Module Title: The Mystery Fish of Science

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Introduction

This document describes an activity that has been successfully carried out with dozens of school groups ranging in size from 10 to 75 and in age from elementary school to high school/community college. The goal of the exercise is to engage the students in observing a phenomenon, developing an explanation, testing the explanation and revising as needed—essential elements of critical thinking and the practice of science.

Materials Required

Mystery fish

The materials required are “Mystery Fish of Science” (our name for them— they are sold as “Fortune Telling Fish”). They are amazingly cheap and available from many outlets. They are priced (2012) as low as $4.00 for 144 of them, so shop around. They are so cheap that it is possible to give out extra fish to students either because they damaged theirs or even just so they can take them home to show off to friends and family. The come individually packaged as well which is an added convenience. Information about the actual composition of the Mystery Fish is provided in the supplementary material.

Laboratory gloves
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The other required material is a pair of laboratory gloves for each student. We use disposable vinyl or nitrile light duty laboratory gloves. These are somewhat more costly (about $0.30/pair in 2012) but are essentially free of the potential for an allergic reaction as can occur with latex gloves. The Center for Disease Control recommends nitrile gloves to avoid latex allergy effects. They also come in cool colors like blue and purple which many students find appealing. They may even ask to take them home, and you can do so as there is no glove contamination hazard in this activity.

Paper towels

You will also need a small stack of damp paper towels at the front of the classroom for the wrap-up portion of the exercise.

The Activity

To introduce the activity, first show students one of the fish and talk about the claims made for them. On the back of the package is a chart which is supposed to predict your mood based on how the fish behaves in your hand. Explain that the class is going to investigate this phenomenon scientifically.

Next, hand out one fish to each student, instructing them to leave them in the package until all students have their fish. For the first set of observations, ask the class to remove the fish from the packet and lay it on the table in front of them. Do the same to illustrate. Ask the class to make any observations. They may note that there is writing on one side of the fish, that it is thin, semi-transparent, red, and other qualities that you can elicit.

Next, ask the class to lay the fish in the open palm of their hand. Again, do the same to illustrate. At this point, there will likely be spontaneous interest as students see the fish move, Many will refer to the back of the package to try and interpret the results. Allow the class a few minutes to spontaneously explore the behavior and to share their observations with each other. This usually leads to some lively discussion among students which is a good reinforcement for the exercise.

During this time you can ask students to describe what happened to their fish and try to elicit specific descriptions. For example, students often say ‘it moved’ – this is an opportunity to probe further. Did it fly away? What part of it moved? Some fish will curl into a cylindrical shape along its long axis, some will develop spiral curvature, etc. This is a good opportunity to work on precision of descriptive language with the class if you choose.

If you wish, you can then ask the students to return the fish to the desk in front of them and make further observations. The fish will likely slowly straighten out again and become still.
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Having the students return the fish to their desk should help them focus on you as you move to the next part of the activity.

**Hypothesis building**

Next, ask the students ‘Why do you think the fish just lies on your desk top but moves on your hand?’ This is the phenomenon we will investigate for the remainder of the inquiry. Students will come up with a variety of ideas – wind, static electricity, or others, but most students will propose that the warmth of your hand is responsible for the movement. Pick up on this idea and promote it to the top of the list of explanations without being too obvious about it. Explain that you will come back to their other ideas later, if time permits.

**Hypothesis testing**

Next, congratulate the class on coming up with good ideas and then ask if they have any suggestions on ways to test this explanation. If no suggestions are forthcoming, you can guide their thinking by asking a question like “so if it is the warmth of your hand that is responsible, how could we change the warmth of your hand to see if it changes the fish’s behavior?”

This may elicit some good and not-so-good ideas; acknowledge and praise their efforts, and then either seize on or propose the idea that we could warm our hands by rubbing them together very fast to generate frictional heat and see if warmer hands change fish behavior. Instruct the class to put down their fish, put their palms together and rub as hard and fast as they can. This generally elicits an enthusiastic response and it can be fun to egg them on calling out ‘Harder!’ ‘Faster!’ ‘Feel the burn!’ or the like for a moment (keeping this going for 20-30 seconds provides a good result). Then tell the students to quickly put the mystery fish on their palm and report their observations. Again, modeling this action yourself is helpful in engaging their interest.

Most students will report that the fish did indeed move more in their warmed palm. Some will not, and this can be an opportunity to note that scientists must always deal with uncertainty in their observations. In general the class consensus will very likely be that the rubbing did increase fish motion, a result that would seem to confirm the proposed explanation that the fish is responding to warmth.

This is generally a satisfying outcome for the students, but now is the time to make the point that a good scientists do not stop at one experiment. They will try and come up with additional ways to confirm that the explanation is correct.
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Ask the class if they have another way to warm the fish while sitting at their desk other than rubbing their hands together. In most cases, one or more students will suggest breathing on the fish. Seize upon (or suggest yourself if necessary) this idea.

