STEM Curriculum Planning Guide

This instructional design guide serves as the template for the design and development of STEM units of instruction at the Dayton Regional STEM Center in Dayton, Ohio. The guide is anchored to the *STEM Education Quality Framework* also developed at the Dayton Regional STEM Center.

STEM Unit Title	**Practical Frac-tile**
Economic Cluster	Human Performance & Medicine
Targeted Grades	4 and 5
STEM Disciplines	Technology Engineering Math
Non-STEM Disciplines	English Language Arts

Section I: STEM Unit Overview

Unit Overview

Students will engineer a functional cafeteria floor plan when given the room's area as well as specific stationary objects. The created floor plan will show both cafeteria functions (cashier, snack table, silverware station, trash, recycling, etc.) human traffic patterns which will be achieved with the tile patterning. Student engineers will work within a given budget utilizing fraction and geometry prior knowledge. Students will compute decimals/fractions, tessellate various polygons, utilize perimeter and area, convert fractions, decimals, and percents while implementing the engineering design process to produce optimal cafeteria traffic flow.

Essential Question

How can fractions be used to create visual patterns seen in our everyday world?

Enduring Understanding

Students will be able to manipulate two-dimensional shapes, construct models utilizing surface areas, integrate proportional reasoning, use fractional parts and compute using fractions and decimals. Students will apply the use of a budget in an engineering design challenge. They will learn how budget constraints affect project plans.

Engineering Design Challenge

Students are challenged to design a cafeteria floor plan that shows cafeteria functions and a traffic pattern for student movement. Teams will be given a specific area for their cafeteria as well as predetermined stationary objects that would be in the cafeteria to work around. The design must include various shaped tiles and be completed under a specified budget. They will decide the necessary components and organization of the cafeteria, as well as what is needed in the floor design (for example, possibly including a location for milk purchases). Teams will also need to think about how people move throughout the cafeteria (for example, what direction students will walk to go through the line and then return their lunch trays?). They will design a floor pattern to show these elements by tessellating different shaped tiles. After the students create their initial design, they will be asked to redesign their floors by using less money. There is incentive for the design team that saves the greatest amount of money.

Time and Activity Overview

Day	Time Allotment	Actvities
1	60 minutes	Pre-test Present Engineering Design Challenge Discuss Math Preparation for Challenge
2	60 minutes	Create Rough Drafts Begin Budget Template
3	60 minutes	Continue Day 2
4	60 minutes	Present Justifications Redesign Create Final Copies

5	60 minutes	Calculate Floor Plans
6	60 minutes	New Budget Redesign
7	60 minutes	Optional Day - Geometer's Sketch Pad or GeoGebra
8	60 minutes	Presentations and post-test

Pre-requisite Knowledge & Skill	Students should know that fractions, decimals, and percents are parts of a whole and are related to one another. Students should know the definitions of perimeter and area and how to calculate these measurements of quadrilaterals.

Academic Content Standards

Add Standard	Mathematics	Ohio
Grade/Conceptual Category		
Domain		
Cluster		
Standards		

Add Standard	Mathematics	Ohio
Grade	5	
Standard	Numbers and Operations-Fractions	
Benchmark	Use equivalent fractions as a strategy to add and subtract fractions	
Indicator	1. Add and subtract fractions with unlike denominators (including mixed numbers) by replacing given fractions with equivalent fractions in such a way as to produce an equivalent sum or difference of fractions with like denominators.	

Add Standard	Mathematics	Ohio
Grade	5	
Standard	Number and Operations-Fractions	
Benchmark	Apply and extend previous understandings of multiplication and division to multiply and divide fractions.	
Indicator	6. Solve real world problems involving multiplication of fractions and mixed numbers.	

Add Standard	**Mathematics**
Grade	4
Standard	Measurement and Data
Benchmark	Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.
Indicator	3. Apply the area and perimeter formulas for rectangles in real world mathematical problems.

