A CAPSTONE PROJECT

Proficiency Rubrics for LEARN & M^4CTE Lesson Guides

Maine MATHEMATICS and SCIENCE Alliance

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Proficiency Rubrics for LEARN & M^4 CTE Lesson Guides

This guide, as well as additional resources, can be found on the Maine Mathematics and Science Alliance's website (http://mmsa.org/learn-m4cte-project-guides)
If you have any trouble viewing the materials please contact us.

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Preface

The *Learn, Experience, Apply in a Regional Network (LEARN) Mathematics* and *Mid-Coast Maine Mentoring Mathematics and Career Technical Education (M^4CTE)* programs created regional professional learning communities that brought together Career & Technology Education (CTE) instructors with middle or high school teachers to develop curriculum units. Teachers collaboratively planned and co-taught multi-day lessons that integrated mathematical concepts and theory with practical, hands-on applications. Self-reflection and feedback from colleagues helped teachers make sustained improvements to their practice, while experienced leaders served as mentors to new teacher participants.

These projects were designed to improve teacher content knowledge, content specific pedagogical knowledge and skills, and instructional practices in the areas of measurement and approximation, data analysis and statistics, and probability with the expected outcome of improving student achievement in these content areas. Students had the opportunity to carry out investigations, collect data, and/or perform research to demonstrate achievement as they completed individual or group projects.

The National Assessment of Educational Progress (NAEP), also known as the Nation's Report Card, revealed that students of teachers who conduct hands-on learning activities on a weekly basis outperform their peers by more than 70% of a grade level in math and 40% of a grade level in science (U.S. Department of Education, 1999). As implied by the NAEP, teachers participating in the LEARN and M^4CTE projects reported student results that indicated significant gains in mathematics and, in some cases, science. Beyond improving student achievement, teachers and students involved in the LEARN and M^4CTE projects reported greater student engagement as well as a sense of satisfaction from collaborating with other teachers.

In March 2013, a set of project guides developed and implemented by the LEARN and M^4CTE participants during the 2011–2012 school year was published by the Maine Mathematics and Science Alliance. A second set of project guides was published in 2014 and covered projects developed during the 2012–2013 school year. These guides are intended to give inspiration and guidance to teachers who are looking to develop collaborative units that include mathematics and career and technical education. The project guides contain a wealth of resources that can be used as is or adapted to fit particular partnerships. All projects in both publications have the intended outcome of improving student engagement, participation, and achievement.

As the M^4CTE and LEARN projects came to an end, MMSA proposed a Capstone Project to extend the work done on the projects by showing how several of them can be used to demonstrate graduation proficiency requirements. This document is the result of that work and includes a series of rubrics for Probability and Statistics, Algebra 2 and Geometry graduation proficiency requirements. These rubrics cross reference Common Core Standards to the Proficiency Requirements and have been written to be universal in nature. This makes them very flexible by allowing teachers to use them for any classroom activity that supports the same Proficiency requirements. Additionally there are descriptions for nine of the M^4CTE/LEARN projects that define how they can be extended to meet the Proficiency Requirements.

Project Leadership

The leadership team for the LEARN and M^4CTE projects included:

- *Margaret (Meghan) Southworth, Elementary and Secondary Education Act Title II Coordinator (formerly Maine Mathematics and Science Alliance Mathematics Specialist and LEARN & M^4CTE Project Director 2011–2012)*
- *Irene Haskins, Maine Mathematics and Science Alliance Mathematics Specialist and Lecturer, School of Sciences and Humanities, Husson University and M^4CTE "A Capstone Project" Lead Author*
- *Jessica McGreevy, Maine Mathematics and Science Alliance Mathematics Specialist and M^4CTE and LEARN Project Director 2012–2013*
- *Lynn Farrin, Maine Mathematics and Science Alliance Science Specialist and M^4CTE and LEARN Project Facilitator 2013-2014*

A special note of thanks to Carissa Veit of RSU 13, for graciously sharing her work cross-referencing the Common Core Standards and proficiency-based graduation requirements. Her work was instrumental in producing this document.

Hydroponic Arithmetic

Project Developers

- *Stacy LaBree, Mathematics Teacher, Brewer High School*
- *Jeff Beswick, Horticulture Instructor, United Technology Center (UTC)*

Short Summary of Project

Hydroponic Arithmetic brings together math, science and horticulture in a hands-on project in which students build and maintain hydroponic gardens. Data is collected to help students see what relationships exist between attributes such as plant growth and pH and plant growth and light. The project includes separate lessons for students in each of two schools and three joint activities.

The individual lessons addressed measurement, data collection and analysis of data. The first two joint activities centered on hydroponics, horticulture and building the gardens. Once the gardens were built and planted, the students at each school took regular measurements of several variables. The third joint activity involved having the students work together to perform an analysis of all the data collected. A key part of this activity was creating scatter plots of two variable data.

Hydroponic Garden

Using This Project for the Proficiency Rubrics

The key to using this project to demonstrate proficiency lies in the amount of data that is collected by the students. The following table indicates which pieces of data are categorical, quantitative or could be used as either, depending on context.

For those requirements requiring a single count, any of the data values can be used, as long as it is the appropriate type (categorical or quantitative).

CC.9-12.S.ID.5 requires two categorical variables. It is suggested that the following variables be used:

- EC (when used as a categorical variable)
- pH (when used as a categorical variable)
- Plant Height (when used as a categorical variable)

Standards CC.9-12.S.ID 6a,b,c. require two quantitative variables to compare. Some examples of data pairs for these standards would be

- EC versus plant height (when both are used as quantitative variables)
- pH versus plant height (when both are used as quantitative variables)

Individual growing pod

Data for the Project:

As with most of the M[4]CTE/LEARN projects, an integral component of Hydroponic Arithmetic is having the students collect their own data. This gives them the experience of using "real life" data. Because data was collected on two hydroponic gardens, students can analyze the data from their school and also compare the data sets from both schools.

The following table shows the data collected for this project.

Data Variable	**Type**
Date (Number of days since start of garden)	Quantitative
EC (electrical conductivity) *** EC data could be used as a categorical data value for example, if viewed as High, Medium, Low readings	Quantitative or Categorical
pH *** pH data could be used as a categorical data value for example, if viewed as High, Medium, Low or acidic/alkaline/neutral	Quantitative or Categorical
Water Temp (need to use consistent units across the schools or convert)	Quantitative
Light (Foot Candles (FC))	Quantitative
Plant Height *** Plant Height data could be used as a categorical data value for example, if viewed as High, Medium, Low growth with the classifications based on a given number of inches/centimeters a plant has grown since planted.	Quantitative or Categorical
Solution height	Quantitative

Cross-Reference Table

The following table cross-references the data for the Hydroponic Arithmetic project to the Proficiency-Based standards for Statistics and Probability

Statistics and Probability Standard/Data	**Date**	**EC (Electrical Conductivity)**	**pH**	**Water Temperature**	**Weight of car (mass in grams)**	**Foot Candles (light)**	**Plant height**	**Solution Height**
Standard: CC.9-12.S.ID.1 *Summarize, represent, and interpret data on a single count or measurement.* **Definition**: Represent data with plots on the real number line (dot plots, histograms and box plots).	✓	✓	✓	✓	✓	✓	✓	✓
Standard: CC.9-12.S.ID.2 *Summarize, represent, and interpret data on a single count or measurement variable*. **Definition**: Use statistics appropriate to the shape of data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.	✓	✓	✓	✓	✓	✓	✓	✓
Standard: CC.9-12.S.ID.3 *Summarize, represent, and interpret data on a single count or measurement variable*. **Definition:** Interpret differences in shape, center and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers)	✓	✓	✓	✓	✓	✓	✓	✓
Standard: CC.9-12.S.ID.5 *Summarize, represent, and interpret data on two categorical or quantitative variables.* **Definition:** Summarize categorical data in a two-way frequency table. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data. (Note: Definition for this standard is specific to categorical data only.)		✓	✓			✓		

Statistics and Probability Standard/Data	**Date**	**EC (Electrical Conductivity)**	**pH**	**Water Temperature**	**Weight of car (mass in grams)**	**Foot Candles (light)**	**Plant height**	**Solution Height**
CC.9-12.S.ID6 *Summarize, represent, and interpret data on two categorical or quantitative variables.* **Definition**: Represent data on two quantitative variables on a scatter plot and describe how the variables are related. (Note: Definition for this standard is specific to quantitative data only.)	✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.6a *Summarize, represent, and interpret data on a single count or measurement variable.* **Definition**: Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Using a given functions or choose a function suggested by the context. Emphasize linear, quadratic and exponential models.	✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.6b Summarize, represent, and interpret data on a single count or measurement variable. **Definition**: Represent data on two quantitative variables on a scatter plot and describe how the variables are related.	✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.6c *Summarize, represent, and interpret data on a single count or measurement variable.* **Definition:** Fit a linear function for a scatter plot that suggests a linear association.	✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.8 *Interpret linear models.* **Definition:** Compute (using technology) and interpret the correlation coefficient of a linear fit.	✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.9 *Interpret linear models.* **Definition:** Distinguish between correlation and causation.	✓	✓	✓	✓	✓	✓	✓	✓

Boards and Cords: The Mathematics of Forest Sustainability

Project Developers

- *Jeff Beswick, Environmental Horticulture Instructor, United Technologies Center*
- *David Jefferies, Special Education Teacher, Brewer High School*
- *Stacy LaBree, Special Education Teacher, Brewer High School, Brewer ME*

Short Summary of Project

Boards and Cords uses mathematics and science to help students understand how trees are measured in terms of marketable wood and what actions can be taken to assure that the forests are sustainable.

