Chapter 5
Creativity and Ingenuity, Design and Problem Solving

One of the most used and abused approaches to technology studies in the schools is creative
design and technological problem solving. Current research suggests that it is not clear what
students learn, if anything, in many creative design and technological problem solving activities.
Recalling the previous chapters, it is not enough to merely involve students in activities and
problems. Emotions, knowledge and skills must be articulated, organized and demonstrated.
Inferences from mistakes and successes must be drawn. Procedures must be practiced. One of
the reasons that creative design and technological problem solving activities are often without
adequate results is that technology teachers tend to take creativity, design and problem solving
for granted. We assume that creativity, design and problem solving are automatic components of
what we practice in technology studies. However, little is automatic in education. There is more
to design and problem solving than learning methods and resolving technical problems. In this
chapter, current research is brought to bear on creative design, ingenuity and technological
problem solving.

In technology studies, one of our missions is to demystify the processes and products of
design and technology. It is not enough to merely teach students to express their creativity,
design or solve problems. We use the processes of creative design and problem solving to
disclose self-knowledge and feelings as well as the cultural and material conditions of
subsistence, work and home life. It is relatively easy to say this is the case. What remains is for
us to describe how technology teachers can derive knowledge and feelings from technologies.
How does doing lead to knowing? This chapter explains eleven methods of disclosive analysis
for teachers to use with their students to demystify the processes and products of design and
technology. The chapter concludes with an explanation of design briefs, an essential tool for
engaging students in design and problem solving.

Creativity, Imagination and Ingenuity

Can creativity and ingenuity be taught? Can the imagination be nourished? If so, how? What is
creativity? A typical library catalogue search for the word creativity produces over 1,000 titles,
and searches of commercial book dealers on the Internet produces 680,000 titles. The entry of
creativity as a keyword in the ERIC (Educational Resource Information Center) database produced 25,348 journal articles in 2001. When one enters the phrase "technology and creativity" into the Google web search engine, 787,000 sites are listed. An ERIC search using the same phrase produces 1,614 possible journal articles (Lamonde, 2001, pp. 56-58). Coming to terms with creativity is overwhelming. On one hand, the volume of references to creativity reveals its significance. On the other hand due to this popularity, it is difficult to take it seriously.

Early inquiries into creativity isolated four stages in the creative process: preparation, incubation, illumination and verification (Wallis, 1926). Not coincidentally, the four stages reflected the stages of problem solving isolated by Dewey in 1916. Many a teacher attempted to provoke creative thought in their students by walking them through these four stages. Other teachers emphasized Guilford's (1950) criteria for creative products: ideational fluency, flexibility, elaboration and originality. Definitions of creativity referred to both the process of reaching a novel achievement and the novel achievement itself. Researchers generally defined creativity as the "recombination of known elements into something new" (Ciardi, 1956) or more currently as "bringing something into being that is original (new, unusual, novel, unexpected) and also valuable (useful, good, adaptive, appropriate" (Ochse, 1990, p. 2).

Of course, we want students to reach for novel achievements. Of course we want unique expressions. Teachers want students to be novel within their world of norms and conformity, to think outside the box. But how novel is novelty if everyone is novel? In order to avoid the pitfalls of defining a creative process or identifying criteria to judge creative products, we will start with current dispositions toward creativity.

According to Howard Gardner (1983, 1993), each and every human has the capacity to be creative in one or a number of eight areas that correspond with theories of multiple intelligences. In Chapter 2 we identified these capacities as: Bodily-kinesthetic, Interpersonal, Intrapersonal, Musical, Logical-mathematical, Linguistic, Naturalist and Spatial. Creativity in technology, or ingenuity, directly involves bodily-kinesthetic, logical-mathematical and spatial capacities. However, ingenuity indirectly draws on the other capacities. In fact, ingenuity is typically defined by uniqueness inspired through the inter- and intrapersonal, musical, linguistic and naturalist capacities. In other words, ingenuity requires that we bring capacities to bear on design and technology that are not normally associated with design and technology. Ingenuity
requires a strange brew of capacities; it requires mobility from capacity to capacity. This is the lesson for teachers of creativity. If we want to teach creativity, we cannot limit our curriculum to a few capacities. The operative word is mobility.

Like intelligence, creativity and ingenuity result from a dynamic of biological and cultural (or environmental) forces and functions. Given the cultural sources of creativity, theorists, such as David Perkins (1986) assert that we can teach students to be creative in any and all areas of their life. It is through culture, and especially through material culture, that creativity and ingenuity are developed. Our theory of practice, explained in Chapter 6, grounds the development of creativity and ingenuity, and ultimately design. Creative impulses toward design are inspired through the manipulation of images, information, instruments, materials, tools, machines and products of all sorts. Technologies in general, and manipulatives in education specifically, are not merely media for the expression of creativity. In our theory of practice, creativity and ingenuity are stimulated through skills and the manipulation of technologies. Of course, we creatively approach and design the technologies we use. But the issue is one of priority. In our theory of practice, the priority is from manipulatives and skills to creativity and ingenuity. Manipulative skills do not dominate creativity, knowledge or feelings; cognition, emotions and skills are integral parts of the subject of technology studies.

Like cognition, creativity is neither fully individual nor fully social. Creativity, like cognition, is distributed among information, people and things. Remove the information, objects and social group and what is left is a partially creative person, an incomplete individual. This of course, is counter to romantic individualism and psychoanalytic theories suggesting that the social group crushes the individuality and creativity of its members. Materials and technologies are not merely instrument to creativity and ingenuity; technologies are not merely resources. Technology is not a mere medium for the expression of creativity. Rather, technologies are integral to creative acts. In an exhaustive analysis of the theoretical underpinnings of creativity, Lamonde (2001) concluded that the imagination and creativity are dependent on symbolic thought (e.g., language) and media. We learn to be creative, she concluded, by learning how to communicate with people and how to manipulate things. Hence, we cannot merely analyze what goes on in individual, "creative" minds to determine what creativity is or how to teach creativity. To understand creativity we must study environments, events, processes and situations. To teach creativity and ingenuity, we must create inspiring and stimulating conditions, environments,
processes and situations (Fig. 5.1). Creativity and ingenuity can be intentionally inspired and stimulated, or designed— IF we intentionally situate creative people in creative places.