Add Standard	**Mathematics**
Grade	5
Standard	Number and Operations-Fractions
Benchmark	Apply and extend previous understandings of multiplication and division to multiply and divide fractions.
Indicator	5. Interpret multiplication as scaling (resizing) by: a. Comparing the size of a product to the size of one factor on the basis of the size of the other factor, without performing the indicated multiplication.

Add Standard	**Mathematics**
Grade	4
Standard	Number and Operations-Fractions
Benchmark	Understand decimal notation for fractions, and compare decimal fractions.
Indicator	Express a fraction with denominator 10 as an equivalent fraction with denominator 100, and use this technique to add two fractions with respective denominators 10 and 100.

Add Standard	**Mathematics**	
Grade	4	
Standard	Number & Operations - Fractions	
Benchmark	Understand decimal notation for fractions, and compare decimal fractions.	
Indicator	6. Use decimal notation for fractions with denominators of 10 or 100. For example, rewrite 0.62 as 62/100 on a number line diagram.	

Add Standard	**Mathematics**	
Grade	4	
Standard	Measurement & Data	
Benchmark	Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.	
Indicator	2. Use the four operations to solve world problems involving distances, intervals of time, liquid masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of small units. Represent measurement quantities using diagrams such as a number line that feature a measurement scale.	

Add Standard	**English Language Arts**	
Grade	5	
Strand	Speaking and Listening	
Topic	Comprehension and Collaboration	
Standard	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse patterns on Grade 5 topics and texts, building on others' ideas and expressing their own clearly.	

Add Standard	English Language Arts	Ohio
Grade	5	
Strand	Speaking and Listening	
Topic	Presentation of Knowledge and Ideas	
Standard	4. Report on a topic or text or present and opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.	

Add Standard	English Language Arts	Ohio
Grade	5	
Strand	Speaking and Listening	
Topic	Presentation of Knowledge and Ideas	
Standard	5. Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes.	

Add Standard	English Language Arts	Ohio
Grade		
Standard		
Benchmark		
Indicator		

Add Standard	Social Studies	Ohio
Grade		
Theme		
Strand (pk-8 only)		
Topic		
Content Standard		

Add Standard	Social Studies	Ohio
Grade		
Standard		
Benchmark		
Indicator		

Add Standard	Science	Ohio
Grade		
Theme		
Topic		
Content Standard		

Add Standard	Science	Ohio
Strand		
Course Content		
Content Elaboration		

Add Standard	Science	Ohio
Grade		
Standard		
Benchmark		
Indicator		

Add Standard	Fine Arts	Ohio
Grade		
Subject		
Standard		
Benchmark		
Indicator		

Add Standard	**Technology**	
Grade	4	
Standard	Design process	
Benchmark	A - Describe and apply a design process to solve a problem.	
Indicator	1. Apply the design process to purposefully solve a problem (e.g., how to improve recycling at school and home).	

Add Standard	**Technology**	
Grade	4	
Standard	Design Process	
Benchmark	A - Describe and apply a design process to solve a problem.	
Indicator	2. Generate solutions for solving a problem using the design process with information collected about everyday technological problems.	

Add Standard	**Technology**	
Grade	4	
Standard	Technical Communication	
Benchmark	A - Describe and apply a design process to solve a problem.	
Indicator	4. Make sketches and paper models to visualize possible solutions to a technological problem (e.g., use computer drawing program to prepare cut-out patterns).	

Add Standard	**Technology**
Grade	5
Standard	Design Process
Benchmark	A - Describe and apply a design process to solve a problem.A
Indicator	Arrive at a solution to a technological problem and fabricate a prototype model for the solution.

Add Standard	**Technology**
Grade	5
Standard	Design Process
Benchmark	A - Describe and apply a design process to solve a problem.A
Indicator	3. Make sketches with a list of parts required for a solution to a technological problem.

Add Standard	**Technology**
Grade	5
Standard	Optimization and Trade-offs
Benchmark	A - Describe and apply a design process to solve a problem.
Indicator	Analyze the requirements for a design including such factors as the desired elements and features of a product or system and limits that are placed on the design (e.g., if the class were to prepare and deliver food to the homeless or a nursing home, what are the desired features and what limits are there to what can be done?).