Students learn how to make sample measurements on a plot of land to make inferences about the amount of cords that can be harvested from the entire plot of land. The sampling makes use of two simple tools like a penny and a calibrated piece of woods called a "Biltmore Stick".

The project consisted of multiple joint activities between the CTE and sending school students. In the first activity, students made their own Biltmore Stick. Activity 2 took students to a forest to learn how to make measurements with a Biltmore stick and/or a Clinometer. Activity 3 focused on the student's making measurements in a forest for designated 1 acre plots and using that data to calculate number of board feet and cubic feet of marketable wood in their 1 acre plots. The 4^{th} joint activity brought the students together to make presentations on Forest Management Plans they have developed based on the date collected in Activity 3.

This project was originally devised for a horticulture class in a Career Technical Education (CTE) school and two high school special education math classes, but can be easily adapted to meet high school graduation proficiency requirements in statistical analysis.

An integral part of the project is having the students collect their own data. For calculating purposes, the students will want to combine their data together to get a large enough sample size for statistical analysis.

The following table shows the data collected for this project.

Data Variable	**Type**
Height of tree	Quantitative
Angle of elevation	Quantitative
Diameter of tree at breast height	Quantitative
Number of 16 foot logs in the tree	Quantitative
Number of board feet in the tree.	Quantitative

Using This Project for the Proficiency Rubrics

The key to using this project to demonstrate proficiency lies in the amount of data that is collected by the students. The data lends itself to both statistical and algebra requirements.

For those requirements requiring a single count, any of the data values can be used, as long as it is the appropriate type (categorical or quantitative).

Standards CC.9-12.S.ID 6a,b,c. and CC.9-12.F.IF.4, CC.9-12.F.IF.5, CC.9-12.F.IF.6 require two quantitative variables to compare. Some examples of data pairs for these standards would be

- Height of Tree vs diameter of tree
- Height of tree versus number of board feet in tree
- Diameter of tree versus number of board feet in tree
- Height of tree versus number of 16 foot logs in tree
- Diameter of tree versus number of 16 foot logs in tree

Cross-Reference Table
The following table cross-references the data for the project to the Proficiency-Based standards for Statistics and Probability.

Statistics and Probability Standard/Data	**Height of Tree**	**Angle of Elevation**	**Diameter of Tree**	**Number of 16 Foot Logs in Tree**	**Number of Board Feet in Tree**
CC.9-12.S.ID.1 *Summarize, represent, and interpret data on a single count or measurement.* **Definition**: Represent data with plots on the real number line (dot plots, histograms and box plots).	✓	✓	✓	✓	✓
CC.9-12.S.ID.2 *Summarize, represent, and interpret data on a single count or measurement variable*. **Definition**: Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.	✓	✓	✓	✓	✓
CC.9-12.S.ID.3 *Summarize, represent, and interpret data on a single count or measurement variable*. **Definition:** Interpret differences in shape, center and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers)	✓	✓	✓	✓	✓
CC.9-12.S.ID6 *Summarize, represent, and interpret data on two categorical or quantitative variables.* **Definition**: Represent data on two quantitative variables on a scatter plot and describe how the variables are related. (Note: Definition of this standard is specific to quantitative data only.)	✓	✓	✓	✓	✓
CC.9-12.S.ID.6a *Summarize, represent, and interpret data on a single count or measurement variable.* **Definition**: Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Using a given function or choose a function suggested by the context. Emphasize linear, quadratic and exponential models.	✓	✓	✓	✓	✓
CC.9-12.S.ID.6b *Summarize, represent, and interpret data on a single count or measurement variable.* **Definition**: Represent data on two quantitative variables on a scatter plot and describe how the variables are related.	✓	✓	✓	✓	✓
CC.9-12.S.ID.6c *Summarize, represent, and interpret data on a single count or measurement variable.* **Definition:** Fit a linear function for a scatter plot that suggests a linear association.	✓	✓	✓	✓	✓

Statistics and Probability Standard/Data	**Height of Tree**	**Angle of Elevation**	**Diameter of Tree**	**Number of 16 Foot Logs in Tree**	**Number of Board Feet in Tree**
CC.9-12.S.ID.8 *Interpret linear models.* **Definition:** Compute (using technology) and interpret the correlation coefficient of a linear fit.	✓	✓	✓	✓	✓
CC.9-12.S.ID.9 *Interpret linear models.* **Definition:** Distinguish between correlation and causation.	✓	✓	✓	✓	✓

The following table cross-references the data for the project to the Proficiency-Based standards for Algebra.

Algebra 2 Standard/Data	**Height of Tree**	**Angle of Elevation**	**Diameter of Tree**	**Number of 16 Foot Logs in Tree**	**Number of Board Feet in Tree**
CC.9-12.F.IF.4 Interpret functions that arise in applications in term of the context. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities and sketch graphs showing key features given a verbal description of the relationship.	✓	✓	✓	✓	✓
CC.9-12.F.IF.5 Interpret functions that arise in applications in terms of the context. Relate the domain of a function to its graph and where applicable, to the quantitative relationship it describes.	✓	✓	✓	✓	✓
CC.9-12.F.IF.6 Interpret functions that arise in applications in terms of the context. Calculate and interpret the average rate of a function (presented symbolically or as a table) over a specified interval; Estimate the rate of change from a graph.	✓	✓	✓	✓	✓

Catapults

Project Developers

- *Angela Szuks, High School Mathematics Instructor, Brewer High School*
- *Dave Stevens, Construction Instructor, United Technologies Center*

Short Summary of Project

The Catapults project brings together mathematical research, modeling, data collection and modeling, design planning and modification and construction together in a very interactive and highly engaging project.

One of the key mathematical concepts that this project revealed to students was a practical application of parabolas. Many times students view parabolas as something in their algebra book, not realizing that they arise in real world applications.

Students from both the sending school algebra class and the CTE building construction class worked together to research catapults and then designed and built small–scale prototypes adhering to engineering design criteria. The students collected data from the prototypes to determine which models worked best. Two designs were selected and the students jointly built two large-scale catapults. Data was collected from the catapults, scatterplots made, and quadratic models determined and used to calibrate the catapults for the purpose of getting a basketball launched from the catapult to land in a basketball hoop.

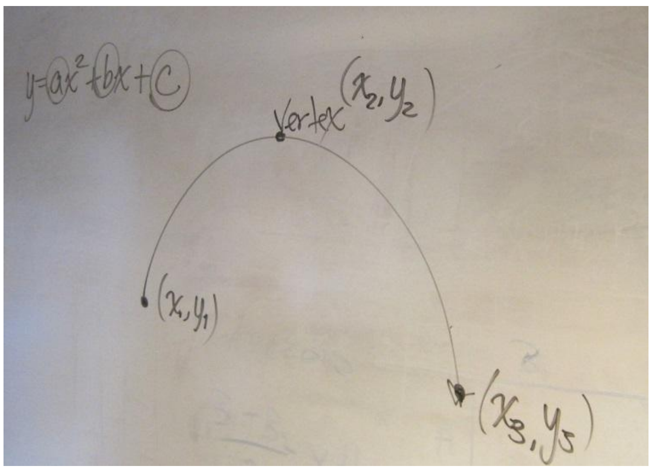
Two quadratic models were derived using a graphing calculator.

- Model 1: time, vertical height
- Model 2: horizontal distance, vertical height

This data was captured using a video camera to collect the three data points.

The following table shows the data collected for this project.

Data Variable	**Type**
Time (number of seconds since launch)	Categorical
Vertical Height of ball	Categorical
Number of seconds to reach vertex	Quantitative
Horizontal distance	Quantitative
Initial height of projectile	Quantitative



Plans for building a catapult

Students compete using their designs

Cross-Reference Tables

The following table cross-references the data for the project to the Proficiency-Based standards for Algebra.

Algebra 2 Standard/Data	Time (number of seconds since launch)	Vertical Height of ball	Number of seconds to reach vertex	Horizontal distance	Initial height of projectile
CC.9-12.F.IF.4 Interpret functions that arise in applications in term of the context. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities and sketch graphs showing key features given a verbal description of the relationship.	✓	✓	✓	✓	✓
CC.9-12.F.IF.5 Interpret functions that arise in applications in terms of the context. Relate the domain of a function to its graph and where applicable, to the quantitative relationship it describes.	✓	✓	✓	✓	✓
CC.9-12.F.IF.6 Interpret functions that arise in applications in terms of the context. Calculate and interpret the average rate of a function (presented symbolically or as a table) over a specified interval; Estimate the rate of change from a graph.	✓	✓	✓	✓	✓

The following table cross-references the data for the project to the Proficiency-Based standards for Statistics and Probability.

