Chapter 2

CONCEPTS

How People Develop Symbol-Sense

By definition, every symbol "stands for" something else. A common error, especially among small children, is to think that the symbol is actually inherent in the thing it represents. For example, a child may ask, "How did they know the names of all the animals?" This question reveals the view that, for example, the word *dog* is part of the concept of a dog. As children become older, they realize that there is more than one word for dog, and that people invented all of these words.

According to Piaget (1981), children first distinguish between a concept and its symbol when they are between one and two years old. Some of the early reflections of this distinction are:

- Talking about people or things;
- Using dolls or action figures as substitutes for real people; and
- Re-enacting an event that has already happened

Here is a true story:

A little girl of about a year old is in a room with some adults who haven't seen her for a while. They are gushing over how cute she is, and several people walk over to her to pinch her cheek, laughing excitedly as they do so. A few minutes later, after most of the adults have left, the little girl tries pinching her own cheek. As she does so, a look of puzzlement seems to come over her face, as if to say, "What was all that fuss about?"

This child has replaced the adults' act of cheek-pinching with her own imitation. A younger child would not have been able to make this separation.

The confusion between the concept and the sign is the basis for some jokes, such as puns and "plays on words." Here is an example:

- *"Waiter, there's a needle in my soup!"*
- *"I'm sorry, sir. That's a spelling error. It's supposed to be a noodle!"*

Could a needle and a noodle be confused with each other, just because the words *needle* and *noodle* are similar?

Because a symbol is different from what it stands for, it is possible to have one without the other. Use of a symbol absent the corresponding reality is called *deceit.* Lying is an obvious example, but deceit is not always a bad thing. Charades, magic shows, dramatic performances, and many forms of politeness are all situations where a symbol is not matched by the reality it is supposed to represent.

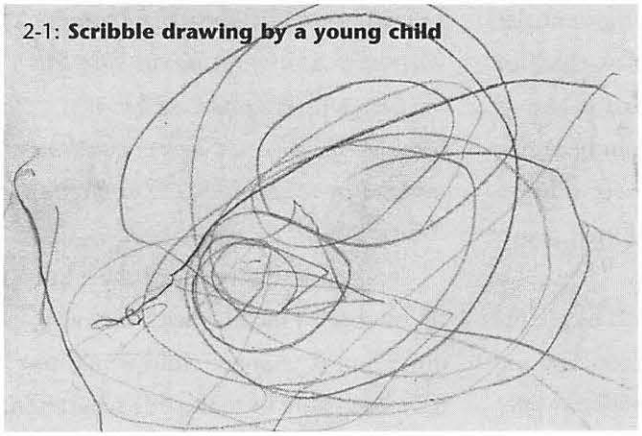
Can animals other than humans use symbols to represent concepts? There is considerable debate on this issue. There have been well-publicized efforts to teach sign language to monkeys and to teach talking birds to name objects and make simple sentences. Apparently, animals can learn to use symbols created by humans, but not to create them, let alone express complex ideas. Very young children are far better than any animal at inventing and manipulating symbols. According to Donald (1991), languages and other symbol systems permit us to manage the complex social interactions that are uniquely human.

Young children have an amazing facility for acquiring spoken language. Based on his studies of Creole languages, Bickerton (1996) extends this point even further. A Creole language arises after a large number of immigrants from many different parts of the world come to an island, such as Hawaii or Jamaica, within a short period of time. Bickerton discovered that these immigrants never develop a common language, but their children develop a Creole language within a single generation, so they can communicate with one another. Creole languages from different parts of the world have similar structures, suggesting some sort of innate human language facility.

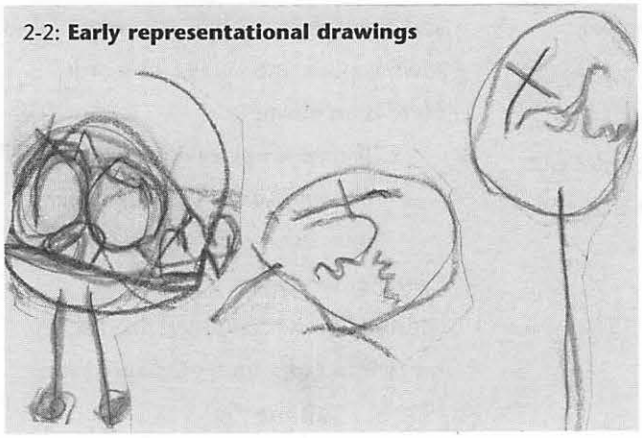
Based on the evidence about Creole languages, Thomas (1996) proposes that children may have invented all spoken languages. He connects the development of language with humans' relatively long period of childhood, compared with that of other animals. Language is so essential to social interaction that without it human society would not be possible. The long period of human childhood, Thomas suggests, may have evolved to nurture the development of language.

Languages are only one category of symbol systems. How do children develop other forms of symbolic expression? Nearly all children enjoy drawing, which they begin doing without much training or prompting. According to Arnheim (1974), the earliest scribbles, starting around age two, are not symbolic at all, but just a way of recording hand motions. (See Figure 2-1.) Some monkeys also produce these kinds of scribbles.

At about age three, however, children begin to do something monkeys apparently can't do. Near-circles appear among the zigzags and scribbles, and the young artist explains that these are faces, dogs, the sun, the moon, or other circular things in the environment. (See Figure 2-2.) Although apes have the manual dexterity to make marks on a page, they seem unable to represent things on paper. According to Bickerton (1996), this is evidence that humans alone have the ability to create mental categories. You can draw a dog because your brain can represent the concept of a dog. Symbolism is built into the way humans think.



