The Scientific Method Made Easy

The scientific method is a series of 5 steps that scientists use to do research. But, honestly, you use it every day too! The five steps are Observation, Hypothesis, Test, Collect Data, and Report Results. That sounds pretty complicated but don't worry, they are just big words. Let me tell you what these words mean and then we'll play with them.

Observation means what do you see, or hear, or smell, or feel. What is it that you're looking at? Is that what it usually does? Is that what it did last time? What would happen if you tried something different with it? Observation is the beginning of scientific research. You have to see or touch or hear something before you can start to do stuff with it right?

Once you observe something, you can then form a hypothesis. All hypothesis really means is "guess". Hypothesis is an educated guess. Tonight at dinner, when someone asks you "Do you want peas or carrots?" Say, "I hypothesize that I would like the carrots." Everyone will think you're a genius! Basically you're saying "I guess that I would like the carrots". Hypotheses aren't right or wrong they are just your best guess. To see if your guess is correct, you need to do the next step in the scientific method, test. The test is just what it sounds like; running experiments to see whether or not your hypothesis is correct.

As you do your tests, you need to collect data. That means collecting the numbers, the measurements, the times, the data of the experiment. Once you collect your data, you can take a look at it, or in other words analyze it.

Once you analyze your data you can report your results. That basically means tell someone about it. You can put your data in a chart or a graph or just shout it from the rooftops!

Here's a great way to remember the 5 steps. Remember the sentence "Orange Hippos Take Classes Regularly". The first letter in each word of that goofy sentence is the same as the first letter in each step of the scientific method. That's called a mnemonic device. Make up your own to remember all sorts of stuff.

"Ok, so that's what the words mean. How do I use that everyday?"

Well, I'm glad you asked that question. If you had cereal for breakfast this morning, you did the scientific method. On the table you had a bowl of cereal with no milk in it. As you looked at your dry cereal, you made an observation, "I need milk!" At that point,

you made a hypothesis, “There’s milk in the fridge.” You can’t be sure there’s milk in the fridge. Someone might have used it up. It might have gone bad. Aliens may have used it to gas up their milk powered spaceship. You just don’t know! So you have to do a test.
What would be a good test to see if there is milk in the fridge?....Open the fridge! Now once you move the week old spaghetti and the green Jell-O (at least you hope it’s Jell-O) out of the way, you can see if there is milk or not. So you collect your data. There is milk or there isn’t milk. Now you can finally report your results. If there is milk you can happily pour it on your cereal. If there isn’t any milk you report your results by shouting, “Hey Mom...We need milk!” Scientific method, not so hard is it?

Experiment: Underwater Presidents

How many drops of water can a penny hold?

What you need:
Pennies
Eye or medicine dropper
Water

1. Make your observations of the penny; the size, the cleanliness, heads or tails etc. Next look at the water dropper? How big is the opening? How big are the drops that come out, etc?

2. Make your hypothesis. Make a scientific guess as to how many drops you can get on that penny before the water drips off the penny. Unless you’ve done this before, you will almost certainly have a hypothesis that is not very close to your results. Don’t worry about it.

3. Do your test. Slowly but surely put drop after drop on that penny. Eventually you will see a surprisingly large mound of water on the penny that will burst and overflow.

4. Collect your data. Keep a careful count of how many drops are sitting on that penny. For accuracy’s sake, you may want to do this several times (besides, it’s fun) and average your results. (To get an average, add up all your results and then divide by the number of results you got. For example, if you did the experiment three times and got the results 14, 16, and 30 you would add those numbers together (60) and then divide that by 3 (the number of results). So your average would be 20 drops.)

5. Report your results. Once the water spills over the edge, construct an interplanetary telecommunications

device to broadcast your results across the universe....or you could just tell your kid brother. It's up to you. I've seen folks get more then 70 drops on a penny! Pretty amazing really. The average seems to be between 30 and 40. The reason the water mounds up like that is because water really likes to stick to itself. It takes a good amount of weight before the water breaks apart.

Would you like to do more with this experiment? What would happen if you used different coins? Is there a mathematical relationship between the number of drops and the size of the coin? Is there a difference between the head side and the tail side of the coin?

