Chapter 6
Learning Theory, Technology and Practice

Why do we use technologies in technology studies? Couldn't we teach technology in a classroom without the complex lab and workshop infrastructures that characterizes technology studies? We could argue that this is by tradition; this is the way it always was. We could argue that we are involved in training students for occupations that use the technologies we use. We could argue that technology is naturally practical and demands that we offer practical activities. Tradition, vocation or imitation. Not one of these three will get us very far. We could argue that students learn best when they are active; enactive experiences are best. With this argument, we verge on theoretical issues that underpin technology studies. However, neither experience-based learning nor enactivism account for technologies in any adequate way. We need to retheorize learning theory to make it work for technology studies.

Learning theories deal with specific notions of feelings, knowledge and skills by addressing the problem of how we learn. Whether we are aware or not, our teaching practices are necessarily shaped by any number of learning theories. We are conditioned or socialized to express particular learning theories through years of participation in schooling and informal education. Sayings such as "we teach who we are" or "we teach how we were taught" suggest the power of our socialization into education. We are all products of our formal schooling and informal education. The problem is that we are typically not exposed to a range of learning theories over time. In fact, we are socialized, through formal and informal education, to believe that knowledge is information that is transmitted from generation to generation, person to person or node to node over the internet. We have been socialized to believe that feelings and motor skills are secondary to knowledge and intellectual skills. We have been socialized to accept that, a la Plato, a controlling mind is superior to a subservient body. In turn, we were taught to accept that mental labor is more valuable than emotional or physical labor, and the liberal arts are more valuable than the servile arts.

Popular learning theories, such as behaviorism and constructivism, take feelings, skills and technologies for granted. Or for the most part, these theories reduce feelings, skills and technologies to an incidental position. They are incidental to an adaptive construction or transmission of knowledge. Biases, against feelings, skills and technologies due to predominant
social values are built into our most common and popular learning theories. New learning theories such as activity theory and situated cognition contradict this hierarchy of head over hand by bringing the body back into the process of learning. Technology educators can either blindly adopt learning theories that undermine their endeavors or search out and develop learning theories that reposition feelings, skills, technologies and knowledge. We absolutely have to embrace learning theories that take technology as a serious subject. Anything less invalidates our existence and the need to study technology in schools.

This chapter begins with a learning theory that derives from practice in technology studies. Indeed, we begin with what is by nature a disclosive theory of practice. We then turn to theories of experiential learning and their implications for technology studies. The chapter concludes with an overview of various learning theories and a focus on distributed cognition and activity theory.

**Head, Heart, Hand and Feet**

In the movie *Metropolis*, released in 1929, the protagonist Maria labors to educate the managers and workers of the futuristic, technological city of Metropolis. At one point, in a clandestine meeting with the workers, she pleads for an understanding of a basic arts and crafts premise: "The mediator between brain and hands must be the heart!" This premise appears a number of times throughout Fritz Lang's film. Most attribute this premise to John Ruskin, philosopher of the English arts and crafts movement during the mid 1800s. This philosophy was ratcheted up during the 1880s in the post-secondary institutions for African Americans in the US south. Booker T. Washington, the intellectual architect of technical education institutions in the south, stressed mobility and the importance of gaining a footing for elevating the status of African Americans. At schools such as the Tuskegee Institute, students were provided with an education in cultivating the soil on seven hundred acres of land. When he transformed the curriculum of the Christiansburg Industrial Institute in the mid 1890s, he changed Tuskegee's basic philosophy into the "heart, head, hand and feet." The heart stood for compassion, the head for knowledge, the hands for skill and the feet for the grounding, mobility and the earth.
This philosophy accompanied every form of education for the working classes across the world (Fig. 6.1). For example, Otto Salomon, the Swedish proponent of the Norwegian version of manual training, was fond of making this case in the 1890s. Manual training, or what he called sloyd, was based on a "Harmonious balance" of the head, heart and hand. This premise underpins the past of technology studies and the same premise underwrites the learning theory of technology studies today (Fig. 6.1).

