Does It Make the Grade?

Print:

How purchasing agents use their knowledge of calculating with fractions, decimals and percents to make comparisons among different suppliers and materials

Industry Sector: Advanced Manufacturing
Content Area: Mathematics
Core Topic: Decimals, fractions and percents

Expand All | Collapse All

Common Core State Standards

Standards for Mathematical Practice:

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.

High School—Number & Quantity: Quantities

N-Q.1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N-Q.2. Define appropriate quantities for the purpose of descriptive modeling.
N-Q.3. Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

High School—Modeling
High School—Geometry: Modeling with Geometry

G-MG.1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
G-MG.3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Adult Basic Education Standards

Number Sense

Standard N-1: Represent and use numbers in a variety of equivalent forms in contextual situations.

Patterns, Functions and Algebra

Standard P-1: Explore, identify, analyze, and extend patterns in mathematical and adult contextual situations.
Standard P-2: Articulate and represent number and data relationships using words, tables, graphs, rules, and equations.
Standard P-3: Recognize and use algebraic symbols to model mathematical and contextual situations.

Industry Overview

Today's Manufacturing Workplace

A manufacturing renaissance is occurring in the United States. The United States is the largest manufacturing economy in the world, producing 21 percent of the goods manufactured across the globe. In addition to the 12 million Americans working directly in the manufacturing industry, manufacturing supports more than 6.5 million other jobs, thus accounting for nearly 17 percent of all private sector jobs in the United States. In 2010, the average U.S. manufacturing worker earned $77,186, including pay and benefits (the average in all industries was $56,436).[1]

While manufacturing jobs in Massachusetts have declined, as they have nationally, manufacturing is still a critical industry in this state and provides opportunities for good, high-paying jobs. In the Greater Boston area, most of the manufacturing jobs are in computer and electronics companies, and much of the state relies on manufacturing positions in these and other very high-tech areas, such as aerospace and biotechnology.[2]

Advanced manufacturing involves the use of computers and technology in the manufacture of products. While not all manufacturing companies use technological innovations in developing their products or processes, the competitive advantage of the United States in the manufacture of goods relies on technological innovations. This means that today's manufacturing workplace is usually highly technical, which accounts for the high-paying positions many workers in this field receive in compensation for their work. It also means that today's advanced manufacturing workplace is very different from many people's conceptions of factories and mills as dark, dirty, and unsafe. Today's advanced manufacturing facilities are usually bright, clean, and very safe, and the emphasis is on working efficiently—with as little waste as possible.

In the advanced manufacturing industry, there has been a marked shift from the traditional role of line workers to workers who demonstrate creativity and innovation. Innovation is a hallmark of the U.S. manufacturing industry, and key to maintaining its position in the global market since products can often be produced at a lower cost in developing countries. Critical-thinking, problem solving and reasoning are important components of the innovation process. Today's manufacturing workers are expected to formulate solutions to problems using critical thinking and reasoning skills while working independently and/or in teams.

1. http://www.nam.org/~/media/AF4039988F9241C09218152A709CD06D.ashx
2. http://www.bostonglobe.com/business/2012/05/08/high-end-factory-jobs-boston-paying-high-wages/3gZuNc6GywDGKoYNP2hnaO/story.html?camp=pm

Careers in Advanced Manufacturing

The manufacturing sector includes jobs related to planning, managing, and performing the processing of materials into intermediate or final products and related activities such as production planning and control, maintenance, and engineering. Thus, this industry includes not only those people who actually produce the manufactured goods, but also managers, maintenance staff, scientists and researchers, analysts, administrative personnel, and IT personnel.

Career Pathways

The manufacturing industry includes six career pathways:

- Production is the construction and assembly of parts and final products. People in these positions work in factories and mills, with machines, to make or assemble parts, construct components of parts (such as plastics), and print materials. Occupations in this pathway range from production helpers who move parts and materials around the factory, to numerical control machine operators who run the computer-controlled machines that modify metal and plastic to create products, to manufacturing production technicians who oversee production.

