Chapter 13
Creating Solutions

Did You Know?

- Mechanical drawings use symbols that help explain features of the drawings. These symbols are standard so everyone who looks at a drawing can understand it. Different types of drawings use different sets of symbols.

- The symbols used in welding drawings explain how the parts should be welded together. Some common welding symbols include the following:

  - Seam
  - Weld “V” groove
  - Weld all around

  Symbols used in engineering drawings include the following:

  - Diameter
  - Drill through
  - Countersink

  Some common architectural symbols include the following:

  - Door
  - Window
Objectives

The information given in this chapter will help you do the following:

➢ Define ideation.
➢ Explain brainstorming, graphic organizers, and questioning.
➢ Describe a rough sketch.
➢ Describe a refined sketch.
➢ Summarize the procedure for creating sketches.
➢ Identify the difference between shading and shadowing.
➢ Create an isometric sketch.
➢ Produce an oblique sketch.
➢ Explain and create a perspective sketch.

Key Words

These words are used in this chapter. Do you know what they mean?

box
brainstorming
cone
cylinder
elements of design
graphic organizer
ideation
isometric sketch
oblique sketch
orthographic drawing
pictorial drawing
pyramid
questioning
refined sketch
rough sketch
shading
shadowing
sketch
sphere
thumbnail sketch
The design process can be divided into two sections: problem seeking and problem solving. The first two steps of the process are problem seeking. In step one, the problem is identified, and a design brief is created. The problem is then researched in step two. Both of these steps deal with seeking information about the problem. Step three is the first step to involve solving the problem. In this step, the designers begin to think of ways the problem can be solved. They will develop many ideas and draw sketches for each of the ideas. See Figure 13-1. The sketches will help to explain their ideas to others. The ideas and sketches developed will then be refined, modeled, and tested in the next steps of the design process.

**Exploring Ideas**

Some people may come to this step and think they already know what their final solution will be. They might feel that developing a number of solutions is a waste of time. This is the wrong attitude to have. Designers must explore a number of ideas. The more ideas explored, the better the design will be. Designers should generate original and creative ideas. They have to think broadly and develop a wide variety of ideas. If designers use narrow thinking, their designs will not be unique. For example, imagine you are designing a telephone. You should explore many different ideas (broad thinking). One idea may be a phone fitting in your ear like a hearing aid. Another idea could be a digital phone with a computer video display. See Figure 13-2. These are two unique solutions to the problem of a new telephone. You would not want to create ideas like a red desk phone and a black desk phone. That would be narrow thinking. These ideas are essentially
the same thing, with only the color differing. The small changes, like color, can be made later. It is important that designers explore many ideas. Exploring ideas is called ideation.

**Ideation**

Creating a number of new ideas to solve a problem is ideation. The process of ideation is creative and imaginative. See Figure 13-3. Creativity leads to new ideas and solutions. The solutions created at this step should be simple and rough. Later in the process, the solutions will be revised and refined. Ideation begins by reviewing the problem and design brief. Remember, the solutions developed must solve the problem. The solution must also fit the criteria and limitations. After reviewing the design brief, the research conclusions must be reviewed. This review will help the designer understand what others have done and what people want from the solution.

Ideation is a free flowing activity. Ideas must be able to flow without others shooting them down. In ideation, all ideas are good ideas. There are no right or wrong answers. It is important to record (sketch or write down) all ideas. Ideas seeming silly or wild at first may make more sense later. If you do not record them, you may forget some good ideas.

The environment you use to create solutions is very important. You must be able to concentrate on the problem. In front of the television at home may not be the best place to focus on creating ideas. Many designers find quiet places to work. They may leave their offices and work outside or in a library. See Figure 13-4. The only

**Figure 13-3.** Unique products are the results of creativity and imagination. (Patent No. 5,050,855, U.S. Patent and Trademark Office)

**Figure 13-4.** Designers often work best in quiet areas away from their offices and desks. (Tony Gothard)
things needed to create ideas are a pencil and paper. Ideation can be done almost anywhere. When creating ideas, designers often flip through magazines or books. They may even listen to inspiring music. Designers often see pictures or hear words, which spark ideas for solutions to their own problems.