2-1: **Scribble drawing by a young child**

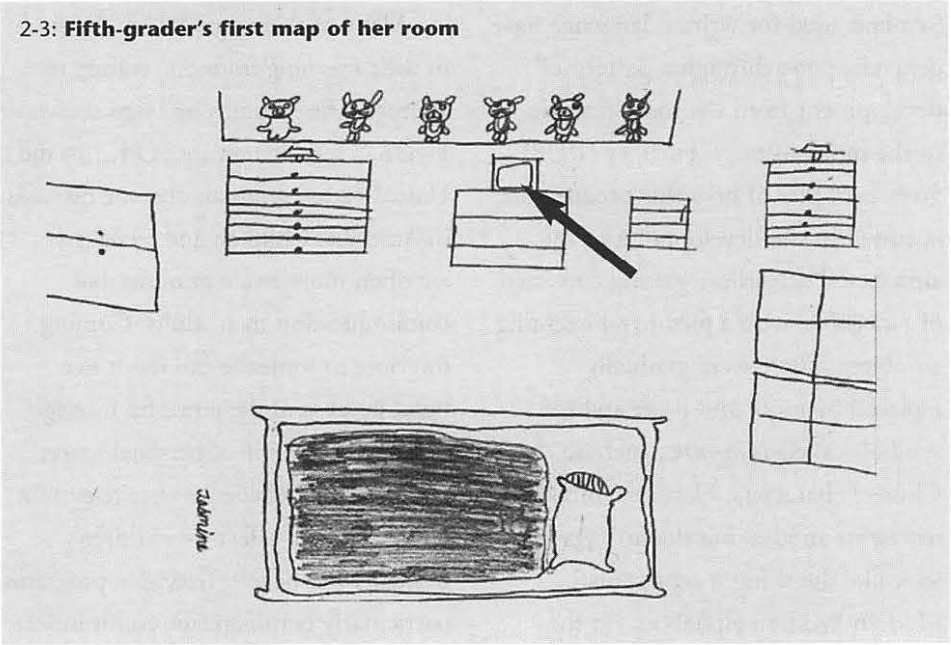


2-2: **Early representational drawings**

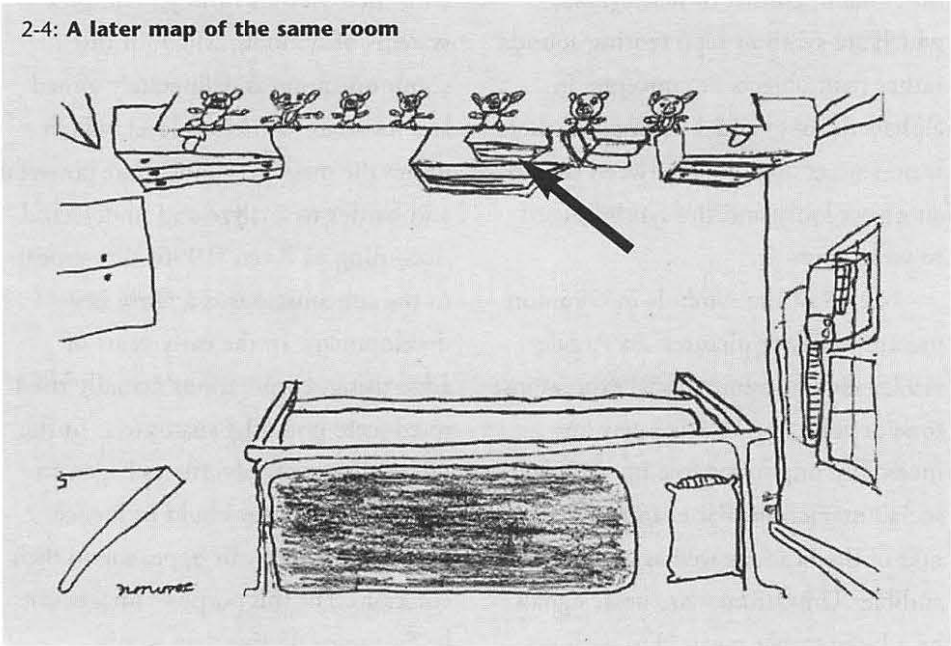
Thomas and Silk (1990) show that children's earliest drawings of real things are more like abstract symbols than they are like pictures. The sun is represented by a quarter circle or triangle at the top left corner of the page, with a smiley face inside and a few rays sticking out. Similarly, every house has a door in the middle, a window on either side, and a smokestack, regardless of whether or not the house really looks that way.

Figure 2-3 shows a fifth-grader's map of her room from a bird's-eye view. The TV set, marked by the arrow, is represented by a rectangle with an oval inside, which is a conventional symbol for a television, but is not how it would look from above. As children become more proficient at drawing, they gradually modify these formulas, and come up with more realistic ways of representing things. As they look at things more carefully, they represent more of what they actually see. Figure 2-4 shows a map of the same room, which the same child drew after some discussion in the class about points of view. The TV set is now drawn as it might actually look from a "birds-eye" view of the room. Goodnow (1977) describes this process as moving "from old to new equivalents."

2-3: **Fifth-grader's first map of her room**



2-4: **A later map of the same room**



Symbols used for written language have generally gone through a pattern of development from the more realistic to the more abstract. Furtiger (1998) gives examples of how this progression occurred in the development of the alphabet. The earliest writing consisted of *pictograms,* with a picture representing an object. These were gradually replaced by more and more stylized symbols called *ideograms,* such as Chinese characters. Here, a symbol represents an idea, but doesn't necessarily look like the thing it represents. Modern Western alphabets, on the other hand, consist of *phonograms,* which are symbols representing sounds rather than objects or concepts. In alphabetic languages like English, there is no connection at all between the way an object looks and the symbols used to write about it.

Not all of the symbols in common use are words or pictures. As Argyle (1975) shows, gestures, facial expressions, tone of voice and the like play an incredibly important role in everyday social interaction. For example, a slight nod of the head, as well as a barely audible "Um-Hmm," are both signals by a listener that mean "I'm with you, keep going." Most conversations would fall apart without these subtle forms of nonverbal communication.

