SCIENCE FAIR PROJECT TO IMPROVE 21ST CENTURY COMPETENCE

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Abstract: The 21st century is characterized by the availability of abundant information, advanced technology, a rapidly changing society, greater convenience in daily lives, and keener international competition. In response to these change, innovation in education is no longer simply encouraged; it has to become an imperative because school are at the front line of this change and need to think about how they can prepare young people for the future workplace. The science fair project is a long-term project where you will plan, conduct, and share results from your own independent investigation. Science Fairs offer students the opportunity to create original scientific research, innovative projects and develop 21st Century learning skills; critical and creative thinking, collaboration and communication The project includes complete the pre-planning steps, conducting a science experiment, recording your data, analyzing your data, and creating a tri-fold poster to share your project. By means of literature study, it obtains the result that the steps done by the students in science fair project are able to improve the ability of 21st century elementary school students.

Keywords: Science Fair Project, 21St Century Competence

1. Introduction

The 21st century is characterized by the availability of abundant information, advanced technology, a rapidly changing society, greater convenience in daily lives, and keener international competition. In response to these change, innovation in education is no longer simply encouraged; it has to become an imperative because school are at the front line of this change and need to think about how they can prepare young people for the future workplace (Trilling and Fadel, 2009).

Why students need 21st century skills? There are compelling economic and civic reasons for education systems to develop students' 21st century skills. The economic rationale is that computers and machines can cost-effectively do the sorts of jobs that people with only routine knowledge and skills can do, which means the workplace needs fewer people with only basic skill sets and more people with higher-order thinking skills (Saaveda, 2012). Further, there is also a globalization encompasses for schools to increase their focus on developing students' 21st century skills. Massive global migration, the internet, long-haul flights, interdependent international markets, climate instability, international wars, and other factors remind us daily that countries, states, and individuals are part of a globally interconnected economy, ecosystem, and political network and that people are part of the human race. This interconnectedness makes it even more urgent for students around the world to learn how to communicate, collaborate, and problem-solve with people beyond national boundaries (Saaveda, 2012).

21st century competence framework states that by only having the knowledge of major subject is not enough, but must be equipped by ability; 1) innovation and creativity, 2) critical thinking, 3) communication and 4) collaboration. Transforming existing education systems is a global challenge and one that many countries are currently engages with in an effort to remain competitive. As the prime minister of Singapore stated, "we have got to teach less to our students so that they will learn more (Loong, 2009), less dependence on rate learning, repetitive tests and a 'one size fits all' type of instruction, and more on engaged learning, discovery through experimentation, differentiated teaching, the learning of life-long skills, and the building of character though innovative and effective teaching approaches and strategies (as well as) holistic learning so that students can go beyond narrowly defined academic excellence to develop the attributes, mindset, character and values for future success (Tharman, 2005). Since education standards and the purposes of education are changing, instructional methods must also change.

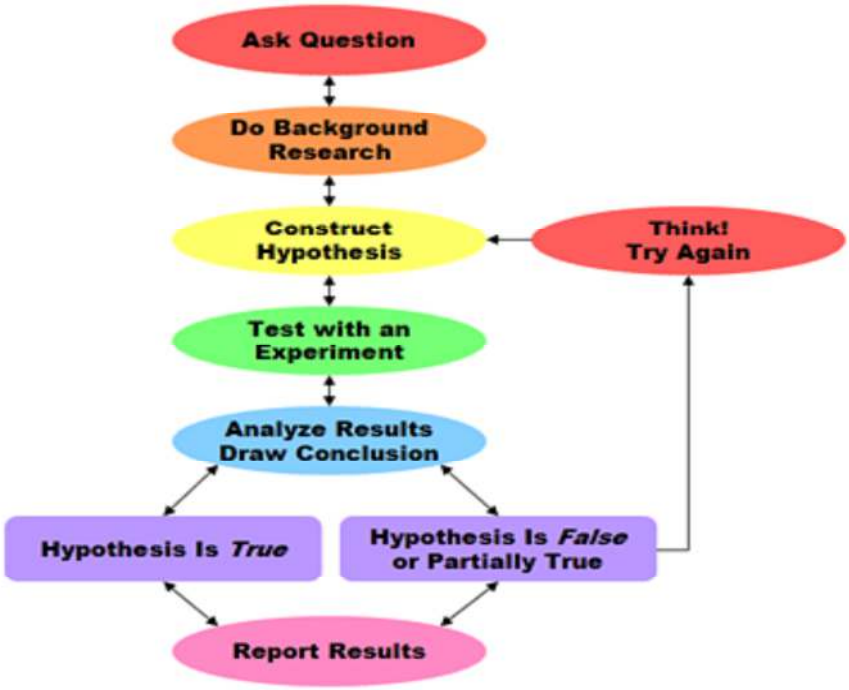
The science fair project is a long-term project where you will plan, conduct, and share results from your own independent investigation. Science Fairs offer students the opportunity to create original scientific research, innovative projects and develop 21st Century learning skills; critical and creative thinking, collaboration and communication. Projects can be displayed at various levels of competition: school, district, regional, national and international. Therefore, this research intends to know how science fair project are able to improve the ability of 21st century elementary school students.