There are several different methods of ideation. Some people find one works better for them than others. Three of the main methods are brainstorming, graphic organizers, and questioning.

**Brainstorming**

*Brainstorming* is a method used to develop many ideas. It is useful in small groups for coming up with unusual solutions. Brainstorming is a process beginning with the design problem. The process has several steps.

In the first step, the small group must choose a leader and a recorder. The leader will start and end the brainstorming and make sure the group stays on task. The recorder will be in charge of recording all the ideas shared. See Figure 13-5.

Next, the leader will set a time limit. Brainstorming is done best when a time limit is set. The group members will stay more focused if they only have a certain amount of time. At this point, the leader will share the design brief with the group. The leader will make sure everyone understands the problem. The ideas generated must solve the problem. The group leader will also share the research conclusions.

It is important that the research is used to come up with ideas.

Next, the members of the small group all focus on the problem. The group leader then asks for ideas. The group members try to list as many creative ideas as possible. Solutions can become very creative when people get ideas from each other. One person may present a new idea. The new idea may spark an idea in your mind. You may have never thought of it without the other person’s idea. Brainstorming works well when the group members use each other’s ideas to add to their own. In brainstorming, like other forms of ideation, it is important that there is no criticism. If people are criticizing or making fun of ideas, people will not want to share their thoughts. The best thoughts may not be shared if people are afraid to give their ideas.

Throughout the whole session, the recorder makes notes of all the ideas developed. When the time is up, the leader must stop the session. The

![Figure 13-5](image-url). A typical brainstorming session can generate many ideas. (Product Development Technologies, PDT)
leader may ask all of the group members for one final idea. Once the group is done, the brainstorming is over. The notes will be reviewed later in the design process. The main purpose of brainstorming is to develop a list of ideas. It is not the purpose to choose the final solution.

**Graphic Organizers**

A **graphic organizer** is another method of developing ideas. It is a diagram that helps to organize thoughts. One person or a group of people can create a graphic organizer.

To create a graphic organizer, designers begin with a blank sheet of paper. They write the problem in the middle of the sheet and circle it. Then they create branches from the circle. The branches are the major features or functions of the design. If the design problem is to design a new camera, the word camera goes in the middle circle. See Figure 13-6. The branches are features, such as type of camera, loading the film or media, focusing the picture, taking the picture, and changing the settings. Below the branches, the designer lists the possible ways to design the features or functions. Under the **taking the picture** branch, the solutions might be a button on the top of the camera, a voice activated control, an automatic timer, and a handheld switch.

The graphic organizer helps to make sure all the features of the problem are considered. It is also helpful because all the solutions are listed on the same sheet of paper. It is easy to see all the ideas you have developed.

**Questioning**

**Questioning** is the third method of ideation. It is done differently than brainstorming and graphic organizing.
Questioning is a process in which the designer asks the question “Why?” It is done while working with existing products. See Figure 13-7. The designer asks why things are done the way they are in the existing product. Imagine you are designing a better way to toast bread. If you were using the questioning method, you would locate a toaster and a loaf of bread. You would use the toaster and ask yourself questions like the following:

- Why is the bread loaded from the top?
- Why do I push a lever to start the toaster?
- Why does a knob control the darkness scale?

The key to questioning is that the questions are written. Once the questions are asked, they need to be solved. Designers often find creative solutions to problems because they asked “Why?”

Brainstorming, graphic organizers, and questioning are all useful methods of creating ideas. These approaches to ideation all result in lists of solutions. Lists, however, are not always the best way to describe solutions. Have you ever tried to describe an idea you had using a list? It can be very difficult to do. Imagine if someone asked you to describe how your bicycle works or what the White House looks like. Would these things be easy to describe? They would probably be

Figure 13-7. Questioning relies on the written answers to the steps involved in the process.
hard to describe without drawing the
gears of your bike or the front of the
White House.