The next time you're about to do something around the house apply the scientific method to it. For example, if you're about to write something you could apply the scientific method by saying, "I observe that I need a pencil. I hypothesize that there is a pencil in my drawer. I will test this by opening my drawer. I will collect data by looking in the drawer. I will report my data by writing with my pencil or by asking mom where the pencils are." How could you apply the scientific method to making a peanut butter and jelly sandwich, or walking into a dark room, or buying an ice cream cone? Can you think of others?

Variables

Now let's use the scientific method to discover a couple of things about pendulums. Before we start, I need to tell you two new terms. One is constant variable and the other is changing variable. A variable is a part of your experiment, like the coin in the Underwater Presidents experiment. If it is a constant variable, it stays the same for every trial of that experiment.

For example, we always used the same penny in the Underwater Presidents. Those variables never changed. A changing variable is what you change for each trial. It is often what you are testing for; "If I change this, what happens to that?"

For example, in the Underwater Presidents experiment, if we tried water in the dropper, then we tried vegetable oil, then corn syrup; the changing variable would be the liquid we are using in the droppers. When you do an experiment you have to try very hard to keep all variables constant except for the one you are testing for. If you don't keep all but one variable constant, you won't know why you are getting the results you're getting. If you change the size of the coin, and the type of liquid with the Underwater Presidents experiment, you will have a hard time knowing if it's the change of coin or the type of liquid that's causing more or fewer drops on the coin. Let's try the following experiment and see if this becomes clearer.

The Size of the Swing

What you need:
String
Weight of some sort
Tape
Timer (or a watch with a second hand)

First of all, you have to make your pendulum. A pendulum is really nothing more than a weight at the end of something that can swing back and forth. The easiest way to make one is to get a string and tape it to the edge of a table. The string should be long enough so that it swings fairly close to the ground. Tie a weight of some sort (a washer, a watch, your dog (just kidding, live things make poor pendulums)) to the bottom of your string and you've got a pendulum. Now, for this experiment the changing variable is going to be the length of string. In each trial you will be changing the length of the string. The rest of the variables will be constant. The weight at the end of the string, the string itself, the time you will be letting it swing will be the same for every trial. Getting the hang of constant and changing variables now? Okay so here's what you want to do:

1. Make an observation. Play with the pendulum a bit and see how it behaves.

2. Make a hypothesis. How will the length of string effect the number of swings in 10 seconds? Will there be more, less, or no change in the number of swings as the string gets shorter.

3. Set a timer for 10 seconds or get someone who has a watch with a second hand to tell you when 10 seconds are up.

4. Now for the test. Pull the pendulum back as far as you'd like (the pendulum swings smoother if you don't lift the weight higher than the top of the string).

5. Start the timer and let go of the weight at the same time.

6. Count the swings the pendulum makes in 10 seconds.

7. Write down what you found (collect the data). This works well if you make a chart with two columns, one for length of the string, and one for number of swings.

8. Do two more trials with the string at that same length.

9. Now change the changing variable. In other words, shorten the string. I would recommend shortening it at least an inch.

10. Redo steps 3 through 9.

11. Continue shortening the string and doing trials until you get at least five

trials with five different lengths of string.

12. Now report your results. Take a look at your data and see if you find a trend. Do you get more swings as the string shortens, less swings, or does the length of the string matter? Something interesting to notice is that at a certain length you will get 10 swings in 10 seconds or a swing a second. This is why pendulums are used in grandfather clocks. They keep good time!

A Weighty Problem

What you need:
String
Several weights of some sort (a bunch of the same kind of washer works very well)
Tape
Scale (optional)
Timer (or a watch with a second hand)
Use the same pendulum set up you used for "The Size of the Swing" experiment.

1. Make an observation. Play with the pendulum a bit and see how it behaves.

2. Make a hypothesis. How will the weight of the bob (the weight at the end of the pendulum) effect the number of swings in 10 seconds? Will there be more, less, or no change in the number of swings as the bob gets heavier.

3. Set a timer for 10 seconds or get someone who has a watch with a second hand to tell you when 10 seconds are up.

4. Now for the test. Pull the pendulum back as far as you'd like.

5. Start the timer and let go of the weight at the same time.

6. Count the swings the pendulum makes in 10 seconds.

7. Write down what you found (collect the data). This works well if you make a chart with two columns, one for weight of the bob, and one for number of swings.