Statistics and Probability Standard/Data	Time (number of seconds since launch)	Vertical Height of ball	Number of seconds to reach vertex	Horizontal distance	Initial height of projectile
CC.9-12.S.ID.1 Summarize, represent, and interpret data on a single count or measurement variable.	✓	✓	✓	✓	✓
CC.9-12.S.ID.2 Summarize, represent, and interpret data on a single count or measurement variable.	✓	✓	✓	✓	✓
CC.9-12.S.ID.3 Summarize, represent, and interpret data on a single count or measurement variable.	✓	✓	✓	✓	✓
CC.9-12.S.ID.5 Summarize, represent, and interpret data on two categorical or quantitative variables. (Note: Definition this standard specific to categorical data only)					
CC.9-12.S.ID6 Summarize, represent, and interpret data on two categorical or quantitative variables (Note: Definition this standard specific to quantitative data only)	✓	✓	✓	✓	
CC.9-12.S.ID.6a Summarize, represent, and interpret data on a single count or measurement variable.	✓	✓	✓	✓	
CC.9-12.S.ID.6b Summarize, represent, and interpret data on a single count or measurement variable.	✓	✓	✓	✓	
CC.9-12.S.ID.6c Summarize, represent, and interpret data on a single count or measurement variable.	✓	✓	✓	✓	

CO_2 Cars

Project Developers

- *Rebecca Shields, Camden Hills High School*
- *B. J. Burns Camden Hills High School*
- *Suzanne Hall, Curriculum Coordinator, Maine Coast School of Technology*
- *Monique Moreau, Health Sciences Instructor, Maine Coast School of Technology*
- *Danica Wooster, Automotive Body Instructor, Maine Coast School of Technology*
- *Glenn Wooster, Small Engine Repair Instructor, Maine Coast School of Technology*

Short Summary of Project

The CO_2 Cars project is a highly interactive project which combines math, science and engineering. Student teams designed and built soft wood CO_2 race cars based on a set of engineering design criteria. Two joint teaching sessions brought together sending school students and CTE students. In the first of these, the students measured their cars to assure that they met engineering constraints. An available wind tunnel allowed students to assess how aero-dynamic their cars were. They performed friction tests to assess the impact of different surfaces and different size tires. The first joint session ended by racing the student's cars down a 65 foot track. With the information learned in the first joint session, the students reengineered their cars for a second run in joint session 2.

The group who developed this project was unique in that it included two algebra teachers, a CTE curriculum coordinator and instructors in health sciences, small engine repair and automotive body work. They found clever ways to develop a project that incorporated math, science, engineering and health sciences.

Over the course of the project, the students took several measurements on the cars. Some of the measurements were used to validate that the cars met required engineering design constraints and some were used to help make design decisions. Collecting measurement and other data supports demonstrating proficiency in measurement and data analysis.

An integral part of the project is having the students collect their own data. Using their data gives them the experience of using "real life" data. For calculating purposes, the students will want to combine their data together to get a large enough sample size for statistical analysis. For example, if they wanted to summarize, interpret represent and interpret data for a single count or measurement, they could use the weight data collected for all of the cars. For each of the standards described in the rubric, suggested data sets are shown in *italics*.

The following table shows the data collected for this project.

Data Variable	**Type**
Gender	Categorical
Friction Test: Surface type	Categorical
Increase in pulse rate before and after race (Yes or No)	Quantitative
Pulse Rate: Before and after race pulse rates	Quantitative
Weight of car (mass in grams)	Quantitative
Length of dragster (inches)	Quantitative
Front wheel diameter (inches)	Quantitative
Rear wheel diameter (inches)	Quantitative
Wind tunnel rating	Quantitative
Speed of car (attempted, but not captured)	Quantitative
For Friction Test: Number of paper clips to get car to roll on different surfaces. This will be multiple data points, depending on number of surfaces tested and number of different tire sizes.	Quantitative

Using This Project for the Proficiency Rubrics

The key to using this project to demonstrate proficiency lies in the amount of data that is collected by the students. The table above indicates which pieces of data are categorical, quantitative or could be used as either, depending on context. The table below shows which pieces of data can be used for which standards.

For those requirements requiring a single count, any of the data values can be used, as long as it is the appropriate type (categorical or quantitative).

Standard CC.9-12.S.ID.5 requires two categorical variables. It is suggested that the following variables be used:

- Gender
- Increase in pulse rate (before and after)

Standards CC.9-12.S.ID 6a,b,c. require two quantitative variables to compare. Some examples of data pairs for these standards would be

- Wind tunnel rating versus speed of car
- Weight of car versus speed of car
- Friction test result versus speed of car

Completed cars from CHRHS & MCST students

Taking measurements to ensure cars meet design specifications

Cross-Reference Table

The following table cross-references the data for the CO_2 project to the Proficiency-Based standards for Statistics and Probability.

Statistics and Probability Standard/Data	**Gender**	**Friction Test: Surface type**	**Increase in pulse rate before and after race (Yes or No)**	**Pulse Rate: Before and after race pulse rates**	**Weight of car (mass in grams)**	**Length of dragster (inches)**	**Front wheel diameter (in.)**	**Rear wheel diameter (in.)**	**Wind tunnel rating**	**Speed of car**	**Friction Test: Number of Paper Clips**
CC.9-12.S.ID.1 *Summarize, represent, and interpret data on a single count or measurement.* **Definition**: Represent data with plots on the real number line (dot plots, histograms and box plots).				✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.2 *Summarize, represent, and interpret data on a single count or measurement variable.* **Definition**: Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.				✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.3 *Summarize, represent, and interpret data on a single count or measurement variable.* **Definition:** Interpret differences in shape, center and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).				✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.5 *Summarize, represent, and interpret data on two*	✓	✓	✓								

Statistics and Probability Standard/Data	**Gender**	**Friction Test: Surface type**	**Increase in pulse rate before and after race (Yes or No)**	**Pulse Rate: Before and after race pulse rates**	**Weight of car (mass in grams)**	**Length of dragster (inches)**	**Front wheel diameter (in.)**	**Rear wheel diameter (in.)**	**Wind tunnel rating**	**Speed of car**	**Friction Test: Number of Paper Clips**
categorical or quantitative variables. **Definition:** Summarize categorical data in a two-way frequency table. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data. Note: Although this requirement refers to categorical or quantitative variables, the definition is written in terms of categorical data.											
CC.9-12.S.ID6 *Summarize, represent, and interpret data on two categorical or quantitative variables.* **Definition**: Represent data on two quantitative variables on a scatter plot and describe how the variables are related. (Note: Definition of this standard specific to quantitative data only.)				✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.6a *Summarize, represent, and interpret data on a single count or measurement variable.* **Definition**: Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Using a given functions or choose a function suggested by the context. Emphasize linear, quadratic and exponential models.				✓	✓	✓	✓	✓	✓	✓	✓

Statistics and Probability Standard/Data	**Gender**	**Friction Test: Surface type**	**Increase in pulse rate before and after race (Yes or No)**	**Pulse Rate: Before and after race pulse rates**	**Weight of car (mass in grams)**	**Length of dragster (inches)**	**Front wheel diameter (in.)**	**Rear wheel diameter (in.)**	**Wind tunnel rating**	**Speed of car**	**Friction Test: Number of Paper Clips**
CC.9-12.S.ID.6b Summarize, represent, and interpret data on a single count or measurement variable. **Definition**: Represent data on two quantitative variables on a scatter plot and describe how the variables are related.				✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.6c *Summarize, represent, and interpret data on a single count or measurement variable.* **Definition:** Fit a linear function for a scatter plot that suggests a linear association.				✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.8 *Interpret linear models.* **Definition:** Compute (using technology) and interpret the correlation coefficient of a linear fit.				✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.9 *Interpret linear models.* **Definition:** Distinguish between correlation and causation.				✓	✓	✓	✓	✓	✓	✓	✓

Corrosive Properties of Metals with Different Automotive Coatings

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Project Developers

- *Patricia Crawford, Fifth and Sixth Grade Teacher, Islesboro Central School*
- *Danica Wooster, Automotive Collision Repair Instructor, Mid-Coast School of Technology*

Short Summary of Project

This project brings together math, science and automotive repair by having students study the corrosive properties of metals. Metal plates are suspended in a variety of corrosive liquids and the students take weekly measurements to determine the amount of corrosion. The students use their measurements to determine the amount of the original sample that has not deteriorated away. They also make comparisons of the results across the various solutions to determine which solutions are most corrosive to metals.

An integral part of the project is having the students collect their own data For calculating purposes, the students will want to combine their data together to get a large enough sample size for statistical analysis.

The following table shows the data collected for this project.

Data Variable	**Type**
Length of metal sample	Quantitative
Width of metal sample	Quantitative
Thickness of metal sample	Quantitative
Weight of metal sample	Quantitative
Number of days sample in corrosive solution	Quantitative
Remaining area of sample	Quantitative

Using This Project for the Proficiency Rubrics

Although the project as written targets 5th and 6th grade students, it is easy to extend the basic concepts and add a statistics component to compliment the data collected by the students and in turn use this for proficiency requirements.

All of the data collected for this project is quantitative data. For those requirements requiring a single count, any of the data values can be used.