Assessment Plan

What evidence will show that students have acquired the enduring understandings for this STEM unit?

Performance Task, Projects	Cafeteria Floor Plan Budget Report Redesigned Floor Plan Rubrics
Quizzes, Tests, Academic Prompts	Pre-test Post-test
Other Evidence (e.g. observations, work samples, student artifacts, etc.)	Final Presentation
Student Self- Assessment	Exit Slips and Reflections Rubrics

Technology Integration

ADISC Technology Integration Model*

	Type of Integration	Application(s) in this STEM Unit
A	Technology tools and resources that support students and teachers in ***adjusting, adapting, or augmenting*** teaching and learning to meet the needs of individual learners or groups of learners.	Geometer's Sketchpad or GeoGebra
D	Technology tools and resources that support students and teachers in ***dealing effectively with data***, including data management, manipulation, and display.	Geometer's Sketchpad or GeoGebra Excel Calculator
I	Technology tools and resources that support students and teachers in conducting ***inquiry***, including the effective use of Internet research methods.	Geometer's Sketchpad or GeoGebra
S	Technology tools and resources that support students and teachers in ***simulating*** real world phenomena including the modeling of physical, social, economic, and mathematical relationships.	Geometer's Sketchpad or GeoGebra
C	Technology tools and resources that support students and teachers in ***communicating and collaborating*** including the effective use of multimedia tools and online collaboration.	Computer-based presentation program
	**The ADISC Model was developed by James Rowley PhD, Executive Director of the Institute for Technology-Enhanced Learning at the University of Dayton*	

Career Connections

Career Description

Human Factors
Industrial Designers
Architects
Interior Designers
Graphic Designers
Computer Engineers
CAD/CAM (computer aided designs/computer aided manufacturing)
Construction/contractor/mason/tile setter
Electrical Engineer
Mechanical Engineer

Careers in these fields may utalize use Human Factors engineering which utilizes topics such as the study of characteristic human features, known as ergonomics, and the study of human behavior resulting from the operation of systems, known as engineering psychology, to estimate operator awareness & comprehension of a device or environment and to make corrections to the design of a human user interface (HUI).

Section II: STEM Lesson Plan

Title of Lesson	**Day #1**
Time Required	60 minutes
Materials	Pre/Post Test (Appendix A) - one per student Protractors (for test) - one per student Rulers (for test) - one per student Engineering Design Challenge (Appendix C) - one per student Engineering Design Process (Appendix D) - one per student Floor Plan (Appendix G) - one per student Budget Template (Appendix F) - one per student Design Rubric (Appendix E) - one per student Day #1 Exit Slip (Appendix J) - one per student Folder for each student loose leaf paper
Objectives	Define Engineering Design Challenge (EDC) Identify math concepts necessary to solve EDC
Instructional Process	1. Administer pretest (Appendix A). 2. Create student design teams of two to four students. 3. Present Engineering Design Challenge (EDC) (Appendix C) to students. 4. Allow time for design teams to discuss the challenge with their design team. 5. Discuss the problem and explain the Engineering Design Process (Appendix D). Point out the the Engineering Design Process is ongoing and that the circular pattern is continuous. 6. Have students complete one or both of the Day #1 exit slips (Appendix J). (Exit slips for each lesson may be used as homework or class work depending on time)
Differentiation	In order to offer more teacher assistance as needed, consider homogenous grouping for this unit. Allow students to choose which Exit Slip to complete Students may use 3-5 colors in their floor plans. The number of colors allowed by each team can be decided by the teacher. Use the Vocabulary Cards (Appendix O) for students that need extra vocabulary review.

