San José State University Writing Center
www.sjsu.edu/writingcenter
Written by Jane Juan

Research Papers in the Sciences (Undergraduate)

Scientific research is shared through scientific research papers. It's considered part of the duty of the scientist to share information with the scientific community. There are three important things to keep in mind when writing a scientific research paper as an undergraduate researcher. First, the paper should be written understandably for an audience that may know nothing about the research. Second, the paper should be written in enough detail so that the experiment can be replicated to show the legitimacy of the findings. Finally, it's important to know what else is being discussed on your topic in the scientific community and to then write your own paper within that context. This last part is crucial because conveying how your research builds on and affects other research—why your research is important—is the primary goal.

Main Sections

At minimum, the scientific research paper should be split into titled sections based on the following components. (Please note that although citations aren't addressed and aren't in the examples because the focus of this handout is the content, citations should be used throughout the paper for any ideas that are not your own.)

Abstract

Abstracts are used to quickly convey to the reader what your paper is about so that they can decide if the topic is relevant to their interests. It's a 150- to 250-word paragraph that should summarize your introduction, materials and methods, results, and conclusions. Note that the example below is a full example while the other examples in this handout are all abridged; in a real scientific research paper, the level of detail in the abstract should be less than the level of detail in any of the other sections (as abstracts should be brief).

Abstract Example

Copper is used in many industries, from wiring to coinage to cookware, which is why it is essential to assure its structural integrity and safety when it comes to its usage. Specifically, oxidized copper is a concern as its oxidation leads to changes in properties. Oxidized copper isn't conductive and doesn't solder well. One method to address this issue is to remove the oxidized copper. As vinegar is known to remove rust from iron, there seemed to be a possibility that it could be used to remove oxidized copper as well. In addition, as vinegar, 5% acetic acid, is also a cost-efficient and safe solution, it was chosen for this experiment. A copper penny with an oxidized layer was put in vinegar for one hour, and once it was removed, the oxidized layer was gone. A control was done where a corresponding penny was placed in deionized water for an hour; no visible changes were noted. Therefore, it was concluded that the removal of the oxidized layer of copper was likely due to the acetic acid in vinegar. A possible future experiment would be to test what percentage of acetic acid is required to remove the oxidized layer from copper.

Introduction

The introduction explains to the reader the context of the experiment and the basic goals, methods, and results. Context is needed to explain the overall goal and to give necessary background information: the topic, the relevant existing research done on the topic, and the connection the experiment has with past research (i.e., how the research is unique and important). In addition, the introduction should explain what hypothesis the experiment was intended to prove, what general method was used, and what the expected results were. It should provide a brief overview of the rest of the paper.

Abridged Introduction Example

Copper can be oxidized, meaning copper atoms react with the oxygen in air and form copper oxide. This leads to a change in properties, which can affect the structural integrity and safety of items that are made out of copper. A safe and inexpensive method that was hypothesized to solve this issue was soaking oxidized copper in vinegar, 5% acetic acid, since vinegar is already known to remove rust from iron. The experiment tested whether acetic acid could remove an oxidized layer from copper.

Materials and Methods

The material and methods section explains how the experiment was done. This section should be written following the order of the steps of the experiment. It should be written like a narrative that excludes personal mentions; both the researchers involved and the writer of the paper should not be explicitly mentioned.

When choosing which details to include, a few questions can be asked:

- If this factor was changed, would it affect the experiment? If not, then that factor doesn't need to be mentioned.
- Is this a value that was measured in the experiment (i.e., temperature, mass, volume)? If it is, then it should be included in this section of the paper.

The rationale for the steps of your experiment should be explained.

Abridged Materials and Methods Example

A solid copper penny was placed in enough 5% acetic acid vinegar to cover the entire coin for an hour to ensure all the oxidized portions were in contact with the acid. The penny was rinsed with deionized water and dried to clean off any loose but lingering oxidized copper. As a control, a solid copper penny with an oxidized layer was placed in enough deionized water to cover the entire coin for an hour. It was then rinsed and dried as well.

It can be noted that the container did not matter and so was not mentioned. Similarly, the exact amount of vinegar did not matter in this situation and so was not mentioned. However, some necessary details had to be mentioned: the penny was solid copper, and the vinegar was 5%

acetic acid. These details are important as the amount of acetic acid needed and the type of metal used all have an effect on the results of the experiment.