Standards CC.9-12.S.ID 6a,b,c. require two quantitative variables to compare. Some examples of data pairs for these standards would be

- Number of days sample in corrosive solution versus length of sample
- Number of days sample in corrosive solution versus width of sample
- Number of days sample in corrosive solution versus thickness of sample
- Number of days sample in corrosive solution versus remaining area of sample

Cross-Reference Table

The following table cross-references the data for the project to the Proficiency-Based standards for Statistics and Probability**.**

Statistics and Probability Standard/Data	**Length of metal sample**	**Width of metal sample**	**Thickness of metal sample**	**Weight of metal sample**	**Number of days sample in corrosive solution**	**Remaining area of sample**
CC.9-12.S.ID.1 *Summarize, represent, and interpret data on a single count or measurement.* **Definition**: Represent data with plots on the real number line (dot plots, histograms and box plots).	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.2 *Summarize, represent, and interpret data on a single count or measurement variable*. **Definition**: Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.3 *Summarize, represent, and interpret data on a single count or measurement variable*. **Definition:** Interpret differences in shape, center and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers)	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID6 *Summarize, represent, and interpret data on two categorical or quantitative variables.* **Definition**: Represent data on two quantitative variables on a scatter plot and describe how the variables are related. (Note: Definition of this standard specific to quantitative data only.)	✓	✓	✓	✓	✓	✓

Statistics and Probability Standard/Data	**Length of metal sample**	**Width of metal sample**	**Thickness of metal sample**	**Weight of metal sample**	**Number of days sample in corrosive solution**	**Remaining area of sample**
CC.9-12.S.ID.6a *Summarize, represent, and interpret data on a single count or measurement variable.* **Definition**: Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Using a given functions or choose a function suggested by the context. Emphasize linear, quadratic and exponential models.	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.6b Summarize, represent, and interpret data on a single count or measurement variable. **Definition**: Represent data on two quantitative variables on a scatter plot and describe how the variables are related.	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.6c *Summarize, represent, and interpret data on a single count or measurement variable.* **Definition:** Fit a linear function for a scatter plot that suggests a linear association.	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.8 *Interpret linear models.* **Definition:** Compute (using technology) and interpret the correlation coefficient of a linear fit.	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.9 *Interpret linear models.* **Definition:** Distinguish between correlation and causation.	✓	✓	✓	✓	✓	✓

Math, It Does a Body Good: The Mathematics of Nutrition

Project Developers

- *Carol Pelletier, Culinary Arts Instructor, Mid Coast School of Technology*
- *Sue Watts, Seventh Grade Teacher, Thomaston Grammar School*

Short Summary of Project

This project focuses on nutrition and the underlying mathematics that students might not readily see that is critical to their daily lives. Students learn about the importance of good nutrition choices and the long term costs of unhealthy eating.

One aspect of the project entailed having the students strenuously exercising daily for 5 days and tracking their resting heart rate before and afterwards. They also tracked their eating habits and calculated nutrient content and assessed them relative to the student's weight, gender, age and activity level.

This project was originally written for a 7th grade math class and high school culinary students. As with many of the projects, simple extensions to the original project provides ample examples to fulfill proficiency graduation requirements in statistics in algebra.

An integral part of the project is having the students collect their own data. For calculating purposes, the students will want to combine their data together to get a large enough sample size for statistical analysis.

The following table shows the data collected for this project.

Data Variable	Type
Resting heart rate before exercise	Quantitative
Resting heart rate after exercise	Quantitative
Number of days since exercise began	Quantitative
Pizza: Calories	Quantitative
Pizza: carbohydrates grams	Quantitative
Pizza: fat grams	Quantitative
Pizza: protein grams	Quantitative
Pizza: fiber grams	Quantitative
Pizza: sodium mg	Quantitative
Pizza: Percent Calories carbohydrates	Quantitative
Pizza: Percent Calories fat	Quantitative
Pizza: Percent Calories protein	Quantitative
Pizza: Percent Calories fiber	Quantitative

Using This Project for the Proficiency Rubrics

The key to using this project to demonstrate proficiency lies in the amount of data that is collected by the students. The data lends itself to both statistical and algebra requirements.

For those requirements requiring a single count, any of the data values can be used, as long as it is the appropriate type (categorical or quantitative).

Standards CC.9-12.S.ID 6a,b,c. and CC.9-12.F.IF.4, CC.9-12.F.IF.5, CC.9-12.F.IF.6 require two quantitative variables to compare. Some examples of data pairs for these standards would be :

- Resting heart before Exercise versus Number of Days Since Exercise Began
- Resting heart after Exercise versus Number of Days Since Exercise Began
- Pizza: Fat grams versus Pizza: Calories
- Pizza: Carbohydrates grams versus Pizza: Calories
- Pizza: Fiber grams versus Pizza: Calories
- Pizza: Protein grams versus Pizza: Calories
- Pizza: Percent calories fat versus Pizza: Calories
- Pizza: Percent calories carbohydrates versus Pizza: Calories

Cross-Reference Table

The following table cross-references the data for the project to the Proficiency-Based standards for Statistics and Probability.

Statistics and Probability Standard/Data	Resting Heart Rate Before Exercise	Resting Heart Rate After Exercise	Number of days since exercise began	Pizza: Calories	Pizza: carbohydrates	Pizza: fat	Pizza: protein	Pizza: Percent Calories fiber	Pizza: Sodium mg	Pizza: Percent Calorie carbohydrates	Pizza: Percent Calorie fat	Pizza: Percent Calorie protein	Pizza: Percent Calorie fiber
CC.9-12.S.ID.1 *Summarize, represent, and interpret data on a single count or measurement.* **Definition**: Represent data with plots on the real number line (dot plots, histograms and box plots).	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.2 *Summarize, represent, and interpret data on a single count or measurement variable*. **Definition**: Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.3 *Summarize, represent, and interpret data on a single count or measurement variable*. **Definition:** Interpret differences in shape, center and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Statistics and Probability Standard/Data	**Resting Heart Rate Before Exercise**	**Resting Heart Rate After Exercise**	**Number of days since exercise began**	**Pizza: Calories**	**Pizza: carbohydrates**	**Pizza: fat**	**Pizza: protein**	**Pizza: Percent Calories fiber**	**Pizza: Sodium mg**	**Pizza: Percent Calorie carbohydrates**	**Pizza: Percent Calorie fat**	**Pizza: Percent Calorie protein**	**Pizza: Percent Calorie fiber**
CC.9-12.S.ID6 *Summarize, represent, and interpret data on two categorical or quantitative variables.* **Definition**: Represent data on two quantitative variables on a scatter plot and describe how the variables are related. (Note: Definition of this standard specific to quantitative data only.)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.6a *Summarize, represent, and interpret data on a single count or measurement variable.* **Definition**: Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Using a given functions or choose a function suggested by the context. Emphasize linear, quadratic and exponential models.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.6b Summarize, represent, and interpret data on a single count or measurement variable. **Definition**: Represent data on two quantitative variables on a scatter plot and describe how the variables are related.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.6c *Summarize, represent, and interpret data on a single count or measurement variable.* **Definition:** Fit a linear function for a scatter plot that suggests a linear association.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Statistics and Probability Standard/Data	Resting Heart Rate Before Exercise	Resting Heart Rate After Exercise	Number of days since exercise began	Pizza: Calories	Pizza: carbohydrates	Pizza: fat	Pizza: protein	Pizza: Percent Calories fiber	Pizza: Sodium mg	Pizza: Percent Calorie carbohydrates	Pizza: Percent Calorie fat	Pizza: Percent Calorie protein	Pizza: Percent Calorie fiber
CC.9-12.S.ID.8 *Interpret linear models.* **Definition:** Compute (using technology) and interpret the correlation coefficient of a linear fit.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.S.ID.9 *Interpret linear models.* **Definition:** Distinguish between correlation and causation.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Algebra 2 Standard/Data	Resting Heart Rate Before Exercise	Resting Heart Rate After Exercise	Number of days since exercise began	Pizza: Calories	Pizza: carbohydrates	Pizza: fat	Pizza: protein	Pizza: Percent Calories fiber	Pizza: Sodium mg	Pizza: Percent Calorie carbohydrates	Pizza: Percent Calorie fat	Pizza: Percent Calorie protein	Pizza: Percent Calorie fiber
CC.9-12.F.IF.4 Interpret functions that arise in applications in term of the context. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities and sketch graphs showing key features given a verbal description of the relationship.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.F.IF.5 Interpret functions that arise in applications in terms of the context. Relate the domain of a function to its graph and where applicable, to the quantitative relationship it describes.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CC.9-12.F.IF.6 Interpret functions that arise in applications in terms of the context. Calculate and interpret the average rate of a function (presented symbolically or as a table) over a specified interval; Estimate the rate of change from a graph.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Pendulum Palooza

Project Developers

- *Sara Gilfenbaum, Sixth Grade Teacher, Thomaston Grammar School*
- *Clare Stinson, Introduction to Applied Engineering Instructor, Mid Coast School of Technology*
- *Gretchen Tripp, Sixth Grade Teacher, Rockland Middle School*

Short Summary of Project

Pendulum Palooza is a highly interactive project in which students conduct experiments on table–top pendulums to determine the impact of variables such as length of string and weight of bob to the frequency of a pendulum. Scientific inquiry is a fundamental component to data collection and analysis.

Students set up and conducted three experiments on table–top pendulums using variables of length of string, weight of bob and angle of release. Data collected from the experiments is used to predict how the pendulum's frequency is affected by changes to the variables. Data collected from the table top pendulums is used to model and predict the behavior of a large scale pendulum.

This project was originally devised for a 6th grade class, but can be easily adapted to the high school level by having the students perform more rigorous statistical analysis to the data covered and perform modeling on the table size data to make predictions for the gigantic pendulum behavior.

An integral part of the project is having the students collect their own data. For calculating purposes, the students will want to combine their data together to get a large enough sample size for statistical analysis.

The following table shows the data collected for this project.

