Ideation

Basics of Scientific Research

Ideation

Often times, how successful a research project is depends on if it started with a good idea. Simple as that sounds, coming up with a good idea is one of the hardest parts of any research project. A good idea should have these aspects:

- Strong, Real World Application
- Feasible for you to investigate
- Originality

Doesn't sound like a lot, but it is **incredibly difficult** for an idea to actually pass through all of the criteria.

Let's break it down.

Strong, Real World Application is probably one of the most difficult to meet. When you come up with an idea, ask yourself: What is the purpose of testing this idea? Will it do anything besides satisfy curiosity?

In terms of science fair, this application has to be even more direct- you have to be working to solve a problem, or improving on current technology in meaningful ways. Your application **should not be just "it will find out something"**. If your idea is to "find out something", this "something" should be of importance to a major application.

For example, in the simple idea "I would like to find out which disinfecting agent works the most effectively", by finding out which disinfecting agent is the most effective, the **application would then be** that the disinfecting agent found to most effective should be used more in order to improve public health, decrease surface contamination and reduce surface based disease transmission. **In essence, application isn't about "finding out", but why what you will find out is important.**

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A lot of the times, your idea should tie into a **common theme of application**. This is especially apparent in certain science fair categories. For example, projects in **Biochemistry, Behavorial Science, Microbiology, Medicine and Health, Biomedical Engineering** will most likely, if not definitely, tie into the application of improving human health and medicine. Projects in **Plant Science** will typically tie into increasing agricultural production or combatting environmental problems such as pollution and erosion. Projects in **Environmental Engineering, Environmental Science and Energy & Transportation** would typically tie into combatting environmental problems or suggest new environmentally friendly technologies or methods. Other categories in science fair often tie into these categories as well, as their categories are less defined by application, but more so by discipline. **Often times these categories' projects also tie into the applications above.**

Next, your project should be **feasible for you to do.** Realistically, you are not going to be able to access the James Webb Telescope to discover new planets and stars, or use the Gravitational Wave Detector to detect the emission of gravitational waves from the collapse of neutron stars. You are not likely going to be able to work in person with pathogenic (harmful) diseases, as most laboratories **do not allow students under 18** to work with anything more dangerous than **Biosafety Level 1.**

Before starting a project, it is best to have a good idea of the materials and resources that will be needed to conduct the research and where you can acquire those materials and resources. **This is not a place to say "I will figure that out later"**. Chances are you will find a material/resource problem you won't be able to overcome, and all the previous work will be **wasted.**

Finally, this study should be **ORIGINAL.** Look up the topic or problem you are investigating, and see if it has been done or solved before. **If it has been done or solved before, or within a google search away, it is not worth doing unless you can think of how to improve on the current solution in a meaningful way.**

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Let's do a little activity. Which one of these is the best idea?

Case 1: Create a non-Newtonian gel that is extremely malleable and fun to play with.

Case 2: Grow duckweed in different conditions to increase starch production, which can be used as a biofuel.

Case 3: Identify which kind of commercial disinfectant kills bacteria the best.

Case 4: Engineer an ion engine that ionizes radon to generate thrust, which can create faster ion engine spacecraft.

Case 5: Create a software that can predict the structure of cancer causing proteins accurately in order to enable drug design targeting these proteins.

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The answer is Case 2. It checks all the boxes: Students **can grow duckweed**, can introduce it to different growing conditions or add certain chemicals to induce growth, and the **application of biofuel/renewable energy is very useful for the real world**. **The idea is also original**, depending on the originality of various conditions you introduce to the duckweed.

Case 1 checks the box for feasible for you to do, but that is about as far as it goes. Super malleable non-Newtonian gel already exists, and is called Oobleck. Thus it is **not original**. The application of "fun to play with" does not solve any significant problems or any economic, environmental or health related benefits, and thus **does not check the box for Strong, Real World Application either.**

Case 3 is a little tricky. Knowing what commercial disinfectant kills bacteria sounds like a very sound application, and it is definitely within the realm of feasibility, using a simple petri dish test. **However, it is not original.** Case 3 is a project that is commonly seen at science fairs, and a little literature review would reveal that commercial disinfectants all act similarly against the bacteria strains accessible to middle schoolers and high schoolers.

Case 4 checks the boxes for originality and real world application; radon ion thrusters indeed have not been developed, and faster ion engines would be beneficial and applicable to the future of human spacetravel. Yet this project is **wildly infeasible.** Radon is a radioactive element, and ion engines are extremely advanced and expensive machines **completely inaccessible to 99.9% of high schoolers**, and even if you somehow had access, it is **beyond the safety guidelines for science fair**.

Case 5 checks the box for application: its application is very sound and applicable to medicine and health. That is where the good about the idea stops, however. Literature review would reveal that this idea **not original**, and is at the forefront of computational biology, and programs such as AlphaFold2 already predict protein structures to maximum accuracy that current technology allows. **Chances are, you do not have the resources or technical knowhow to do better than the researchers that have spent millions of dollars in grant money and years working** on AlphaFold.

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It seems that we have spent a lot of time talking about what your idea should and shouldn't have. **But how do you come up with it?**

The common method teachers tell students when they try to come up with science fair ideas, is to simply broadly read scientific articles and news on the fields of their interest. It is a way to start, but in my opinion, it is too inefficient and often does not yield fruit.

It is best to **have an idea of what you want to achieve** before beginning the process of reading, which is called **Literature Review.** What do I mean? Think back to when I mentioned the main categories of applications. Which one of those interests you?

Would you like to improve public health and medicine? Then you can look into things such as:

- Modeling of disease spread and pandemics
- Drug design
- Disease diagnostics
- Disease treatment
- Mental disorder/illness treatment

Would you like to solve environmental problems? Then you can look into things such as:

- Water and air filtration
- Combatting pollution
- Renewable energy sources
- Bioremediation
- Biodegradable and reusable materials development
- Food production
- Clean technology

Engineering and computer science are categories in science fair, but are both often tools to finding solutions to problems, not the application themselves. If you can identify the problem you are trying to solve or know the product you are trying to develop, then look into how to apply engineering or computer science aspects to solve the problem or engineer the product.