Requirements for Grades 9-12 Project Submission

PART 1 SLIDES

Summary

Your project will contain the following:

- Maximum of 12 8.5x11 slides (plus possible appendix slides noted below) in PDF Form. No images of trifold boards.
- A separate one page Quad chart in PDF form

Optional: A maximum 2 minute video in MP4 format but only if you need to demonstrate a moving object in your project.

You may prepare your Project Presentation using any software tools that you desire, but the final document submitted for display to the judges and the public must satisfy the following requirements.

1. Project Slides Format Requirements

1. Your project must be a single PDF document. (Quad chart is a separate pdf document. See Part 2 below.
    a. Limited to 12 pages except one additional appendix slide for each of the following if applicable. Instructions for these appendix items are included below in Part 3.
        i. Defense of Statistical Procedures used
        ii. Presentation of validation of machine learning code
        iii. Explanation of how you controlled PCR (Polymerase Chain Reaction) processes
2. You must use a page size no larger than 8½"X11"
3. The pages must be created in Landscape mode.
4. Your PDF document must:
    a. Have no animation or active hyperlinks.
    b. Have no instructions to open in "full screen mode." Eliminating this mode automatically precludes page transitions and embedded videos or animations,
5. The page background color must be a light color and not affect readability. Text color must be predominantly dark to support readability.
6. The smallest allowable font size of body text is 14 pt. and an 18 pt. font is recommended. *Exception:* You may use a smaller font size, down to 10 pt., for figure captions or photo credits.

2. Format Guidelines:

1. Do not use non-standard fonts or colors to “stand out from the crowd” or to be entertaining.
    a Use Arial, Calibri, Helvetica or Century Gothic.
    b If you cannot use these fonts, please contact us at scifairdir@plu.edu.
2. Page titles should all be the same size and larger than the text font Titles may be bold.
3. **Avoid long expository paragraphs and sentences. State your points succinctly.**
4. Use bullets or numbers to set out individual points of interest.

Science Project

These slides are required. The additional 5 slides are up to the student.

1. **Project ID and Title**
    a. The following should be included:
        i. Project ID. This ID will be provided by South Sound.
        ii. Project Title
        iii. Finalist Name (s)
        iv. School(s)
2. **INTRODUCTION - What is your research question?**
    a. Explain what is known or has already been done in your research area. Include a brief review of relevant literature. If this is a continuation project, a brief summary of your prior research is appropriate here. Be sure to distinguish your previous work from this year’s project.
    b. What were you trying to find out? Include a description of your purpose, your research question, and/or your hypothesis.

3. **METHODS - Explain your methodology and procedures for carrying out your project in detail.**
    a. What did you do? What data did you collect and how did you collect that data? Discuss your control group and the variables you tested.
    b. DO NOT include a list of materials.

4. **RESULTS - What were the result(s) of your project?**
    a. Include tables and figures which illustrate your data.

b. Include relevant statistical analysis of the data.

5. **DISCUSSION - What is your interpretation of these results?**
    a. What do these results mean? Compare your results with theories, published data, commonly held beliefs, and expected results.
    b. Discuss possible errors. Did any questions or problems arise that you were not expecting? How did the data vary between repeated observations of similar events? How were results affected by uncontrolled events?

6. **CONCLUSIONS - What conclusions did you reach?**
    a. What do these results mean in the context of the literature review and other work being done in your research area? How do the results address your research question? Do your results support your hypothesis?
    b. What application(s) do you see for your work?

7. **SAFETY – Does your project involve safety issues?**
    a. If so, please tell us what they are and what you did to avoid problems.
    b. If you do not have room in your 12 slides, you may put safety on an additional slide.

8. **REFERENCES**
    This section should not exceed one page. Limit your list to the most important references.

JOURNALS - Please see journal submission requirements.

Follow the Journal button at the bottom of our website home page.
https://www.plu.edu/scifair/

Engineering Project

These slides are required. The additional 5 slides are up to the student.

1. **Project ID and Title**
    a. The following should be included:
        i. Project ID. This ID will be provided by South Sound.
        ii. Project Title
        iii. Finalist Name (s)
        iv. School(s)
2. **INTRODUCTION - What is your engineering problem and goal?**
    a. What problem were you trying to solve? Include a description of your engineering goal.

b. Explain what is known or has already been done to solve this problem, including work on which you may build. You may include a brief review of relevant literature.
c. If this is a continuation project, a brief summary of your prior work is appropriate here. Be sure to distinguish your previous work from this year's project.

