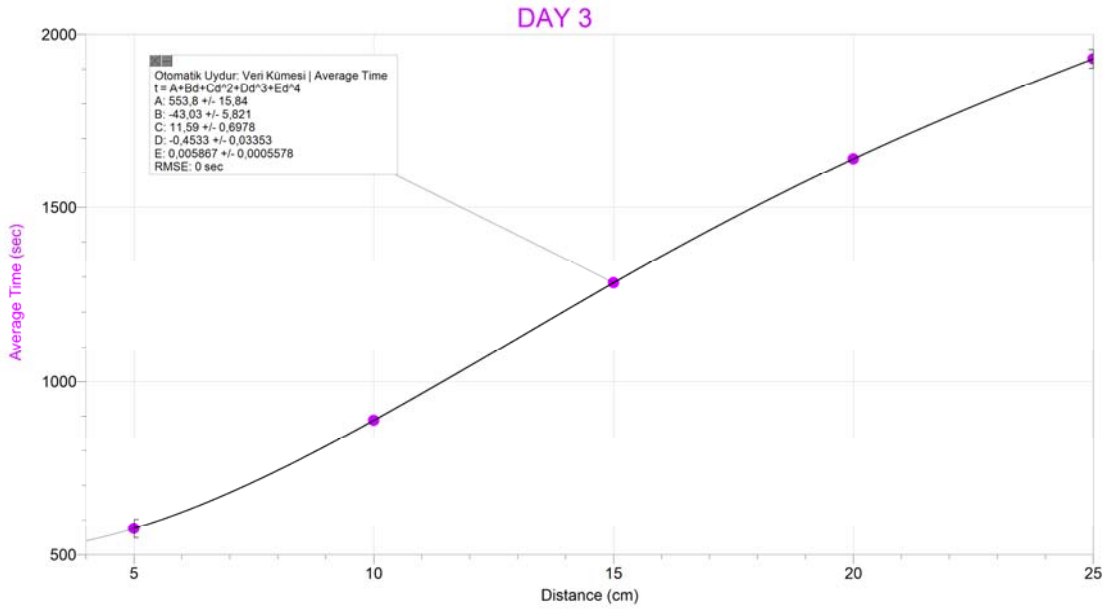
Graphs of these tables are shown as below;



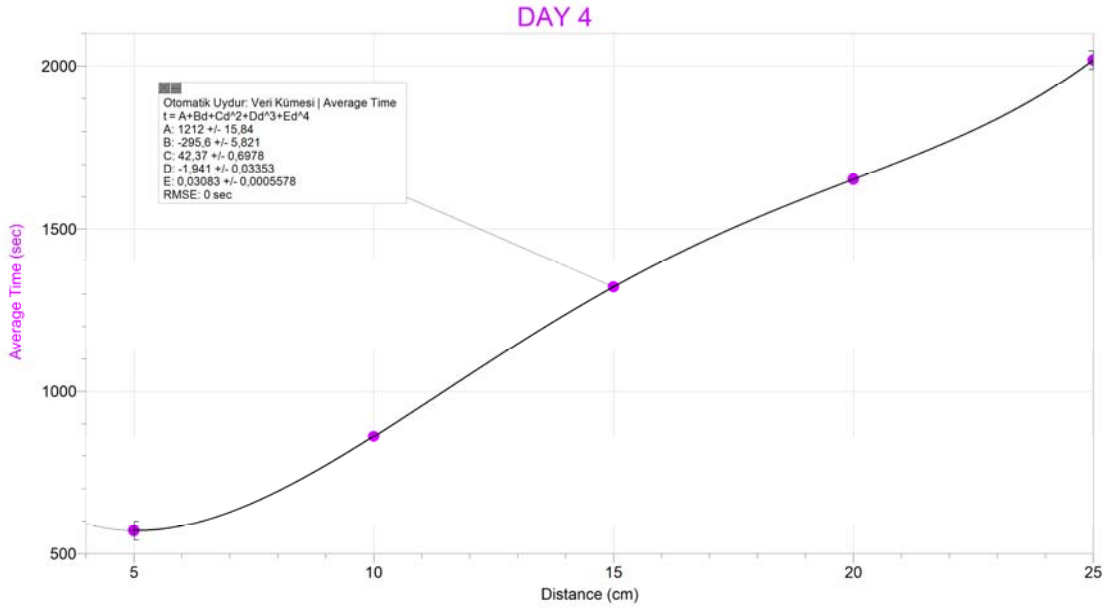
Graph 1. Presents the average time to swim across the obstacles versus distances between the obstacles in days 1. The uncertainties did not calculated because they are too small, even they do not change the graph.