2. Results and Discussion

a. Science Fair Project

The science fair project is a long-term project where you will plan, conduct, and share results from your own independent investigation. The project includes complete the pre-planning steps, conducting a science experiment, recording your data, analyzing your data, and creating a tri-fold poster to share your project. Science Fairs offer students the opportunity to create original scientific research, innovative projects and develop 21st Century learning skills; critical and creative thinking, collaboration and communication. There are many types of science fair projects, however most projects start with a question which can have many answers. A science fair project can be an investigation that is designed to solve a problem or answer a question. It is a science fair project because you use the Scientific Method to answer the question. The Scientific Method is a means by which you can ask and answer a scientific question by making observations and doing experiments.

Gambar 1. Steps of the Scientific Method



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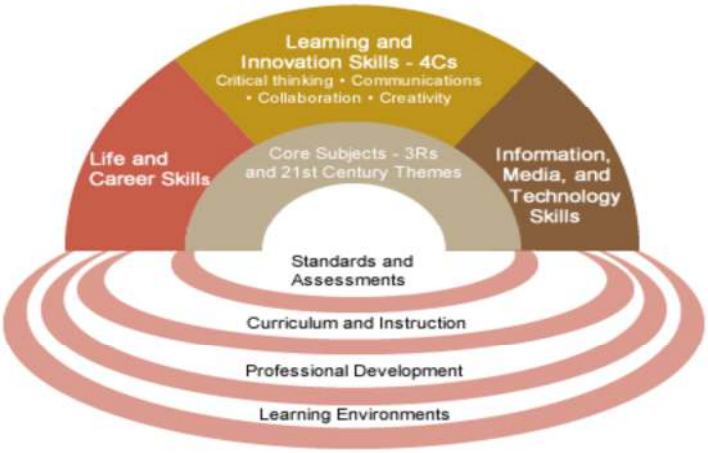
b. **21st Century Competence in Elementary School (4th – 6th Grade)**

The skills of 21st century are 1) life and career skill (flexibility and adaptability, initiative and self-direction, leadership and responsibility, productivity and accountability, social and cross-cultural skills), 2) learning and innovation skills (critical thinking and problem solving, creativity and innovation, collaboration, communication), and 3) information, media, and technology skills (information literacy, media literacy, information and communications technology (ICT) literacy) (Trilling and Fadel, 2009).. Those three skills are summarized in a scheme with each indicator called 21st century rainbow knowledge skills. The skills of 21st century should be taught since elementary school because according to Vygosky in (Yamin, 2013), a learning is effective if the learner continues the developments.



Source: Saaveda, 2012

To be able to develop 21st century competence to each student we have to know every explanation from each competence in age level and educational level. Here is the explanation about the competence of 21st century of 4th – 7th Grade of elementary school students.