**Figure 5.1. Instructional design for Creativity and Ingenuity**

Synectics, or operational creativity, is a theory of collective creativity especially attuned to education. Synectics rejects the notion that creativity is simply individual, accidental or serendipitous. The theory holds that creativity and ingenuity can be methodically and systematically inspired. Through certain techniques of synectics, creativity is entered into the solution of problems. Five extremely helpful synectic techniques for individual/group creativity are:

1. **Deferment**: look first for viewpoints rather than solutions.
2. **Autonomy of the Object**: Let the problem take on a life of its own.
3. **Use of the Commonplace**: Take advantage of the familiar as a springboard to the strange.
4. **Involvement/detachment**: Alternate between entering into the particulars of the problem and standing back from them in order to see them as instances of a universal.
5. **Use of metaphor**: Let apparently irrelevant, accidental things suggest analogies which are sources of new viewpoints. (Lincoln 1962, p. 274)
Design

"There's enormous opportunity in the concept of design to bridge from talking about concrete things like pencils and paper clips to more abstract things like processes: shopping in the supermarket, for instance, or the algorithm for long division, or computer programs" (Perkins, 1986b, p. 14). As mentioned in the previous section, creativity can be intentionally stimulated and inspired, or designed. Creativity can be taught or designed, and the corollary is also true: creativity is the process of design. To say that creativity can be taught is to merely say that design can be taught. However, it is insufficient to simply teach design, to teach students to design things, and call it creativity. It is necessary to think in designerly ways and to see the world through what David Perkins (1986, p. 35) calls "design-colored glasses." Design is not only about changing the world. Design is about understanding the world as well.

Creativity involves the creation of products, whether material or intangible, concrete or abstract. Each of these products is a design. Design can be simply defined as "a structure adapted to a particular purpose" (Perkins, 1986a, p. 2). Hence, structures adapted to particular purposes can be arguments, books, cars, genetic maps, houses, the internet, numbers or a speech. These are deliberate designs. Some designs of nature are also suited to particular purposes through evolution, such as the wings on a bee or bird, and can be considered to be natural designs; they came into being through natural processes and selection. Other senses of design, such as a pattern that serves no particular purpose (crystal lattices, ripples on sand dunes, solar system) are treated as nondesigns. They are regular patterns of nature that serve no particular purpose. Spiritual or theological analysts may attribute natural designs and nondesigns to divine intervention and design. Theoretically then, it is helpful to distinguish deliberate designs from natural designs from nondesigns (Perkins, 1986a).

Creativity is design, and we can also think of knowledge as design. Thinking of knowledge as design allows us to dispense with the notion that knowledge is information, or an accumulated data base that can be applied when the circumstance arises. Here, knowledge is passive and in storage for potential uses. Knowledge as design conveys a more dynamic view of knowledge, as generative rather than applicative. Knowledge generates action, and of course, action or experience generates knowledge. Knowledge is both the process and product of creative action. To make a transition in education from knowledge as information to be transmitted from teacher to students, to knowledge as design, we have to systematically put the
notion of design to work. Perkins (1984; 1986a) provided a **designerly thinking** method to help make this transition. His questions help demonstrate that knowledge is design or the process and product of creative action. These four questions that we ought to ask of any design are essential to putting design to work in the service of demystifying technology:

- What is its purpose (or purposes)?
- What is its structure?
- What are model cases (concrete examples)?
- What are the arguments that explain and evaluate it?

Take a paper clip for example. Its **purpose** is clenching or squeezing paper to aid in arranging and organizing. It can also be used for punching holes in paper, ejecting floppy disks, making mini sculptures, picking locks or an electrical conductor. Paper clips are categorized in the family of fasteners according to their primary purpose. Fasteners function by one or more of the following operational principles:

1. **Adhesion**: Substance with qualities of glue is used to adhere one object to another (glue, tape).
2. **Encircling**: Material wraps around objects (elastic band, string, tape, wire).
3. **Friction**: Objects are clenched or pressed together and friction is increased (bolt, nail, screw, paper clip).
4. **Magnetism**: Magnetic materials are used to increase principle of friction (magnets).
5. **Penetration**: Implement is used to penetrate objects to fasten one to another (nails, pins, thumbtacks).
6. **Squeezing**: Objects are clenched together with some implement which increases friction (clothes pin, paper clip).
7. **Static**: A static charge is induced which serves to bond two material together.

The question of the **structure** of paper clips can refer to its major materials, parts, material or operational properties, relations, shape and so on. For any design, we can simply identify structural features that are most illuminating and revealing. Common paper clips consist of a single strand of steel wire that is bent in three places to allow for the separation of one part from another. Plastic paper clips are built on a similar design. A paper clip can easily be constructed, drawn or found to provide a **model** of its structure. Any single, common paper clip can be used as a model to demonstrate the function of all paper clips (Fig. 5.2).
An argument or evaluation can easily be made on why the paper clip works (engineering, science) and why its designed the way it is (aesthetics, history, material properties). Principles of physics, material properties and the process of clenching can be brought to bear on the argument. For example, friction typically increases when objects are squeezed together. Different paper clips can be compared and evaluated through pros and cons about their designs. We can evaluate the elegant simplicity of the paper clip through aesthetic principles. Their simplicity adds to their ecological sensitivity. Paper clips are extremely ecological in that they require a small amount of material to produce and are nearly infinitely reusable. In theory, no paper clips should be wasted; no paper clips should end up in the waste can. We can explain why some work better than others and why some are more aesthetically ornate than others. Paper clips are universal and will clench any paper anywhere at anytime. The first bent wire paper clip was patented in 1867 and by the mid 1890s, paper clips had made pins obsolete as fasteners for paper. The production of paper clips capitalized on the widespread availability of steel wire in the late 1800s and the design of machinery that could reliably and automatically bend the wire into paper clips for pennies per box (Petroski, 1992, p. 60). Paper clip shapes varied by the dozens, reflecting the creative approach that designers took to solving an everyday problem. The marketing of paper clips was competitive, and suppliers boasted that the superiority of their designs rested on certain characteristics:
1. Does not catch, mutilate, or tear papers
2. Does not get tangled with other clips in the box
3. Holds a thick set of papers
4. Holds papers securely
5. Is thinner and takes less space in files
6. Is easily inserted
7. Is light weight and requires less postage
8. Is cheap (because it uses less wire)

We can evaluate the effects of the paper clip on everyday life through McLuhan's Laws of Media. Each artifact or medium, McLuhan and his students (1988, 1989) argued, can be analyzed through its effects, or through what the artifact enhances, retrieves, reverses into and obsolesces. These laws help us understand the structure of all artifacts and reveal the hidden effects, meanings and properties of media. We can begin by asking four questions of any artifact:

1. What does any artifact enlarge or enhance?
2. What does it erode or obsolesce?
3. What does it retrieve that had been earlier obsolesced?
4. What does it reverse or flip into when pushed to the limits of its potential?

In a two by two tetrad form, the Laws of Media can be used for the paper clip. The paper clip is a microcosm of the larger world of design, production and consumption.