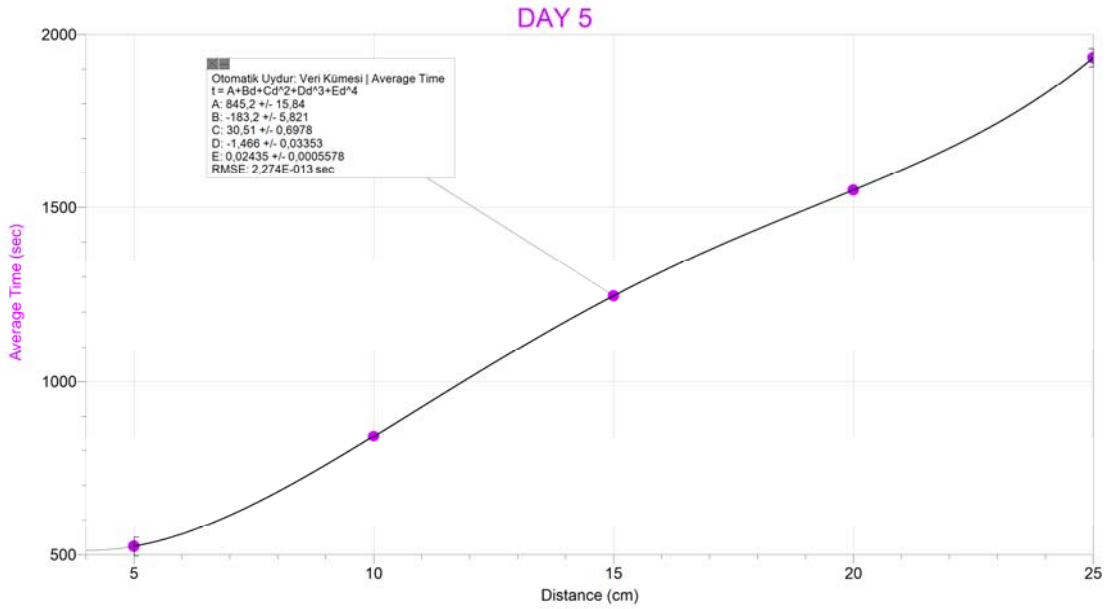
Graph 2. Presents the average time to swim across the obstacles versus distances between the obstacles in days 2. The uncertainties did not calculated because they are too small, even they do not change the graph.



Graph 3. Presents the average time to swim across the obstacles versus distances between the obstacles in days 3. The uncertainties did not calculated because they are too small, even they do not change the graph.



Graph 4. Presents the average time to swim across the obstacles versus distances between the obstacles in days 4. The uncertainties did not calculated because they are too small, even they do not change the graph.



Graph 5. Presents the average time to swim across the obstacles versus distances between the obstacles in days 5. The uncertainties did not calculated because they are too small, even they do not change the graph.

From the graphs, it can be seen that as the distance between obstacles increases, the time for *Poecilia reticulate* to swim across increases. The day does not matter. However, it can also be seen that as days passed, the time for *Poecilia reticulate* to reach the other side of the aquarium decreases. In 5th days for all distances, *Poecilia reticulate* was able to swim faster when compared to other days of the experiment.

Additionally, mean, variance and standard deviation for the experiment is calculated as shown below.

	COUNT	MEAN	VARIANCE	STANDARD DEVIATION
1st DAYS	5	1521.36	354632.16	595.51
2nd DAYS	5	1298.76	305842.18	553.03
3rd DAYS	5	1263.40	300358.80	548.05
4th DAYS	5	1285.08	273110.76	522.60
5th DAYS	5	1219.04	249220.61	499.22

Table 8. represents the mean, variance and standard deviation for different days.

	COUNT	MEAN	VARIANCE	STANDART DEVIATION
5 CM	5	613.84	8960.52	94.66
10 CM	5	904.16	4536.02	67.35
15 CM	5	1314.12	3951.38	62.86
20 CM	5	1741.08	81510.25	285.50
25CM	5	2014.44	9006.01	94.90

Table 9. represents the mean, variance and standard deviation for increasing distances.

	5 CM	10 CM	15 CM	20 CM	25 CM	TOTAL
N	5	5	5	5	5	25
Σx	3069.2	4520.8	6570.6	8705.4	10072.2	32938.2
MEAN	613.84	904.16	1314.12	1741.08	2014.44	1317.528
Σx^2	1919838	4105668.96	8650363.4	15482829.32	20325870.68	50484570.36
VARIANCE	8960.068	4535.608	3951.632	81507.872	9007.028	295315.3996
STD. DEVIATION	94.6576	67.3469	62.862	285.4958	94.9054	543.4293
STD. ERROR	42.3322	30.1185	28.1127	127.6776	42.443	108.6859

Table 10. represents organized descriptive statics of each distance. TI 84-Plus is used in each calculations.

