How can I tell if students are working like a scientist?

Richard Feynman quote;

"It doesn't matter how beautiful your theory is, it doesn't matter how smart you are. If it doesn't agree with experiment, it's wrong."

Strategies scientists use when working;

> "Research has shown that science teaching is dominated by fair testing. The principles of fair testing are important, but may not always enable students to understand ideas or concepts, answer their questions, or understand how scientists work and the nature of science."
>
> http://scienceonline.tki.org.nz/Teaching-science/Teaching-Strategies/Types-of-investigation

Notes of Caution:

1. In industry and research, the **majority** of work carried by scientists is done using strategies **other than** the 'scientific method' or fair testing.
2. The TKI website refers to "researching" in a specific way. Researching something is not about reading books or looking up articles on the internet. In industry and research scientists often carry out research using more than one of the strategies below. Research is an **umbrella term** to encompass any and all of the strategies listed below but can include reading background information.
3. Models **do not** have to be physical objects such as a plastic model eye or pull apart model heart. They can be simplified imaginings about the way a process works or imaginings about how an object is put together.
4. The TKI website **omits** the important strategy of making things or developing systems. Scientists often develop the technology they need to carry out their investigations. Early scientists had to build a microscope before they could go looking for things with it. Try not to separate technology and science unnecessarily.

Is my project a Science or Technology exhibit?

Please use the information below as well as the summary table on the following page to ensure that students are not disappointed by finding their entry has been incorrectly classified or is ineligible for judging.

	Technology		Science
Approach	Synthesis *'Connects the findings'*	The boundary is neither definite nor fixed	Analysis *'Finds the Connections'*
Process	**Design**		**Scientific strategies**
Typical Steps	Recognise a need/opportunity Define the problem Gather information Analyse information Develop a plan Design alternative prototypes Evaluate prototypes Produce a solution Evaluate responses		Question or Hypothesis Prediction Controlled experiments/observations *Or* Observations Valid data Theory or relationships identified
Main Purpose	Develop a 'solution'		Explain how the world works
Practise Yields	Products, processes, environments		Ideas & understanding
Serves	Human needs and opportunities		Truth & knowledge

Making a static display model (rather than using *modelling,* explained later) or a project that simply summarises ideas of others **does not** fall into either of the required categories and should **not** be entered into the Fair.

Scientists use many different methods when investigating some specific about the world around us. There is no single 'scientific method' but a number of different investigation strategies they use. School students often use **Fair Testing** (or consumer product testing) strategy which requires comparisons and controls to see what variables are at work or which is the 'best' product.

It is important to note that scientists also make observations and measurements using **other** strategies such as….

Observation: This strategy involves making careful observations of objects or events. Not all explorations are scientific unless carried out explicitly for scientific purposes. For example, a student could make careful observations of a leaf for an art project (not scientific) or for displaying in a classification key (scientific). Examples of a science exploration could include "How does a caterpillar develop over time?" or "What are the different parts of a bicycle?" To be considered as a science investigation data should be collected and conclusions drawn.

Pattern seeking: This strategy involves students observing natural phenomena. Because of this, students cannot manipulate or control factors easily. This method is well suited to system sciences like geology, astronomy, ecology, or meteorology. Observations are recorded that would permit trends and patterns to be seen. Once a pattern has been observed this may lead to other investigations in an effort to try to explain why a particular pattern occurs, and to a classifying and identifying system. Pattern seeking can also help us create models to explain observations, for example, to explain the phases of the Moon. Questions might include "Do people with long legs jump higher?" or "Where do we find most snails?"

Classifying and identify: This strategy involves sorting a large range of objects or events into manageable groups or categories based on observable/measureable features. Clear systems (criteria) must be developed and used. Classification keys are often used with criteria noting special features to aid the classifying process, for example, identifying and naming plants.

Modelling or making a simulation: Modelling is a simulation, or likeness, made to make sense out of an incomplete understanding of how nature works. This strategy must not be confused with "making models' as static displays, out of, say, cardboard and glue. A scientific model as a simulation could be a mathematical equation, eg, the equation for predicting how quickly a hot object cools down, or a computer programme. **However,** students could build a model out of cardboard, etc if it helps them visualise, contrast and compare the features of each model to decide which model is a 'good fit' with reality. Measurements and data collected must be used to see how closely the model (as a simulation of reality) works to the real thing, eg, a model of a new artificial heart is tested for flow rate, blood pressure, fatigue, etc.

Making things and developing systems: This strategy involves using science knowledge to develop a device or system to meet a human need. For example, you want to find a way to develop an artificial eye to detect ultra-violet or infra-red light from the sun. This type of strategy is a technological development and therefore a **technology** exhibit.

Identifying exhibits as science or technology projects.		
CIRCLE the "yes" boxes to help you decide which section your project belongs to….	**Science**	**Technology**
Is the main strategy (method) • Fair testing (consumer product testing, eg, which is the 'best'battery) • Classifying & identifying • Simulating reality (use modelling , comparing results from the model with real-world data) • Pattern seeking • Observation	Yes	
Was most of the research aimed at gathering new data in response to an observation and/or hypothesis?	Yes	
Did the gathering and processing of data ensure its validity and aim to determine its significance to causes of an effect?	Yes	
Has a theory been formulated to explain the observations?	Yes	
Is a design process the core process? (strategy of *making things & developing systems*)		Yes
Is the exhibit a response to an identified human need or opportunity for a product, process or environment?		Yes
Was some of the research aimed at confirming the validity of the original need or opportunity, and/or finding out the precise nature of the problem to which they are developing a solution?		Yes
Was much of the research aimed at guiding the development and/or improving the performance of the product, process or environment?		Yes
Does the exhibit identify as important such attributes as: efficiency, optimisation, reliability, cost-effectiveness, appropriateness of materials, ergonomics, aesthetics, etc?		Yes
Does the exhibit show that the satisfaction of the end-users of a product, process or environment was a key factor in guiding the development?		Yes
TOTALS		

The column with the most "yes" responses (within reason and as appropriate to your particular project) indicates which category your project should be exhibited under.