<table>
<thead>
<tr>
<th>Enhances</th>
<th>Reverses into</th>
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<tbody>
<tr>
<td>Organization, Consumption, Aesthetic Variety</td>
<td>Obsession with Neatness, Gadgets</td>
</tr>
<tr>
<td>Retrieves</td>
<td>Obsolesces</td>
</tr>
<tr>
<td>Convenience, Simplicity, Temporality</td>
<td>Pins, Permanence</td>
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</tbody>
</table>

In summary, our **disclosive analysis** of a paper clip includes knowledge about purpose, structure, models and argument (evaluation). We do not fully understand a design until we understand these four things about the design. By using these four questions to interrogate concrete and abstract designs, students come to understand a theory of knowledge where knowledge is dynamic and generative. This theory helps to contradict traditional theories of knowledge and teaching where knowledge is inert information and the teacher is the purveyor of this information.
But to treat knowledge as design, the four questions must be extended to abstract things, such as insurance policies or the Pythagorean theorem. What is the purpose (or purposes) of an insurance policy? What is the structure of these policies? What are model cases (concrete examples) of insurance policies? What are the arguments that explain and evaluate insurance? What of the Pythagorean theorem? Can we teach students a designerly disposition to the world? Can we help them understand the dynamic nature of knowledge?

**Design and Problem Solving**

Creativity and design often take the form of abstract situations that require a highly developed use of the imagination and intellect. However, students do not necessarily have the aptitude to immediately handle the abstractions of design. The teacher’s challenge is to arrange for the conditions that ground abstract problems. While abstract problems are a necessity of design, the degree to which these problems are confidently handled and successfully solved is dependent on our ability to make these problems concrete. The first condition for problem solving in technology is that problems can be made concrete.

The ability to design, to solve design problems, is also dependent on a range of factors and traits. As indicated, one important characteristic is a designerly disposition toward knowledge. To adopt a designerly disposition is to see knowledge as dynamic. There are four important characteristics that govern creativity in the solution of design problems (Zanker, 1971, p. 43):

- The ability, held by an individual or group, to identify the situation which generates the basis of the problem.
- An ability to isolate the megastructure of the problem and to see clearly the constituent elements within this.
- A divergent and unblinkered ability to think around the problem in an inventive and perceptive way.
- The determination to succeed at all costs should not be influenced by known solutions as unsatisfactory elements.

Creativity, ingenuity, design and problem solving require the teaching of designerly dispositions. At issue here is not whether dispositions should be taught. The issue is how designerly dispositions are best taught. Although there are and were a few exceptions, educators teach and taught the dispositions of design and problem solving by focusing on methods, or what some call

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"soft skills." The premise was that by learning a method, or "soft skills" of problem solving, students would discipline their minds to methodically recognize and address problems of various kinds.

The problem solving method was derived from scientific (hypothetico deductive) methods, which Dewey (1910, 1929, 933) and Polya (1945/1957) made popular in education. Dozens of problem solving methods or models were derived from four basic steps:

1. *Find*, Understand, and Represent the Problem;
2. *Devise* a Plan;
3. *Execute* the Plan;
4. *Check* the Solution and Reflect to Consolidate Learning.

Dewey and Polya wanted students to learn a generic scientific method in schools and expected that the method would transfer to everyday, real world problems. They argued that the problem solving method was universal and applicable to all problems, anywhere, at all times. As long as students were using a problem solving method, it was assumed that they were solving problems. In effect, the method came to be a routine school procedure that had less to do with the resolution of problems than with the methods of schooling. For example, the method provides teachers with a structure for classroom management: everyone defines their problem by today, develops four alternative solutions by tomorrow, designs a prototype by the next day and so on.

In technology studies, the problem solving method, called "the technological method," is as overused as it is in other subject areas (Savage & Sterry, 1990, p. 6). This method (Identify and Represent a Problem, Generate Solutions, Choose, Model, and Test the Best Solutions, and Implement and Evaluate the Design) is also generic to designers and systems engineers. And as Romiszowski (1981, p. 8) suggested, it is also generic to educational technologists. The technological method is a step by step process of design and problem solving:

<table>
<thead>
<tr>
<th>Technological Method</th>
<th>Design Method</th>
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<tbody>
<tr>
<td>1. <strong>Defining</strong> the Problem</td>
<td>1. <strong>Generating</strong>, or envisioning future states of affairs;</td>
</tr>
<tr>
<td>2. <strong>Developing</strong> Alternative Solutions</td>
<td>2. <strong>Modeling</strong>, or providing descriptions of these states; and</td>
</tr>
<tr>
<td>3. <strong>Selecting</strong> a Solution</td>
<td>3. <strong>Testing</strong>, or analyzing their feasibility.</td>
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<tr>
<td>4. <strong>Implementing</strong> and Evaluating</td>
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<tr>
<td>5. <strong>Redesigning</strong> the Solution and</td>
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<tr>
<td>6. <strong>Interpreting</strong> the Solution</td>
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All of these variations on the basic problem solving method seemingly capture, in general terms, the essences of what are somewhat visible and politically correct. They neglect the essences of the distasteful practices of problem solving and design. Nonetheless, no matter the form, the four models are derived from the generic essences of Dewey and Polya (Fig. 5.3) (BC MOE, 1997).

![Diagram of Models of Design and Problem Solving](image)

**Figure 5.3. Models of Design and Problem Solving (BC MOE, 1997)**

The questions for researchers and teachers are: do these methods work? Is this how designers, engineers or technologists solve problems? Are these the most important essences of problem solving, or are there others that are ignored in these models? Problem solving, like
creativity and design, is a misunderstood and overused concept in the vocabulary of teaching methods, phrases and terms. The use of problem solving methods has become a ritual, some have suggested, having more to do with classroom culture than actual problem solving. In short, the problem solving methods provided above have been found to bear little resemblance to the way problems are solved in everyday life or the way that designers, engineers, and scientists do their work. They are simplified, rules of thumb that students should learn nonetheless. There is a fundamental discipline built into the methods that students ought to adopt in solving problems. But research suggests that teachers ought to move fairly rapidly from the basic to more sophisticated models with their students.

Extensive reviews of research on thinking and learning suggest that problem solving involves whole brain functions and is an innate human capacity. Human brains generally function through three steps in inquiry: 1) searching for and rendering of a context for problems, 2) ordering of details and information, and 3) decision making, evaluation, or conclusion. In an initial stage of problem solving, the problem solver searches for problems or for insight into the context of the problem, and generates a picture of the problem at hand. Similarly, research on learning suggests that in initial stages of the learning process, about three quarters of learners prefer broad, holistic and contextual pictures to provide meaning and insight into the nature of ensuing events. Hence, there is evidence that problem solving, and to a large degree learning, begins with insight into contexts—big pictures. By establishing a context for problems, we generate meaning and purposes for creativity, design and problem solving. A study of political decision making and problem solving has suggested that the first question in problem solving is not "what's the problem?," but rather "what's the story?" (Clark, 1988, p. 22).