Many of these signals vary drastically in their meaning from one culture to another. The "thumbs-up" sign shown in Figure 2-5, which means "O.K." in the United States, sends an obscene message in Australia. Children and teenagers are often more aware of nonverbal communication than adults. Coming too close to someone can result in a fight, because of the powerful message sent by an invasion of personal space.

It is widely believed that television has a powerful effect on children's thoughts and beliefs. Television programs, particularly commercials, communicate with their viewers through complex systems of symbols. Much of this communication is deliberately aimed at a less-than-conscious level, which makes the messages all the more powerful and harder to analyze and understand. According to Ewen (1996) this appeal to the subconscious is a fairly new development. In the early years of advertising, corporations actually tried to educate potential customers. In the 1920s, however, advertisers began to recognize that they could influence people more surely by appealing to their emotions. For this purpose, images can be far more effective than words.

To cite one example, Marlboro cigarettes are now the largest selling product in the world, ahead even of

2-5: **"Thumbs-up" sign**

Coca Cola. Currently, more than half of all young smokers use Marlboros. According to Hine (1995), the success of Marlboro is a direct result of clever use of symbolism. Prior to 1955, Marlboro was a little-known brand, targeted primarily at wealthy women. That year, Phillip Morris launched the "Marlboro Country" campaign, featuring the "Marlboro Man." They also changed the package colors to white and red, and introduced the "flip-top" box. Although Marlboros are basically the same as other filter cigarettes, these innovations turned the product into a symbol for manliness, comfort, the outdoors, and (ironically) fresh air.

If symbols are such an important part of daily life, why aren't they studied explicitly as part of the curriculum? There is an academic field called

How Symbols Work

semiotics, which is described as the science of symbols. Although the subject of semiotics is communication, few in the field have actually tried to communicate with general audiences, let alone teachers or children. It is a shame that nearly every work on semiotics is so obscure, because the field offers insights that could be really helpful in revealing the powerful and often covert work of symbols. Thankfully, there are a few clear expositions of semiotics, such as those by Guiraud (1975), Berger (1984), and Sebeok (1986).

Symbols are everywhere. Much of education consists of learning what symbols mean and how to use them. These symbols include written and oral language, mathematical notation, and graphic devices such as maps, diagrams, and graphs. Specialized pursuits, such as music, architecture, and proofreading, have developed their own systems of symbolism. On an everyday basis, symbols govern every form of social interaction, from the most casual encounters to formalized events, such as sports matches, business meetings, and professional appointments.

Corporations, politicians, and government agencies routinely use symbols in their efforts to influence public opinion and behavior. The importance and power of symbols make them an essential object of study.

What It Takes to Communicate

Here is an excerpt from Theresa Luongo's narrative in Chapter 4 (pp. 64-69):

> **In the Block Area, students started using the small broken wooden signs we have. One sign meant, "NO U-TURN." (See Figure 2-6.) Shaquill, a kindergarten student, had built an arch. He placed the sign on top of his structure. When I asked him what it meant, he said "Don't go underneath." Because the "U" was upside down, it looked like an arch instead of a "U!"**

2-6: **"NO U-TURN" sign**

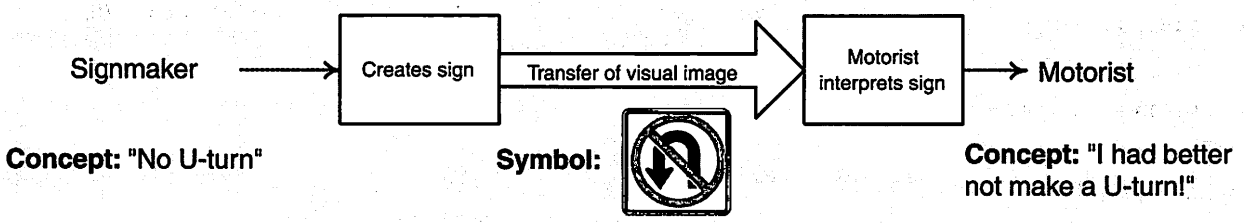
This kind of thing happens all the time. A sign or symbol created for one purpose winds up serving a totally different function. Surprises in communication call attention to the communication process itself, which is normally taken for granted. Figure 2-7 shows in detail what happens in the typical case, where the "NO U-TURN" sign is interpreted correctly.

An anonymous sign maker has created a sign that uses a standard symbol for "NO U-TURN." This symbol has three components:

1. A circle with a diagonal slash through it, which is a widely recognized symbol for "DON'T!"
2. An inverted "U" that looks like the path of a U-turn, from the point of view of a driver; and
3. An arrow showing the direction of the forbidden maneuver.

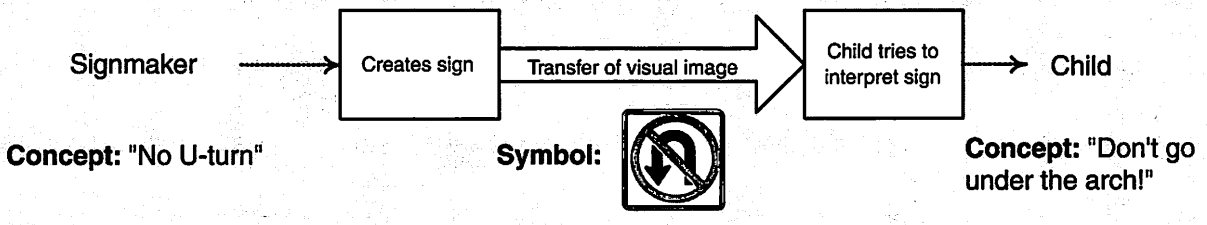
When people learn to drive, they must be able to interpret this symbol the way the sign-maker intended; otherwise, it would be useless as a road sign.