Figure 6.1. Head, Heart, Hand and Feet

Technology studies was introduced into American, Canadian and English schools during the late 1800s and early 1900s under the guise of manual training and the British arts and crafts philosophies of Robert Morris and John Ruskin. The intent of arts and crafts and manual training was to provide simple experiences in hand labor to expose students to working class knowledge, skills and dispositions. From its earliest days, technology studies was meant to educate "the hand, the head and the heart," as Ruskin argued, "and the feet" as Washington added. Arts and crafts philosophies were critical of capitalism, mass industrialization, the demise of craft skills and knowledge, and the divorce of the arts from industry. But by the mid 1910s, the arts and crafts philosophy on handicraft was sympathetic to industry and the use of machines. Design schools such as the Bauhaus in Germany demonstrated that the use of machines did not have to come at the expense of craft skills and design. Bauhaus students were trained to integrate design with industrial production. In technology studies, the use of machines provided a disclosive power for attaining cultural ends; technical skills should disclose democratic dispositions and knowledge. With the use of machines in the workshops of the 1920s, technology teachers were challenged to disclose the problems and promises of production and consumption. With this premise, the subject's most articulate advocate in the 1920s and 1930s, defined industrial arts, as it was called in those days, as "the study of sources of materials, methods of changing materials, factory organization, inventions, employer and labor
cooperation, distribution of products, and regulative measures to secure justice alike to producers and consumers” (Bonser, 1930, p. 2). This was quite a sophisticated definition that could nearly serve today as a definition of technology studies. Nevertheless, technical skills dominated as ends in themselves (skills for skill's sake) and the disclosive power of technology was generally neglected. One reason for this is that we have never had clear articulation of theory that accounts for technologies in the learning process.

Joseph Luetkemeyer, a professor of mine, used to say that our disclosive theory of practice reiterates the way that technology studies has been formed over time. Prior to formal schooling, handicraft was the primary mode of practice with technology. Craftsmen and craftswomen learned their skills for subsistence or for the sake of the craft and trade. When manual training (MT) entered the schools in the mid 1800s, a psychological premise for doing handicraft was derived from the activity of working with one's hands. At this time we heard enthusiasts argue the psychological value of MT: Handicraft builds moral character, strengthens the mind, and intrinsically motivates individuals to learn and be industrious. Skills were secondary to psychological values. Throughout the 1900s, a logical organization of content was eventually derived from the activity of working with technology. In the 1960s, logical content structures were established for the subject of technology studies. Both skills and psychological values were secondary to content. Our theory of practice recapitulates our history of practice. The direction is from skills and technologies to values and content.

Feeling and Knowing Issue from Doing

Of course, we have feelings and knowledge prior to, during and following our practice with technology. And of course teachers often derive curriculum from their students' values and knowledge. However, the point is that, in technology studies, we provoke feelings and knowledge by engaging students in practice. We provoke feelings and knowledge by engaging students in skill development. Pragmatically and theoretically, we use the skills as an intermediary to feelings and knowledge. To say that the use of technologies, or skill development, provokes the heart to care, the head to think and the feet to move is to say that skills motivate. Activity motivates.

This is not to say that materials and technologies are merely incidental to or an instrument to larger ends, such as values and knowledge. We can say that our use of materials
and technologies, or skill development, is an end in itself (skills for skill's sake). The technologies we use in practice are the subject of study. Skills are prioritized first in our theory of practice, or in our theory of how we learn about, through and for technology. However, we must keep the ends of education in a complex world in perspective. Skills are no more important in practice than feelings and knowledge about technology. Sure enough, skills motivate. Sure enough, technology is a subject in its own right. But we cannot stop there. Practice in technology studies is incomplete if restricted to the hand or skills. Practice is incomplete if restricted to the technical-empirical dimension (Fig. 6.2).

![Diagram of Practice in Technology Studies](image)

**Figure 6.2. Model of Practice in Technology Studies**

In our theory of practice, skills (or engagements with technologies) are used to disclose and provoke feelings and knowledge. This is different than saying that skills or technology are applications of knowledge and values. Skills and technology certainly enrich or reinforce knowledge and values. However, in our theory, skills play the role of revelation and stimulation rather than amplification or fortification. In return, feelings and knowledge empower skills. As described in Chapter 2, propositional knowledge and emotions empower procedural knowledge, or skills. The figure below reminds us that while skills and technologies may be reliable agents in the construction of knowledge and values, students bring feelings and knowledge to their development of skills and engagement with technologies. We try to accommodate the students' prior knowledge and dispositions by attending to their learning styles and by making parts of the curriculum student-directed. Nevertheless, our task as teachers is to create a curriculum that will move students from the known to the unknown, from the familiar to the unfamiliar and from
injustice to justice. As Helen Thelan asserted, "if we get too comfortable, we stop growing. Students can put pressure on us to work within their comfort zone. Let’s be kind about that. Kind enough to let them learn to be uncomfortable." In our theory, we use skills to move students from their comfort zones and to new knowledge, dispositions and values (Fig. 6.3).