Table 1. Skill Defination of Competence 21st Century at Elementary School

Competence 21st century	**Skill definition in science**	**Competence (4th – 7th grade)**
Critical Thinking and Problem Solving	Critical thinking and creative problem solving are the hallmarks of the scientific process. Students can use abilities developed in science to think logically and reasonably about concepts they are learning, and to apply them to their everyday lives. Compelling, and often complex, problems are at the root of many science investigations.	Students construct their own scientific understanding and develop their scientific process skills by asking scientific questions, designing and conducting investigations, constructing explanations from their observations, and discussing their explanations with others.
Communication	Effective communication is central to scientific research practices. Scientists describe their work so that the research can be duplicated, confirmed, and advanced by others, but also understood by public, non-technical audiences. Scientific thinking is communicated in many different ways including oral, written, mathematical, and graphical representations of ideas and observations	Students prepare and interpret a variety of methods for demonstrating understanding and explaining the results of investigations including charts and graphs, diagrams and illustrations, photographic images, and informational and procedural text.
Collaboration	Science is inherently a collaborative process with 21st Century emphases on interdisciplinary and international research, as well as increasing collaboration between "hard" science and social sciences. A trend toward greater specialization in scientific careers requires researchers to rely on the disciplinary expertise of others as collaborators in their work.	Students work collaboratively with others, both in small and large groups, in their science classroom.
Creativity and Innovation	Science is, by its nature, a creative human endeavor. Scientific and technical innovations are advanced through processes that build on previous knowledge and the application of theory to real world situations. Modern societal and environmental challenges require new and creative scientific and technical approaches, as well as investigations that are more cross-disciplinary.	Students provide concrete examples of science as a way of thinking that involves both systematic and creative processes that anyone can apply as they ask questions, solve problems, invent things, and develop ideas about the world around them.
Information Literacy	Being information literate in the context of science involves assessing the credibility, validity, and reliability of information, including its source and the	Students are able to locate reliable scientific information in reputable print and electronic resources.

	methods through which the information and related data are derived, in order to critically interpret scientific arguments and the application of science concepts.	
Media Literacy	Media interpretation of scientific information may be different from the interpretation by the scientific community of that same information. Complexities in science do not always convert well into short media messages.	Students can generate guiding questions to help them evaluate media claims based on evidence rather than simply believing the message as presented.
ICT Literacy	Increased computing capacity enables large-scale data analysis, wide-array instrumentation, remote sensing, and advanced scientific modeling. ICT innovations provide new tools for doing science including gathering and analyzing data and communicating results.	Students can give examples that demonstrate how technology extends the ability of people to observe and interact with the world including how people communicate, gain knowledge, and express ideas.
Flexibility and Adaptabilllity	Flexibility and adaptability are valued in science because evidence-based reasoning can change previously held ideas and hypotheses. Over time, changing technologies and expanding scientific understanding create new fields of interdisciplinary study and new ways of doing things.	Students can provide illustrative examples of science as an ongoing process that includes expanding, revising, and sometimes discarding theories based on new evidence, and that our understanding of a topic can change as more research is completed.
Initiative and Self-Direction	As the nature of science is to raise questions, science cultivates initiative and self-direction, and encourages lifelong learning. Curiosity motivates scientific thinkers to make careful observations and try things out as a way to seek answers to questions and to develop solutions to identified problems.	Students are able to design an investigation based on a question they have generated from their own curiosity.
Social and Cross-Cultural Skill	Social and cross-cultural skills are important to science because doing science involves many different kinds of work and engages men and women of all ages, backgrounds, and physical abilities. Science is advanced by synthesizing the different observations, perspectives, opinions, and interpretations of many individuals.	Students can describe ways that people from many cultures, backgrounds, and abilities participate in science.
Productivity and Accountability	The high ethical standards and collaborative nature of science promote expectations for accountability and productivity. Scientists use a variety of tools and instruments to enhance their ability to produce and replicate accurate data, and to meet expectations for sharing their findings with the scientific	Students identify a variety of tools and techniques that scientists use to gather scientific information depending on what it is they want to know and the circumstances under which data will be collected.

	community and general public.	
Leadership and Responsibility	Science involves a code of conduct that is openly and frequently discussed, with high standards for ethical responsibility around referencing the work of others, drawing conclusions based on evidence, recognizing the potential for bias, avoiding political and financial influence, constructing and conducting safe investigations, and appropriately applying research results and other scientific knowledge.	Students can describe how doing science carries responsibilities for assuring the safety and rights of others and can provide examples of their own responsibilities while doing science activities at school.

c. Steps of Science Fair Project to 21st Century Competence

After knowing the explanation about 21st century competence to elementary school level then the analysis result that through student activities in science fair project step can improve the ability of 21st century students drawn in the table below.