2-7: **How the typical motorist understands the "NO U-TURN" sign**



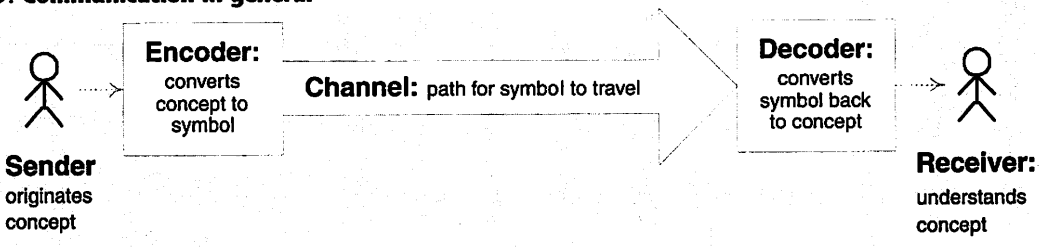
Now let's consider what happened when Shaquill, the kindergarten student, looked at the sign. He knew that the circle and diagonal line meant "DON'T," but had no way of knowing what the sign maker meant by the upside-down "U." At the same time, he had a problem to solve—i.e., protecting his arch from being knocked down. Furthermore, the inverted "U" shape in the sign looked very much like the arch. So Shaquill simply put these concepts together and concluded that that the sign could mean, "DON'T GO UNDER THE ARCH!"

2-8: **Diagram of how Shaquill understood the "NO U-TURN" sign**



Generally, there is no way for one person to know what another is thinking, unless the first person finds a way to send a message to the second. Ideas and concepts develop somehow within the brain, but not in a form that anyone else can access. To make them understood, the originator must express these ideas through symbols that are intelligible to another person. A sign or symbol is a device designed to transfer information. This general process is summarized in Figure 2-9.

2-9: **Communication in general**



Getting the Message from Here to There

Human beings have a limited number of routes through which they can receive information. The medium through which a message passes is called the *channel.* The most commonly used channels are sound and sight. Speech, music, alarm clocks, whistles, and sirens all use the auditory channel to convey information; while writing, gestures, dance, signs, traffic lights, sign language, and referees' signals use the visual channel. The channels of touch, taste, and smell are far less frequently used than hearing or vision. Table 2-1 compares the five communication channels.

Table 2-1
THE FIVE COMMUNICATION CHANNELS COMPARED

Channel	Advantages	Disadvantages	Examples
Sight	Operates at a distance; very high information capacity; all humans can produce images, and most can receive them; images persist over time, unless there is motion	Receiver's gaze must be directed at sender; nothing can be blocking "line of sight"; ambient light is required	Writing, drawing, graphic images, gestures, facial expressions, photos, films, computer screens
Sound	Operates at a distance; high information capacity; orientation of the receiver's head is not important; most people can produce and receive sounds	Sounds do not persist after being generated; it is hard to distinguish among simultaneous sounds; noise can interfere with messages; human voice has limited range	Speech, tone of voice, emphasis, nonverbal utterances, radios, alarms, bells and sirens
Touch	Interpreted as strong expression of feeling; high sensitivity of human body	Requires close proximity; culture prohibits some forms of physical contact	Taps, pats, punches, kicks, pinches, kisses, handshakes
Smell	Persists over time; conveys strong meanings	Low information capacity; requires fairly close proximity; humans cannot produce smells at will (with a few unpleasant exceptions)	Perfume, flowers, deodorant, smell added to natural gas to warn of gas leak
Taste	Association with food	Low information capacity; requires close physical proximity; risk of poisoning	Gourmet foods and beverages

Encoding and Decoding

Suppose a person with an idea wants to convey it to someone else. Most likely, he or she will use the visual or auditory channel, or both. The sender may send the message directly, for example by a gesture or speech, or may instead employ a form of technology to produce sounds or images. The process of converting a concept into a visible or audible message is called *encoding.* Table 2-2 shows some technological devices for encoding messages as sounds or images.

Table 2-2
TECHNOLOGIES FOR PRODUCING AUDIO/VISUAL MESSAGES

Produce audio messages:	Produce visual messages:
Whistle	Paper & pencil
Musical instrument	Paint & sign board
Car horn	Signal flag
Megaphone	Blackboard & chalk
Beeper	Automobile turn signal
Audio tape player	Printing press
Telephone	Camera
Radio transmitter/reciever	Slide projector/screen

At the receiving end of the channel, there is the opposite problem of *decoding:* changing the sign back into a concept in the receiver's mind. The goal of the whole process, of course, is that the concept that is received should be identical to that intended by the sender. Often, this doesn't occur, as in the example of Shaquill's interpretation of the "NO U-TURN" sign.

How does the receiver figure out the meaning of the symbol? There are two basic ways:

- Some symbols express their own meaning, because they share important characteristics with the concepts they represent. For example, the symbol for "Wheelchair Access" would probably be understood by nearly anyone who had ever seen a wheelchair. (See Figure 2-10.) This type of sign is more-or-less self-explanatory. We will call these *expressive symbols.*
- Other symbols have no logical connection with the concepts they represent, and their meanings must simply be memorized. In contrast with the wheelchair symbol, the symbol "H" for "Hospital" would not mean very much to someone who had never been told what it means. (See Figure 2-11.) A symbol that needs to be learned, because its meaning is not obvious, we call an *arbitrary symbol.*

2-10: **Symbol for "WHEELCHAIR ACCESS"**

2-11: **Symbol for "HOSPITAL"**

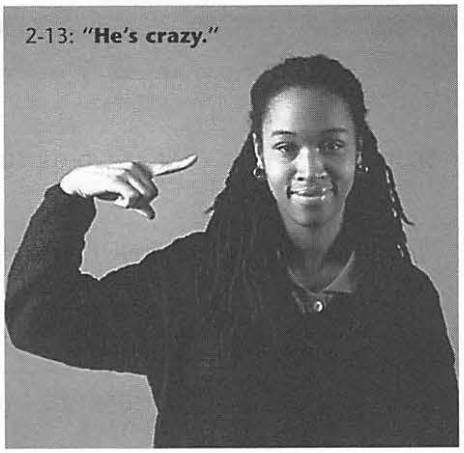
2-12: **Road sign meaning "SLIPPERY ROAD"**

In nearly every category of common signs and symbols, there are both expressive and arbitrary types.