8. Do two more trials with the same bob.

9. Now change the changing variable. In this case you want to increase the weight of the bob. If you have several washers of the same kind, the easiest way to do this is to just add more washers to the end of the string. You can also add paperclips if you have quite a few of them. If you don't, then change the bob to different objects that get heavier and heavier with each trial. If you change the number of objects, just

record how many you have (3 washers, 10 paper clips, etc.). If you change the type of object and have a scale, record the weights of the objects. If you don't have a scale, just put the objects in order of increasing weight. The actual mass of the objects doesn't really matter as you'll see by your conclusions. Remember to change the weight of the bob, but don't change the length of string. The weight of the bob is your changing variable this time. The length of string is… what variable? Constant. Right, you're getting the hang of this!

10. Redo steps 3 through 9.

11. Continue increasing the weight and doing trials until you get at least five trials with five different weights.

12. Now report your results. Take a look at your data and see if you find a trend. Do you get more swings as the weight increases, less swings, or does the weight of the bob matter? Are you surprise by the fact that weight didn't matter? Next lesson we will discuss gravity and then this odd result will make sense.

Feel free to continue playing with the pendulum. You dropped the bob from about the same height each time. Would you get different results if you dropped the bob from different heights? Try it, but remember to keep the string and the weight constant. If you do this experiment, what is your changing variable? The height of the drop, right? See you are paying attention!!

A constant variable is one that does not change from trial to trial. A changing variable is the one variable you are testing for. It does change from trial to trial. One of the most difficult things to do in scientific research is to know what all of your variables are and to keep all but one variable constant. In these pendulum experiments other variables were the temperature of the room, the humidity, the spin of the Earth, the design of the pendulum, etc., etc. We made an assumption that all those variables remained constant and didn't really matter to our experiments. In this case, that's a safe assumption but sometimes you can't be too sure!

Constant and changing variables are around you all the time. What would be some variables in your breakfast? Which ones change from morning to morning? Which ones stay the same? What about some variables in the car? Which are constant and which are changing?

Observation

The first step of the scientific method is observation. In my opinion, this is the most important and enjoyable part of the scientific method. Observation is the skill of "seeing" things that are there, "seeing" things that aren't there and "seeing" things that should be there.

Observation is the skill that separates scientists from super scientists. Einstein, Galileo and Newton, for example, were fantastic observers. They were able to "see" beyond and through what other people were able to "see" before them in order to get to deeper truths inside science.

I'm putting "see" in quotes because there's more to observing then just seeing with your eyes. First, you need to detect something. You can use your eyes, ears and nose to detect things. You can also use instruments like telescopes, microscopes or prisms to detect things. Somehow, something needs to come to your attention.

But that's not all there is to observing something. Next you need to use your knowledge and your intuition, to fully observe what's happening. When you look up into the night sky you might only see bunches of little white dots, but a trained astronomer would see stars of different magnitudes, galaxies and constellations. The astronomer's knowledge allows her to "see" more. This is why I think observation is so much fun.

Observing allows you to know things and knowing things allows you to observe more things! You can't help but get smarter if you spend your time observing! In this lesson, we're going to spend time becoming better observers. Try this activity.

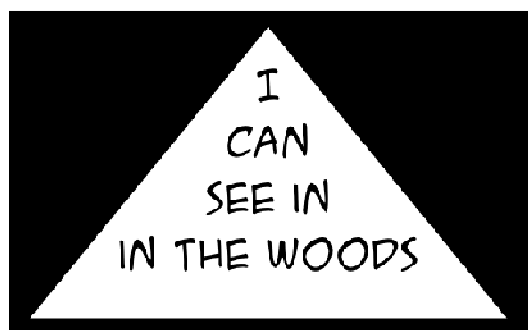
What Do You Mean, That's Not Right?!

You need:

A partner

1. Tell your partner that you are going to give them about 5 seconds to read a sentence.

2. Let your partner take a look at the sentence and count to 5 slowly in your head and then take the sentence away.



3. Ask your partner what the sentence says.

4. If they are wrong, which they almost always are, give the sentence back to your partner and let him or her look at it again.

5. Marvel at how long it takes your partner to find out what the sentence really says!

This activity never fails to amaze me. This is a great example of the difference between seeing and perceiving. Your eyes see, your mind perceives and unfortunately, it's not uncommon for something to get messed up along the way! Your eyes saw that second "in" but your mind edited it! In fact, you had to focus quite hard before your mind allowed you to "see" what was really there! Strange but true.