Tabel 2. Steps of the Science Fair Project Analysis

Steps of the science fair project	Students activity	Students project	Competency developed
Ask Question	The first step to completing a good science fair project is to choose a topic that interests you (elementary science fair notebook). Try to come up with your own question, answer the question: What topic do you want to learn about? Think about a question that you wonder about like "I wonder how that works?" or "I wonder what would happen if …" or "I wonder what that is?" Any of these can be the basis of your topic. Make sure your question is something that can be tested or measured and answered using the scientific method	• Science fair timeline • Science fair calendar	• Critical Thinking and Problem Solving • Creativity and Innovation • Social & Cross-Cultural Skills
Do Background Research	After you have chosen a question you need to research more about your topic (elementary science fair notebook). Come up with some questions related to your topic and search for the answers, you should research it carefully by finding out everything you can about the topic. Use reliable Internet sources, books from the library, your science book, or other resources.	• Background research plan worksheet • Bibliography information template	Information Literacy
Construct a hypothesis	Write a hypothesis that shares your reasoning, make predict the answer or outcome to the problem. Think about what was one thing being tested or changed in your experiment. A hypothesis is supposition or tentative explanation for (a group of) phenomena, (a set of) facts, or a scientific inquiry that may be tested, verified or answered by further investigation or methodological experiment (Power UP). In other words a hypothesis is an educated guess to explain an observation made, which is then explored further through experimentation. Students must state a	Hypothesis checklist	• Critical Thinking and Problem Solving • Information and Communications Technology (ICT) Literacy

	hypothesis that is easily measurable. It is not important for a hypothesis to be accurate! Make sure you can measure outcomes.		
Experiment – test your hypothesis	Now that you have a hypothesis, you need to create an experiment to test whether your hypothesis is true or false. Think about how you will conduct a fair experiment by considering the variables you will control. List your materials, including quantities. Write step-by-step procedures so that others could replicate your experiment. Run your experiment a minimum of five times, more is better. It is very important that you confirm your results. Running the experiment a number of times ensures proper results. Record the results for each trial (even if they don't go with your other results) (power up). Collecting data and observations throughout your experiment is very important and you can record everything.	Experimental procedure	• Collaboration • Critical Thinking and Problem Solving • Flexibility & Adaptability • Initiative & Self-Direction • Leadership & Responsibility
Analyze data	Once your experiment is complete, you must collect all of your results and analyze them to see if your hypothesis was true or false. In many instances your hypothesis will be false, as explained earlier this was a possibility. Do not change your data to match your hypothesis. When analyzing your data you should keep these questions in mind; 1) what can be learned from looking at this data?, 2) how does the data relate to my original hypothesis?, 3) did your independent variable cause changes in your dependent variable?	Analyze data of experimental	• Communication • Productivity & Accountability
Report results	Once data has been analyzed, it is time to summarize your results. Your final report will entail putting together the information you have collected and summarizing it into one document.	Poster science fair project	• Communication • Social & Cross-Cultural Skills

3. Conclusion

Prepare the students to have 21st century ability is very important so that the students are able to compete in global competition and millennial that is full of technology. The efforts that can be done by the teachers at developing 21st century student ability is through a learning innovation that demands the students to do activities with four principles, such as 1) instruction should be student-centered, 2) education should be collaborative, 3) learning should have context, and 4) school should be integrated with soviety. Science fair project is one of learning innovations that can improve the ability of 21st century students through the activities done inside, such as pre-planning steps, conducting a science experiment, recording your data, analyzing your data, and creating a tri-fold poster to share your project. This analysis result is only obtained through literature review, therefore it is expected that experimental research can be done in the future so that a proven result that science fair project is able to improve 21st century student ability can be obtained and can be used by the teacher as a learning innovation in 21st century education.