The psychology of motivation speaks to the importance of relevance. Theory and practice in problem solving should recognize the significance of both context and relevance. If the search for context and meaning is accepted as an initial and significant part of problems, a challenge for teachers is to guide students into and through contexts that are problem rich. The challenge is to establish contexts that are relevant (Fig. 5.4). Of course, problems are neither found nor solved in vacuums and students are generally aware of this. They are always contexts nested within contexts, whether teachers choose to identify these or not.
There are two major changes that characterize the current state of theory in design and technological problem solving. The first shift is from product design to lifestyle design. The second is from problem solving to problem life cycle. Both of these changes reflect a deep regard for ecology and the state of the environment. No longer can design be simplified as the intuitive creation of individuals working independent of nature. While design and technological problem solving involve a web of natural and social relations, one of their failures has been a lack of sensitivity toward the complexity of life within this web. This insensitivity has been reinforced through a near total reliance on the conventional methods described earlier. As mentioned, design and problem solving involves more than politically correct essences (e.g., Identify Problem, Generate Solutions, Choose, Model, and Test the Best Solutions, and Implement and Evaluate the Design). In cybernetic grammar, these essences of design and
technological problem solving look like a system of inputs, processes, outputs, and feedback loops. The entire process of design and problem solving is reduced to a simple cybernetic system (Fig. 5.5).

![Figure 5.5. Cybernetic System](image)

An alternative is to include critical, dynamic essences in product life cycles and to design for sustainability. In an ecocentric model of design, rather than any static inputs and outputs or means and ends, the focus is on conditions and processes of design and technology (Fig. 5.6). In the model provided below, which is intended to be ecocentric, the process of waste is the pivotal center around which the other cycles revolve. Each of the ten cycles combine to create, and are integral to holding together, a larger product life cycle. Of course, these cycles are inseparable but are separated here for clarity. For example, one does not "use" resources without disrupting someone’s cultures, ecologies and geographies. It is not important which cycle you start with, as long as all the cycles are attended to their interrelations within any given design or technological problem. Contrary to simple methodological "how to" models in design and technology education, this model is helpful in accounting for the life cycle of design and problem solving.
The emphasis is on awareness and prevention in order to break our current cycle of production—consumption—waste. It is crucial that we leave open the option that, in school, a design or technological problem may be halted for lack of accountability to an ecologically sustainable resource stream. Another option is that thirty student problems or projects may be consolidated into two small-scale problems. There are difficult questions to address: If we know little about the resource stream in which our materials arrive, ought we produce anything at all? If we slow down or halt production and consumption in design and technology education, can we still teach? What is our ecological footprint? Students ought to be encouraged to do nothing less than ask and answer some difficult questions (Petrina, 2000b).
Ecocentric Questions for Students

- Where do our materials come from—from whose backyard and at what ecological cost?
- How did the materials get here—through whose backyard and at what ecological cost?
- How sustainable is our material practice?
- Where does the waste of our production and consumption go—to whose backyard and at what ecological cost?
- How do I change my lifestyle to produce and consume less?
- How much embodied energy does the product or process require over time? (Embodied energy refers to the amount of energy necessary for the production of materials in the product or process)
- Are renewable or sustainable resources used in the product or process?
- Are there less energy-intensive, longer lived alternatives to the resources used?
- Whose resources and labor was used in extraction and manufacturing?
- Are local resources for the product available?
- What hazardous, gaseous, aqueous, or solid wastes are created? What ecologies and people are exposed to this waste in extraction, construction or manufacturing?
- Can this waste be reduced through alternative materials and techniques?
- Does the product require special techniques, treatments or finishes that are health and safety hazards?
- How much energy is required for transporting the materials and product?
- How easy is it to maintain and recycle the product?
- How much maintenance does the product require over its life?
- How resource-intensive is the maintenance program?
- What wastes are produced in maintenance? Who will maintain the product or process?
- Can the product be recycled or reused at the end of its useful life?
- Do different materials offer better chances of resource recovery at the end of the product’s life?
Our challenge is greater than teaching design and technological problem solving in a way that merely results in "making stuff and doing things." Despite all the questions that we may ask in the name of greening our "making and doing," current research suggests that design is about lifestyles. As noted in Chapter 3, design is about controlling environments, experiences and emotions. We have to face the reduction of waste issue inside and outside of school. Good design and technology education is about reduction in production and consumption. In technology studies, we demystify the processes and products of design through disclosive analysis.

**Disclosive Analysis**

Disclosive analysis refers to a group of methods that are used to derive meaning from the artificial and natural worlds. In the next chapter we explain the theory behind disclosive analysis. This section provides a description of disclosive methods of analysis. The most common disclosive methods for technology teachers include basic causes, designerly thinking, ecological footprints, laws of media, life cycle assessment, quotidian deconstruction, resource streams, reverse engineering, sociologics, systems analysis, technology assessment and forecasting.

In a previous section, we introduced the notion of **designerly thinking** to help us think about knowledge in dynamic terms. The four basic questions that Perkins (1984; 1986a) provided help us disclose the conditions and workings of individual designs or technologies:

1. What is its purpose (or purposes)?
2. What is its structure?
3. What are model cases (concrete examples)?
4. What are the arguments that explain and evaluate it?

We also outlined McLuhan's **laws of media**. These laws help us understand the structure of all technologies and reveal their hidden effects, meanings and properties. The laws of media form a two by two tetrad for each technology. For example, the Laws of Media that govern cable television can be disclosed by asking the following four questions:
Again, we cannot stop with surface features. For McLuhan, the laws of media should be used to penetrate the inner workings of media and disclose forces and politics that are hidden or taken for granted.

**Basic Causes**

Disclosive analysis generally originated with Aristotle who, in *The Physics*, identified four basic causes that explain why artificial and natural things are as they are. His logic was practical: Instead of merely accepting things as we see them, we have to explain and interpret things. Marx would later challenge this by arguing that the intent of interpretation was to change things. Aristotle asked: why is a statue a statue? What causes a statue to be a statue? He suggested that there were four causes that explain why things are as they are. There are four different explanations for natural and material things (Fig. 5.7). The four explanations answer to four different sorts of questions:

1. What is it made of?
2. What sort of thing is it?
3. What brought it about?
4. What is the purpose of the thing?

These questions correspond to his four causes: 1) Material cause, 2) Formal cause, 3) Efficient cause, and 4) Final cause. Some philosophers dubbed these the four becauses to emphasize that they are explanations. They do not relate to the way that we tend to think of causation, as in cause-effect. Aristotle's method has also been called an etiological analysis (inquiry into causes).
Teachers can assist their students to do disclosive analyses to interpret the technologies they use or produce. The four basic causes can be used to disclose a story behind things that is hidden or distorted. Aristotle's causes disclose a story of material, form, force and function. How can we explain a table using the four basic causes? At first glance, the table's matter, form and function seem obvious. We can simply say that the table is made of wood. It takes the form of four legs and a flat top. We can surmise that a carpenter made the table. It serves the functions of eating and writing. This would be an analysis that dealt strictly with surface features. Disclosive analyses must penetrate the surface of things, as Aristotle prescribed. Why was wood used? Where did it come from? Why does the table take the form that it takes? What were the conditions under which the carpenter worked? Was it primarily machine produced? Is the purpose of the table purely functional? What happens when it comes into use?