Data Variable	Type
Length of string	Quantitative
Weight of Bob	Quantitative
Angle of Release	Quantitative
Frequency of Pendulum	Quantitative
Pendulum Size (small or gigantic)	Categorical
Change in Pendulum Frequency (increase, decrease or none)	Categorical
Change in variable categories: increase in length of string, increase in weight of bob, increase in angle of release, decrease in length of string, decrease in weight of bob, decrease in angle of release.	Categorical

Student analysis of pendulum data

Large scale pendulum

Using This Project for the Proficiency Rubrics

The key to using this project to demonstrate proficiency lies in the amount of data that is collected by the students. The table above indicates which pieces of data are categorical, quantitative or could be used as either, depending on context. The table below shows which pieces of data can be used for which standards.

For those requirements requiring a single count, any of the data values can be used, as long as it is the appropriate type (categorical or quantitative).

CC.9-12.S.ID.5 requires two categorical variables. It is suggested that the following variables be used:

- Change in Variable
- Change in Pendulum Frequency

Standards CC.9-12.S.ID 6a,b,c. and CC.9-12.F.IF.4, CC.9-12.F.IF.5, and CC.9-12.F.IF.6 require two quantitative variables to compare. Some examples of data pairs for these standards would be

- Length of string versus frequency of pendulum
- Weight of bob versus frequency of pendulum
- Angle of release versus frequency of pendulum

Cross-Reference Table

The following table cross-references the data for the Pendulum project to the Proficiency-Based standards for Statistics and Probability.

Statistics and Probability Standard/Data	**Length of String**	**Weight of Bob**	**Angle of Release**	**Frequency of Pendulum**	**Pendulum Size**	**Change in Pendulum Frequency**	**Change in Variable**
CC.9-12.S.ID.1 *Summarize, represent, and interpret data on a single count or measurement.* **Definition**: Represent data with plots on the real number line (dot plots, histograms and box plots).	✓	✓	✓	✓			
CC.9-12.S.ID.2 *Summarize, represent, and interpret data on a single count or measurement variable*. **Definition**: Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.	✓	✓	✓	✓			
CC.9-12.S.ID.3 *Summarize, represent, and interpret data on a single count or measurement variable*. **Definition:** Interpret differences in shape, center and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers)	✓	✓	✓	✓			
CC.9-12.S.ID.5 *Summarize, represent, and interpret data on two categorical or quantitative variables*. **Definition:** Summarize categorical data in a two-way frequency table. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data. Note: Although this requirement refers to categorical or quantitative variables, the definition is written in terms of categorical data.					✓	✓	✓

Statistics and Probability Standard/Data	**Length of String**	**Weight of Bob**	**Angle of Release**	**Frequency of Pendulum**	**Pendulum Size**	**Change in Pendulum Frequency**	**Change in Variable**
CC.9-12.S.ID6 *Summarize, represent, and interpret data on two categorical or quantitative variables.* **Definition**: Represent data on two quantitative variables on a scatter plot and describe how the variables are related. (Note: Definition of this standard is specific to quantitative data only.)	✓	✓	✓	✓			
CC.9-12.S.ID.6a *Summarize, represent, and interpret data on a single count or measurement variable.* **Definition**: Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Using a given functions or choose a function suggested by the context. Emphasize linear, quadratic and exponential models.	✓	✓	✓	✓			
CC.9-12.S.ID.6b Summarize, represent, and interpret data on a single count or measurement variable. **Definition**: Represent data on two quantitative variables on a scatter plot and describe how the variables are related.	✓	✓	✓	✓			
CC.9-12.S.ID.6c *Summarize, represent, and interpret data on a single count or measurement variable.* **Definition:** Fit a linear function for a scatter plot that suggests a linear association.	✓	✓	✓	✓			
CC.9-12.S.ID.8 *Interpret linear models*. **Definition:** Compute (using technology) and interpret the correlation coefficient of a linear fit.	✓	✓	✓	✓			
CC.9-12.S.ID.9 *Interpret linear models.* **Definition:** Distinguish between correlation and causation.	✓	✓	✓	✓			

Algebra 2 Standard/Data	Length of String	Weight of Bob	Angle of Release	Frequency of Pendulum	Pendulum Size	Change in Pendulum Frequency	Change in Variable
CC.9-12.F.IF.4 Interpret functions that arise in applications in term of the context. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities and sketch graphs showing key features given a verbal description of the relationship.	✓	✓	✓	✓			
CC.9-12.F.IF.5 Interpret functions that arise in applications in terms of the context. Relate the domain of a function to its graph and where applicable, to the quantitative relationship it describes.	✓	✓	✓	✓			
CC.9-12.F.IF.6 Interpret functions that arise in applications in terms of the context. Calculate and interpret the average rate of a function (presented symbolically or as a table) over a specified interval; Estimate the rate of change from a graph.	✓	✓	✓	✓			

Wind Turbines

Project Developers

- *Shari Arnold, English Teacher, Bangor Christian School*
- *John Milligan, Construction Engineering Technology Instructor, United Technologies Center*
- *Emily Spaulding, Science Teacher, Bangor Christian School*

Short Summary of the Project

Wind Turbines is a highly interactive project that combines English, science, math and construction in which students design and test their own wind turbine blades. The project encompassed a series of activities and field trips that included how to make scientific posters, developing hypotheses and designs, visiting a wind farm, touring the wind turbine blade test facility at the University Maine, and a culminating event to build and test their wind turbine blades.

The student designed wind turbine blades were tested using weights and fans.

This project was heavily focused on science, however part of science is collecting data and that ties directly to statistics.

Wind turbine blades

Touring the wind turbine test facility at UMaine

An integral part of the project is having the students collect their own data. For calculating purposes, the students will want to combine their data together to get a large enough sample size for statistical analysis.

The following table shows the data collected for this project.

Data Variable	Type
Angle of blade	Quantitative
Length of blade	Quantitative
Number of blades	Quantitative
Time to lift 5 weights	Quantitative
Time to lift 10 weights	Quantitative

Using This Project for the Proficiency Rubrics

The key to using this project to demonstrate proficiency lies in the amount of data that is collected by the students. The data lends itself to both statistical and algebra requirements.

For those requirements requiring a single count, any of the data values can be used, as long as it is the appropriate type (categorical or quantitative).

Standards CC.9-12.S.ID 6a,b,c. and CC.9-12.F.IF.4, CC.9-12.F.IF.5, CC.9-12.F.IF.6 require two quantitative variables to compare. Some examples of data pairs for these standards would be

- Length of blades versus time to lift 5 weights
- Angle of blades versus time to lift 5 weights
- Number of blades versus time to lift 5 weights
- Length of blades versus time to lift 10 weights
- Angle of blades versus time to lift 10 weights
- Number of blades versus time to lift 10 weights

Cross-Reference Table

The following table cross-references the data for the Wind Turbines project to the Proficiency-Based standards for Statistics and Probability

Statistics and Probability Standard/Data	**Angle of blades**	**Length of blades**	**Number of Blades**	**Time to lift 5 weights**	**Time to lift 10 weights**
CC.9-12.S.ID.1 *Summarize, represent, and interpret data on a single count or measurement.* **Definition**: Represent data with plots on the real number line (dot plots, histograms and box plots).	✓	✓	✓	✓	✓
CC.9-12.S.ID.2 *Summarize, represent, and interpret data on a single count or measurement variable*. **Definition**: Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.	✓	✓	✓	✓	✓
CC.9-12.S.ID.3 *Summarize, represent, and interpret data on a single count or measurement variable*. **Definition:** Interpret differences in shape, center and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers)	✓	✓	✓	✓	✓
CC.9-12.S.ID6 *Summarize, represent, and interpret data on two categorical or quantitative variables.* **Definition**: Represent data on two quantitative variables on a scatter plot and describe how the variables are related. (Note: Definition of this standard is specific to quantitative data only)	✓	✓	✓	✓	✓
CC.9-12.S.ID.6a *Summarize, represent, and interpret data on a single count or measurement variable.* **Definition**: Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Using a given functions or choose a function suggested by the context. Emphasize linear, quadratic and exponential models.	✓	✓	✓	✓	✓

Statistics and Probability Standard/Data	**Angle of blades**	**Length of blades**	**Number of Blades**	**Time to lift 5 weights**	**Time to lift 10 weights**
CC.9-12.S.ID.6b Summarize, represent, and interpret data on a single count or measurement variable. **Definition**: Represent data on two quantitative variables on a scatter plot and describe how the variables are related.	✓	✓	✓	✓	✓
CC.9-12.S.ID.6c *Summarize, represent, and interpret data on a single count or measurement variable.* **Definition:** Fit a linear function for a scatter plot that suggests a linear association.	✓	✓	✓	✓	✓
CC.9-12.S.ID.8 *Interpret linear models*. **Definition:** Compute (using technology) and interpret the correlation coefficient of a linear fit.	✓	✓	✓	✓	✓
CC.9-12.S.ID.9 *Interpret linear models.* **Definition:** Distinguish between correlation and causation.	✓	✓	✓	✓	✓

Algebra 2 Standard/Data	**Angle of blades**	**Length of blades**	**Number of Blades**	**Time to lift 5 weights**	**Time to lift 10 weights**
CC.9-12.F.IF.4 Interpret functions that arise in applications in term of the context. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities and sketch graphs showing key features given a verbal description of the relationship.	✓	✓	✓	✓	✓
CC.9-12.F.IF.5 Interpret functions that arise in applications in terms of the context. Relate the domain of a function to its graph and where applicable, to the quantitative relationship it describes.	✓	✓	✓	✓	✓
CC.9-12.F.IF.6 Interpret functions that arise in applications in terms of the context. Calculate and interpret the average rate of a function (presented symbolically or as a table) over a specified interval; Estimate the rate of change from a graph.	✓	✓	✓	✓	✓

Ramp It Up

Project Developers

- *Cynthia Blanchard, Mathematics Teacher, Old Town High School*
- *Jack Ledger, Technology Teacher, Orono High School*
- *Dave Stevens, Building Management Instructor, United Technology Center (UTC)*

Short Summary of Project

Ramp It Up! is a hands-on interactive project that integrates mathematics and building construction. Students design and construct an actual wheelchair ramp according to ADA (American Disability Act) specifications. Two key constraints of the ramp design focus on the slope of the ramp and the dimensions of the building it will attach to.