	Method of design team creation (i.e., ability, random, or student chosen)
Assessments	Use the Pre-Test results as a guide for modifying the unit in order to meet the needs of your specific classes and individual students. Exit Slips

Section II: STEM Lesson Plan

Title of Lesson	**Days #2 and #3**
Time Required	120 minutes (2 days)
Materials	Floor Plan (Appendix E) - one per student Budget Template (Appendix F) - multiple copies for each students (rough draft, final, and mistakes) Day #3 Exit Slips (Appendix K) - one per student colored pencils student folders from the first day
Objectives	Identify necessary components of a cafeteria. Develop the floor plan rough drafts.
Instructional Process	1. Present discuss the Budget Template (Appendix F) and Floor Plan (Appendix G) handouts with the teams. 2. Review rubric requirements and budget calculations for the EDC. 3. Inform students that they will evaluate themselves at the end of the challenge as well as be evaluated by the teacher. 4. Lead the class in brainstorming the math concepts necessary to complete the challenge. For example, ask the students, "What will you need to calculate to s solve this problem?" 5. Have all students keep papers in a folder throughout the lesson. 6. Review the EDC, Budget Template, and Design Rubric with the class. 7. Instruct student design teams to share their exit slip ideas as they discuss the necessary components they will include in their team design. For example: location for milk purchase, lunch tray return, trash cans, or cashier. 8. Have teams decide the location of the elements they decided to include in their cafeteria. 9.Thoroughly discuss with students that each square on the floor plan paper is not a tile box. The graph paper is used to guide measurements, the various tiles will fill that much area on the graph paper. 10.Explain the Budget Template (Appendix F) and remind them to make sure their design falls within their budget. 11.Instruct teams to design and color a rough draft of their cafeteria floor plans using the floor plan paper. 12.Have each member draw and color his or her own copy of the team floor plan.

13. Have students complete Day #3 Exit Slip (Appendix K) at the end of class or for homework. Inform them that their justifications will be a part of the final presentation.

Differentiation	Challenge student by having them create their floor plan to a given scale. Allow students to use a calculator as needed. Increase or decrease the amount of tables and/or color requirements. Take measurements of your school's cafeteria and redesign. Students may use 3-5 colors in their floor plans. The number of colors allowed by each team can be decided by the teacher.
Assessments	Exit Slips for Day #3 (Appendix J)

Section II: STEM Lesson Plan

Title of Lesson	**Day #4**
Time Required	60 minutes
Materials	Copies of the Floor Plan (Appendix E) - one per student Day #4 Exit Slips (Appendix L) - one per student colored pencils student folders
Objectives	Justify floor plan design to the class. Complete final floor plan drawing.
Instructional Process	1. Allow time for the design teams to meet and review their exit slips from Day #2 (Appendix J). Instruct them to develop a final justification for their design to inform the class of the cafeteria elements they choose and reason for their choices. These will be part of the final presentation. (10 minutes) 2. Have each team present the justification for their design to the class. Instruct the other design teams to ask questions about their decision and decision making process. (3 minutes per team) 3. After listening to other presentations and answer questions about their design, have design teams discuss possible changes to make to their rough drafts from the previous day. (10-15 minutes) 4. Instruct students to include any changes they decided to make with their rough draft and create the final copies of their floor plans. (20 minutes) 5. Have students complete the Day #4 Exit Slip (Appendix L).
Differentiation	Have students work with scales and limited color choices. Allow students to choose which Exit Slip question they will answer.
Assessments	Justification Presentation Exit Slips

Section II: STEM Lesson Plan

Title of Lesson	**Day #5**
Time Required	60 minutes
Materials	final designs student folders Calculations Worksheet (Appendix H) - one per student Day #5 Exit Slips (Appendix M) - one per student
Objectives	Calculate area, fractional part, decimal part, and percent for each colored area of the team's final design.
Instructional Process	1. Review Exit Slip answers with students to check the understanding of area and perimeter. Provide additional instruction if needed. 2. Go over directions for Calculation Worksheet (Appendix H) with students. 3. Instruct students on perimeter, area, fraction, decimals, and percents using team designs as examples. 4. Instruct students to show their work as they individually complete the Calculation Worksheet. 5. Teacher will help individuals as they have questions, pausing the whole class as necessary to answer questions and go over concepts again. 6. Assign the Day #5 Exit Slip (Appendix M) for completion.
Differentiation	Assist individual students with calculations as necessary. Allow use of calculators. Allow students to choose which Exit Slip question they will answer.
Assessments	Calculation Worksheet Exit Slips

