Early example of experimental design

In 1747, while serving as surgeon on HM Bark *Salisbury*, James Lind, the ship's surgeon, carried out a controlled experiment to develop a cure for scurvy (rotting and diseased gums).

Lind selected 12 pirates from the ship, all suffering from scurvy, and divided them into six pairs, giving each group different additions to their basic diet for a period of two weeks. The treatments were all remedies that had been proposed at one time or another.

They were:
- A quart of cider every day
- Twenty five gulps of *elixir* three times a day upon an empty stomach,
- One half-pint of seawater every day
- A mixture of garlic, mustard, and horseradish in a lump the size of a nutmeg
- Two spoonfuls of vinegar three times a day
- Two oranges and one lemon every day.

The men who had been given citrus fruits recovered dramatically within a week. One of them returned to duty after 6 days and the other became nurse to the rest. The others experienced some improvement, but nothing was comparable to the citrus fruits, which were proved to be substantially superior to the other treatments.

In this study his subjects' cases "were as similar as I could have them"; that is he provided strict entry requirements to reduce extraneous variation. The men were paired, which provided replication. From a modern perspective, the main thing that is missing is randomized allocation of subjects to treatments.

The scientific method has been practiced in some form for over one thousand years. Ancient Egyptians even practiced experimental scientific method.

In 1950, Gertrude Mary Cox and William Gemmell Cochran published the book *Experimental Designs* which became the major reference work on the design of experiments for statisticians for years afterwards.

EXPERIMENTAL RESEARCH AND DESIGN

Experimental Research - An attempt by the researcher to maintain control over all factors that may affect the result of an experiment. In doing this, the researcher attempts to determine or predict what may occur.

Experimental Design – Experimental Design is the blueprint of the procedure that enables the researcher to test his hypothesis by reaching valid conclusions about relationships between independent and dependent variables. It refers to the conceptual framework within which the experiment is conducted.

Experimental Design (scientific method)
- Purpose
- Research
- Hypothesis
- Experiment
  - Gather materials
  - Set a control group for comparison
  - Identify independent and dependent variables
  - Conduct experiment
  - Make observations and measurements
  - Collect data
- Analysis
- Conclusion
  - Accept or reject hypothesis
  - Describe event or change
  - Communicate results

(Please Return Homework Essays After Class)
Basic Experimental Design Vocabulary

Qualitative Research- Research or experiment that measures the quality of something; Observations are collected and described.

Quantitative Research- Quantitative research or experiment that measures the quantity of something; Observations are collected and measured.

Constant- Constants are things that do not change in the experiment; In order for the experiment to be valid, only one independent variable should be applied at a time. All other elements should remain constant.

Variable- Something that changes in the experiment

Independent Variable- The variable the scientist is changing. It is the variable that is being manipulated in order to measure its affect on an outcome. (Hint- Something that “I” change).

Dependent Variable- The dependent variable is the variable that the scientist is measuring or observing. This variable is dependent on the independent variable. (Hint- It is dependent on what was changed.).

Control Group- The group that does not receive the test. It is kept in its natural state to use for comparison.

Test Group- The group that receives the test. The independent variable is applied to this group and dependent variables are measured to accept or reject hypothesis.

Bias- When results are skewed or manipulated in order to prove what you want to be proved. i.e., paying test subjects, taste test between Coke and Pepsi and only using Pepsi drinkers as the subjects.

Reliable- All experiments should be reliable. The test should be able to be repeated several times with similar or the same results.

Valid- Measurement of the quality of the experiment; If the experiment is valid then it should be without error.

Model- A scaled representation of something that may be unsafe, too large, or too small to observe or test in its natural state (i.e., the solar system, cell, etc.) Models can be used for experimental design.

Hypothesis- is a suggested explanation of a phenomenon. It is an educational guess or intelligent prediction based on previously established information. For most competitions, the hypothesis statement should be in the format of “If…, then…, because…”

Accept or Reject Hypothesis- This is a description and rationale to support or not support your original hypothesis.

Communicating Results- Standard ways of communicating scientific results in public schools comes in the form of observation journals, science log books, research presentation, and science fair exhibits. Please check the rules and regulations of your science fair competition for specific
Title: Spinning Coins

Problem: How does the mass of a coin placed in a clear balloon affect the spinning time?

Purpose is to figure out how the mass of an object affects the time it spins once centripetal force is present. This has application to space and the motion of objects in space.

Research: Each student needs to complete one page, written in their own words in paragraph format on a separate sheet of paper.