Keep the following general rules in mind when writing the materials and methods section:

- It should be written in past tense because the actual events (conducting the experiment) happened in the past.
- This section should be detailed enough to allow the reader to create their own procedure and duplicate the experiment.
- This section isn't intended to be a set of instructions but an explanation of how the experiment was done.
- Procedures borrowed from another source can be cited and don't need to be rewritten unless they were changed.
- Potential sources of error due to minor mistakes should not be mentioned here but should be included in the discussion and conclusion.
- The results shouldn't be directly stated in here. If necessary, mention that the results were recorded, but the actual data should be saved for the results section.

Results

Here, the results of the experiment should be stated objectively; there should be no interpretations of the data. When choosing what to include, ask whether the statement is a fact or whether the statement is debatable. To help explain the data, it's important to use charts, figures, diagrams, and tables. (These all have specific rules for their titles, captions, and in-text references. One good way to ensure those rules are followed is to look at a published article that is in the same formatting style as your paper.)

Abridged Results Example

The solid copper penny placed in the 5% acetic acid vinegar had no visible oxidized copper on it after the experiment. The solid copper penny placed in the deionized water had no visible change in the amount of oxidized copper after the experiment.

When writing the results section, keep the following details in mind:

- Facts can include trends.
    - *Example*: As the concentration of reactants increased, there was an increase in product concentration.
- Material that's appropriate for the conclusion shouldn't be included.
    - *Example*: The increase in product concentration is due to the increase in reactant concentration.
        - This statement discusses cause and effect, so it should be included in the discussion and conclusion section.

Discussion and Conclusion

The discussion and conclusion section is where the data is interpreted. These two sections can be merged together or stand separately. For the discussion, it should be stated whether the data

supports the hypothesis, and any areas where the data is not as expected should be noted. Any sources of error that may have affected the data should be mentioned as well. The conclusions drawn from the data should be stated. There may be multiple interpretations of your data; it's important to mention all the possibilities and any caveats to your interpretations. It's crucial to remain as honest and objective as possible. For the conclusion, the conclusions and data should be restated and connected to other research in the same field. The significance and possible future application of your results and conclusions should be mentioned as well.

Abridged Discussion and Conclusion Example

The 5% of acetic acid vinegar removed the oxidized layer from the solid copper penny. As vinegar is 95% water and 5% acetic acid, and water did not remove the oxidized layer from the solid copper penny, the 5% of acetic acid is most likely what removed the oxidized layer from the solid copper pennies. Using vinegar could be a possible solution to oxidized copper, keeping items made from copper safe to use. To further test the extent of the effects of acetic acid on oxidized copper, different concentrations could be tested to see whether a higher percentage of acetic acid could have any negative effects on copper. Different lengths of time could also be tested to see whether having the copper in acetic acid could have any negative effects.

The Writing Style

The writing in scientific research papers should be formal and objective. This is important in order to sound credible. Writing formally means avoiding slang and colloquialisms. Writing objectively means avoiding both writing opinions and mentioning the researchers.

The purpose of removing any mention of the researchers is to emphasize the objectivity of the experiment. Adding 'you' or 'I' or 'he/she' (when he or she is not being used for a subject but for a researcher) implies that the person who conducted the experiment is one of the reasons for the end results. Since an experiment is only considered valid if it is reproducible by anyone following the same method, this would undercut the validity of the experiment.

Using third person and avoiding any mention of the researchers are traditionally accepted in the scientific community. However, first person is generally easier to understand, so it is slowly becoming more acceptable. In the end, it's more important to know what will be considered acceptable by who is directly reviewing your paper (your audience).

Point of View

First person is when the narrator writes from their own perspective; second person is when the narrator writes from the audience's perspective, and third person is when the narrator writes from other people's perspectives. First person and second person language should be avoided in any portion of the essay. Third person language should be used, but whether it should be used implicitly or explicitly varies. When subjects in the experiment are being discussed, third person language should be used explicitly. When the experiment's researchers are being discussed, the sentence structure should be rearranged to avoid any explicit mentions. (This idea will be further expanded upon in the passive voice and active voice section below.)