3. **METHODS - Explain your methods and procedures for building your design.**
   a. What did you do? How did you design and produce your prototype? If there is a physical prototype, you may want to include pictures or designs of the prototype.
   b. If you tested the prototype, what were your testing procedures? What data did you collect and how did you collect that data?
   c. DO NOT include a separate list of materials.

4. **RESULTS - What were the result(s) of your project?**
   a. How did your prototype meet your engineering goal?
   b. If you tested the prototype, provide a summary of testing data tables and figures that illustrate your results.
   c. Include relevant statistical analysis of the data.

5. **DISCUSSION - What is your interpretation of these results?**
   a. What do these results mean? You may compare your results with theories, published data, commonly held beliefs, and/or expected results.
   b. Did any questions or problems arise that you were not expecting? Were these problems caused by uncontrolled events? How did you address these?
   c. How is your prototype an improvement or advancement over what is currently available?

6. **CONCLUSIONS - What conclusions did you reach?**
   a. Did your project turn out as you expected?
   b. What application(s) do you see for your work?

7. **SAFETY – Does your project involve safety issues?**
   a. If so, please tell us what they are and what you did to avoid problems.
   b. If you do not have room in your 12 slides, you may put safety on an additional slide.

8. **REFERENCES**
   This section should not exceed one page. Limit your list to the most important references.

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PART 2 QUAD CHART

QUAD Chart 9-12

Your QUAD chart is a summary of your project. Before reviewing detailed slides the QUAD chart allows judges and others to quickly see a summary of your project. A "quad chart" is a single page divided into four quadrants providing a high-level summary of the project. It is intended to be more visual than detailed to quickly introduce your judges to what is important about your project. Follow the model below that corresponds to the Project Presentation template you selected.

1. In order to provide sufficient space, please use a wide-screen page format similar to the American Legal standard 8½"X11" and arranged in Landscape orientation.
2. The page background color must be a light color and text color must be predominantly dark to support readability.
3. The minimum allowable font size is 13 pt. *Exception*: You may use a smaller font size, down to 9 pt., for figure captions or photo credits.
4. All four quadrants of your Quad Chart should each be the same size with a single border line delimiting each, as in the examples below. The Title section should be only as tall as necessary to include your project title and other identifying information (see section on Quad Chart Title).
5. The Quad Chart should not include a bibliography, references, or acknowledgments.

Quad Chart Title:

- In the upper right-hand corner, list the Project ID (You will receive this after registering.)
- Line one is the title of your project
- Line two is your name and school.

Quadrant 1: Research Question/Engineering Objectives

- This should reflect material in #2 of the Project Presentation Outline.
- Please state the research question or engineering problem being addressed
- A leading core graphic or visual is encouraged, but not required.

Quadrant 2: Methodology/Project Design

- This should reflect material in #3 of the Project Presentation Outline.
- Please provide a succinct, bulleted summary of the methodology/project design

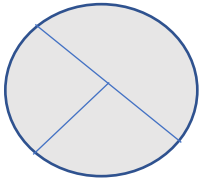
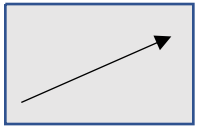
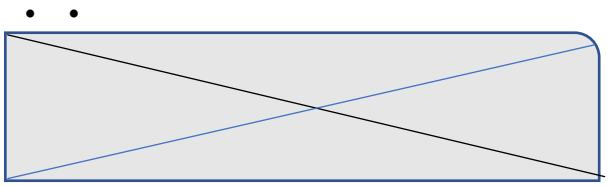
Quadrant 3: Data Analysis & Results

- This should reflect material in #4 and 5 of the Project Presentation Outline.
- It is advised that this quadrant should primarily be a graphic representation of relevant data and results.

- Text should be kept to a minimum.