- Manufacturing production process development occupations are involved in designing products and manufacturing processes. People in these occupations work with production workers to set up the machines and processes to develop new products. These occupations include engineers and production managers.

- Maintenance, installation and repair workers take care of products after they've been sold and delivered to customers—they install the products, perform maintenance on machines, tools, and equipment so that they work properly, and repair systems that are not performing adequately. Workers in this pathway include automotive technicians, automotive electronics installers, building maintenance workers, industrial electronics repairers, industrial machinery mechanics, millwrights, and small engine mechanics.

- Quality assurance is provided by quality control inspectors and technicians, who ensure that products both meet design standards and are of high quality.

- Logistics and inventory control workers ensure that those working in Production have the materials they need to complete their work. Workers in these occupations inventory materials and products, move materials to the line, and pack and ship finished products. Thus, they include production and planning clerks, and operators of moving machinery such as cranes and forklifts, and packers.

- Health, safety and environmental assurance occupations are focused on keeping the workplace safe by ensuring that workers are using equipment safely and that manufacturing processes are as safe as they can be. The also conduct investigations and conduct inspections.

Mathematics and Communication Skills Needed in Advanced Manufacturing

Mathematics and communication are key skills needed for success in today's high-performance advanced manufacturing workplaces. Mathematics is used in the advanced manufacturing industry to measure the amounts and sizes of materials and parts, create "recipes" used to manufacture man-made materials, and analyze data. Data analysis is critical at many levels of a manufacturing organization in order to ensure quality and to continuously improve both quality and processes. Today's manufacturing industry must operate extremely efficiently and produce very high-quality products in order to maintain competitiveness. Many front-line workers are involved in collecting data and working to improve quality and efficiency. Thus, in addition to basic mathematical calculations (which rarely involve simple whole numbers), workers are engaged in mathematical reasoning and solving problems using a variety of mathematical tools.

To succeed and move up the ladder in today's advanced manufacturing workplace, workers need reading skills to understand technical concepts, vocabulary, and to bring together information needed for a particular situation; to locate, organize, and document written information from various sources needed by co-workers and customers; and to locate written information needed by co-workers and customers. They need to use correct grammar, punctuation and terminology to write and edit documents and to develop and deliver formal and informal presentations using appropriate media to engage and inform audiences. In addition, they need to interpret verbal and nonverbal behaviors to

enhance communication with co-workers and clients/participants; apply active listening skills to obtain and clarify information; and interpret and use information in tables, charts, and figures to support written and oral communications. They also must communicate with co-workers and customers using technology tools. As they move up the corporate ladder they will need to explain written organizational policies, rules and procedures to help employees perform their jobs.

Career Opportunities in Advanced Manufacturing with Education from Community Colleges

Massachusetts Community Colleges play an important role in preparing the state's citizens to take advantage of the career opportunities available in advanced manufacturing. Degree and certificate programs prepare students to enter advanced manufacturing occupations, including:

- production occupations, including people who work as assemblers (such as airplane assemblers), machine operators, machinists, systems operators, CNC machine tool operators, machine setters, laminators/fabricators, metal and plastic workers, packers, molders, semiconductor processing operators, welders and solderers, tool and die makers, and other production workers;

- manufacturing production process development occupations, including numerical control tool programmers who write the programs that control machine tools and industrial production managers who plan and oversee production;

- maintenance, installation and repair occupations include automotive, electronics, and biotechnology technicians, industrial machinery mechanics, and millwrights (who install and maintain heavy equipment);

- quality assurance occupations including quality control technicians and inspectors.

Recent Career Opportunities in Massachusetts

The following is a sample of advanced manufacturing job listings in Massachusetts that require associate's degree or certificate:

- Manufacturing Engineering Technician, Randstad Corporation, Framingham, MA, [show]
- Quality Control Technician, QD Vision, Lexington, MA [show]
- Manufacturing Technican, Hologic, Marlborough, MA [show]

Employment Outlook for Advanced Manufacturing

Advanced manufacturing continues to be a high-growth industry, given the knowledge capital in the United States. However, the work in this industry is increasingly technical and requires far fewer workers as more tasks are automated. Entry-level positions in this industry require the same skills that only a select group of highly-experienced and well-paid workers once had. Unfortunately manufacturers find it difficult to fill these high-skill positions. A 2011 survey found that there is a persistent skills gap between the skills that are needed in the today's manufacturing workplace and the skills that candidates bring to the workforce.