Where Did That Come From?

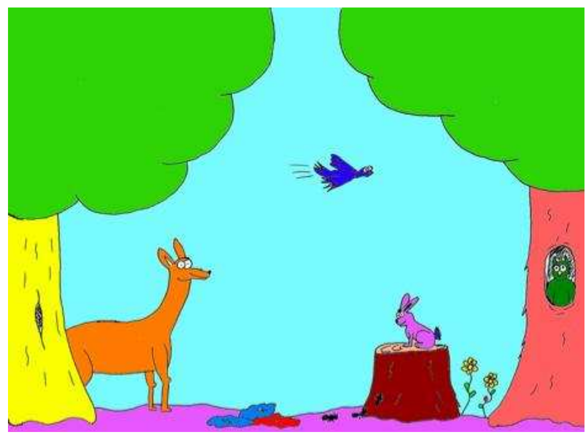
You need:

Paper

Pencils

Volunteers

1. Tell your volunteers that you are going to give them 30 seconds to look at a picture and try to remember as many things as they can about the picture.
2. Let them see the picture and count to 30 in your head.
3. Now hand each of them a piece of paper and a pencil or pen.
4. Tell them to draw as much of the picture as they can, in as much detail as possible. Tell them not to worry about being artistic but just try to include as much about the picture as possible in their drawing.
5. Tell them to write the color of the objects on their drawing as well.
6. Let them take about 2-5 minutes to create their drawing.
7. When folks are done, show them the picture again so that they can compare their drawings with the picture.



Did your artist draw everything? Did something get forgotten? Did something get added? Was there something that was the wrong color? Now ask your artist how sure they were that something in their drawing was actually in the picture.

I always enjoy watching the faces of the students when I show them the picture the second time. They always get surprised when something is in the picture that was not in their drawing, or even more fun, when something was in their drawing that was not in the picture!

Chances are they were pretty confident that there was a cloud in the picture, or that the dog was yellow or whatever it may have been. Your eyes see what is there, all the colors and shapes. Your mind, however, has to interpret what your eyes see and pretty often it will forget things or completely change them around! Again, your eyes see but your mind perceives!

Picture Detective

You need:

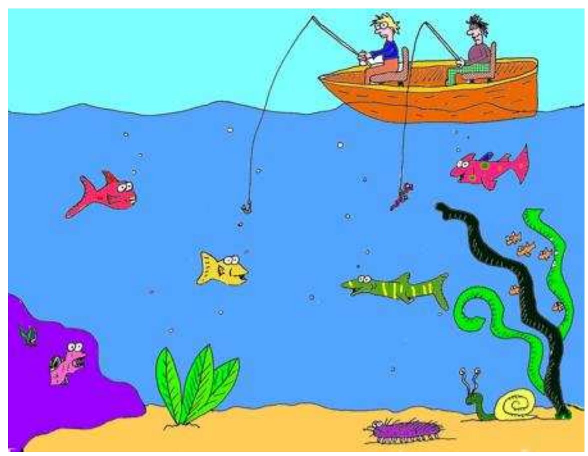
The question sheet below

Paper

Pencils

Friends

1. Tell your friends you're going to show them a picture for 30 seconds. You want them to try to observe the picture carefully and remember as much about it as possible.
2. Now show them the picture and count to 30 in your head.
3. Take the picture away and hand them a piece of paper.
4. Have them number the paper from 1 to 10.
5. Tell them to try to answer each question as best as they can. Make a guess if necessary. If they can't remember the answer at all, they can leave that question blank.
6. Also, tell them to put a check mark next to any answer they are certain is correct.
7. Read them the questions.
8. When your friends have answered all the questions, let them see the picture and check their answers.
9. Take a look at the answers they were certain they had the right answer. Did they?



Questions for the Fishy Scene

1. How many small fish are in the sea weeds?
2. Is the worm on the right or the left hook?
3. How many leaves does the sea weed on the rock have?
4. Is the snail pointing left or right?
5. Is the fellow in the blue shirt smiling or frowning? Can you guess why?

6. What color spots does the spotted fish have?
7. How many fish have stripes?
8. What color hair do the fishermen have?
9. What color is the fish that doesn't have a dorsal fin (the fin on the back)?
10. How many plants are in the picture?