Section II: STEM Lesson Plan

Title of Lesson	**Day #6**
Time Required	60 minutes
Materials	Floor Plan (Appendix E) - one per student Budget Template (Appendix F) - one per student Calculation Worksheet (Appendix H) - one per student Customer's Request to Minimize Expenses (Appendix I) - one per team Day #6 Exit Slip (Appendix N) - one per student student folders colored pencils
Objectives	Complete floor plan with new budget incentive.
Instructional Process	1. Review the budget incentive with students. 2. Discuss the following as a class: * What team created the least expensive floor plan, the most expensive? * What do you think attributed to the differences in costs? * How do the floor plan costs compare to the aesthetics of the designs? * What are different reasons that the budget could change? What other "hiccups" could happen during a project like this? 3. After the discussion, inform students that there is an incentive to create the floor design using less money. The school needs them to spend the least amount of money possible, while still meeting the constraints of the floor design. Let them know that customers will often go with the least expensive price that fits their needs. 4. Handout Customer's Request to Minimize Expenses (Appendix I). 4. Re-visit the Engineering Design Process (Appendix D). Discuss how this part of the problem fit into the Engineering Design Process. 5. Allow time for students to redesign their floor plans and complete a new Budget Sheet (Appendix E) for their design. 6. Reassign the Calculation Worksheet (Appendix G) (or a portion) to students. 7. Assign the Day #6 Exit Slip (Appendix N) for completion.
Differentiation	Teams could be given a New Budget A or New Budget B depending on skill level. Allow use of calculators. Allow students to choose which Exit Slip question they will answer.

Assessments	Reassign Calculation Worksheet (or portions) to complete using new design to assess retention of these skills. Exit Slips

Section II: STEM Lesson Plan

Title of Lesson	**Day #7**
Time Required	60 minutes
Materials	GeoGebra or Geometer's Sketch Pad (teacher's choice) Computers for each student or team Day #7 Exit Slip (Appendix O) - one per student student folders document camera (optional) - one per class
Objectives	Transfer designs to a computer based design program.
Instructional Process	1. Review with students how to use the computer program you choose. 2. Have students transfer their team's design (original or new budget design) to the program and print final design. Students can work as individuals or in their design teams depending on the number of computers available. 3. If time permits, have students put both designs into the computer program. 4. Instruct teams to create a multi-media presentation (Prezi.com, Google Presentation, PowerPoint, etc.) slide to show the class their computer-based project. If a document camera is available, students could simply show their printed designs under the camera. 5. Assign Day #7 Exit Slip (Appendix O) for completion
Differentiation	Provide a template for assisting students with presentation creation if needed.
Assessments	Final computer-based design Exit Slips

Section II: STEM Lesson Plan

Title of Lesson	**Day #8**
Time Required	60 minutes
Materials	Post-Test (Appendix A) - one per student Protractors (for test) - one per student Rulers (for test) - one per student student folders
Objectives	Present final design to the class.
Instructional Process	1. Give students about 15 minutes to meet with their design teams and create a 2-3 minute informal presentation for the class that includes: their original design, their new budget design, explanation for the changes that they made, the changes in their calculations based on new budget, and their computer program design. 2. Allow each team time to present their information to the class. 3. Administer the Post-Test.
Differentiation	Modify the test as necessary to meet individual student or class needs.
Assessments	Presentation Post-test

Section III: Unit Resources

Materials and Resource Master List

Copies of attached Appendices
Colored Pencils
Folders
Calculators
GeoGebra or Google Sketch Pad

Key Vocabulary

Area: The number of square units needed to cover a surface or figure.

Decimal: numerals to the right of the decimal point - represents parts of a whole (2.5).

Denominator: The number below the fraction bar in a fraction (represents the total number of parts in the whole).

Engineering Design Process: A process or set of steps used to devise creative solutions to solve problems and/or develop innovative products

Equivalent: having the same value or amount.