Most of the advanced manufacturing companies in Massachusetts are small to mid-sized operations that employ smaller numbers of workers and rely on computer-operated machinery for production. While the numbers of workers are smaller than in the past, the more highly-skilled nature of the work means that these are high-paying jobs and provide workers with opportunities to grow through training and education and to be part of the effort to innovate.

Resources:

Advanced Manufacturing Industry

- National Council for Advanced Manufacturing
- Advanced Manufacturing
- Brookings: "Why Does Manufacturing Matter? Which Manufacturing Matters?" (2012)
- National Association of Manufacturers: "A Manufacturing Renaissance: Four Goals for Economic Growth" (2012)

Advanced Manufacturing Industry Outlook Information

- Bureau of Labor Statistics: Manufacturing Industry at a Glance
- Massachusetts Labor Market Data
- Massachusetts Career Information System

Careers in Advanced Manufacturing

- Massachusetts Career Information System
- Manufacturing Career Opportunities
- Manufacturing Career Pathways
- Industry Competency Model for Advanced Manufacturing shows the skills and knowledge needed to work in this industry
- National Association of State Directors of Career Technical Education Consortium's Common Career Technical Core
- National Association of State Directors of Career Technical Education Consortium's Knowledge and Skills: Manufacturing
- O*NET
- WorkKeys Occupational Profiles
- Manufacturing's Missing Generation
- A Career in Toolmaking or Machining Technologies: The Right Choice for Students, Community, & Country

Workplace Scenario (8th Grade Level)

This scenario is based on the work of a purchasing agent. For more information, review this webpage.

You are a purchasing agent at a small manufacturing company. A purchasing agent is responsible for buying materials at the best value. You must also ensure reliable delivery. There are a number of things you need to be effective in your work. A working knowledge of your company's processes is important. You also need to understand quantity and quality. Finally, you need to negotiate to get the best terms you can.

Your company just received a new contract. The client wants your company to manufacture components for a model car. You are responsible for buying all materials to create the components. (The technical guidelines for them are provided.) You need to estimate quantities of materials based on the guidelines. You also need to check if any of the material is already in stock. The project is on a tight timeline. Choosing suppliers and materials takes thought. You must consider price, quality, and availability. You must also weigh the cost of transportation and time.

You review the purchase order and sales records. You check current inventory levels of stock required for this job. You also speak with co-workers. Then you evaluate and compare the different options for buying the materials. Will you buy the metal stock from a foreign or domestic supplier? Should you purchase the metal material in bar stock? Or, would it be best to buy stock cut into smaller slugs? To make the best decisions, you need good reading and estimation skills.

One challenge is that materials are sized differently. Materials can be listed in metric lengths or English units. English units are unlikely to be whole numbers. You have to convert all materials to the same measurements. This will help you make a fair comparison. You may not need to order all materials at once. Only a percentage may be needed to begin the work. Then you can order the materials at the best cost.

Workplace Scenario (High School Level)

This scenario is based on the work of a purchasing agent. For more information, review this webpage.

You are a purchasing agent at a small metal manufacturing company in Western Massachusetts. To be effective in your work, you must have a working knowledge of the manufacturing processes used by

your company and customer requirements. You also need to understand quantity and quality, and be able to negotiate effectively to get the best terms for your company.

Your company just received a contract to manufacture components for a new model car. As a purchasing agent, you are responsible for buying all of the materials to make the components. (The specifications for the materials are provided to you by technical staff.) Since you work for a small company, you need to estimate quantities of required materials based on the specifications. You also need to check any inventory in stock (some materials and components are used in different products). The project is on a tight timeline, with manufacture to begin within the month. Choosing suppliers and materials takes thought. You must consider price, quality, and availability. You must also weigh the cost of transportation and time.