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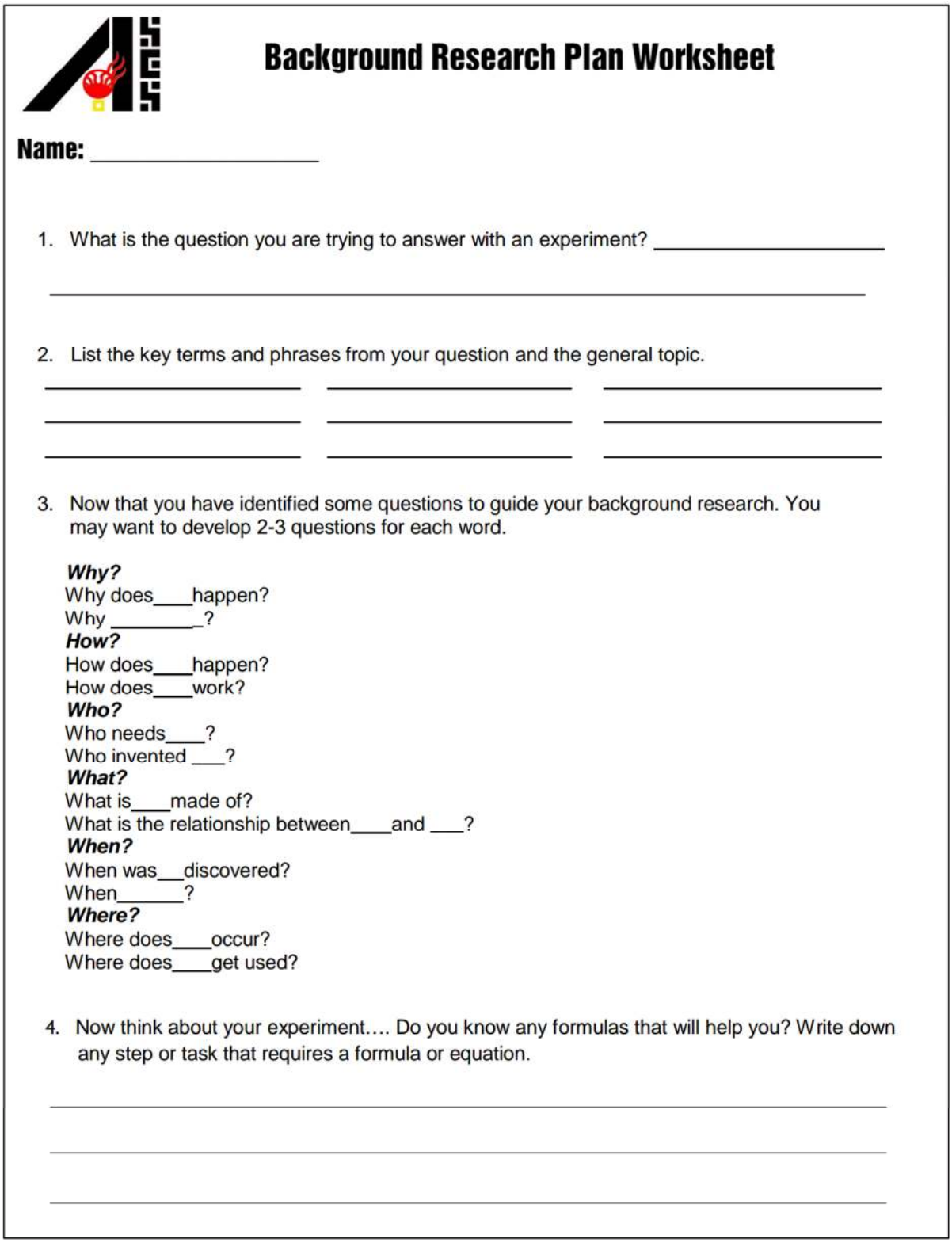
Appendix 1. Example of Background Research Plan Worksheet



Background Research Plan Worksheet

Name: _____

1. What is the question you are trying to answer with an experiment? _____

   _____

2. List the key terms and phrases from your question and the general topic.

   _____ _____ _____

   _____ _____ _____

   _____ _____ _____

3. Now that you have identified some questions to guide your background research. You may want to develop 2-3 questions for each word.