Sketching

Using a sketch can make describ-
ing ideas much easier. The methods of
ideation can be very helpful in com-
ing up with ideas, but sketches are
useful for describing the ideas to other
people. See Figure 13-8. Sketches are
tools that help designers communicate
their ideas. They are a way to record
the designers’ thoughts on paper. As
thoughts flash into the heads of
designers, the designers sketch them
so others can see them. Sketching is
usually done in two steps:

- The first step is often called design,
  preliminary, or rough sketching. These
  sketches are quick and simple sketches.
- The second step is often called working, final, or refined sketching. These sketches are more detailed
  and require more time to complete.

Rough Sketches

During the design process, design-
ers always have ideas that “pop” into
their heads. This is especially true dur-
ing the ideation stage. Designers may
have finished a brainstorming session
and have an idea on the way home or
during dinner. For this reason, many
designers carry sketchpads and note-
books to record such ideas. When
designers forget their sketchbooks,
you may see them make sketches on
napkins or small pieces of paper. At
this point, it is not important what
type of paper or writing utensil the
designer uses. All that matters is that
the designer gets the ideas onto paper.
The designers are not concerned with
the quality of the sketches. Good
designers try to capture as many ideas
as they can.

These sketches are called rough
sketches. See Figure 13-9. The word
rough may seem to suggest that the
sketches are hard to understand. This,
however, is not the case. Rough just
means the sketches are in the early
stage of development. They are not
completely thought out. Rough
sketches are basic ideas showing
shapes and outlines. They do not
show a great amount of detail.

Rough sketches can be ideas of a
complete solution, like an entire bicycle.
The bicycle designer would create
rough sketches of bicycles of different
sizes, shapes, and designs. Size and shape are two elements of design developed using rough sketches. The sketches can also be ideas of smaller parts of the whole solution. See Figure 13-10. In the bicycle example, the rough sketches could be different ideas for the brakes and gears of the bicycle.

These sketches are also known as thumbnail sketches because of their size. Most rough sketches are fairly small, with several rough sketches fitting on a sheet of paper. Good designers are able to create rough sketches fairly quickly. These sketches may take beginners a while to create. The time spent on creating rough sketches is not what is most important. The importance of rough sketches is that many ideas are generated.
Refined Sketches

After ideation, the designer should have a large number of rough sketches. These sketches may contain many good ideas. There may be ideas on how to solve the entire problem or how to solve small pieces of the larger problem. The sketches are simply ideas on paper. They make up a library of solutions. The rough sketches need more work done to them before they become proposed solutions to the problem. From the rough sketches, the designer must select the most promising solutions. This is the first time in the entire design process the ideas may be reviewed. In the brainstorming and rough sketching stages, all ideas were valid. No ideas were criticized or discarded.

The designer now creates new sketches based on the best ideas from the rough sketches. The new sketches are called refined sketches. See Figure 13-11. A refined sketch may focus on one rough sketch. It may, however, combine parts of several sketches to make one new idea. The sketches combine the ideas ideation created. The purpose of the refined sketch is to narrow down the design ideas. The designer will create several different refined sketches. The best solutions will be chosen in the next step of the design process.

Figure 13-11. Refined sketches are more detailed than rough sketches. (DaimlerChrysler)
The Sketching Process

Sketches are not always easy to create. See Figure 13-12. Sketching is a technique. There is a certain way to sketch. Sketching has several steps:

1. Visualizing the object.
2. Blocking out shapes.
3. Adding an outline.
4. Drawing design features.

Visualizing the Object

The technique of sketching begins with visualizing the object. Visualizing or seeing the object may seem like a simple thing. You may be able to look at an object and sketch it. In rough sketching, however, you may not be able to look at something real. If you are creating a new and innovative product, there is no image at which to look. You may only have the idea in your mind and have to “see” the object in your imagination. Sketching is often thought of as seeing and thinking with a pencil. Good designers can easily see their ideas and use pencils to recreate them. Seeing your ideas takes practice. The more designers sketch, the better they become.