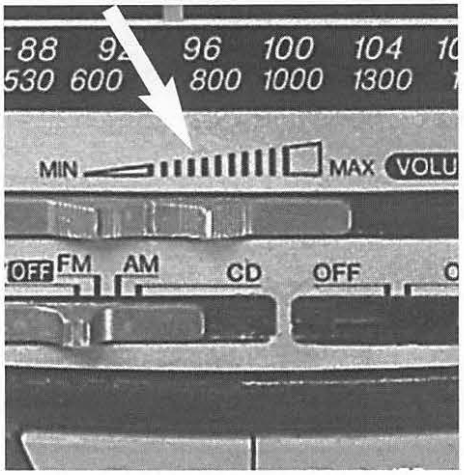
Arbitrary signals have no logical connection with the concepts they represent. There is no way you can "figure them out." They simply have to be memorized. The alphabet, punctuation marks, and numerals (except perhaps for "0" and "1") are all arbitrary symbols. The sound represented by a letter such as "F" seems obvious to anyone who can read, but the connection between the letter and the sound is purely arbitrary. Nobody would know this connection unless they had memorized it at some point.

Expressive symbols, sometimes called *icons,* have some kind of physical resemblance to the things or actions they stand for. A symbol never represents *everything* about the concept, but only some aspect that is easy to remember. For example, the "Slippery Road" sign in Figure 2-12 suggests its meaning by the tilt of the car and the skid marks. The "He's crazy!" gesture in Figure 2-13 implies that something is whirring around in the head. The volume control icon in Figure 2-14 uses a metaphor: increasing the volume is like increasing the size of the little vertical lines because it "makes the sound bigger."

2-13: **"He's crazy."**



2-14: **Volume control icon using lines of increasing size to symbolize "increased volume"**



Arbitrary and expressive symbols are summarized in Table 2-3.

Table 2-3

EXAMPLES OF ARBITRARY AND EXPRESSIVE SYMBOLS

Category	Arbitrary Symbols	Expressive Symbols
Writing	Letters	Pictograms (icons)
Speech	Most words, such as: "dog," "cat," "house"	Onomatopoetic words, like: "bang," "zoom," "chirp"
Number symbols	Arabic numerals: "2," "3"	Roman numerals: "II," "III"
Road signs	Traffic light, "STOP" sign	Symbol for "Slippery Road" (figure 2-12)
Gestures	Nod, shrug of shoulders, "thumbs-up" gesture (see Figure 2-5)	Bowing (to indicate humility), pointing, circular motion of finger near head to say "Crazy!" (see Figure 2-13)
Computer software commands	Keystroke combination	Computer icon
Appliance	Written instruction manual	Graphic instructions (see Figure 2-14)
Car alarm	Siren	"Talking" alarm which says "Burglar! Burglar!"
Tactile symbols	Braille	Child's early reader, showing the word "rough" next to a piece of sandpaper and "smooth" next to a piece of felt

What Can Go Wrong with Symbols

Kathy Aguiar, a third-grade special education teacher who is featured in Chapter 4 (pp. 70-72), asked a group of students to make up a graphic symbol for "TELEPHONE." Here is what happened:

> **Each group member began to draw his or her own symbol. Three students drew conventional pay phones.... One person drew what looked like a cell phone. ... José had no idea what Natalie had drawn, because he had never seen that kind of cell phone. As we continued to talk, I asked them about the types of phones they had at home. Out of this discussion, several other types of phone emerged.**

This story uncovers a basic fact about expressive symbols. Because a symbol is used to communicate, it can work only if the creator of the symbol and the person trying to interpret it share a common context. In this case, Natalie had represented the idea "phone" by a cell phone. José had never seen a cell phone of that type, so he couldn't recognize it as a phone. Their teacher, Kathy, recognized the need for a common context for the symbol to be mutually understood. To establish such a context, Kathy asked the students to describe the phones they had at home. Even expressive symbols, such as a pictorial symbol for a phone, have an arbitrary aspect to them. There are no symbols that are entirely self-evident.

Same Symbol, Many Meanings

When a single word has more than one meaning, the word is called a *homonym.* Many puns are based on homonyms

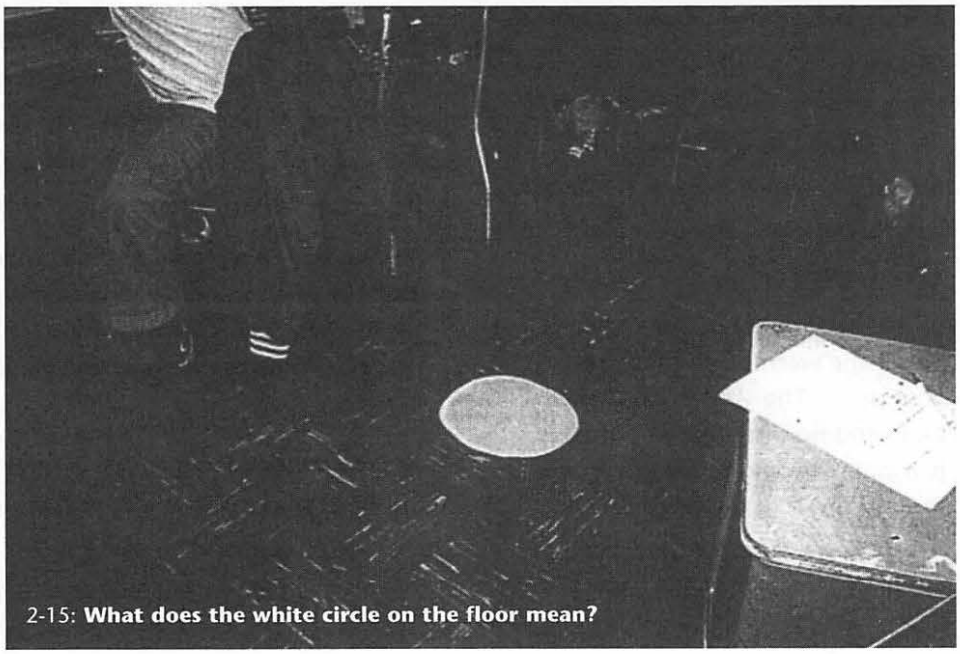
Q: Why does an empty wallet stay that way?