In the first three chapters we more or less distinguished doing from knowing from feeling. We acknowledged that while we differentiate between domains of learning, these domains are intricately interrelated. A common term for this is embodiment. Our thoughts and feelings are embodied. Educators tend to ignore this by prioritizing the mind over the body. Educational systems generally emphasize knowing over doing and feeling. Technology educators tend to reverse the order a bit and emphasize doing over feeling and knowing. Our theory of practice purposefully contradicts these priorities by demonstrating how doing, knowing and caring are interrelated. In the models provided in this section, we nevertheless depict affective, cognitive and psychomotor realms of experience as separate and divided. Similarly in the next section, our model depicts the ecological, ethical, political and technical dimensions of technology as separate and divided. We do this for analytical purposes; the separations allow us to talk about

© Stephen Petrina. (in press). Curriculum and Instruction For Technology Teachers
the importance of each and reflect on the nature of learning. In practice, of course, our experience is unified and embodied. Teachers are challenged to think in wholes and unities while at the same time thinking in terms of fragments and divisions. With that said, then why designate an order for our theory of practice? Why say that caring and knowing derive from doing and the disclosive power of technology?

**Practice Draws From the Disclosive Power of Technology**

"We learn by doing if we reflect on what we have done"— John Dewey

What are the roles of technologies in our theory of practice? John Dewey, one of the great philosophers of the twentieth century, was extremely interested in the role of technologies in education and experience. Dewey was especially interested in the roles of creativity, materials, machines and tools in the practices of education. According to Dewey, technologies have a "disclosive power" or a power to reveal the conditions of the world to individuals (Blacker, 1994, p. 309). Technologies disclose self-knowledge and feelings as well as the cultural and material conditions of subsistence, work and home life. Rather than choosing technologies to develop a certain skill, teachers would choose technologies to disclose insights into the conditions of the world. With this idea of disclosive power, Dewey declared that "doing leads to knowing" and more specifically, "we learn by doing if we reflect on what we have done." As students worked with and studied certain technologies, and, with the help of the teacher, as these technologies disclosed the conditions and workings of everyday life, students would develop what Dewey called "industrial intelligence." "Unless the mass of workers are to be blind cogs and pinions in the apparatus they employ," Dewey and his daughter reasoned, "they must have some understanding of the physical and social facts behind and ahead of the material and appliances which they are dealing" (Dewey & Dewey, 1915/1962, p. 178). Today, we call this technological literacy (see Chapter 7). If doing leads to knowing, what exactly should students be led to know?

Of course, technologies do not automatically give up revelations concerning the conditions and workings of the world. Doing does not automatically lead to knowing. We have to reflect, and with the guidance of a teacher and other resources, we have to observe, examine, contemplate and care about our doings in the world. We have to use disclosive analysis, as
described in Chapter 5. Education is supposed to be designed with this purpose in mind and heart. In technology studies, we specify the terms in a slightly more focused way than doing, feeling and knowing (Fig 6.4).
Since the subject is technology, we focus on the dimensions of technology that correspond to action, emotion and cognition. For reasons that will be elaborated in this chapter, we take Dewey's precedence at face value. In our theory of practice, the technical-empirical dimension of technology discloses the ecological-natural, ethical-personal and socio-political dimensions of technology (Fig. 6.4). Applications disclose implications and explanations. Learning about technology is cyclical, not linear. Practice that is stalled in one dimension is restricted and limited. Dewy gave us a starting point in the cycle.

Dewey defined an order for practice and teaching in technology. He gave a logical and psychological precedence to technology and skills, noting that doing precedes feeling and knowing in practice. He gave an order to the arts and crafts mantra of the head, heart, hand and feet, or to action, emotion and cognition. Through the notion of the disclosive power of technology, he gave an order to the technical-empirical, ecological-natural, ethical-personal and socio-political dimensions of technology. And there is an order to the question of applications, implications and explanations (Figs. 6.4, 6.5). In our theory of practice, we move from the problem of how things work to the problems of how things work for some but not others and who's in charge? We move from doing and feeling to knowing and changing the way things are— the head, heart, hand and feet are represented and given direction.