You review the purchase order requirements and sales records. You also check current inventory levels of stock required for this job and speak with co-workers. Then you evaluate and compare the different options for obtaining the necessary materials. Will you buy the metal stock from a foreign or domestic supplier? Should you purchase the metal material in bar stock? Or, would it be best to buy stock cut into smaller slugs? To make the best decisions, you must be able to integrate your reading, estimation, and critical thinking skills with your knowledge of the company's manufacturing processes. You know that one of the most critical functions for a purchasing agent is procuring the material at the best value. This means you buy it at a good price for good quality. It's also important to have reliable delivery.

One challenge in evaluating purchasing options is that materials are sized differently. Materials can be listed in metric lengths or English units. In that case they are unlikely to be whole numbers. You have to convert all materials to the same measurements so that you can make a fair comparison. You also have to determine what percent of the necessary materials you actually need to order (based on what is available in inventory already). Then you can order the needed materials at the best cost to meet production needs.

Core instructional context

Understanding fractions, decimals and percents, and being able to calculate, compare, and convert them are foundational concepts for understanding algebra. In addition, the numbers that we deal with in our daily lives are rarely whole numbers—dealing with money, measuring ingredients in a recipe, dividing things evenly between children, mixing formula for a baby—all of these tasks require using parts of a whole. Similarly, in the workplace, the numbers that people are dealing with a rarely whole numbers—whether they are dealing with money, medication dosages, lengths of fabric to make clothing, or the time is takes to complete a particular task.

This scenario shows students how these basic mathematical skills are applied in the advanced manufacturing industry, where comparisons aren't just about which number is bigger, but also about the best value—which includes quality, reliability, and availability. Numbers are used in advanced manufacturing to communicate information quickly, but workers need to be able to convert these numbers so that they can compare prices, sizes and quality; workers also need to be able to compare the amount of materials received or produced to what is needed.Thus, workers in advanced manufacturing communicate with numbers.

While the exact math knowledge required of workers in advanced manufacturing varies from job to job, fundamental mathematical knowledge and practices, including a strong working understanding of fractions, decimals and percents are essential for being able to manufacture quality products. For example:

- A purchasing agent needs to calculate or estimate the cost of materials from different suppliers in order to compare the relative value—may need to compare costs of materials in U.S. standard measures and metric measures
- Workers in the receiving department checks that the requirements in the materials received match the purchase order, including whether the amounts match
- Tool and die makers set up and operate tools that are used to produce precision metal parts and machines; they must convert between different decimals, fractions, and percents for this extremely precise work

Worked Examples

1. You want to buy a metal bar that is $150.00. If the sales tax rate is 6.5%, what is the total cost of the bar?
   Answer: $150 + (0.065 * $150) = $159.75

2. In a neighboring state, you find another equivalent metal bar for only $120, but the sales tax rate is 9.5 %. Which is the better deal?
   Answer: $120 + (0.095 * $120) = $131.40 —this is the better deal, even with the higher tax

Contextualized learning activities

Introduction to Scenario

Have students read the scenario. A purchasing agent is responsible for buying the materials or components needed for a manufacturing company's own manufacture processes--he or she needs to negotiate the best possible value for the company, ensuring a good price for materials that meet the quality standards of the company. Ask students to brainstorm ways that they use math to help with purchasing activities in their own lives, such as purchasing groceries to make a meal or fabric to make curtains, for example. In particular, ask students if they can identify any ways that fractions, decimals, and/or percents might be used.

How Good a Deal?

Have students look at the price per unit for the same items in different grocery stores or different brands in the same store. Ask them what the best value is—they may look at the price for equal units (needing to find a way to compare like amounts) but may also bring in quality as a factor. For example, look at different paper towel or toilet paper options at:

- wholesale club
- grocery store
- pharmacy

Acting the Part—A Role-Play

A purchasing agent receives materials specifications for a new contract. The purchasing agent needs to review the purchase order requirements and sales records, check current inventory levels of stock required for the job, and speak with co-workers about the best options for obtaining the necessary materials. Once a potential supplier or suppliers have been identified, the purchasing agent negotiates for the best terms on the purchase—to get high-quality materials on time and at the best price possible.