A: Because there isn't any *change* in it!

This joke exploits the fact that "change" is a homonym that could mean either "loose coins" or "alteration."

The term homonym is usually applied to words, but it could be used with other kinds of symbols as well. In one of the stories told in Chapter 4 (pp. 73-79), Gullermina Montano describes how her third-graders interpreted a new symbol she had just invented:

At the beginning of the day, I taped a white circle, about 20 inches in diameter, to the floor in the front of the classroom... (See Figure 2-15.) That afternoon, when the prep teacher [relief teacher during a preparation period] relieved me for my prep period, I secretly stayed outside the room. I waited there to see how [my students] would behave with the prep teacher. Of course, they started to "act out." I immediately re-entered the classroom, and stood inside the white circle with my arms behind my back, not saying a word. The children immediately quieted down.



2-15: **What does the white circle on the floor mean?**

Afterwards, Guillermina asked her students what the white circle could mean.

Karen listed a variety of possible meanings for the circle on the floor:

- **A happy face**
- **A shape with a figure inside**
- **A symbol**
- **A sign**
- **A sphere for world peace**
- **A clock**
- **A map**
- **A sign to be silent**

The same white-circle symbol could represent more than one concept. Which of these meanings was intended by Guillermina, the creator of the symbol? When Guillermina stood in the circle, the students knew that they were misbehaving. They decided correctly that the circle must be a place where she would stand to get their attention. The context—in this case, their bad behavior—provided the missing clue to interpreting the symbol. Many errors in communication occur because a symbol has more than one possible meaning.

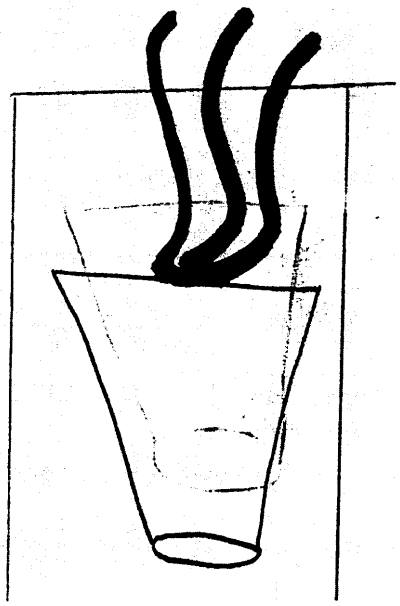
In the design of signs and symbols, it is important to provide enough context so that the intended meaning

becomes clear. Christine Smith, another teacher featured in Chapter 4 (pp. 99-104), asked a group of sixth-graders to symbolize "WARNING! HOT LIQUID!" without using words. One of their designs is shown in Figure 2-16. Christine tested the design by showing it to the other students. They had trouble with the wavy lines:

We spent a lot of time talking about the warning sign for hot liquids. . . . The steam was drawn in blue, and no one figured out what it was. Edwin suggested using red around the cup, to indicate heat.

Wavy lines could mean "hair," "string," or a host of other things besides "steam." Edwin's idea was to make some lines red to narrow down the meaning.

2-16: **Sign for "WARNING! HOT LIQUID!"**



Many Symbols, Same Meaning

We have just seen some examples in which the same symbol could represent a variety of concepts. The opposite situation can also occur. When more than one word means the same thing, the words are called *synonyms.* Generalizing this idea, two symbols that represent the same concept could also be called synonyms. Here is a further excerpt from Guillermina Montano's narrative:

At the end of my prep period, we did another experiment. My prep teacher tried standing in the white circle to see how the children would respond. They immediately told him to step out of the circle, because I was the only one allowed in it!

Teachers use many signals to ask for students' attention. These are synonyms, because they are different symbols that represent the same concept. Children have strong expectations about who will use a particular symbol to represent a concept. Guillermina's students believed that she alone could use "standing in the circle" as a signal for quiet. If the prep teacher wanted quiet, he would have to use some other symbol, such as turning off the lights.

A common source of error in communication is the expectation that a particular symbol—not a synonym—will be used in a particular situation. As every teacher and parent knows, children make up many of their own expressions. For example, a rich code language has taken root in kids' online messages. How many adults could translate "g2g" as "Got to go" or "brb" as "Be right back"? These online abbreviations are synonyms that children have reserved for their own use.

When there are synonyms for representing the same concept, it is possible to translate from one symbol to another. The *key* to a map or diagram shows the translation between graphic symbols and words. Appendix A (pp. 149-156) provides several examples of keys.