Individual lessons at the sending and CTE schools address scaled and three-dimensional drawings, material and cost estimates, developing construction plans and measurement. Joint activity days are used for construction, finishing, delivery and set-up of the ramp. The design is sketched and then entered into Google Sketch-Up software to provide a 3-dimensional schematic of the ramp. Using the schematic, the students are able to estimate the materials required and estimate cost. Mathematic concepts such as slope, trigonometric ratios and Pythagorean Theorem allow students to see them in action in a real-world application.

UTC, Old Town & Orono HS Students build wheelchair ramp

As with most of the M^{4}CTE/LEARN projects, student collection of their own data plays an integral role in this project. Using data they've collected gives them the experience of using "real life" data. The data for this project quantitative and is critical to design the ramp.

The following table shows the data collected for this project.

Data Variable	Type
Length of house	Quantitative
Placement of door (number of feet from edge of door to end of house)	Quantitative
Height of door from ground level	Quantitative
Length of desired deck	Quantitative
Width of deck	Quantitative
Width of ramp	Quantitative

Using This Project for the Proficiency Rubrics
This project requires the students to make many accurate measurements and use those measurements to determine the final dimensions of an ADA-compliant wheel chair ramp and estimate the cost to build it. The table below shows which pieces of data can be used for which standards.

Cross-Reference Table
The following table cross-references the data for this project to the Proficiency-Based standards for Statistics and Probability.

Geometry Standard/Data	Length of House	Placement of door	Height of door from ground level	Length of desired deck	Width of deck	Width of ramp
Standard: G.9-12.MG.1 *Apply geometric concepts in modeling situations.* **Definition**: Apply geometric concepts in modeling situations. Use geometric shapes, their measures and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder.	✓	✓	✓	✓	✓	✓
Standard: CC.9-12.MG.3 *Apply geometric concepts in modeling situations.* **Definition**: Apply geometric concepts in modeling situations. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize costs).	✓	✓	✓	✓	✓	✓

Rubrics for Capstone Project

The following rubrics show how aspects of the M^4CTE/LEARN projects can be used to fulfill Performance Indicators associated with Proficiency-Based diploma requirements. The actual assessments for each of the standards have been written to be universal in nature so that a teacher could use them as a model to demonstrate proficiency for any class work supporting the same standards.

This section contains rubrics for Probability and Statistics, Algebra 2, and Geometry. The standards for these areas are those that are applicable to the LEARN/M^4CTE projects. There are other standards in each of these areas not covered in these rubrics.

Roadmap to the Rubrics

The rubrics are given in the following spreadsheets and categorized by Performance Indicators for each of the mathematical areas. The Performance Indicators have been cross-referenced to Common Core standards. Each sub-standard is presented separately to allow the ability to demonstrate proficiency for specific pieces of a standard.

The columns of the rubric spreadsheets are set up as follows:

Column 1:

- Definition of the Standard.

Columns 2 – 4:

- Criteria for "(1) Attempted Demonstration", " (2) Partial Demonstration" and " (3) Proficient Demonstration" for the standard. This rubric does not include a 4th level for proficiency that is above and beyond the standard, but that could easily be added.
- Note: This section is written in more general terms so a teacher could use this for any activity or project they are doing that supports the same standards.

Column 5:

- This column provides a space to record a student's demonstrated proficiency rating for the standard.

Proposed detailed criteria to demonstrate proficiency and examples are provided beneath each table.

Performance Indicator: Statistics and Probability

Standard: CC.9-12.S.ID.1 Summarize, represent, and interpret data on a single count or measurement.	**(1) Attempted Demonstration (Does Not Meet Standards)**	**(2) Partial Demonstration (Partially Meets Standards)**	**(3) Proficient Demonstration (Meets Standards)**	**Rating Scale (1 -3)**
Standard Definition: Represent data with plots on the real number line (dot plots, histograms and box plots).	Student can present a set of single count or measurement variable data by constructing one of the following: dot plot, histogram or box plot	Student can represent a set of quantitative single count or measurement variable data by constructing two of the following: dot plot, histogram and box plot	Student can represent a set of quantitative single count or measurement variable data by constructing a dot plot, histogram and box plot.	

Detailed Criteria Definitions:

***Summarize means that given a set of single count data, the student can calculate the following: mean, median, interquartile range, standard deviation.

***Representation means that given a set of single count data, the student can use that data to construct a dot plot, histogram and box plot.

*** Interpret means given a set of single count data the student can write a statement explaining what the summary data and corresponding representation means in terms of the data.

An example would be: The data set has a mean of 25.5, a median of 24.4 and a standard deviation of 4.3. The lower and upper quartiles occur at 19.4 and 29.6, respectively. A histogram and dot plot of the data shows that most of the data values fall near the center of the data with fewer data values at the high and low ends. The lower and upper quartiles tell us that 50% of the data values fall between 19.4 and 29.6.

Standard: CC.9-12.S.ID.2 Summarize, represent, and interpret data on a single count or measurement variable.	**(1) Attempted Demonstration (Does Not Meet Standards)**	**(2) Partial Demonstration (Partially Meets Standards)**	**(3) Proficient Demonstration (Meets Standards)**	**Rating Scale (1 -3)**
Standard Definition: Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.	Student can determine the shape of each of the data distributions, but is not able to report the center (median or mean) or spread of the data sets (standard deviation). No comparison of the data sets can be made.	Student can determine the shape of the data distributions, and is able to only do one of the following: Correctly report center and spread based on the shape of the data distributions. Make a comparison of the center and spread of the data sets.	Student can determine the shape of the data distributions, and is able to do all of the following: Correctly report center and spread based on the shape of the data distributions. Make a comparison of the center and spread of the data sets	

Detailed Criteria Definitions:

***Determine shape means that given two different sets of single count data, the student is able to determine the shape (unimodal, symmetrical, skewed, etc.,) of each of the data distributions. The shape would be determined by examining a graphical representation such as a histogram.

***Summarize means that given two different sets of single count data, the student can calculate mean, median, interquartile range, standard deviation for each of the data sets.

**** Reporting the appropriate center and spread means that given two different sets of single count data, the student will use the shape of the data to determine the appropriate center and spread of each data set. The mean and standard deviation are reported for data that is unimodal and roughly symmetrical and the median and Interquartile Range are used for data that has a skewed distribution.

*** Interpret means the student can write a statement explaining their comparison of the two data sets based on their summary data and representation.

An example would be: Both data sets are skewed to the higher values. Because of this, it is appropriate to report the median as the center of the data and the Interquartile Range as a measure of the spread of the data. The second data set has lower data values over all. Further examination of the box plots shows that the middle 50% of the second data set is lower than the upper 50% of the data values in the first data set.

CC.9-12.S.ID.3 Summarize, represent, and interpret data on a single count or measurement variable.	**(1) Attempted Demonstration (Does Not Meet Standards)**	**(2) Partial Demonstration (Partially Meets Standards)**	**(3) Proficient Demonstration (Meets Standards)**	**Rating Scale (1 -3)**
Standard Definition: Interpret differences in shape, center and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers)	Student is able to interpret one of the following: shape, center or spread, but cannot identify potential extreme values or assess their impact.	Student is able to interpret two of the following: shape, center or spread for a data set. They can identify potential extreme values, but are not able to assess their impacts.	Student is able to interpret all of the following: shape, center and spread for a set of data and state what they mean for the set of data. The student is able to identify potential extreme values and assess their impacts.	

Detailed Criteria Definitions:

***Interpret differences in shape, center and spread means that after examining a set of single count data, the student will be able to discuss the shape, center and spread and what they mean in the context of the data set.

An example for a set of data related to the height of 8 year old girls would be: The data set is unimodal and roughly symmetrical. The data shows that the mean height of an 8 year old girl is XX inches. The standard deviation means that the average distance of the height values from the mean is YY inches.

***Account for possible effects of extreme data points (outliers) means that the student will be able to identify any potential outliers using an accepted methodology and then be able to explain the possible impact of any potential extreme values.

An example would be: The data set of house prices in the Springbrook neighborhood shows most houses sell between $225,000 to $265,000. One house sold for $745,000 and has been identified as a potential outlier. The impact of the outlier to the data is that it inflates the mean home price for the neighborhood.

CC.9-12.S.ID.5 Summarize, represent, and interpret data on two categorical or quantitative variables.	**(1) Attempted Demonstration (Does Not Meet Standards)**	**(2) Partial Demonstration (Partially Meets Standards)**	**(3) Proficient Demonstration (Meets Standards)**	**Rating Scale (1 -3)**
Standard Definition: Summarize categorical data in a two-way frequency table. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies.) Recognize possible associations and trends in the data.	Student is able to correctly create a two way frequency table, but is unable to interpret the relative frequencies of the data, nor are they able to recognize possible associations or trends between the categorical variables.	Student is able to correctly create a two way frequency table and is able to do only one of the following: ➢Student can interpret the relative frequencies in the context of the data. ➢Student is able to recognize possible associations and trends using the relative frequencies in the table.	Student is able to create a two way frequency table and is able to interpret the relative frequencies in the context of the data. They are able to recognize possible associations and trends using the relative frequencies in the table.	