**Life Cycle Assessment, Resource Stream and Footprint**

Product life cycle, or **life cycle assessment** (LCA) began as an engineering design model for analyzing products over the course of expected and actual lifetimes— from cradle to grave. Early design issues focused on stages of product introduction, growth, maturity, and decline, much as technology assessment dealt with stages of invention, development, innovation, and diffusion. The idea was that decisions on engineering feasibility at early stages in the design of a technology were to be fully informed by knowledge of parts and product affordability, availability, usability, reparablebility, reliability, and disposability. In life cycle models, product design, production, use, and disposal are the same issue: design for life. LCA eventually became concerned with sustainability, and became a way of accounting for material flows or streams.
from "cradle to grave." The life cycle of technologies came to be seen as intricately interrelated with life cycles of living organisms.

The premise of LCA is that by thinking in terms of material or resource streams we can avoid malignant production practices and reduce our net consumption. The emphasis is on awareness and prevention in order to break our current cycle of production—consumption—pollution. The emphasis is also on interconnectedness and sustainability. **Resource stream** is an ecocentric method that traces the flow of materials from their *extraction* through their incorporation into part and product *production* and their ultimate *disposal*. Resource streams make visible the fact that *materials* are extracted and refined, and manufactured into parts and products, which are consumed, used and maintained. Products and materials with no remaining *value* are discarded with percentages of the waste being either disposed, dispersed, or recycled. A resource stream suggests that within any technology, through capital and labor some material was extracted from some(one’s) place and harnessed for some use over time with some waste along the way and in the end. Accountability and sustainability mean that all costs—ecological, cultural, social—and not merely economic costs are figured into design decisions. Establishing a clear, visible account for resource streams is central to the LCA and ecological footprint analysis.

The **ecological footprint** analysis was developed to account for resource streams (Wackernagel & Rees, 1996, p. 3). The ecological footprint "accounts for the flows of energy and matter to and from any defined economy and converts these into the corresponding land/water area required from nature to support these flows." Wackernagel & Rees argue that we account for our resource consumption and waste assimilation requirements in terms of land area, or footprint. The footprint represents the "appropriated carrying capacity" of terrestrial ecosystems necessary to support a given person, society, country or product (p. 11). This appropriated area necessary to support the habits of affluent countries has gradually increased throughout this century. The current ecological footprint of a typical North American is "three times his/her fair share of the Earth’s bounty. Indeed, if everyone on Earth lived like the average Canadian or American, we would need at least three such planets to live sustainably" (p. 13). A planet where everyone imposes an over-sized footprint is not sustainable. The ecological footprint puts our accounting of resource streams into local and global perspectives. Ecological footprint analysis helps teachers and students disclose the natural consequences of products and
processes by quantifying land and water use (Formula and automated strategies are available on the web).

While the ecological footprint is a way of accounting for the sum of demands on nature from given lifestyles, the materials used in products and processes are disclosed in a resource stream analysis. When we trace the resource stream of technologies, the interconnections between technology and nature are disclosed. This is an essential, albeit difficult, task for life technology teachers and their students. Take for example the average pair of sneakers or "cross-trainers." These shoes are labeled, or "branded," and designed by a multinational corporation in the US, engineered in Taiwan and South Korea, manufactured in China, South Korea, or Southeast Asia, and mostly purchased, worn, and disposed of in North America. The leather upper of the shoes, consisting of about twenty parts, is typically from cows raised and slaughtered in Texas. The hides are shipped to Asia and treated through a chemical-intensive chrome tanning process, with a by-product of toxins dumped into an Asian river. The synthetic parts of the shoes are made from petroleum-based chemicals from Saudi Arabia, and distilled and cracked in a Korean refinery, with wastes again making their way into rivers. The midsole is Ethylene Vinyl Acetate foam which requires a number of processes to synthesize. The sole is made from styrene-butadiene rubber, synthesized from Saudi petroleum in a Taiwanese factory. In the factory, the sole is molded and cut, generating the largest amount of solid waste in the shoe production process. The shoes are assembled in a Tangerang factory or similar Asian factories. Most of the assembly is done through the labor of children and women cutting, gluing, and sewing under sweatshop conditions of high temperatures (100 degrees F) and toxic fumes from solvent-based toluene glues and paint. Their average wage is about 15 cents per hour over their 65 hour work week. The finished shoes are hand packed with light-weight tissue from Sumatran rain forest trees and placed in a box. The unbleached, corrugated cardboard for the shoe box was made in a closed-loop paper mill in New Mexico. The shoe box itself is folded in a mill in Los Angeles and shipped to Asia. The boxed shoes are shipped as cargo back to the west coast of Canada and the US, transported to local outlets, purchased for about $60.00 to $150.000 (USD) per pair, and worn for occasions having nothing to do with sports or training. The average pair of cross-trainers lasts less than a year and usually ends up in a landfill. This particular resource stream flowing into and through the production and consumption of these shoes is an example of current practices of globalization.
Understanding this resource stream is a necessary, but incomplete, disclosive analysis of the shoes. A full disclosive analysis of the ecology of products would follow LCA with product wake analysis or technology assessment (see below). Let us imagine that our pair of trainers was branded by Nike. Established in 1972, Nike's annual average sales is $9.6 billion. The company has produced 900 different types of shoes, most of which have been sport related and marketed, figuratively or literally, by athletes. Nike endorses more than 3,000 athletes through its advertising fold, including 72% of the National Basketball Association players, 60% of the Major League Baseball players, and 50% of the players in the National Football League. Over 200 universities fly the Nike banner for their sports teams. Nike sells about 160 million pairs of trainers each year, and nearly one of every two are purchased in the US. The average American teenager buys between three and ten pairs of athletic shoes (specialty sports and fashion) each year at prices ranging from $50.00 to $150.00 per pair. Nike's brand logo is recognized by about 97% of all Americans and Canadians, but the "swooshification" of culture is global. And it has little to do with shoe sales and sports. Nike produces consumer demand, images, and brands of blackness and whiteness. With distribution increasing in Asia, distinct brands of being Chinese, Japanese, or Korean are also represented in advertisements and shoes. We could continue with this disclosive analysis by analyzing how the shoes are consumed by students.

**Quotidian Deconstruction**

Quotidian deconstruction is a form of disclosive analysis that focuses on the feelings that people derive from their quotidian or everyday experiences with technology (Feng, 2003). The intention is to show how we experience culture, nature and technology in tandem. Quotidian deconstruction enables students to realize that technology is nature transformed (as nature formed into technology) and culture is technology transformed (as everyday, mundane technologies, like buttons, spoons or utensils, formed into culture). Students focus on their everyday life with technology and use phenomenology to help them disclose their desires and feelings about culture, nature and technology. There are two basic directions to this method of disclosive analysis. The first is toward deconstruction by connecting everyday technologies to their natural sources. Feng uses the example of a clay spoon that has its source in the mud of a riverbed in China. The second is toward phenomenology by connecting the same technology to personal experiences. Here, the spoon provokes personal meanings and memories for its users.
Things have value well beyond their economic and functional value. Phenomenology means that we express how we experience something, prior to any theorizing about it. We deal with the raw feelings and experiences. The experiences disclosed may be traumatic or we may have fond memories. The goal is to let the artifacts speak in the two directions outlined: toward their source (material form) and the way we experience them (phenomenology). The everyday technologies that we use hold stories and disclose our feelings toward them. Quotidian deconstruction is a way of letting these stories emerge with our feelings.