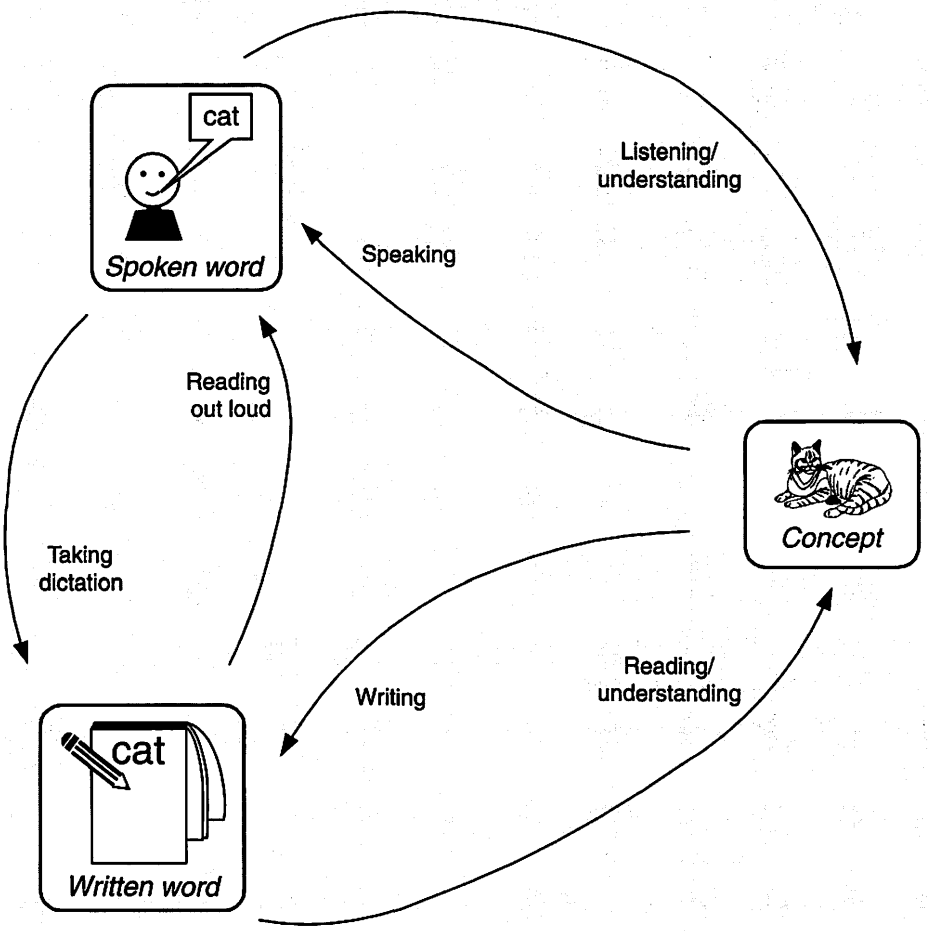
Symbols Are Fundamental

Much of education is concerned with learning to interpret and create (or "read" and "write") in various symbol systems, such as written and spoken language, and mathematical notation. Writing and speech are two very different symbol systems for representing concepts. Figure 2-17 shows some of the relationships between written language, spoken language and concepts, using "cat" as an example. The concept of a cat can be represented by the spoken word and/or the written word. The arrows indicate the six possible ways of moving between symbol and symbol or symbol and concept. Each of these transformations is a fundamentally different operation.

Going from one symbol system to another—for example, from written to spoken language—is a form of *translation.* Starting with a concept and expressing a symbol for it—e.g., by saying its name—is an example of *encoding.* Taking the symbol and interpreting the concept behind it is what we have called *decoding.*

A classic controversy in the teaching of reading is between advocates of the "phonics" method and proponents of the "sight vocabulary" method. The phonics approach is to translate one or a few letters at a time into their corresponding sounds, and then combine the sounds into words. The sight vocabulary approach involves interpreting entire words (or even larger units) into their corresponding concepts.

2-17: **The concept of a cat and two ways to represent it**



As Frank Smith (1997) points out, both approaches are hampered by the fact that the correspondences are not one-to-one. For example, phonics assumes that one can uniquely associate sounds with letters. Smith counts eleven different ways the letters "ho" can be pronounced, using only cases where they appear at the beginning of a word:

> **ho**t **ho**pe **ho**ok **ho**ot **ho**use **ho**ist **ho**rse **ho**rizon **ho**ney **ho**ur **ho**nest

Similarly, the existence of word homonyms and synonyms makes it impossible to assign unique meanings to words or particular words to concepts. Children do learn to read, but only because they bring a knowledge of the context with them. Much of reading is predicting what the words will mean, not simply decoding them. Frank Smith argues that reading makes the same sorts of demands on the eyes and brain as recognizing faces, objects, and places. His definition of "reading" includes making sense of signs, posters, graphic instructions, Morse code, Braille, maps, and mathematical formulas.

As in reading and writing, the learning of mathematical symbols is complicated by the fact that there are many homonyms and synonyms. As an example of a synonym problem, beginning algebra students find it hard to accept that these all mean the same thing:

- 2x
- x + x
- two times x

The symbol "x" is an example of a homonym. It could represent a variable or it could be a symbol for multiplication. As a variable, it could represent a wide variety of numbers. These potential areas for confusion need to be addressed explicitly.

Every language or symbol system has two major components: *semantics* and *syntax*. The semantics of the language answers the question, *What do the symbols mean?* The syntax is the *set of rules for organizing and manipulating the symbols.* This distinction is important, not only for learning verbal languages such as English, but also other symbol systems, such as mathematical notation. Traditional mathematics education emphasizes syntax at the expense of semantics. It focuses on the rules for manipulating the symbols, rather than on what the symbols actually mean. According to Herscovics (1989), the overemphasis on syntax leads to many of the common errors in elementary math. The following example has been studied extensively:

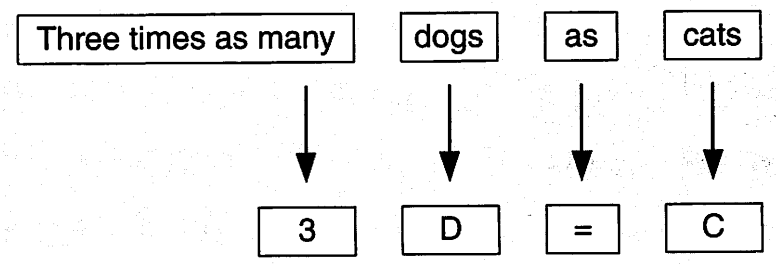
> *Write an equation that expresses the fact that there are three times as many dogs as cats, using "D" to represent the number of dogs, and "C" for the number of cats.*

Given a problem of this type, a large majority of college freshmen write:

3D = C

This answer could not be correct, because the statement says there are more dogs than cats, while the equation implies the opposite. The correct answer is D = 3C. The error arises from copying the syntax of "three times as many dogs as cats" directly into the equation "3D = C," as shown in Figure 2-18. This obvious (but invalid) solution preserves the syntax while ignoring the meaning (semantics) of the symbols.