Detailed Criteria Definitions:

***Summarize categorical data for two categories in two-way frequency tables means the student can create a two-way table and distribute the categorical data in the table. The student would need to set up the table with the categories of one of variables listed in the first column and the categories of the second variable listed on the first row of the table and then distribute the data based on quantities for each category.

Example: The following Two-Way table shows the distribution of the results of a survey of students in a statistics class. The two categorical variables are: Gender (Male/Female) and Tried Shushi? (Yes/No).

	Male	**Female**	**Total**
Sushi – Yes	7	5	12
Sushi - No	7	11	18
Total	14	16	30

***Interpret relative frequencies into the context of the data means that the student is able to calculate the relative frequencies (joint, marginal and conditional) of the data and can write a statement describing what the relative frequencies mean for the given set of data.

***Recognize possible associations and trends in the data means student can recognize possible associations between the categorical variables and trends in the data by examining the relative frequencies data across the rows, columns and margins of the table.

CC.9-12.S.ID6 Summarize, represent, and interpret data on two categorical or quantitative variables	**(1) Attempted Demonstration (Does Not Meet Standards)**	**(2) Partial Demonstration (Partially Meets Standards)**	**(3) Proficient Demonstration (Meets Standards)**	**Rating Scale (1 -3)**
Standard Definition: Represent data on two quantitative variables on a scatter plot and describe how the variables are related.	Student is not able to create a scatter plot, but is able to describe how the variables are related if given a scatter plot of quantitative variables to examine.	Student is able to create a scatter plot, and is either not able to describe how the variables are related or if they are able to see there is a relationship, they cannot describe it.	Student is able to create a scatter plot and describe how the variables are related.	

Detailed Criteria Definitions:

***Represent data on two quantitative variables on a scatter plot means that given two sets of quantitative data, the student can identify coordinate pairs (x,y) for the data sets and plot the pairs on a standard x-y coordinate plane.

***Describe how the variables are related means that the student can examine a scatter plot and describe how the variables are related by determining whether the scatter plot is linear in nature and if there is an association between the variables and the strength and direction of that association. This is accomplished by determining how close the coordinate points fall to a line. The closer the points fall to a line, the stronger the association.

Sub-standard of CC.9-12.S.ID6				
CC.9-12.S.ID.6a Summarize, represent, and interpret data on a single count or measurement variable.	**(1) Attempted Demonstration (Does Not Meet Standards)**	**(2) Partial Demonstration (Partially Meets Standards)**	**(3) Proficient Demonstration (Meets Standards)**	**Rating Scale (1 -3)**
Standard Definition: Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Using a given function(s) or choose a function suggested by the context. Emphasize linear, quadratic and exponential models.	Student is able to create a scatter plot of the data, but is not able to identify function type as linear, quadratic or exponential or fit a function to the data. Student is not able to use a function fitted to the data to solve problems in the context of the data.	Student is able to create a scatter plot of the data and can identify function type as linear, quadratic or exponential or fit a function to the data. Student is not able to use a function fitted to the data to solve problems in the context of the data.	Student is able to create a scatter plot of the data and can identify function type as linear, quadratic or exponential or fit a function to the data. Student is able to use a function fitted to the data to solve problems in the context of the data.	

Detailed Criteria Definitions:

*** Fit a function to the data, means the student can use a scatter plot to identify the type of function (linear, quadratic, or exponential) for each data set. This is accomplished by visually inspecting the characteristics of the scatter plot of each data set and comparing them to the characteristics of the base graphs for linear, quadratic and exponential models and selecting the model that best represents the shape of each of the scatter plots.

**** Use functions fitted to the data to solve problems in the context of the data means that the student can use given functions, solve them for a specific value and relate the results to the context of the data.

For example, assume that a student has fitted a set of data relating to the age and price of used Prius cars to a linear model. If they evaluate the equation for a 4.5 year old car, the interpretation would be: Using a linear model based on the set of data, the estimated the price of a 4.5 year old Prius would be $XX,XXX.

***Use given function or choose a function suggested by the data context means that when given examples of functions, the student can correctly choose the most appropriate function (linear, exponential, etc.) for the data. This would be done examining the scatter plot, determining the function type and selecting from a set of examples, the most appropriate function.

Sub-standard of CC.9-12.S.ID6				
CC.9-12.S.ID.6b Summarize, represent, and interpret data on a single count or measurement variable.	**(1) Attempted Demonstration (Does Not Meet Standards)**	**(2) Partial Demonstration (Partially Meets Standards)**	**(3) Proficient Demonstration (Meets Standards)**	**Rating Scale (1 -3)**
Standard Definition: Informally assess the fit of a function by plotting and analyzing residuals.	Student is able to use a function to calculate predicted values for the "x-values" of an actual set of data values, but is not able to determine the resulting residuals or create a plot of the residuals.	Student is able to use a function to calculate predicted values for the "x-values" of an actual set of data values. They are able to determine the resulting residuals and create a plot of the residuals, but cannot assess the fit of the function to a linear model by analyzing the plot residuals.	Student is able to use a function to calculate predicted values for the "x-values" of an actual set of data values. They are able to determine the resulting residuals and create a plot of the residuals They can assess the fit of the function to a linear model by analyzing the plot of the residuals.	

Detailed Criteria Definitions:

*** Informally assess the fit of a function by plotting and analyzing residuals means that the student will use the function to determine the residual (i.e., difference in the actual data "y" value and the predicted data "y" value from the function for each data point of the original data set). They will then create a scatter plot using the "x" value of the actual data points and the residual quantity for the "y". The student would then assess the pattern of scatter plot. If the data is truly linear, then a residual plot showing data with no apparent pattern would indicate that a linear function was indeed the proper model for the data.

Sub-standard of CC.9-12.S.ID6				
CC.9-12.S.ID.6c Summarize, represent, and interpret data on a single count or measurement variable.	**(1) Attempted Demonstration (Does Not Meet Standards)**	**(2) Partial Demonstration (Partially Meets Standards)**	**(3) Proficient Demonstration (Meets Standards)**	**Rating Scale (1 -3)**
Standard Definition: Fit a linear function for a scatter plot that suggests a linear association.	Student is able to plot a set of data and determine that it suggests a linear pattern, but is not able to determine a linear function that fits the data.	Student is able to plot a set of data and determine that it suggests a linear pattern. They are able to partially get through the least squares regression calculations, but are not able to correctly find a linear equation that fits the data.	Student is able to plot a set of data and determine that it suggests a linear pattern. They are able to use least squares regression calculations to correctly find a linear equation that fits the data.	

Detailed Criteria Definitions:

*** Fit a linear function for a scatter plot that suggests a linear association means that given two sets of quantitative data, the student can use algebraic means (i.e., least squares regression) to determine a linear equation that models a set of data that appears to be linear.

CC.9-12.S.ID.8 Interpret linear models	**(1) Attempted Demonstration (Does Not Meet Standards)**	**(2) Partial Demonstration (Partially Meets Standards)**	**(3) Proficient Demonstration (Meets Standards)**	**Rating Scale (1 -3)**
Standard Definition: Compute (using technology) and interpret the correlation coefficient of a linear fit.	The student does not understand that the correlation coefficient can be used to assess the direction and strength of the relationship between two quantitative variables. Student is able to use technology to enter a data set, but cannot interpret the resulting correlation coefficient.	The student understands that the correlation coefficient can be used to assess the direction and strength of the relationship between two quantitative variables. Student is able to use technology to enter a data set, but cannot correctly interpret the resulting correlation coefficient.	The student understands that the correlation coefficient can be used to assess the direction and strength of the relationship between two quantitative variables. Student is able to use technology to enter a data set and can correctly interpret the resulting correlation coefficient.	

Detailed Criteria Definitions:

*** Compute (using technology) means that given two sets of quantitative data, the student will enter a set of data into technology (i.e., TI graphing calculator, Excel or other software) to determine the equation that best fits the data.

*** Interpret the correlation coefficient of a linear fit means that the student can explain what the coefficient means in terms of direction and strength of correlation.

For example, a correlation value of .94 indicates a strong positive linear relationship between the two quantitative data variables.

CC.9-12.S.ID.9 Interpret linear models	**(1) Attempted Demonstration (Does Not Meet Standards)**	**(2) Partial Demonstration (Partially Meets Standards)**	**(3) Proficient Demonstration (Meets Standards)**	**Rating Scale (1 -3)**
Standard Definition: Distinguish between correlation and causation.	Student can determine that a numerical correlation exists between two quantitative variables using a correlation coefficient, but cannot distinguish between correlation and causation.	Student can determine that a numerical correlation exists between two quantitative variables using a correlation coefficient. They understand that there are many factors that could impact whether one variable "causes" the other, but they view correlation as implying causation.	Student can determine that a numerical correlation exists between two quantitative variables using a correlation coefficient. They understand that there are many factors that could impact whether one variable "causes" the other and understand that correlation does not imply causation.	

Detailed Criteria Definitions:

***Distinguish between correlation and causation means that student fully understands that numerical correlation between two quantitative variables does not imply causation between the variables. For example: A strong correlation between height of elementary school children and reading level does not necessarily mean that height causes increased reading levels. (note: The height could be related to age and account for the reading level.)