If you choose, you can ask the students whether it would be better to breathe on the fish while resting in their hand or on the desk. After some discussion, you can reinforce that leaving it on the desk top will avoid any effects caused by the warmth in their hand. This is an opportunity to talk about ‘confounding variables’ in scientific inquiry. Scientists work to ensure that they change only one thing in a given experiment so that they can be sure that the thing they change is responsible for the effect they observe. If the fish were breathed upon in their hand, how would they know whether its motion was caused by their breath or by their hand?

Now ask the class to try this test. Instruct the students to lay the fish on the desk. It can be helpful to emphasize that we are going to try and cause the fish to move with our ‘warm breath,’ using gentle breath and an open mouth to get the warmest breath possible.

Sure enough, the fish appears to move more when breathed upon. Pont out that that we appear to have strengthened the hypothesis that warmth is responsible for fish movement with this additional observation.

Depending on the age of the class, you can add at this time that in scientific practice, an hypothesis that has been repeatedly tested by observation is referred to as a theory. This is an important point to make as many students equate the scientific use of the term ‘theory’ with their more colloquial usage of ‘theory’ as being equivalent to a ‘guess.’ This confusion is frequently encountered through the statement ‘It’s only a theory.’ You can point out that to a scientist a theory is much more than a guess or an opinion – it is an explanation supported by experimental observations and confirmed independently by other scientists.

**Theory revision**

In this section, it is usually necessary to introduce an additional test – students are unlikely to come up with this next test on their own.

Hand out a pair of disposable gloves to each student (if your budget permits – this could be done as a demonstration if necessary). Ask them to put on the gloves. Next, repeat the frictional heat exercise with gloved hands. Students will likely remark that they can feel quite a bit of heat through the gloves as they rub their hands together. Again, ask the students to immediately place the fish on their warm gloved hand and report out their observations. In this case, the consensus will be that the fish did not move, or moved minimally compared to movement on a warmed hand or in response to breath.
Ask the class if this result is consistent with the hypothesis that warmth is responsible for fish movement. They should understand clearly that it is inconsistent.

Here you can make the point that this frequently happens in scientific research. Scientists make some observations, attempt to confirm their theory about the observations and at some point may encounter a result that is inconsistent with their theory. At this point, a good scientist will attempt to seek out other explanations that explain all of the results.

Next, ask the class to try and come up with an alternative explanation, other than warmth, that might explain all of the observations made to this point. To guide the inquiry, you can ask “what else is in your breath besides warmth?” Depending on the age of the class, a variety of answers may be forthcoming, such as carbon dioxide. If necessary you can lead the class further by asking ‘what do you see when you breathe on a mirror?’ Ultimately, the class will agree that breath also contains moisture.

You can reinforce that perhaps what happens with one’s breath is that the fish is responding not to warmth, but to the moisture in breath. Others may have made this suggestion earlier and you can point this out to acknowledge their contribution.

Next, ask what happens when you rub your palm’s together fast besides warmth. With some prompting, students will usually come up with the idea that your palms also can become sweaty.

Ask the class then if this would be further confirmation that moisture is responsible for the movement of the fish. They should agree, and you can point out that this means that we have a new hypothesis – that the fish move in response to moisture, either from the moisture in palm of the hand or from breath.

**Revised theory confirmation**

Finally, you can ask the students if the theory that moisture is responsible is consistent with the observations they made with gloved hands. They should immediately see that it is – the gloves prevent moisture from hands from contacting the fish.

Here you can emphasize that the first theory (warmth) explained some of the results (warm palm and breath) but not others (warm gloved hands). In contrast, the new theory (moisture) explains all of the results explained by the first theory and also explains the result with warm gloved hands.

Scientists would say that the theory that moisture is responsible has more ‘explanatory power’ than the theory that warmth is responsible. In other words, a theory that explains more observations is preferred over a theory that can only explain some observations. For more
advanced students, you could point out that Einstein’s special theory of relativity (which is accurate at low speeds as well as at speeds approaching the speed of light) has more explanatory power than Newton’s laws of motion (which are accurate only for low speeds) and hence is now the preferred explanation.

Additional activities

If you choose, you can offer the students the opportunity to further test the moisture theory at their desk. Alternatively, and because it saves class time and keeps the mess under control, you can place a previously prepared small stack of damp paper towels at the front of the class and demonstrate the effect of gently laying a fish on the stack. You can point out that the paper towels are moist but not warm. The fish should react immediately, providing further confirmation that our new theory is correct.

As an additional wrap-up discussion, you can refer back to the original packaging of the Mystery Fish and ask whether the Fish are actually telling your fortune. You can point out that in fact all that they claim to detect is your mood, not your fortune. You can then lead a discussion of whether the fish could in fact detect your mood. Indeed, since a person in a high emotional state may have ‘sweaty palms,’ the fish will in fact react more to such a person than to a quiet, calm person.

Further, you can mention that the classical ‘lie detector’ used in criminal investigations actually includes sensors that sensitively detect skin surface moisture (the ‘galvanic response’) on the hypothesis that a person who is lying will reveal the stress of lying by the appearance of minute amounts of sweat on their skin which the lie detector can detect.

So even though the Mystery Fish won’t tell your fortune, their behavior could in fact be indicative, in a very general and imprecise way, of an individual’s state of mind.

A further, more advanced, activity is provided in the supplementary materials.