**Pedagogical Movement is From:**

![Diagram](image)

*Figure 6.5. Precedence in Technology Studies*

This was analytical— Dewey realized that emotions can rise quite unexpectedly in anticipation of the mere thought of doing things with technology. He realized that an individual...
should know something about a technology prior to using it. He realized that action, emotion and cognition occur simultaneously in experience. The logical and psychological precedence given to doing was based on his observations of how people learn. He noted that individuals learn through cycles of experience. He criticized the schools for the inability to incorporate experience into everyday processes. "That we learn from experience," he said, "and from books and the sayings of others only as they are related to experience, are not mere phrases. But the school has been set apart, so isolated from the ordinary conditions of life, that the place where children are sent for discipline is the one place in the world where it is most difficult to get experience— the mother of all discipline worth the name" (Dewey, 1900, pp. 31).

Dewey's Theory of Experience

It is not experience which is experienced, but nature— stones, plants, animals, diseases, health, temperature, electricity, and so on. Things interacting in certain ways are experience; they are what is experienced. Linked in certain other ways with another natural object— the human organs— they are how things are experienced as well. Experience thus reaches down into nature; it has depth. It also has breadth and to an indefinitely elastic extent. It stretches. That stretch constitutes inference. (Dewey, 1929/1952, pp. 4a-1)

Dewey asked the simple question, "what is an educative experience?" His investigations into this question from the 1910s through the 1930s have been fundamental to experiential education. Dewey noted that experience does not passively unfold through our interaction with the material and natural environment. Rather, experience is actively sought out through extrinsic motivations and intrinsic forces such as curiosity, hunger and an urge for expression or freedom. Inquiry and expression, or sometimes coercion in everyday life, inspire an experience. Dewey argued that education was experience. Education, he said, "is that reconstruction or reorganization of experience which adds to the meaning of experience, and which increases ability to direct the course of subsequent experience" (1916, pp. 89-90). For Dewey, everyday life or "lived experience" has a structure.

The structure of our experiences has three phases: purposive planning, reflective inquiry, and transformative action (Fig. 6.6). The boundaries between these phases are indistinct, but can be analyzed separately. **Purposive planning** can be inspired by any endeavor, but personal meaningfulness is the primary inspiration.
We actively plan for experience with a purpose in mind. **Reflective inquiry** consists of turning our purpose over in the mind and giving it serious and consecutive consideration. Through this process, we step back to abstract meaning or emotions and knowledge from our actions. We check in with our head and heart to determine how things went—how we felt and what we learned. Reflective inquiry is a key for comprehending the significance of personal actions, and for illuminating everyday problems, values, and possibilities. Inquiry is the practice of discovering connections between something that we do and the consequences which result. Reflection is the acceptance of responsibility for our actions and the consequences of anticipated actions. In this way, the structure of experience is tied to a sense of responsibility, values, a search for meaning, and a concern for social consequence.

Dewey asserted that *not* everything had to be, nor could be, learned through experience. Dewey criticized educators for short sighted and naive interpretations of experience, and it was on this issue that much of the so-called experience-based or activity work of design and technology education is challenged. Doing is not, *automatically*, learning. If hands-on activity or experience is to be meaningful, it has to be purposefully planned, reflective and transformative. Dewey argued that teachers should drop the pretense that by merely providing students with hands-on experiences they are educating their students. Most of it could be dismissed as busy-work or what in business and industry are referred to as make-work situations.
Kolb's Theory of Experience

David Kolb expanded on Dewey's work and provided a model of experience that links experience to teaching. Like Dewey, Kolb acknowledged that we perceive the world through sensing and feeling. Our senses and feelings filter how we observe the world and the way we see reality. We also internalize what we perceive and make it our own. We internalize our experiences. From what we perceive or observe, we conceive or conceptualize. Our conceptions, or what we perceive, influence our perceptions, or what we perceive. From what we apprehend, we comprehend and vise versa, within a cycle. We move from the concrete to the abstract and back to the concrete through experience. We move from divergent to convergent action and back again. We assimilate and accommodate. We manipulate the world so that we can change and comprehend ourselves and the world. Experience is a cycle for Kolb, as it was for Dewey (Fig. 6.7).

![Figure 6.7. Kolb's Model of Experience](image-url)

Some people prefer to perceive the world through **concrete experience**. These people perceive by sensing and feeling, and prefer to use intuition to solve the problems of a given task. Other people prefer **abstract conceptualization**. They like to think things through, analyze and intellectualize. They function well in structured situations. Some people prefer to process new information by **active experimentation**. They like to roll up their sleeve and immerse
themselves in the task. They look for practical ways of applying what they learn. They embrace risk-taking and are results oriented. Other people process through reflective observation. They like to watch and ponder the situation. They likely see tasks from several points of view. They value patience and judgment. Concrete experience, abstract conceptualization, active experimentation and reflective observation are four general emphases, or learning styles as noted in Chapter 4.