Quadrant 4: Interpretation & Conclusions

- This should reflect material in #5 and # 6 of the Project Presentation Outline

Science Project Quad Chart	
Q1: Research Question 	Q3: Data Analysis & Results  
Q2: Methodology	Q4: Interpretation & Conclusions 

Engineering Project Quad Chart	
Q1: Engineering Problem & Objectives	Q3: Data Analysis & Results
Q2: Project Design	Q4: Interpretation & Conclusions

Math/Computer Science Project Quad Chart	
Q1: Problem or Question	Q3: Findings
Q2: Framework	Q4: Interpretation & Conclusions

Example Below

Project ID: ROBO057

Phytoplankton detection using machine learning and a mobile application

Q1: Problem

Plankton are the world's largest oxygen producers and first level of all marine food chains, making quantification a measurement for Earth's health. Currently, manual microscopic plankton analysis is a laborious process, but with the rise of artificial intelligence and its implementations in the past decade, automated data collection for plankton has been attempted.

This study set out to create a neural network, programmed in Python, to identify phytoplankton on the characteristics of shape.

Q2: Framework

Plankton collection required to create the dataset.

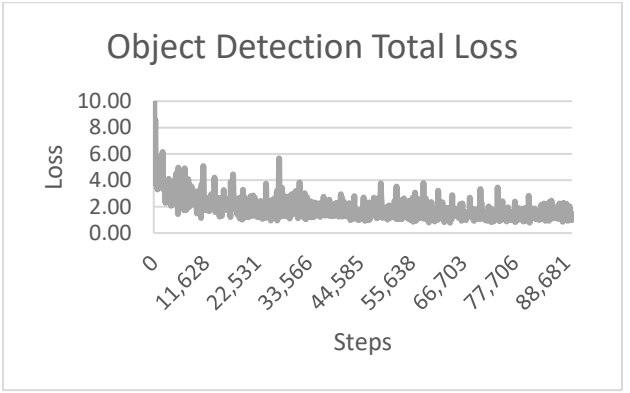
Data augmentation was used to increase the dataset by a factor of 3.

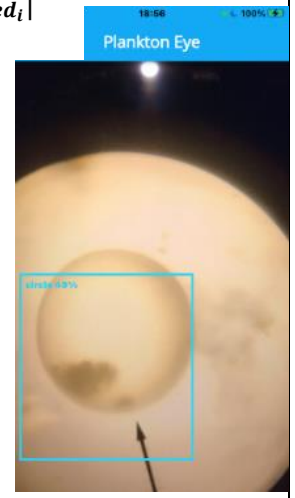
Two models were developed: image classification and object detection.

```
model = Sequential()

model.add(Conv2D(8, (3,3), input_shape = X.shape[1:]))
model.add(Activation("relu"))
model.add(MaxPooling2D(pool_size = (2,2)))

model.add(Conv2D(16, (3,3)))
model.add(Activation("relu"))
model.add(MaxPooling2D(pool_size = (2,2)))

model.add(Conv2D(32, (3,3)))
model.add(Activation("relu"))
model.add(MaxPooling2D(pool_size = (2,2)))

model.add(Dropout(.2))
model.add(Flatten())
model.add(Dense(32))
model.add(Activation("relu"))

model.add(Dense(3))
model.add(Activation('sigmoid'))
```

Q3: Findings

$$Loss = \sum_{i=1}^{n} |y_{actual_i} - y_{predicted_i}|$$





Q4: Interpretations and Conclusions

The machine learning model worked as expected, producing the correct outputs for each shape. Object detection proved to be a more valuable format as having multiple plankton in the frame is quite common allowing for more than one output.

There were limitations caused by the size of the dataset/training data, reduction of image pixel ratio, and training hardware.

Continued research could include expanding the dataset to train a higher caliber model, species-specific classification, and developing an automated quantification feature for the application.

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PART 3 SPECIAL APPENDICES (If required)

A. Statistical Procedures Appendix

Why an appendix?

If you are using statistical procedures to analyze your data it is essential to be aware that statistical analysis can get very complex, even for a seemingly straightforward t-test for significance of difference between data set means. There are several reasons which make use of statistical procedures difficult for Science and Engineering Fairs:

- It is easy to misuse procedures. The existence of many online statistical procedures makes it very easy to run the analysis, but unless these procedures analyze the data sets and flag possible problems for review and correction, certain data set conditions may invalidate the use of the procedure.
- Knowing how to be sure a particular statistical application is valid is very difficult unless individuals are using statistical procedures on a routine basis.
- Most secondary schools do not teach the use of statistical methods. At times projects lack sufficient detail for judges to fairly assess the validity of statistical procedure(s) used. The information requested here is intended to make the judging process more equitable. This appendix is required if you use statistical procedures.