There are two ways designers see objects. They can either see objects in two or three dimensions. When designers see in two dimensions, they see the object in six different views. They see the front, top, left side, right side, back, and bottom. Sketches made in two-dimensional views are called orthographic sketches. See Figure 13-13. Orthographic drawings, which are more precise than sketches, will be discussed more in Chapter 17. People
who are not trained to read them may find orthographic sketches and drawings hard to understand. At this stage in the design process, it is easier for designers to see ideas in three dimensions. Three dimensions are the easiest because that is how the eye sees things. It is also best because almost all people can understand a drawing in three dimensions. These types of drawings are called *pictorial drawings.* The three major types of pictorial drawings are isometric, oblique, and perspective drawings, all of which will be discussed later in this chapter.

Once the designers can see the idea, they begin by breaking down the object. Breaking down the idea requires the designers to divide their ideas into basic shapes. Some designers are able to see the basic shapes easily. Other designers must work harder to see the shapes. See Figure 13-14. All objects, however, can be broken into one or more of these basic shapes:

- **Box.** A box can be either a cube or a prism. A cube is a three-dimensional square. All sides of the cube are the same length. A six-sided die is an example of a cube. A prism is very similar to the cube. The difference is that a prism has at least one side that is a different length. A cereal box is a prism.

- **Cylinder.** A cylinder is a round shaft. The cylinder has one circle on each end, like a tube. A soda pop can is an example of a cylinder.

- **Sphere.** A sphere is a perfectly round object. Baseballs and basketballs are spheres.

- **Cone or pyramid.** A cone is a shape that is round at one end and comes to a point at the other. An ice cream cone is an example of a cone. A pyramid is like a cone because it comes to a point at one end. The other end of the pyramid, however, is a square. The Egyptian pyramids are examples of this shape.

### Blocking out Shapes

After the object or idea has been broken down into pieces, the sketching begins. The sketching starts by blocking out shapes. Blocking out means drawing light lines where the basic shapes will be. These lines will serve as guidelines used to make the sketch. Blocking out is very important for beginners. The more advanced designers are able to block out shapes very quickly. Beginners must take their time to make sure the shapes are correct.

To begin blocking out, the designer draws a vertical line. Next, two lines are drawn at roughly 30°, starting from the bottom endpoint of the vertical line. These three lines are called the *isometric axes.* The intersection of the isometric axes will form the front corner of the sketches. The shapes can now be blocked into the sketch. Each shape is blocked in a little differently.

### Boxes

The box uses the three lines of the isometric axis as its front corner. See Figure 13-15. The vertical line of the axis should be drawn to the same height as the object. The line drawn to the left should equal the length, and the
line to the right should equal the width of the box. Once the axis is drawn, the designer will draw a line the same length as the vertical line at the other two endpoints. Then the designer will connect the three vertical lines. This forms the front and right side of the object. A line is drawn the same length as the two angled lines from the top and right side corners. This creates the top of the box. In a cube, all the lines drawn would be the exact same size.
Cylinders

The cylinder is drawn using a square at the axes. See Figure 13-16. To begin the cylinder, designers use the angled lines of the axes and draw a square. They then draw an ellipse. An ellipse is an isometric circle. The ellipse is drawn through the midpoint of each line of the square. This forms the bottom of the cylinder. To make the top of the cylinder, designers draw vertical lines from the corners of the square. They then create a square positioned at the top of the cylinder. The designers draw an ellipse in the top square.

To finish the cylinder, they draw a horizontal line from one corner of the bottom square to the other corner. Two vertical lines are then drawn where the line crosses the ellipse. These create the sides of the cylinder.

Spheres

Spheres are drawn by first creating a cube. See Figure 13-17. The cube is created as described above. Once the cube is drawn, a circle is created inside of it. The circle is drawn so it touches the midpoint of the outside lines of the
cube. When the sphere is drawn it looks like a plain circle. In order for the sphere to look three-dimensional it must be shaded. Shading will be discussed later in this chapter.