**Reverse Engineering**

Reverse engineering is a method wherein we figuratively and literally disassemble a technology to figure out how it works. It is the physical deconstruction equivalent of our methods of conceptual deconstruction. The method is common in business and industry where the ability to equal or outdo competitors is dependent on innovation and the introduction of competitive products into the market. Reverse engineering is prevalent in the hardware and software industries. Knock-offs or imitations via the disclosure of trade secrets are common. Reverse engineering requires that we physically and analytically disassemble the technologies of interest. Physical disassembly requires that we work backwards from the finished product and part by part reduce it to its simplest components. We figure out the application of the components and how they relate to each other. Analytical disassembly requires that we work backwards from the finished product and, process by process, deduce the mathematical and scientific concepts or principles underlying the processes. We figure out the explanation of the processes and how they relate to the whole. This method is common to the Math-Science-Technology (MST) approach to integration that is described in Chapter 7.

**Sociologics**

Sociologics is a controversial issues method particularly suited to help us to deal with controversy in design, science and technology, or technoscience. Sociologics was developed by Bruno Latour in his now classic book *Science in Action*. What makes design and technoscience exciting, said Latour, is the fact that alternative and competing arguments and products are developed and pursued. And what makes these controversial is the increasingly important role they play in our health, livelihoods and future. Basically, any design or technology has
controversial issues associated with it and sociologics helps teachers address these issues. In a
general framework of the controversial issues method (Chapter 4), sociologics is organized
around five specific questions to ask of the controversy of interests (e.g., disability access, solar
power, toxic waste). Working through the five questions helps students understand the logical
and political ways in which controversies are formed, addressed and resolved (Fountain, 2001).

**Sociologics of Controversies**

1. **Causality:** How are causes and effects attributed? What causes what in the
   controversy and in people's points of view?
2. **Mapping:** What points of view are linked to which other points of view?
   Who is saying what about what?
3. **Credibility:** How credible are the points of view? What are the strengths of
   the links between points of views?
4. **Legitimacy:** Who and what have a voice or role in the controversy? Who is
   excluded and why?
5. **Movement and change:** How are the design and technologies modified in the
   arguments? How are the arguments modified in the controversy?
6. **Resolution:** How will the controversy be settled or resolved? What are the
   options?

**Systems Analysis**

There are two core concepts to design: sustainability and interconnectedness. Systems analysis
helps us to deal with the second concept. Systems analysis is a method of for analyzing human-
machine and machine-machine interconnections by determining the inputs and outputs of a given
system. This is an effective method of disclosive analysis for demystifying the operations and
inner workings of natural, social or technical systems. When we cast a technical system into a
larger context we can analyze the interconnections among natural, social or technical systems.
Figure 5.5 is the classic depiction of a system (inputs, processes, outputs and feedback). Figure
5.6 is a depiction of the interaction of systems.
Technical systems, like ecosystems, are never truly isolated, even though we treat them as such. To identify a system, we must locate where one system or subsystem ends and another begins. We must make some system components visible and leave others invisible. In a systems analysis, it is necessary to identify what the system involves (i.e., energy, processes, resources, effects). It is important to identify individual components of the system. The key to a systems analysis is identifying why a system operates as a system. In systems analysis, we use a simple procedural method:

<table>
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<tr>
<th>Systems Analysis Method</th>
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<tbody>
<tr>
<td>1. Identify the system</td>
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<tr>
<td>2. Conceptually or physically locate and isolate components and sub-systems</td>
</tr>
<tr>
<td>3. Identify inputs and outputs</td>
</tr>
<tr>
<td>4. Identify feedback mechanisms</td>
</tr>
<tr>
<td>5. Identify or deduce processes</td>
</tr>
<tr>
<td>6. Analyze, troubleshoot, maintain or redesign system</td>
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Sociotechnical systems are a bit more complex in that we must analyze the interface between human (social) and non-human (technological) systems. The key is to identify human and machine behaviors and the interconnectedness between the two. Primary interests in sociotechnical systems analysis focus on relationships among components in a dynamic system, rather than components themselves. The behavior, goal or state of a particular system is dependent on cultural, social and technical components being coordinated in some way. The components are coproducers of outcomes or states, and have distinctive characteristics that must necessarily be respected or variance (unprogrammed events) is a result. When the compatibility of components is respected, the probability of variance is reduced. Making certain that components interact harmoniously requires that characteristics are respected and correlated in both initial design and in progressive use. The aim for sociotechnical systems designers is the joint optimization of natural, social and technical systems. Sociotechnical systems analysis requires a knowledge of the way machines and technical systems behave and of the way people and social groups behave. Ecosystems analysis requires that we identify the workings and interconnections among organisms in the ecosystem. Hence, their a number of systems that
students can analyze under the teacher's guidance (e.g., technical systems, sociotechnical systems, ecosystems, economic systems).

Separate systems analyses ought to help students understand the contextual and interdependent nature of systems. All systems have contexts (e.g., economic, social, political). Contexts constitute the designs and uses of technologies. Systems analysis, or specifically contextualism, underscores the idea that technology does not develop in a vacuum. Cultural, social and psychological systems are interdependent with technical systems. Currently, theorists of technology are analyzing systems collectively, rather than separately. They analyze collectives of economic, political, social and technical elements to understand how separate systems interact or dissolve in collectives. In contextualism, technologies shape contexts and contexts shape the technologies in return, more or less in tandem. In interactionism, technologies and other systems are shaped together, simultaneously. Contextualists and interactionists reason that technologies are neither as easily changed as non-determinists argue nor are they as durable as determinists posit (see Chapter 3).

**Technology Assessment**

Technology assessment (TA) is a specific form of disclosive analysis that refers to any methods or processes that are used to assess the measures and consequences (intended, indirect, unintended) of individual technologies or systems of technologies. The consequences of any technology may be collateral (immediate) or deferred (delayed). TA is "the process of identifying the actual or potential secondary effects of a technological development (or set of interrelated technological developments) on social, political, economic, and/or environmental values or institutions" (quoted in Petrina, 1990). TA focuses on all stages of technology, from invention, development, innovation, and diffusion to eventual obsolescence. TA affords citizens (e.g., students) and governmental planners the opportunity to anticipate potential technological developments and their possible collateral, unintended, indirect or deferred consequences. Any given TA should:

1. Describe the specific technological measure and its consequences.
2. Specify viable alternatives based on the distribution of a variety of costs and benefits among affected parties, and
3. Present social choices and policy options compatible with a wide spectrum of future scenarios.