Have students work in pairs to role-play this scenario for the class with one student taking on the role of the purchasing agent and the other taking on the role of the manager who oversees purchasing and receiving. The role-play will focus on the "purchasing agent" explaining the decision about which metal to purchase--the metal bars or the slugs, and from a domestic or foreign supplier. The following information should be considered by both students:

- There are two possible domestic suppliers—one in Worcester and one in Indiana—the prices and quality for these two suppliers are comparable, but shipping from Indiana is more expensive
- The Indiana supplier has both metal bars and slugs available for purchase
- Metal bars can be automatically fed into the machine tool but slugs cannot; on the other hand, slugs don't have nearly as much waste and don't require cutting
- There is a third option, to purchase from a foreign supplier. The cost from the foreign supplier is much cheaper (nearly 1/100th the price of a domestic supplier), but the quality can be less predictable and it will take significantly longer and cost more to ship the materials.

Although the dialogue can be improvised to some extent, students should be aware of where the situation is going and should be evaluated on how well they integrate the various considerations into their role-play performance.

Contextualized Problems

Before having students work on the following contextualized problems, you might first have them work through the worked example problems in the "Core Instructional Context" section individually or in pairs, and share their answers with the class.

1. Purchasing agents needs to be able to compare materials from different suppliers and in different forms. In the scenario, you need to decide which supplier to buy your metal from, and you want to find the cheapest cost per pound of metal. Examine the table below, which shows three different metal suppliers' bar stock characteristics.

	Insignia Metals	**Vanderbuilt Industries**	**Davidson Metallurgy**
Linear Density	0.52 lbs / ft	0.61 lbs / ft	0.56 lbs /ft
Length	8 ft	6 ft	5 ft
Cost per Bar	$4.30	$4.05	$3.64

   a. Which supplier offers the lowest cost per pound?
   Answer: Insignia Metals has the lowest cost per pound ($1.03 / lb.)

   b. Your supervisor would rather purchase materials from Davidson Metallurgy because they deliver quickly and are easy to work with. What is the percentage difference between the cost of the cheapest metal per lb. to that of Davidson?
   Answer: Davidson will cost 26% more per pound than the cheapest brand

2. You're ordering one thousand bars of metal, and each of them takes up 5 cubic inches.

   a. If your storage space is 10,000 cubic inches, what percentage of the space will be taken up by the metal bars?
   Answer: 5,000 $in.^3$ is 50% of 10,000 $in.^3$, so 50% of the space is taken up

   b. If your storage space is 3,000 cubic inches, how many bars will **not** fit into the space?

3. You have to order several parts and store them in this room with a floor that can withstand 5 tons (one ton is 2,000 lbs.), but you're never to exceed 60% of that limit. You are looking at two companies that each sell the parts, but each company makes them out of a unique material. Company A has parts that are 3 lbs. each. Company B sells parts that are 4 lbs. each. From each company, how many parts can you buy and store in the room without exceeding the 60% safety limit?

   Answer: From Company A, you could purchase 2,000 parts; from Company B, you could purchase 1,500 parts

4. A purchasing agent is trying to buy coffee mugs, onto which his company prints logos or designs. The company needs 302,075 mugs to fulfill current orders and would like to have the mugs ready in 4–6 weeks for delivery. He has found three options for purchasing coffee mugs—a supplier in Ohio, another supplier in New Bedford, and a third supplier in China.

   a. If the purchasing agent selects one of the domestic suppliers, he can order however many mugs he wants. It costs $1.99 plus 6.25% sales tax to buy from the Massachusetts supplier and $2.00 plus 5.5% sales tax from the Ohio supplier. Which supplier offers the better deal per mug (including sales tax)?