Answers:

1. 5 small fish.
2. On the right hook.
3. 3 leaves.
4. The snail is pointing left.
5. He's frowning. Probably because he's not getting any bites since he has no bait.
6. Green spots.
7. One fish has stripes.
8. Blond and Black
9. Yellow
10. 3 plants.

This is an excellent exercise in observation. I highly recommend finding other pictures in books and magazines and doing this several times. It's a great way to get better and better at the skill of observation. It's also a nice way to pass the time in a waiting room!

The Old Switcheroo

You need:

5 to 10 small items. Pencils, crayons, balls, eraser, toy cars, buttons, whatever is handy.

A handkerchief or napkin large enough to cover all the items.

Some friends

1. Lay out all the small items on a table.
2. Cover the items with the napkin.
3. Tell your friends you're going to give them 10 seconds to look at and memorize the items and where they are.
4. Take the napkin off for 10 seconds and let your friends look. Cover it back up when time is up.
5. Now move, take away, or add something to the pile of things without letting your friends see what you're doing.
6. Invite your friends to try to guess what it was you moved, removed, or added.
7. Do it again and take turns being the mover.

This is another great exercise to improve your observation skills. I do this with my family at restaurants. I just grab stuff on the table, lay it out and have my family try to guess what's been changed. (Be careful of grumpy waitresses!)

As you can see, observation is a skill just like any other skill and it can be exercised and improved over time. Being a good observer means always keeping your eyes open and being aware of what's around you. With good observation skills and knowledge the world becomes just that much more wonder-filled!

Communication

Fish in the can saws wild apples dog car sidewalk tree. Shirt the table carpet in the floor roof cloud. What? What do you mean I'm not making sense? I'm using simple English words. Oh, I see. I must not be communicating.

Believe it or not, communication is not as easy as it seems. In this lesson, I'm hoping to show you that hearing what someone is saying, and saying what you want someone to hear is quite a skill. A good skill for life and a vital skill for science.

In science, the ability to tell someone what you did, how you did it, and what happened after you did it, is a key skill in sharing science information. Scientists from around the world share information and their measurements and details of what they did must be very precise. To begin with, let's try this little exercise in giving directions.

A Peanut Butter And Jelly Jam

You need:

Peanut Butter

Jelly

Bread

Butter Knife

(Be prepared to make a mess and have fun.)

1. Pick a person to be the sandwich maker (this works better if it's someone who's kind of in on the game).
2. The sandwich maker tells the group that he or she is a robot who does everything that it is told. However, the robot is very literal, so it does EXACTLY what it is told to do.
3. The rest of the group gives one instruction at a time ("Put the jam on the bread.") until the sandwich is made or until no one can stand laughing anymore.

The key to this activity is the sandwich maker. The robot must do exactly what he or she is told. So when the robot is told to put the jam on the bread, the robot takes the jar of jam and puts it on the bag that the loaf of bread is in! When the robot is told to take the bread out of the bag, the robot can't do it because the bread bag isn't open! Have a lot of fun with this, it's messy and makes a great point.

It's a little harder to tell someone how to make a sandwich than you thought right?! Try telling a robot how to tie its shoes. Or for that matter, walk across the room. It's quite hard. Communication involves a lot of assumptions.

An assumption is when you expect someone to know what you're talking about. You assumed that when you told your "robot" to put the jam on the bread, that the robot would know that it needed to open the jar. Then you might have told the robot to open the jar and it didn't know how to do that either! Again, you assumed something that is obvious to you but not at all obvious, perhaps, to something or somebody else.

My father tells the story of when he learned this lesson the hard way. When he was a kid there was a hole under the porch at his house. His Mom noticed a board sitting on the ground and told my Dad to fill the hole with the wood. Well, my father, being a good little boy, did exactly as he was told and put the wood as far into the hole as he could, leaving a good two feet of board sticking out of the hole. His mother came back from what she was doing, took one look at the wood sticking out of the hole and proceeded to yell at my father for being such a dummy. My father was clueless. As far as he could tell, he did exactly what he was asked to do. However, his mother assumed that when she said fill the hole with the wood, he would use the wood to push dirt into the hole. My father followed the directions correctly but was wrong. His mom gave directions correctly and was also wrong.

As you can see, communication can be very difficult. I'm willing to bet this kind of thing has happened to you. You have told someone to do something and they messed it up or someone told you to do something and you messed it up. Keep this in mind the next time something gets messed up. A little better communication can keep a lot of things from getting messed up (and keep you out of trouble as well).