2-18: **Obvious but incorrect translation of "three times as many dogs as cats"**



A major focus of math education is the translation among symbol systems. In middle school, students learn at least four ways to express simple relationships between variables:

- A statement in words;
- A table showing sets of values of both variables;
- A graph showing these values plotted on a two-dimensional grid; and
- An algebraic equation.

Although all four systems can express the same ideas, they are very different in the symbols they use. Learning to make these translations is a matter of understanding the semantics and syntax of the various symbol systems.

Analyzing Signs and Symbols to See How Well They Work

Humans invent technologies for practical purposes. Any technology can be evaluated according to how well it serves the purpose, and it can be redesigned if found to be wanting. Many symbols and symbol systems fit this description of technology. Others are so firmly entrenched that it would be very difficult to replace them, like the punctuation marks and arithmetic operators.

However, new symbols are being designed, tested, and adopted every day. There are many situations where an existing symbol could be improved upon or where no symbol exists but one is needed.

Have you ever found it difficult to figure out how to operate a shower in a motel bathroom or a faucet in an airport restroom? Are you sometimes mystified by whether a door should be pushed or pulled? Is it sometimes less than obvious how to operate a new telephone, camera, remote control device, alarm system, copy machine, projector, coffee maker, or steam iron? These kinds of problems abound in daily life. Perhaps a symbol is needed, or an existing symbol fails to express its meaning. The first step in designing something is often becoming aware that something doesn't work very well and needs to be redesigned.

Here are some questions worth asking about any sign or symbol:

1. **What does this sign or symbol say?** This question gets at the heart of what a symbol is—a way of representing a concept. Once you have identified something as a symbol, you probably have some idea of the message it is supposed to convey. At this point it is also worth asking, *Could this symbol be conveying more than one message?* In other words, is it a homonym? If so, *are there clues that will help users select the intended meaning?*
2. **For whom is this sign or symbol intended?** Another way of asking this question is to turn it around: *Are there people who would not understand this symbol?* For example, a child who had not yet learned to read would not understand a sign that uses words rather than pictures. The question also gets at the issue of the *channel* used to send the signal. If the symbol must be seen to be understood, a visually impaired person might not be able to receive it. Also, a symbol may not be understood because the receiver lacks some of the necessary context, as in the example above of the cell phone symbol for a telephone.

3. **What components of this symbol contribute to its message?** In Chapter 4 (pp. 80-92), Mary Flores describes how her special education students analyzed symbols they found in the school building, the subway, and the street, before designing new ones of their own. One student, Moises, recognized the meanings of colors in road signs: red means "STOP" while yellow represents "SLOW DOWN." The shape of a sign has meaning too. A red circle with a diagonal bar across it tells you about something you CAN'T do (see Figure 2-19), while a yellow warning sign is usually triangular like the "SLIPPERY ROAD" sign in Figure 2-12.
4. **How well do the components work together to convey the message to the audience?** This question may be open to considerable interpretation and debate. For example, some people might consider the "NO PARKING" sign in Figure 2-20 to be clever for the way in which it uses the broom handle as the diagonal "prohibition" sign. Others might find this feature confusing. Another problem is the "P," which might be an obvious symbol for "Parking" in English, but not in another language.

2-19: **No dogs**

2-20: **"NO PARKING" sign**

Redesigning Existing Symbols and Designing New Ones

The fundamental activity in technology is *design:* the creation of something new in order to solve a problem. To find out whether a design is successful, it needs to be evaluated to see whether it did achieve its purpose. In industry, symbol designs such as logos, road signs, product packages, and software icons are tested extensively to determine their effectiveness. Horton (1994) describes how software companies employ typical computer users to evaluate newly designed icons. Children should also evaluate their sign-and-symbol designs to find out how effective they really are. The basic evaluation question is: *How well does it work to convey the message to the audience?* Professional designers use three basic techniques to see how well their symbols work:

1. **The Meaning-for-Symbol Test:** In this test, the designer creates a symbol and then asks people, "Do you know what this symbol means?" Guillermina Montano's third-graders designed graphic symbols asking students not to run on the stairways and not to flood the water fountains (pp. 73-79). They posted these symbols on stairways and over water fountains, and surveyed students from other classes to see if they could tell what the symbols meant. Working with a sixth-grade science class, Christine Smith asked each group to create a graphic symbol for a different message, which was kept secret from the other students in the class (pp. 99-104). For example, one group had to symbolize "SUN GLASSES FOR SALE" without using words. Christine then showed each sign to the entire class, and asked them what they thought it meant.
2. **The Function Test:** The idea here is to place the symbol in its intended context and observe to see whether people interpret the symbol correctly. Felice Piggott's fourth-graders posted "DANGER" signs on bathroom doors and in hallways (pp. 93-98). Then they watched covertly to determine if students from other classes used these bathrooms or not. Angel Gonzalez's fifth-graders designed competing "brands" for identical snack packages sold to raise money for hurricane relief (pp. 108-115). Then they collected sales data to see which "brand" was the most successful.
3. **The Symbol-for-Meaning Test:** This is the most difficult test to do. It consists of creating a variety of symbols for expressing the same idea and then asking people which of the symbols works best. For example, a software company might create a variety of icons for the message "You have mail," and ask users to rate them.

The data from any of these tests usually provides clues for improving the design. In Christine Smith's class, the question was put directly to the students: "What would you do to improve this design?" One of the students said that the "WARNING! HOT LIQUID!" sign in Figure 2-16 would work better if some lines were red instead of blue. The next logical step would be to redesign the symbol and then test the new design. Symbols are an excellent topic for teaching design because the sequence of design-test-and-redesign can take place relatively quickly.