1. Are you using statistical procedures to test a null hypothesis? Explain why or why not.

2. Explain why you chose your procedure and how it is applicable to your data sets.

3. If you use Regression Analysis to establish the relationship between independent and dependent variables, please provide the following:

- R^2 for each regression and your interpretation of the meaning. Note that a small R^2 may not always be bad and a large value may not always be good. If you have very small R2 but feel the analysis is still valid, please explain. (Adjusted R^2 is considered to be a better evaluator of a regression model but many on line statistical algorithms do not include it.)
- Please present a Residual Plot of your data for each regression and explain what the results mean. (Residual plot is used to detect bias in your regression data.) Note that many online regression routines also plot residuals.

Note: for less complex data sets, simple scatter plots may be sufficient.

4. If you are determining the significance between means of different data sets, you may be using t-test, Analysis of Variance or DOE (Design of Experiments). You may use other approaches if you wish.

The most common analysis method is the t-test or Student's t.

- Please include a data table of each data set along with the standard deviation for each data point in each table. If you have extremely large data sets making tables impractical, tell us what N (number of data records) is and the standard deviation for each data set.
- There are conditions within your data sets that can invalidate using a t-test. Some of these situations are complex. We only ask you to be aware of them and tell us if you suspect any may be present. They include.

- Implicit factors: lack of independence within a sample
- Lack of independence: lack of independence between samples
- Outliers: apparent nonnormality by a few data points
- Nonnormality: nonnormality of entire samples
- Unequal population variances
- Patterns in plot of data: detecting violation assumptions graphically
- Special problems with small sample sizes
- Special problems with unbalanced sample sizes

6. Analysis of Variance (ANOVA) and Design of Experiments (DOE) are a significantly more complex procedures. Please let us know if you intend to use this technique. It may take us extra time to evaluate the results of these statistical tools.

You may use more than one slide if needed. Since this is an experimental appendix this year, please let us know if you have difficulties completing the requested information or if you have ideas for making this information better. scifairdir@plu.edu

B. Validation of Machine Learning Algorithms Appendix (Sometimes referred to as AI)

We are requiring any project using machine learning algorithms (custom written or commercially obtained) to present validation information.

There are many ways to validate machine learning algorithms. The purpose is to demonstrate that there is reasonable accuracy.

Validation methods could include:

- Train/test split
- k-Fold Cross-Validation
- Leave-one-out Cross-Validation
- Leave-one-group-out Cross-Validation
- Nested Cross-Validation
- Time-series Cross-Validation
- Wilcoxon signed-rank test
- McNemar's test
- 5x2CV paired t-test
- 5x2CV combined F test

For 2022 we are asking for a k-Fold Cross Validation run where k=5 or 10 along with a graphic or tabular display of the results including a calculation of r squared for each fold. Show a scatter plot of r squared values for each fold. There may be other methods more appropriate to the amount of data you have. If so please ask us ahead of time.

You may use more than one slide if needed. Since this is an experimental appendix this year, please let us know if you have difficulties completing the requested information or if you have ideas for making this information better. scifairdir@plu.edu

Some references:
https://machinelearningmastery.com/k-fold-cross-validation/
https://scikit-learn.org/stable/modules/cross_validation.html
https://towardsdatascience.com/k-fold-cross-validation-explained-in-plain-english-659e33c0bc0

C. Polymerase Chain Reaction (PCR) Appendix

Note: This covers all forms of PCR. PCR, Real-time PCR, Quantitative real time PCR (Q-RT PCR), Reverse Transcriptase PCR (RT-PCR), etc.

1. PCR contamination
The worst form of contamination is PCR product aerosols. Any time you expose amplified material to the air you may contaminate your surroundings with that amplified PCR material. Then your next run could become contaminated.

Please explain how you avoid this potential contamination problem.

2. Negative Control
We prefer that you always run a negative control and report the results. We would like to see photographs of the result.

3. Positive Control
You may also run a positive control if you have the necessary material. Doing so would strengthen the validity of your results. We recognize that the needed material may not be easily available thus we are not requiring this.

You may use more than one slide if needed. Since this is an experimental appendix this year, please let us know if you have difficulties completing the requested information or if you have ideas for making this information better. scifairdir@plu.edu

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