Fraction: A symbol such as 1/2 or 5/8 , used to describe one or more parts of a whole that is divided into equal parts.

Mixed Number: A number written with a whole number and a fraction (2 3/4).

Numerator: The number above the fraction bar in a fraction (represents the number of parts out of the total parts).

Percent: A ratio in which the first term is compared to 100 or out of 100 (50% or 1/2).

Perimeter: The distance around the outside of any polygon.

Simplest Form: A fraction for which the greatest common factor of the numerator and denominator is 1.

Tessellations: An arrangement of shapes which fit together to completely fill a space with no gaps (often forms a repeating pattern or design).

Technical Brief

Industrial designers are responsible for product or construction design criteria during engineering planning phases related to appearance and use of devices or spaces by the end user as Dieter and Schmidt (2009) point to in their 'Engineering Design". Dieter and Schmidt (2009) summarized that this primary design focus requires "attention to human factors engineering, which uses the sciences of biomechanics,

ergonomics, and engineering psychology to assure that the design can be operated efficiently by humans." Designers are concerned with appliance aesthetics for overall appearance, style, maintenance, and the user human interface which includes physical effort, repeat motion, reaction time, and standardized human physical characteristics (called anthropometrics).

Ergonomics is the name given to "an applied science concerned with the characteristics of people that need to be considered in designing things that they use in order that people and things will interact most effectively and safely" (Merriam-Webster Dictionary, 2007)

Visual analytics is the use of drawings and computer graphics to help people reason about difficult problems. If a picture is worth a thousand words, visual analytics attempts to aid a person discover the meaning in the thousand words. Visual analytics goes beyond just information visualization and draws on cognitive and perceptual psychology and interactive computer graphics to help people explore hidden relations and patterns in large complex datasets. For example, the ability to show rush-hour traffic flows and add what-if changes to highway entrances and exits can reveal counterintuitive solutions to eliminating traffic jams. See Thomas & Cook (2005) and Kielman & Thomas (2009).

Engineering psychology is "the science of human behavior in the operation of systems… both in the study and application of principles of ergonomic design of equipment and operating procedures and in the scientific selection and training of operators" (Casey, 1997).

For instance, applying human factors methods in design using engineering psychology may focus on use-group awareness in a variety of ways. Stanton, Salmon, Walker, Baber, Jenkins (2005) cite references to the Situation Awareness Rating Technique (SART) developed by Taylor in 1990 for "subjective estimation of [situational awareness]" for aerospace operations. They show that the developed method uses a pilot's self-assessment and a low-to-high rating scale referring to 10 measurable features, called dimensions, to gauge user environmental understanding. They convey Taylor's 1990 list of dimensions as grouped into the "quicker SART approach" (Stanton et al., 2005), which includes:

I. Demands on attentional resources: A combination of complexity, variability, and instability.
II. Supply of attentional resources: A combination of arousal, focusing of attention, spare mental capacity, and concentration of attention.
III. Understanding of the situation: A combination of information quantity, information quality, and familiarity of the situation.

The data produced from the respondent would then be used to improve the design of the environment surrounding the task in future iterations of construction or product development.

In applying human factors methods, analysts also seek to verify the validity of the results of the survey data since these results are used later for design update considerations. Consultants weigh the advantages and disadvantages of the testing method and seek out alternative techniques that might better approximate user's actual reaction to a formerly executed set of events.

Safety and Disposal

Not Applicable

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Section IV: Appendices

Appendix A - Pre/Post Test
Appendix B - Pre/Post Test Answer Key
Appendix C - Engineering Design Challenge
Appendix D - Engineering Design Process
Appendix E - Design Rubric
Appendix F - Budget Template
Appendix G - Floor Plan
Appendix H - Calculation Worksheet
Appendix I - Day #1 Exit Slips
Appendix J - Day #2 Exit Slips
Appendix K - Day #3 Exit Slips
Appendix L- Day #4 Exit Slips
Appendix M - Day #5 Exit Slips
Appendix N - Day #6 Exit Slips
Appendix O - Vocabulary Cards