The process of TA means underlining the collateral effects of a specific technology and revealing unstable features of this measure, which may lead to long-deferred consequences. TA may dictate effective remedial or preventive actions. TA was institutionalized during the 1960s and 1970s to guide public policy. Technology studies adopted the techniques of TA to assist students in learning to assess certain technologies as well as use these them. TA in the labs and workshops basically involves telling a story of a technology. When our students undertake this challenge, they must analyze the consequences and effects of this technology. Have your students work through the following questions when analyzing their technology (Marker, 1987):

<table>
<thead>
<tr>
<th>Technology Assessment</th>
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<tbody>
<tr>
<td>1. List all the effects you can think of for one technological development.</td>
</tr>
<tr>
<td>2. Categorize the consequences on your list according to whether they were intended, planned and/or foreseen by those who introduced or eagerly adopted the innovation or were unplanned, unforeseen and unintended.</td>
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<tr>
<td>3. Indicate which consequences were felt only in a local area, which were felt regionally, nationally or globally.</td>
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<td>4. Classify the consequences as beneficial or harmful, or both.</td>
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<tr>
<td>5. List four factors (values) you consider to be essential to a good quality environment for humans, and which influenced your choice in item #4.</td>
</tr>
<tr>
<td>6. Which subgroups in society benefited most from the technology you are assessing? Which subgroups of society bear (or did bear) the majority of the harmful effects? List two reasons for the inequitable distribution of benefit and burden.</td>
</tr>
<tr>
<td>7. What was the time lapse between: (a) the invention that made the technology possible and its widespread innovation (adoption and diffusion)? (b) between the planned benefits and the appearance and/or the awareness of the burdens?</td>
</tr>
<tr>
<td>8. What actions were or are being taken to alleviate the burdens? Who (e.g., consumers, industry or government) are taking these actions? Who is paying the cost of alleviating these burdens in money? Who is paying the cost of alleviating these burdens in Quality of Life?</td>
</tr>
<tr>
<td>9. What areas of CHOICE did the technology open up for individuals?</td>
</tr>
<tr>
<td>10. What choices or rights did the technology open up for society in general (seen most likely) in legislative and judicial decisions? What choices or rights were compromised?</td>
</tr>
</tbody>
</table>

The methods and techniques used in TA range from the purely intuitive to purely extrapolative. All too often, TA in the schools simply involves a balance sheet of positive and negative impacts. This type of cost-benefit analysis trivializes the process. The process of TA
typically requires that students draw on any of a range of techniques: Historical survey, input-output analysis, cost-benefit analysis, systems analysis, risk analysis, simulation, trend analysis, news analysis and interviews. Technology assessments can be general, where the students try to be as comprehensive as possible in analyzing cultural, economic, ecological, psychological and social consequences. Or students may concentrate on certain consequences, such as the effects of new technologies on rights.

**Technological Forecasting**

Technological forecasting (TF) refers to any method that is used to predict the future development of technologies. TF is "a prediction of the future characteristics or applications of useful machines, techniques or procedures" (quoted in Petrina, 1990). TF most generally is the forecasting of technological change, or the invention, innovation or diffusion of an individual technology or system of technologies. TF should help to provide not only an indication of what future technologies will be, but also the amount of time that will likely involve the developmental stages of a new technology. TF can help to provide an indication of a point in time when an older technology should be abandoned or replaced. Technological forecasters attempt to (a) analyze a specific allotment of resources (capital and knowledge), (b) project the likelihood of achieving technological developments or capabilities within a given period of time, (c) project the implications and contingencies that may affect the realization of such developments or capabilities, (d) project alternative means of achieving a certain capability, and (e) project alternatives to technological change. For the most part, the scope of TF is generally limited to technical factors of future technological change. Social and cultural consequences of potential technological change are not outcomes of TF. Hence, TF may be integrated or supplemented with economic, political or social forecasting. Plausible and apparent technological changes often become topics of interest for technology assessors. TF typically involves trend extrapolation, impact analyses, scenarios, simulations or analogy and provides us with an idea of the probable changes that will take place within a certain period in the future. Exploratory methods help forecasters project future developments based on history, patterns of growth and technological activity. Forecasting is not a psychic way of divining the future. TF is a trends-based method that draws on a modicum of insight, intuition and courage.
The value of an education is increasingly measured by the degree to which it is future oriented. Advocates of forecasting note that TF heightens our perceptions of current problems. Futurism, or concern for the future, is mentally healthy and helps one to develop self-esteem, goal-orientation and organizational qualities. Futurism deals with descriptions of probable alternative futures and the probabilities of their coming into existence. Futurism is based on the premise that although anything is possible, there are aspects of the future that are highly probable and others that are next to impossible. Just as TA and history are beneficial in assessing the characteristics of change, futurism and TF can help students to anticipate certain changes. Most students find TF to be quite interesting, and even entrepreneurial when it comes to their own variations on existing designs. Although TF provides us with an estimation of future changes, it can also help students evaluate, choose and develop technologies that might best accommodate our cultural, ecological, physical, psychological and social needs.

### Technological Forecasting

1. Survey a range of resources (e.g., historical data, web sites such as Futurist.com, etc.) to extrapolate trends and generate scenarios. Remember, technological forecasting is not pure fiction, but is based on trends and extrapolations.

2. Focus on one economic or technological sector (e.g., business, communication, entertainment, health, manufacturing, residential, sport, etc.).

3. List five plausible developments in a single sector or industry in five year base projections into the future (i.e., 5, 10, 15 and 20 years).

4. Choose one development at one point in time and represent it as best as possible (drawings, words, graphs, etc.).

5. Provide a brief scenario for this development that you are forecasting. Provide a description of how the invention will be used, what its consequences may be and the way it will be created and disseminated. The scenario may be dystopian, utopian or mundane.

6. Provide a brief scenario for planning now to enhance the probability that the forecasted technology will be introduced.
Design Briefs

Design briefs are a popular form for challenging students to think creatively and systemically to resolve design-oriented problems. They are the standard form for communicating technological challenges and design specifications. Design briefs are popular in the design fields as well as commerce. In these fields, the design brief may be a contract that is quite complex. All design briefs have common elements. There is descriptive information that sets the stage. There is a section that states the problem to be resolved and a section that describes any special conditions. There is a section that describes any special responsibilities of the designers.

Design briefs used in design and technology courses abbreviate all of these components. The design brief in technology courses is a short, professional document, at most two pages. It is used to focus the efforts of the student designers. They are one of the most common forms found in technology studies. Design briefs provide an example of how designers actually focus themselves while providing an educational problem solving experience.

Design briefs can address a range of design challenges. A typical skill-building project, where all students more or less follow the same plans, can be presented in the form of a design brief (or what some call a project brief). For the sake of simplicity, design challenges can take one of two forms. Design challenges may be either dynamic or static. Dynamic designs are defined by a series of animations or moving parts driven by some power source, including gravity or human energy. Static designs, such as a brochure or table, are defined by the lack of moving parts (a paper that opens along a crease or drawer do not qualify as moving parts). Design briefs can, like design, present students with open-ended or closed problems, or or a combination of the two.