Communication isn't just giving directions however. It's also hearing what's being said and following directions. How good are you at following directions? Try this.

Get The Picture

You Need:

The instruction sheet, one for each person in the group.

Pencils for each person in the group

1. Pass the instruction sheet to everyone in your group.
2. Tell everyone to read the instructions carefully and to go ahead and get started.
3. The answers for "Get The Picture" are at the end of the lesson.

Get The Picture

Please follow the following directions exactly. Do everything that the instructions say. Read all the following directions before beginning.

1. Circle the word circle in this sentence.

2. Write the third word in this sentence here. ___________________

3. Draw a large square on the back of this paper.

4. Draw a large triangle on top of the square on the back of this paper.

5. Draw a rectangle inside the square with a short side touching the middle of the bottom of the square on the back of this paper.

6. Draw a small square to the right of the rectangle in the large square on the back of this paper.

7. Draw a circle above the left side of the triangle.

8. Ignore every single instruction on this page but this one. Turn your paper over and draw a big smiley face on the paper. There should be nothing on the back of this page but one big smiley face. After you've drawn your smiley face turn this page back over.

Answer to *Get the* Picture: There should be nothing on the page except for a smiley face on the back! So now you've had a chance to see that giving directions is difficult and following directions is difficult. Let's put it all together with this next activity.

Communication Block

You need:

Identical sets of five different objects for each person in your group. For example, each person in the group has the same set of five different blocks, or everyone in your group has their own fork, apple, napkin, pencil and toy car. It doesn't matter what the items are but for the instructions below I'm going to use blocks as my items.

Some sort of screen to allow everyone to keep their items hidden from prying eyes. I use file folders. Open them up about 90 degrees, they stand up nice and the kids can keep their stuff hidden behind them.

1. Pick one person to be the "teller". Everybody else will be "listeners".
2. The teller will put his or her blocks together any way he wants. Make sure no one can see how the blocks are laid out. The teller can stack them on top of one another, lay them end to end or do whatever he feels like. I highly recommend only using three blocks the first two or three times.
3. Now, the teller has to carefully tell the listeners what he or she has constructed. The teller's job is to get all the listeners to build exactly what she has built. The teller should only use her voice to explain how the blocks look. She shouldn't hold any blocks up or use her hands to show how the blocks are laid out.

4. As the teller describes what has been built, the listeners should try the best they can to build what's being described.
5. Once the teller feels he or she has explained everything, he should uncover his blocks and let everyone see what he was trying to describe. Take a look at everyone's blocks. How well do they match?
6. Let everyone have a turn being the teller.
7. For the first couple of times don't let anyone ask any questions. It is completely the job of the teller to make sure everyone can make the same block constructions.
8. After a few tries, let the listeners ask the teller questions. Emphasize that now the listeners have a

responsibility to make sure they get it right. It's no longer only up to the teller. If they have their blocks set up wrong now, they might not have asked a question when they should have.

This is a great activity and it really shows how hard it is to communicate with someone. It does a great job at pointing out assumptions and showing how careful and detailed you have to be with your instructions. It also shows that the listener has an important role to play. The listener must be very careful not to make assumptions and to be sure to take responsibility for what they are hearing by asking good questions.

One more thing this activity does is show how important definitions are to good communication. When I do this activity with my groups, I do it a few times and then take the time to point out some of the definitions the group has been using. For example, when they call one block the red square everyone knows which block that is. I also point out where a definition can come in handy.

For example "Stand the blue block on its side." Well, which side? Long side, short side, fat side, how do you know? At this point, I take the time with the group to create definitions. "Okay, so when we say long side that always means this side of this block." As you do this activity, you'll see where assumptions are made and definitions can come in handy. In science, good definitions are vital. If somebody says, "I put the apparatus one meter from the ping pong ball." Everyone in the world knows how far a meter is. There is a standard for meters, inches, cups, liters, ohms, joules and all sorts of measurements. Without good definitions no one would know what anyone was talking about!

Well, I hope I was able to communicate how important and how difficult it is to have good communication. Whenever you write something, read something, say something or hear something, be very careful to make sure you're not assuming something. Try to make sure your listener truly hears what you're saying, and vice versa, try to make sure you're hearing what someone's telling you.

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