   Why?
   Why does____happen?
   Why _____?
   How?
   How does____happen?
   How does____work?
   Who?
   Who needs____?
   Who invented ___?
   What?
   What is____made of?
   What is the relationship between____and ___?
   When?
   When was___discovered?
   When_____?
   Where?
   Where does____occur?
   Where does____get used?

4. Now think about your experiment…. Do you know any formulas that will help you? Write down any step or task that requires a formula or equation.

   _____

   _____

   _____

Source: POWER UP Science Fair Manual

Appendix 2. Example of Bibliography Information Template

Bibliography Information Template

For Encyclopedias				
Article Title	**Year**	**Encyclopedia Title**	**Publisher**	**Volume/Page (s)**

For Encyclopedias With an Author					
Author (s)	**Year**	**Article Title**	**Encyclopedia Title**	**Publisher**	**Volume/Page (s)**

For Internet Sources (no author)			
Article Title	**Date (Year/Month/Day)**	**URL (Internet Site Address)**	**Access Date**

For Internet Sources With an Author				
Author	**Date (Year/Month/ Date)**	**Article Title**	**URL (Internet Site Address)**	**Access Date**

Book			
Author (s)	**Title**	**Publisher**	**Year**

For Magazines and Other Periodicals				
Author	**Date (Year/Month/ Date)**	**Article Title**	**Magazine Title**	**Vol./No./Page (s)**

Use to keep track of your references

Source: POWER UP Science Fair Manual

Appendix 3. Example of Hypothesis Checklist

What is a hypothesis?

A hypothesis is supposition or tentative explanation for (a group of) phenomena, (a set of) facts, or a scientific inquiry that may be tested, verified or answered by further investigation or methodological experiment.

In other words a hypothesis is an educated guess to explain an observation made, which is then explored further through experimentation.

Now that you have a better understanding of your topic/or question now is the time to refine your question and construct your hypothesis. (A hypothesis is an "educated guess" reported about how something works.) Specifically "If I do this____, then_____will happen."

Students must state a hypothesis that is easily measurable. It is not important for a hypothesis to be accurate! Make sure you can measure outcomes.

Your hypothesis should answer your question.

Hypothesis Checklist

Taken from 3 September 2010, http://www.sciencebuddies.org/science-fair-projects/project_hypothesis.shtml

What Makes a Good Hypothesis?	For a Good Hypothesis, You Should Answer "Yes" to Every Question
Is the hypothesis based on information contained in the Research Paper?	Yes / No
Does the hypothesis include the independent and dependent variables?	Yes / No
Have you worded the hypothesis so that it can be tested in the experiment?	Yes / No
If you are doing an engineering or programming project, have you established your design criteria?	Yes / No

Example:

Topic/Subject: Arm length and throwing distance
Specific: Is there a correlation between arm length and football throwing distance?
Hypothesis: Individuals with longer arms can throw a football further.

Source: POWER UP Science Fair Manual

Appendix 4. Example of Experimental Procedure

Example:

Problem:
Is there a correlation between arm length and football throwing distance?

Hypothesis:
Individuals with longer arms can throw a football further.

Materials:
Measuring tape
football
15-20 participants (7th grade males)