Point of View Vocabulary

First person: I, me, my, we, us, our
Second person: you, your
Third person: he, she, they, them, him, her, their, his, people's names, people's titles

Passive Voice and Active Voice

The general rule is that the researchers should not be mentioned in a scientific research paper. If active voice can be used without mentioning the researchers, then it may be used and is preferred.

Situation 1

Active: The hatchlings did not consume the food.
Passive: The food was not consumed by the hatchlings.

Here, active voice is preferred as it is clearer, and the researchers are not mentioned.
Note that the researchers are implied in both scenarios.

"*The researchers saw that* the hatchlings did not consume the food."
"*The researchers saw that* the food was not consumed by the hatchlings."
The focus of both sentences was switched from the researchers to the hatchlings.

Situation 2

Active: The researchers poured the acid into the water.
Passive: Acid was poured into the water.

Here, passive voice is preferred because it does not mention the researchers.
Note that the researchers are implied in the passive voice statement.

"Acid was poured into the water *by the researchers.*"

Changing the sentence to passive voice in this situation allows any explicit mention of the researchers to be removed.

Activity

This activity is designed to offer practice with writing in a formal, objective way and identifying what kind of information should be included in which sections. An actual research paper should contain a great deal more detail that is true to the complexity of the field and your research. For this activity, write an abridged abstract, introduction, methods and materials, and discussion and conclusion based on the given information:

You wondered if air has a weight since it doesn't feel like it weighs anything. You believed this was an important question since air is nearly everywhere, and so it should play a role wherever it is. You hypothesized that air doesn't have a weight and decided to get a balloon because it can hold varying amounts of air. You get a pack of balloons designed to be filled with water. You weighed a balloon to be 2.1 ounces when it wasn't blown up. You blew up the balloon with a bike pump but accidentally popped it. You weighed another deflated balloon from the same pack, and it was 1.9 ounces. You blew that balloon up with a bike pump. You tied the balloon and then weighed the balloon. It was 2.0 ounces. For your control, you weighed and blew up another balloon with a bike pump and then tied it. You untied it and let it deflate before you weighed it again. It originally weighed 1.9 ounces and weighed 1.9 ounces the second time. You believe this now means that air does have a weight to it. You believe it is possible to expand on your experiment by testing different kinds of air, such as hot air and cold air.

Sample Answers for Activity

- Abstract
    - Air may have a weight to it, and if so, that weight should have an effect anywhere that air is. To test that hypothesis, a balloon was filled up with air and weighed before and after. The weighed balloon was found to be heavier, and it was concluded that air does have weight. It should be questioned what effects the weight of air can have.
- Introduction
    - Air doesn't seem to have a weight to it. However, if it does, then that factor may need to be considered in experiments. An experiment was conducted to test whether air has weight. It was found that air does have weight.
- Methods and Materials
    - In the experiment, a balloon was weighed and then blown up with a bike pump. It was tied and then weighed with the air inside. In the control, a balloon was weighed and then blown up with a bike pump. It was tied and then untied and then weighed after it was deflated.
- Results
    - There was a .1 ounce increase in the weight of a balloon when air was added in it.
    - There was no increase in weight of a balloon after it was blown up and then deflated.
- Discussion and conclusion
    - As there was an increase in the weight of a balloon when it had air inside of it and as blowing up the balloon did not affect the weight of the balloon, it is likely that air is what caused the increase in weight of the balloon. This means that air does have weight, and the weight of air may be a factor in experiments. Experiments that have involved air should possibly reevaluated with this in mind. A possible future experiment to build on this one is blowing up a balloon with cold air or hot air.

This is just a possible response. Try identifying what content this response does or doesn't have compared to your response. Try checking whether you used any slang or colloquialisms as well.

References

The University of Waikato. “Writing a Scientific Report.” *The Library: University of Waikato.* N.p., n.d. Web. 23 Sep. 2019.

Turbek, Sheela P. et al. “Scientific Writing Made Easy: A Step-by-Step Guide to Undergraduate Writing in the Biological Sciences.” *The Ecological Society of America.* John Wiley & Sons, Ltd. 3 Oct. 2016. Web. 23 Sep. 2019.

University of North Carolina. “Scientific Reports.” *The Writing Center.* N.p., n.d. Web. 23 Sep. 2019.