Cones and Pyramids

The cone and pyramid are drawn using the rectangular box. The box is drawn as shown in Figure 13-15. Next, an X is drawn on the top of the box. The center of the X is the center of the top of the box. The center point is the point where the top of the cone and pyramid will come to. To draw the pyramid, the designer draws lines from the corners of the bottom square to the center point. See Figure 13-18.

To draw the cone, an ellipse must be drawn on the bottom square, just like creating a cylinder. See Figure 13-19. Lines are then drawn from the sides of the ellipse to the top center point.

Combinations

Unless the designs are simple products like ice cream cones or basketballs, the sketches created will have more than one basic shape in them. Each of these shapes must be blocked out. You have learned how to block...
Adding an Outline

The blocked-out sketch may not look very much like the designer’s idea. It should be, however, the basic shape and proportion of the idea. The designer must add details to the shapes to make the shapes look the way they want them to look. The first detail added is an outline. Creating the outline may include subtracting parts of the shapes. The guitar in the previous example is several cylinders and boxes. To create the outline, a designer would subtract parts of cylinders to make the guitar rounded. See **Figure 13-21**. It is important that the blocked-out shapes are drawn lightly because they are guidelines. When the designers add the }

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**Figure 13-19.** Cones are sketched using these four steps.

**Figure 13-20.** A guitar would be blocked out using boxes and cylinders.

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out shapes using the isometric axes. Sketches with more than one shape will have more than one set of axes. Imagine designing a guitar. See **Figure 13-20**. You would have several boxes making the shapes of cylinders and one long box representing the neck of the guitar, and you would create the boxes lightly so they could be erased. It may not look much like a guitar at this stage. The look of the guitar will come together in the next stage, adding the outline.
Outline, they will draw the lines darker because these lines will not be removed.

**Drawing Design Features**

The next details to be added are the external features. The external features are objects not included in the outline, but ones that can be seen when looking at the design. The number pad on a telephone is an external feature. These features help in understanding the sketch. The tuning knobs, frets, and sound hole are all external features of a guitar. See Figure 13-22. External features also help to set designs apart from each other. A designer may have a number of sketches for a product that have the same outline. The only differences are the external features. For rough sketches, after the external features are added, the sketches are finished. For refined sketches, additional techniques can be used to add more detail and “life” to the sketches.

**Refining Techniques**

There are some techniques that can be used on refined sketches to make them appear more realistic. Shading and shadowing are the two most common techniques. Both of these techniques illustrate how the objects would look when placed in light. They add depth and dimension to flat sketches.

**Shading**

Shading relies on a light source. Most designed objects come in contact with either sunlight or interior lighting. Shading helps to show how the...
object will look in either of these two light sources. Shading also allows the designer to see the shape and form of the object. To begin shading, the designer must determine from which direction the light source is coming. The direction of the light source will change how the object is shaded. The standard is to imagine the light source is located over the designer’s left shoulder.

There are several techniques used in shading. The most common is using different tones to create the shading effects. A tone is a shade of color. Gray is a tone between black and white. In this method of shading, the area of the object closest to the light source will be the lightest tone. The area furthest from the light will be the darkest. This effect can be created with the edge of a pencil or markers. When using a pencil, designers create the darker areas in one of two ways. They may either press harder in the darker areas or go over them several times. When using markers to shade, the designer selects markers of different tones to create light and dark areas. See Figure 13-23.

Other shading techniques use either dots or lines instead of different tones of color. The dot method uses different amounts of dots to show light and dark areas. See Figure 13-24. The more dots an area has, the darker it is. Pens are normally used for dot shading. Line shading is done with different width lines. The darker areas are shaded with thicker lines. Both of these methods work well for shading a rounded object.