Hypothesis: If different coins are placed inside of a balloon and spun, then the ________ will spin the longest because

Variables:
- Independent:
- Dependent:
- Constants:
  - same
  - same
  - same

Experiment:--List Procedure Steps:
1. Gather the following materials: a penny, a nickel, a dime, a quarter, clear balloons, a stopwatch.
2. Squeeze a penny through the mouth of a clear balloon. Make sure the penny goes into the balloon so there will be no danger while blowing up the balloon.
3. Blow up the balloon and tie off the end.
4. Grip the balloon at the stem end and swirl it around in a circular motion. The neck of the balloon will be in your palm and your fingers and thumb will extend down the sides of the balloon. While holding the balloon, palm down, swirl it in a circular motion. The penny may bounce around at first, but it will soon begin to roll around the inside of the balloon.
5. Once the coin begins spinning, use your other hand to stabilize the balloon and stop making a circular motion. Start the stopwatch as soon as the circular motion is stopped.
6. Record how long the penny spins.
7. Repeat steps 4-6 two more times for the penny and find an average.
8.
--Data Table/Observations:

Analysis:

Conclusion:
Research:

From Steve Spangler Science

Spinning Penny experiment:
Squeeze a penny through the mouth of one of our clear balloons. Make sure that the penny goes all the way into the balloon so that there is no danger of it being sucked out while blowing up the balloon. Blow up the balloon. When properly inflated, the balloon will be almost clear in the middle and cloudy at area near the neck and at the end opposite the neck. The cloudiness at the ends is unstretched latex, which provides stress relief. If the balloon is completely clear, all over, it is over inflated. Tie off the balloon and you’re ready to go. Grip the balloon at the stem end as you would a bowling ball. The neck of the balloon will be in your palm and your fingers and thumb will extend down the sides of the balloon. While holding the balloon, palm down, swirl it in a circular motion. The penny may bounce around at first, but it will soon begin to roll around the inside of the balloon. The best orbit or path for the coin is one parallel to the floor. Once the coin begins spinning, use your other hand to stabilize the balloon. Your penny should continue to spin for 30 seconds or more.

How this Works:
Centripetal force is the inward force on a body that causes it to move in a circular path. The old concept of the “centrifugal force” (an outward or center fleeing force) has been largely replaced by a more modernistic understanding of “centripetal force” (an inward or center seeking force). When we attach a ball to a string and swing it in a circular path, we feel the forces of the ball pulling on the string, and that of the string pulling on our hand. That effect is probably responsible for the misconception of a centrifugal, or center fleeing force. The hex nut circles inside the balloon due to centripetal force. What makes this experiment different from the previous one with the spinning penny is the shape of the hex nut. A hex nut has six sides, and these flat edges cause the hex nut to bounce or vibrate inside the balloon. The screaming sound is made by the sides of the hex nut vibrating against the inside wall of the balloon.

Conceptual - Difference between Centrifugal Force and Centripetal force

The centripetal force is the external force required to make a body follow a curved path. Hence centripetal force is a force requirement, not a particular kind of force, like gravity or electromagnetic force. Newton's description is found in the Principia. Any force (gravitational, electromagnetic, etc.) (or combination of forces) can act to provide a centripetal force.

Centripetal force is directed inward; toward the center of curvature of the path

Centripetal force should not be confused with centrifugal force. Centripetal force is a kinematic force requirement deduced from an observed trajectory, not a kinetic force like gravity or electrical forces. Centripetal force requirements may be deduced from a trajectory in any frame of reference (although the trajectory of an object and the deduced centripetal force will vary from one
frame to another). Because centripetal force is a kinematic force requirement inferred from an established trajectory, it is not used to deduce a trajectory from a physical situation, and centripetal force is not included in the inventory of forces that are used in applying Newton's laws $F = ma$ to calculate a trajectory.

Centrifugal force, on the other hand, is treated in a rotating frame as a kinetic force, that is, as part of the inventory of forces used in Newton's laws to predict motion. Centrifugal force is a fictitious force, however, that arises only when motion is described or experienced in a rotating reference frame, and it does not exist in an inertial frame of reference. In classical mechanics, centrifugal force (from Latin centrum "center" and fugere "to flee") is an apparent force acting outward from the axis of a rotating reference frame. Centrifugal force is a fictitious force (also known as a pseudo force, inertial force or d'Alembert force) meaning that it is an artifact of acceleration of a reference frame. Unlike real forces such as gravitational or electromagnetic forces, fictitious forces do not originate from physical interactions between objects, and they do not appear in Newton's laws of motion for an inertial frame of reference; in an inertial frame, the motion of an object is explained by the real impressed forces. In a non-inertial frame, however, fictitious forces must be included along with the real forces in order to make accurate physical predictions. The fictitious forces present in a rotating reference frame with a uniform angular velocity are the centrifugal force and the Coriolis force, to which is added the Euler force when angular velocity is time dependent.

The centrifugal and Coriolis forces are called fictitious because they do not appear in an inertial frame of reference. Despite the name, fictitious forces are experienced as very real to those actually in a non-inertial frame. Fictitious forces also provide a convenient way to discuss dynamics within rotating environments, and can simplify explanations and mathematics.

An interesting exploration of the reality of centrifugal force is provided by artificial gravity introduced into a space station by rotation. Such a form of gravity does have things in common with ordinary gravity. For example, playing catch, the ball must be thrown upward to counteract "gravity". Cream will rise to the top of milk (if it is not homogenized). There are differences from ordinary gravity: one is the rapid change in "gravity" with distance from the center of rotation, which would be very noticeable unless the space station was very large. More disconcerting is the associated Coriolis force. These differences between artificial and real gravity can affect human health, and are a subject of study. In any event, the "fictitious" forces in this habitat would seem perfectly real to those living in the station. Although they could readily do experiments that would reveal the space station was rotating, inhabitants would find description of daily life remained more natural in terms of fictitious forces.