Performance Indicator: Algebra 2

Standard: CC.9-12.F.IF.4 Interpret functions that arise in applications in term of the context.	**(1) Attempted Demonstration (Does Not Meet Standards)**	**(2) Partial Demonstration (Partially Meets Standards)**	**(3) Proficient Demonstration (Meets Standards)**	**Rating Scale (1 -3)**
Standard Definition: Interpret functions that arise in terms of the context. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior and periodicity.	Student is able to do only one of the following: ➢Given a function for a specific application, the student can write or verbalize a statement that explains what the function means for the particular application. ➢Given a function that arises in an application, the student can only identify and interpret one or two key features of graphs and tables in terms of the context. ➢Given a verbal description of the relationship between variables in a function, the student is able to sketch a graph showing only one or two key features from a verbal description of the relationship.	Student is able to do two of the following: ➢Given a function for a specific application, the student can write or verbalize a statement that explains what the function means for the particular application. ➢Given a function that arises in an application, the student can identify and interpret most, but not all key features of graphs and tables in terms of the context. ➢Given a verbal description of the relationship between variables in a function, the student is able to sketch a graph showing most, but not all key features from a verbal description of the relationship.	Student is able to all three of the following: ➢Given a function for a specific application, the student can write or verbalize a statement that explains what the function means for the particular application. ➢Given a function that arises in an application, the student can identify and interpret all key features of graphs and tables in terms of the context. ➢Given a verbal description of the relationship between variables in a function, the student is able to sketch a graph correctly showing all of the key features from a verbal description of the relationship.	

Detailed Criteria Definition:

*** Interpret functions that arise in terms of the context means the student can write or articulate a statement that explains what the function means in terms of the application it is being used for.

For example, Assume the student was using the following function to calculate the weekly cost C, to rent a car and drive *x* miles. $C=200+.20x$. The interpretation would be that the function calculates the weekly cost to rent a car by adding a $200 fixed fee plus 20¢ per mile driven.

Standard CC.9-12.F.IF.4 Detailed Criteria Definition *Continued*

*** For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities and sketch graphs showing key features given a verbal description of the relationship means.

**** Sketch graphs showing key features given a verbal description of the relationship means that a student can sketch a graph of the function and label all key features: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior and periodicity.

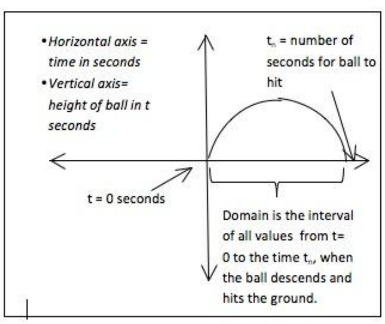
Standard: CC.9-12.F.IF.5 Interpret functions that arise in applications in terms of the context.	**(1) Attempted Demonstration (Does Not Meet Standards)**	**(2) Partial Demonstration (Partially Meets Standards)**	**(3) Proficient Demonstration (Meets Standards)**	**Rating Scale (1 -3)**
Standard Definition: Interpret functions that arise in applications in terms of the context. Relate the domain of a function to its graph and where applicable, to the quantitative relationship it describes. For example, if the function h(n) gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain of the function.	Given a function, the student is not able to identify the domain of the function.	Given a function, the student can identify what the domain of the function based on its graph, but cannot describe the quantitative relationship between the domain in terms of the context of the application.	Given a function, the student can identify what the domain of the function based on its graph and can describe the quantitative relationship between the domain in terms of the context of the application.	

Detailed Criteria Definition:

*** Interpret functions that arise in applications in terms of the context, is defined in **CC.9-12.F.IF.4**

***Relate the domain of a function to its graph means that given an application function, the student is able to use the graph of the function to determine the domain of the function.

An example would be: Given a function that defines the height of a ball "*t*" seconds after it is thrown upward. The graph for this function would be a parabola opening downward in the 1st quadrant in the coordinate plane. The student should be able to determine that the domain would be all values t (time) in the interval from t = 0 to the time when the ball descends and hits the ground (i.e., elevation is zero).



**** Where applicable, relate the domain to the quantitative relationship it describes, means that the student can explain what the domain is relative to the context of the application. They can describe what the domain means for the given application.

For example: Using the same function that models the height of a ball t seconds after being thrown upward, the student should be able to explain that the domain represents the number of seconds from the time the ball is thrown (t = 0) until the time the ball hits the ground. They should also be able to recognize that this would include only positive values.

Standard: CC.9-12.F.IF.6 Interpret functions that arise in applications in terms of the context.	**(1) Attempted Demonstration (Does Not Meet Standards)**	**(2) Partial Demonstration (Partially Meets Standards)**	**(3) Proficient Demonstration (Meets Standards)**	**Rating Scale (1 -3)**
Standard Definition: Interpret functions that arise in applications in terms of the context. Calculate and interpret the average rate of a function (presented symbolically or as a table) over a specified interval; Estimate the rate of change from a graph.	The student can calculate and interpret the average rate of change from a function presented in one of the following ways: • Symbolically • Table format • Graph	The student can calculate and interpret the average rate of change from a function presented in two of the following ways: • Symbolically • Table format • Graph	The student can calculate and interpret the average rate of change from a function presented in all of the following ways: • Symbolically • Table format • Graph	

Detailed Criteria Definition:

*** Interpret functions that arise in applications in terms of the context, is defined in **CC.9-12.F.IF.4**

*** Calculate and interpret the average rate of a function presented symbolically (i.e., in equation form) or as a table over a specified interval means given a function and a specified interval from x = a to x = b, the student can use the following equation to calculate the average rate of change.

$$\text{Average Rate of Change} = \frac{net\ change\ in\ y}{change\ in\ x} = \frac{f(b)-f(a)}{b-a}$$

For this standard, the student will need to determine the "y" values corresponding to the x values at the beginning and end of the given interval. If x = a, then the corresponding y value is f(a). If the student is given a table of x and y values for a function, they simply need to read the values off a table. If they are given the symbolic representation for the function, they need to enter the x =a and x= b values into the equation to find the corresponding y (f(a) and f(b)) values. Once the y values are found, the students can calculate the average rate of change using the equation above.

*** Estimate the rate of change from a graph, means that given a function which is represented as a graph that the student visually inspects the graph and estimates the y value corresponding to x = a and x = b, and then calculates the average rate of change using the equation given above.

*** Interpret the average rate of change means that once the student has calculated the average rate of change that they can express their result in a statement that explains what the rate of change means in the context of the problem.

Performance Indicator: Geometry

Standard: G.9-12.MG.1 Apply geometric concepts in modeling situations.	**(1) Attempted Demonstration (Does Not Meet Standards)**	**(2) Partial Demonstration (Partially Meets Standards)**	**(3) Proficient Demonstration (Meets Standards)**	**Rating Scale (1 -3)**
Standard Definition: Apply geometric concepts in modeling situations. Use geometric shapes, their measures and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder.	Given a modeling situation, the student is not able to describe (i.e., visualize) objects in terms of geometric shapes, even with some prompting.	Given a modeling situation, the student is able to describe (i.e., visualize) objects in terms of geometric shapes, with some prompting from the teacher.	Given a modeling situation, the student is readily able to describe objects in terms of geometric shapes.	

Detailed Criteria Definition:

*** Apply geometric concepts in modeling and use geometric shapes, their measures and their properties to describe objects means student is able look at objects and see them as geometric shapes.

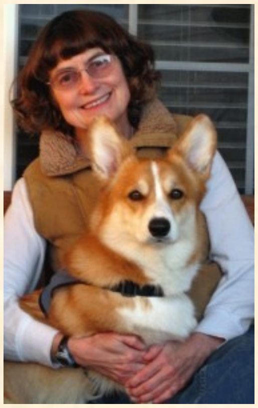
Examples would be: A very simple example would be to view a back yard as a rectangle. If the student were asked to find the volume of a house, they would need to recognize that the house is made of shapes: rectangular box(es) and a prism. From this, they could easily estimate the volume of the house, Using these same properties, they could estimate the surface area of the house as well.

Standard: CC.9-12.MG.3 Apply geometric concepts in modeling situations.	**(1) Attempted Demonstration (Does Not Meet Standards)**	**(2) Partial Demonstration (Partially Meets Standards)**	**(3) Proficient Demonstration (Meets Standards)**	**Rating Scale (1 -3)**
Standard Definition: Apply geometric concepts in modeling situations. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize costs).	Given a modeling situation involving a design problem, the student is not able to model the situation in terms of geometry. In other words, they are unable to see the object(s) or structures as geometric shapes.	Given a modeling situation involving a design problem, the student is able to define the situation in terms of geometry, but is unable to use geometric methods to model a solution that meets design constraints.	Given a modeling situation involving a design problem, the student is able to define the situation in terms of geometry and is able to use geometric methods to model a solution that meets design constraints.	

Detailed Criteria Definitions:

**** Apply geometric concepts in modeling and apply geometric methods to solve design problems means that given a problem applicable to modeling that the student can see that the problem can be viewed in terms of geometric shapes and then use geometric methods to solve a design problem while meeting constraints.

Examples would be: A student is challenged to design a wheelchair ramp that meets ADA (American Disabilities Act) specifications. The student would need to be able to recognize that the basic shape of a ramp is a right triangle and the length of the ramp can be modeled as the hypotenuse of the triangle. The student can then use geometric methods such as Pythagorean Theorem to find the length of the hypotenuse given a specified height and an ADA approved height.



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