**Shadowing**

Once the object is shaded, the designer adds the shadow. **Shadowing** is normally done using a pencil. The shadow is placed on the opposite side of the light source. If the light is coming from the front left side of the object, the shadow would be placed on the

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**Figure 13-23.** Shading and shadowing help designers see the shape and form of the object. (Design Central, design firm; Ingenico, client)

**Figure 13-24.** Drawings can also be shaded dots. (Keith Nelson)
back right side. The shadow should follow the rough shape of the object. Shading and shadowing take a lot of practice to perfect. The best way to practice shading and shadowing is to look at objects around the room and sketch them. Examine the objects to see how the light hits them. Then try to add shading and shadows to the sketches.

Types of Sketches

There are several ways sketches can be drawn. The three most common types of sketches are isometric, oblique, and perspective sketches. Any of these types of sketches can be used to create rough or refined sketches. All of these types are drawn using the same basic process.

Isometric Sketches

The most popular type of pictorial sketch is an isometric sketch. Isometric drawings show the front, top, and sides of an object, just as the eye sees them. Isometric sketches can be drawn with great detail and accuracy, or they can be drawn in rough form. See Figure 13-25. Isometric sketches use the isometric axes described earlier in this chapter. The sketches are created using different shapes. Experienced designers are able to create isometric sketches quickly and easily.

Oblique Sketches

Oblique sketches are similar to isometric sketches. See Figure 13-26. In isometric sketches, the front and side are both at 30° angles. In oblique sketches, only the side view is at an angle. The angle is usually 45°. It can, however, be any angle.

These sketches show the front view in its true shape. Isometric sketches tend to distort shapes like circles and arcs. In an isometric sketch, all circles are shown as ellipses. In oblique sketches, circles in the front view are actual circles. For this reason, circular objects are better drawn as oblique sketches. Also, products having one surface that is the most important are drawn in an oblique sketch. For example, the front views of stoves, radios, and televisions are what most people see. Therefore, oblique
sketches show these designs better than isometric sketches do.

Oblique sketches are produced using the same steps as isometric sketches. See Figure 13-27. The designer begins by drawing the axes. In oblique drawings, the designer creates the oblique axes. The oblique axes are composed of one vertical line, one horizontal line, and one 45° line. There are two types of oblique axes, right and left oblique. In the right oblique, the 45° line is drawn back and to the right. In the left oblique, the line is drawn back and to the left.

The designer uses the oblique axes to block out the shapes. The same basic shapes are used in oblique sketches. The box, cone, pyramid, and sphere are all created the same way as in the isometric sketches. The cylinder is the only shape created differently. The cylinder is created by first drawing a box. A circle is then drawn in the front square, instead of an ellipse.

Once the shapes are blocked out, the designer adds the details. The designer again adds the outline and external features. The last details to be added to refined sketches are shading and shadowing. These details help to make the sketch appear more real.

**Perspective Sketches**

The third type of pictorial sketch is a perspective sketch. Perspective sketches are often used in making refined sketches. They are used to show how objects look to the eye. Imagine yourself standing in the middle of a road. As you look down the road, the buildings get smaller. It looks as though all the buildings and even the road narrow down to one point. This is what perspective drawings look like.
When you look down the road, the road and the buildings seem to come from a single point. This point is called the *vanishing point*. See **Figure 13-28**. The line where the sky meets the road is the horizon line. Vanishing points are always located on the horizon line. The ground line is the line formed at the front of the sketch along the bottom of the objects.

There are several types of perspective sketches. See **Figure 13-29**. The most common are one-, two-, and three-point perspective sketches. The two-point perspective sketch is one that has many applications and is used regularly. See **Figure 13-30**. To create a two-point perspective sketch, the designer follows these steps:
1. Draw the horizon line and the ground line.
2. Add the vanishing points.
3. Sketch a vertical line from the ground line the height of the object.
4. Sketch perspective lines from the vanishing points to the top and bottom of the vertical line. These perspective lines will form the left and right sides of the sketch.