Source of Variation	SS	df	MS	F	P
Between groups	6655720.7584	4	1663930.1896	77.06	<.0001
Error	431848.832	20	21592.4416		

Table 11. represents the results of Anova test. P value is smaller than 0.5, so there is a significant difference between the means of time for distances *Poecilia reticulate* to reach its source of food.

EVALUATION

In this experiment, my prior aim was to investigate *Poecilia reticulate* the ability to memorize simple things. To investigate this, I have also studied the effect of distance between such obstacles for *Poecilia reticulate* to reach its source of food. I made my experiment with a method that I have designed myself, which enabled me to investigate my aim. Although, it was not a famous method, I was able to collect precise data to evaluate the experiment.

In conclusion, the results of the experiment show that as distance between the plates increase, *Poecilia reticulate* fail to swim through the holes in shorter periods of time. Fishes were able to swim through the holes faster in the experiment 1 where distance between plates were 5cm, and followed by 10cm. 15cm and 20cm distance between plates are in third and fourth places. Moreover, in 25cm distance, they were not quick enough to reach their source of food. In 5cm the time passed for them to swim is approximately 10 minutes, which is quite shorter when compared to other results. For 10cm it is 15 minutes; for 15cm it is 21 minutes and for 20cm it is 29 minutes. The longest time for them to reach their food is 33 minutes, which was swum when the distance between the obstacles were 25cm. It can be said that in every 5cm, the time changes approximately 5 minutes, however in between 15 and 20 cm, the difference is way more than 5 minutes. From the results, it can be said that *Poecilia reticulate* cannot easily adapt the change easily when the distance between obstacles is increased to 20cm. Overall, as the distance increased, the time for them to reach their source of food also increases. This means that the change in the distance between plates made them hard to reach the other side. They can hardly adapt the change in the habitat. Also, they cannot able to remember the path, which I have designed. Hence, they fairly shorten the time to swim compared to first days when we look the results for one *Poecilia reticulate* in any distance. For 5 cm for example, *Poecilia reticulate* swam 12 minutes in the first day that is slower when compared to last day when they swam 8 minutes. In the first days in any distance, *Poecilia reticulate* reach the food in extended period of time. As long as the day passes they were able to swim faster and reach the food faster. Interestingly, this means that they are able to remember some information in their short-term memory. As long as adapt the environment, they can easily reach their source of food whether there are some obstacles in their path. They are also able to adapt and overcome some difficulties they faced. This means that

they do not have a long-term memory but they have short-term memory and instincts to reach the source of food. There are some variations in species. For all the distances, and all through the experiment, *Poecilia reticulate* 3 cannot swim as fast as the others. In the experiment, it was the slowest one. So, its ability to memorize is less than the others. This shows that there may be some variations in species. I have thought that this could be a weakness in my experiment. To minimize this, I have used 5 *Poecilia reticulate.* By this way the chance of results being coincidence is also minimized.

The results of the experiment rejected my hypothesis which is ‘’*Poecilia reticulate* will be able to swim faster as they adapt the environment, although the distances between obstacles increase, so they have ability to learn and memorize what they learnt for finding their food.’’ I have hypnotized that as long as the distance increased, they will easily find their way to swim through because there will be more place for them to swim freely. Probably, the distance and more space made them confused. Also as the *Poecilia reticulate* are too small, more space is a problem for them. This maybe made the path harder.

The experiment was designed carefully and repeated many time to collect precise data, however not all errors cannot be eliminated. For example as the fish feeds are made to disperse inside the water, it is not necessary for them to swim across. I tried to find the most solid products but even though I cannot be sure that the source of food really stayed one side of the aquarium. To execute this error, it should be found a fish feed that does not disperse inside the water. Overall, there are small systematic and random errors that can reduce the reliability of the experiment.

CONCLUSION

The study shows that *Poecilia reticulate* has ability to memorize acquired information even there are some changes in the environment. However, as the distance between obstacles increase, the time for *Poecilia reticulate* to reach their food also increases. So, when we look at the results, a clear answer for my research question: ‘‘Is fish memory powerful enough to reuse acquired knowledge when the distance between obstacles increase through their way to source of food?’’.

I made my research about fishes because many people believe that fishes do not have developed memories like humans do. Moreover, they use goldfish to refer some one extremely absent minded. The main reason why I choose this research is to answer the question, are fishes really absent minded, or do they have ability to learn about their environment, for example the positions of obstacles?

There are many studies, for example researches at MacEwan University done in 2014, show that fishes really have ability to remember some simple things. Trevor Hamilton of MacEwan University, Canada, said: "If they are able to remember that a certain area contains food without the threat of a predator, they will be able to go back to that area. Decreases in the availability of food would promote the survival of species that can remember the location of food sources.”. However, there is no study search for the effect of distances between obstacles in time for swim or overall the ability of memory. I believe that my study answers the research question and people can benefit from the research to find answer for same research question.

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