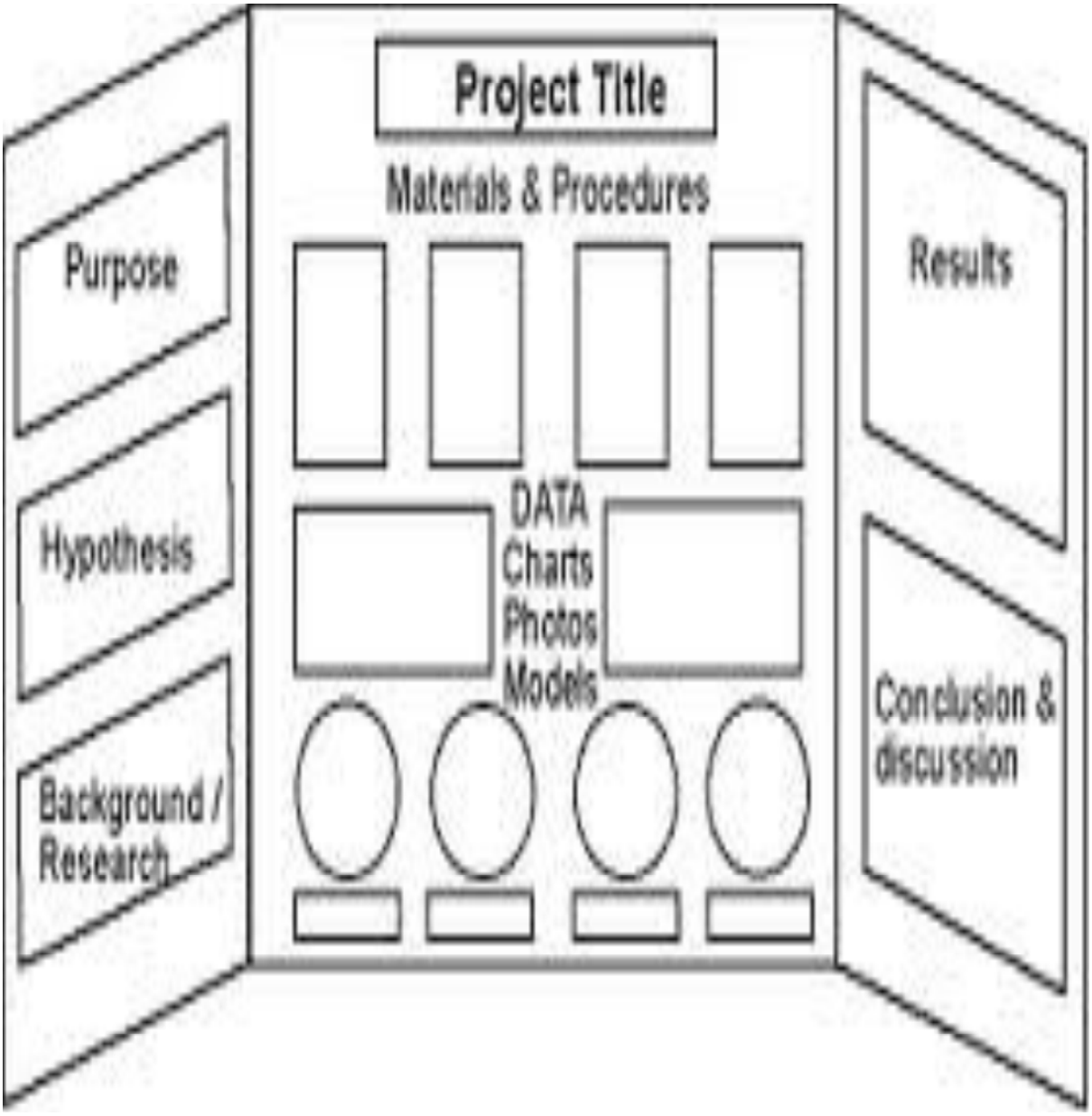
Variables:
Independent Variable – arm length
Dependent Variable – throwing distance
Control Variable- 7th grade boys, same throwing method, all testing done same time of day if need more than one day for testing

Procedures
Step 1: Measure participant's arm (total length, wrist to elbow and elbow to shoulder)
Step 2: Have participant throw football (describe throwing method)
Step 3: Measure throw distance
Step 4: Document data in table
Step 5: Repeat steps 2-4, 5 times (more is better)
Step 6: Repeat steps 1-5 for each participant

***Note*: Some experiments may require additional ISEF paperwork prior to experiment start date. Please see flow chart to see if project needs additional ISEF forms.**

Source: POWER UP Science Fair Manual

Appendix 5. Example of Poster Science Fair Project



Source: Science Fair Project Pocket