**Figure 13-29.** There are three main types of perspective drawings.

**Figure 13-30.** Perspective drawings are easy and fun to draw.
Complex products and devices surround us. Many of these have all kinds of frills and little add-ons designers thought were necessary. Many of these add-ons, however, complicate the designs and make the products hard to use.

The opposite of this is the product meeting a need in the simplest and most effective way. Engineers call these elegant solutions. These solutions should be the goal of every designer of technological artifacts.

**Figure A.** The paper clip is an example of an elegant solution.

5. Sketch vertical lines the width of the object.
6. Block out the shape.
7. Add details.
8. Shade the drawing.

One-point perspective sketches are created almost the same way as the two-point perspectives are created. The difference is that all lines are either vertical or angled to the vanishing point. In the three-point perspective, all the lines are drawn from one of the three vanishing points. There are no vertical lines in a three-point perspective.

**Summary**

The process of creating solutions begins with ideation. Designers use brainstorming, graphic organizers, and questioning to develop as many ideas as possible. It is important that all ideas are taken seriously during
No idea is wrong when the designers are developing ideas. While the designers are creating ideas, they begin to sketch. Sketching is the process of putting ideas onto paper. The ideas begin as rough sketches. The rough sketches are simple quick sketches that help to communicate the designer’s ideas. Designers generate as many rough sketches as possible.

The designers then review all their rough sketches. The ideas coming from the review are then drawn as refined sketches. These sketches are more detailed and better than the rough sketches. The refined sketches are the best ideas developed through ideation and rough sketches.

Isometric, oblique, and perspective sketches are all popular pictorial sketches. They are helpful and allow others to understand the thoughts of the designer. These pictorial drawings are all used in creating solutions. The refined sketches will be taken to the next step of the design process.
Curricular Connections

Language Arts
Examine the methods of ideation used in creative writing.

Science
Study the difference in mass and volume of different shapes.

Mathematics
Measure several simple objects. Use isometric grid paper to draw an isometric sketch of the different objects.

Activities

1. Use a method of ideation to develop ideas about how the layout of your school could be made better.
2. Find and cut out images from magazines and newspapers showing isometric, oblique, and perspective sketches and drawings. Create a poster board showing the different types of pictorial sketches.
3. Use the design brief and the research gathered in the last two chapters to develop ideas and create sketches of possible solutions.
Test Your Knowledge

Do not write in this book. Place your answers to this test on a separate sheet of paper.

1. The process of exploring ideas is called _____.
2. A diagram that helps to organize thoughts is known as a(n) _____.
3. A thumbnail sketch is larger and more detailed than a rough sketch. True or false.
4. A refined sketch uses the ideas from ideation, rough sketches, and the elements and principles of design to create a possible solution. True or false.
5. Give two examples of types of pictorial drawings.
6. _____ is the technique used to show how light hits an object.
7. The process used to show how light hits the space around an object is called _____.
8. Draw an isometric sketch of each of the following:
   A. A box.
   B. A cone.
9. Create an oblique sketch of each of the following:
   A. A rectangular box.
   B. A pyramid.
10. Paraphrase an explanation of a perspective sketch.

Career Highlight

Architects

The Job: Architects are licensed professionals who are trained to design buildings. They identify a client’s needs, develop building concepts to meet these needs, and prepare plans for the building. Architects design the overall look of buildings and develop plans and specifications that construction personnel will use in erecting the structure. They must be able to communicate their vision and plans to clients and construction managers.

Working Conditions: These professionals spend a great deal of their time in offices, consulting with clients and developing drawings. In addition, they spend time visiting construction sites to review projects under construction.

Education and Training: All architects must be licensed before they contract to provide architectural services. Many architecture school graduates work for another architect, however, while they are in the process of becoming licensed. In most states, obtaining a license requires a degree in architecture from an accredited university program. Most of these programs are five-year bachelor of architecture programs. Typically, architecture programs have courses in architectural history, building design, structures, and construction methods. They also require several professional practice, mathematics, science, and liberal arts classes.