	Ohio	**Massachusetts**
Cost per Mug	$2.01	$1.99
Sales Tax	5.5%	6.25%

Answer:

The Massachusetts supplier offers the better deal ($2.11 compared to $2.12 from the Ohio supplier)

b. If the purchasing agent purchases the mugs from China, the cost per mug is much lower—only $0.20. However, there are several downsides:

- it will take at least one month to receive the order
- there will be inventory that the company has to store
- the costs associated with transporting and importing the mugs are much greater than domestic transportation

The mugs from China need to be ordered in multiples of 10,000, so there will be a cost to store unused mugs and the need to buy in advance of receiving orders, which limits the company's cash flow. If he needs to purchase 302,075 mugs, what percentage of the mugs he purchases would be in excess?

Answer:

310,000 - 302,075 mugs = 7,925 excess mugs

7,925 / 310,000 = 2.56% excess

c. Provided in the table below are the costs associated with purchasing the mugs from China, Ohio, and Massachusetts. Based on this information, which supplier offers the better deal?

	China	**Ohio**	**Massachusetts**
Cost per Mug	$0.20	$2.01	$1.99
Sales Tax (if applicable)	N/A	5.5%	6.25%
Number of Mugs to Purchase	310,000	302,075	302,075
Letter of Credit (Required for Importing)	0.75% (for contract up to $100,000)	N/A	N/A
Transportation Cost	$1,000	$500	$100
Inventory Cost (per 100 mugs per day for 10 days)	$0.01	N/A	N/A

Answer: Even with all the extra fees, China is still the cheapest supplier since the base price of each mug is so inexpensive

Contextualized test items

1. For her company, Janet buys a $2,100 shipment of electronics with a 9.5% sales tax. What is the total cost?

   A. $199.50
   B. **$2,299.50**
   C. $22,050.00
   D. $2,109.50

Use the following scenario for the next two items:
George needs to buy 4 tons of steel for a construction project. He has two possible suppliers:

- Buddy's Steel Supply: $0.14 per pound, 12% sales tax
- Steel Unlimited: $0.16 per pound, 10% sales tax

2. Which vendor has the better deal?

    A. **Buddy's Steel Supply**
    B. Steel Unlimited
    C. The cost is the same for both vendors.

3. What would be the difference in cost? (Hint: 1 ton = 2,000 lbs.)

    A. **$153.60**
    B. $88
    C. $6.40
    D. $2,662.40

Contextualized project

Finding the Best Value for Your Money

Have students select an item into which safety is a major consideration in choosing among different options, such as:

- car seat
- car
- space heater
- helmet or sporting equipment
- smoke detector

Then have students conduct research to find at least three viable options to meet their needs, including (but not limited to):

- price
- safety
- quality
- ease of use/user ratings
- availability/ease of purchase

Finally, students should report, either orally to the class or in writing, what the best three options were, which they would select, and give their rationale. You might add factors, such as a price cap, or try to introduce the concept of getting the best value/buy as opposed to the cheapest option.

Camping Equipped

Create several camping scenarios (i.e. backpacking with 2 friends, canoeing with a group of 12, etc) and have students find equipment at the best value. Students should consider the following:

- price
- tax / shipping costs
- weight
- reliability

Students should research each of the following:

- tent(s)
- cooking gear
- outerwear
- medkit

Students will present their findings to the class showing three well-researched products for each of the items and explaining the factors that led to their best choice.

Additional or extension activities, multimedia, readings and/or resources

Readings:

- "All I Need to Know About Manufacturing I Learned in Joe's Garage" by William B. Miller and Vicki L. Schenk
- "The Goal" by Eliya Goldratt
- "Lean Machines" – Learning from Leaders of the Next Generation Industrial Revolution by Richard A. McCormack

Instructor Adapted Classroom Materials

Does It Make the Grade? ESL Lesson Plan, Quinsigamond Community College, ESL

Does It Make the Grade? ABE Lesson Plan, Quinsigamond Community College, ABE/GED

Does It Make the Grade? GED Lesson Plan, Quinsigamond Community College, ABE/GED

Does It Make the Grade? ESL Introductory Lesson Plan, Quinsigamond Community College, ESL

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