The design brief is not merely a single-use document that is referred to at the beginning of the design process. It is referenced throughout the process to ensure that the solution being developed actually fits the problem. It forms the basis for all decisions made by the design team. From a teachers perspective, it is used as a reference point to evaluate the design solutions and to evaluate any other documents submitted by the design team. While design briefs differ from task to task, most share a number of the components in the following format. This is a commonly used format and the standard in technology studies. The example provided is a good example of how a simple challenge can prompt students to think creatively and successfully act on their imagination. It is also a good example of the structure of design briefs.
## Design Brief Format

1. **Title**- Provide a catchy title.
2. **Background/Context**- Provide a short description of the background or setting. This may be a fantasy or realistic context.
3. **Problem**- State the design problem in clear, concise terms. A clear articulation of the problem situation is essential if the correct problem is to be identified and an appropriate solution found.
4. **Constraints**- Provide a comprehensive list of restrictions or parameters that help to shape the design solutions without limiting the solutions to one. Use words such as "Must" and "Cannot." Stay sensitive to the problem of too few vs. too many. Do the constraints limit designs to one solution?
5. **Design Considerations**- Provide a list of issues all the students should consider. These considerations should define what makes an effective design--effective versus ineffective. These may be reminders and prompters that are ecological-natural, ethical-personal, socio-political, technical-empirical, and ecological.
6. **Sequence**- Provide a recommended procedure for students to follow. This should give them direction.
7. **Related Studies**- Provide a list or description of subjects necessary in order to solve the problem.
8. **Management Issues**- Provide a timeline of dates and times that the students will adhere to.
9. **Self Evaluation**- Provide a way for students to evaluate themselves.
10. **Assessment**- Provide a scheme that you will use to assess the students and their designs.

Opinions differ on the creation of design briefs. In most cases, design briefs will be prepared prior to the beginning of the design challenge (by the teacher or other professionals). In some cases, the design briefs will be prepared by students, or groups of students working together on a common design problem. Here, teachers and students refine the problem together and the students prepare their design briefs. Either way, it is important to provide a format for the students to follow:

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Fasten(at)ing Technology—Paper Clips

Context
In the family of fasteners, a paper clip is what you might call a simple, elegant solution to the problem of squeezing or clenching paper. Paper clips are easy to reproduce, easy to use, hold papers together without causing damage or crimping, and have many other uses besides clenching. This is only partially true. Paper clips do cause damage. Some get rusty and stain the paper. Some are too inflexible and leave a permanent crease or crimp in the paper. Your challenge is to improve fastening technologies by designing the perfect paper clip.

Problem
Design and construct a fastener for paper.

Design Constraints
1) The fastener must be designed so it is reproducible.
2) The fastener or clench must be made of one or two single, continuous pieces of material.
3) The fastener must hold two and more sheets of paper together.
4) The fastener must be portable and reusable.
5) The fastener must not damage the paper.
6) The fastener can be made from any material.
7) The design must be scalable (e.g., from paper clip to money clip)

Design Considerations
• Pay close attention to the elegant function of the fastener: does it effectively clench?
• Consider a wide range of possible fastener designs.
• Review the range of paper clip designs presented, but do not duplicate these.
• Is the fastener reproducible and scalable?

Construction Sequence
1. Brainstorm ideas for the fastener’s operation and appearance.
2. Sketch four or five designs and choose appropriate features, forms and materials.
3. May use 2D computer aided design (CAD) or 3D modeling techniques to lay out mechanisms and parts.
4. Locate recycled materials or new materials.
5. Test the materials for the properties.
6. Bend and finish the final prototype fastener.
7. Test the fastener.

Management Issues
• End of Day 1: Approval of fastener ideas.
• End of Day 2: Fastener prototype and sketches explained, presented and submitted.
Related Studies

- Physics
- Business
- Social Studies

- Sociology
- Psychology
- Engineering

Honest Self (Group) Evaluation

1. We stayed within the design constraints and deadlines ______ out of 5 marks
2. Our fastener is unique in its design ______ out of 5 marks
3. Our fastener has makes effective use of materials ______ out of 5 marks
4. Most of the excess materials can be reused or recycled ______ out of 5 marks
5. Our use of materials was creative, economic and efficient ______ out of 5 marks
6. Our fastener successfully satisfies all the design brief requirements (i.e., holds two and more sheets of paper together; is portable, reproducible, reusable, scalable) ______ out of 5 marks
7. The demonstration of our fastener was creative and entertaining ______ out of 5 marks

Total ______ out of 35

Assessment

Group’s Self Assessment  ________ Total/ 35

Design Principles

Features and Form  ________ out of 10

Originality  ________ out of 10

Economics and Ecology  ________ out of 10

Craft and Quality  ________ out of 10

Clenchability  ________ out of 15

Deadlines, Safety and Participation  ________ out of 10

Total  ________ out of 100
Projection and Reflective Practice

In this chapter, we reviewed the current state of research into creativity, design and problem solving. We explained how creativity, design and problem solving were connected. We emphasized that at the core of creative practice are dispositions. Among the most primary of these dispositions is designerly thinking, or the will to see knowledge as designed. Educators adopted a number of techniques to develop dispositions toward creative problem solving and the most important of these is the design brief. These techniques are what some analysts of career preparation and human resource development call "soft skills." In the next chapter we will expand on our theoretical framework for the practice of creativity, design and problem solving. Before moving to the next chapter, complete the design brief challenge for teachers below.

1. **Digital Design Brief Challenge:** Produce a Design Brief for a certain grade (e.g., grade 8). The Design Brief must involve either a dynamic or static technology challenge, and must be planned for a duration from 3 days to 2 weeks. Dynamic designs are defined by a series of animations or moving parts driven by some power source, including gravity or human energy. Static designs include brochures, bumper stickers and other types of graphic products. All information should be provided—The Design Brief must be comprehensive enough to be self-sufficient. Ideally, you will produce a dynamic or static design challenge that has not been done before. Try to produce an original design challenge. With that said, either create a new design challenge OR redesign/rethink an existing challenge. Design Briefs provide the information necessary, such as problem, constraints, and assessment criteria, for completing a design challenge or project. Convert the design brief into digital form with internal links for publishing on the web. Include all steps of the design brief format provided earlier, but not necessarily in the order given. Use the example design briefs in this chapter or the appendix for reference. Overall length should be 2 pages of digital or hard copy.

   **Design Brief Format:**
   1. Title
   2. Background/Context
   3. Problem
   4. Constraints
   5. Design Considerations
   6. Sequence
   7. Related Studies
   8. Self Evaluation
   9. Assessment

   **Criteria for assessment:**
   Creativity, Originality, Appropriateness and Substance
   Comprehensiveness, Graphic layout and Format

2. **Disclosive analysis:** Technology teachers ought to be conversant with a range of disclosive analysis techniques. The common disclosive methods for technology teachers include were provided in this chapter. Choose one of these and work through a disclosive analysis for a particular technology that you will be teaching.