Outdoor educators who deal with camping, climbing, boating, hiking, skiing and the equipment of the outdoor adventure face the same challenges as technology educators. The temptation is emphasize the action and marginalize emotion and cognition. There may be an emphasis on safety and its concomitant dispositions and knowledge, but the tendency is to restrict experience to action or activity. This is where theories of experience are essential to practice. Outdoor educators, like design and technology educators, are challenged to move their students toward responsibility, intimacy, caring, and compassion for, and knowledge of, the natural environment. Dispositions and knowledge never automatically derive from action.

Teachers who work with experiential learning as a basic theory have to complete the cycle by moving their students to reflection and transformation to insure that desired dispositions and knowledge are the outcome. Action leads to emotion and knowledge if we reflect on what we have done. This may entail debriefing and other methods provided in Chapter 4.

Thus far, we have constructed our theory of practice through notions the head, heart, hand and feet, the disclosive power of technology, and cycles of experience. We generally dealt with the place of technologies in our theory of learning, but we have not directly dealt with action in a material world. In Dewey's and Kolb's theories of experience, the role of technologies, the physical setting and the material world is unclear or under-theorized. When we act on the world the world acts on us. As we change the world we change ourselves. These premises may seem basic, but they are extremely important in understanding practice in design and technology. We have to return to the concept of embodiment and demonstrate how we embody the material world and how the material world embodies us. We have yet to fully re-materialize our theory of practice, which has critical implications for curriculum and instruction in technology studies.
Dale's Cone of Experience

One step in re-materializing the cycles of experience is to consider the progression from concrete to abstract learning. In 1946, Edgar Dale introduced the Cone of Experience to demonstrate a progression from direct, first-hand experience to pictorial representation and on to purely abstract, symbolic expression (Fig. 6.8). The Cone of Experience corresponds with three major modes of learning: **Enactive** (direct experience), **Iconic** (pictorial experience) and **Symbolic** (highly abstract experience). Enactive or direct experience involves practicing with objects (the student actually ties a knot to learn knot-tying). Iconic experience involves interpreting images and drawings (the student looks at drawings, pictures or films to learn to tie knots). Symbolic experience involves reading or hearing symbols (the student reads or hears the word "knot" and forms an image in the mind). Enactive experience involves concrete, immediate action and use of the senses and body. Iconic experience is once removed from the physical realm and limited to two or three senses. In symbolic experience, action is removed nearly altogether and the experience is limited to thoughts and ideas.

![Figure 6.8. Dale's Cone of Experience](image-url)
The Cone of Experience does not represent a literal progression from the concrete base to the abstract pinnacle. We do not literally progress through the cone's levels. The cone represents a range of experiences through which we learn, and various levels of the are fluid. Modes of experience are fluid, and learning often involves all three major modes at once. In technology studies, where experiences can be extremely enactive, iconic and symbolic, we give priority to direct first-hand experience. Our richest sense impressions involving feelings and perceptions are formed as we explore the world. We call this lively, embodied participation our bedrock for learning. Through the five senses, or what Dale called the "unabridged experience of life," we generate a wealth of meaningful knowledge and feelings about ourselves and our world. This is not to say that direct experiences are more valuable than iconic or symbolic experiences. All three modes are equally important in learning technology. We give direct experience precedence to orient the trajectory of learning from the concrete towards the abstract; the process is incomplete until we follow through to abstraction and symbolic experience. Teachers are faced with the challenge of how to provide the most suitable combination of concrete and abstract experiences. Technology teachers tend to over-emphasize direct experiences over the abstraction necessary for learning about technology. This is the same as saying technology studies is restricted if we stall in the technical-empirical dimension of technology and fail to move our students into the ecological-natural, ethical-personal and socio-political dimensions. In order for students to develop meaningful knowledge, feelings and skills, their direct experiences must be "associated with abstractions," as Dale noted. Language and expression are essential to skill acquisition.

Although no experience is fully passive, iconic and symbolic experiences are generally more passive than direct experiences (Fig. 6.9). Watching chefs prepare a meal on television, however much our minds are actively engaged, is quite passive compared actually preparing a meal in a kitchen. Dale proposed that active and passive modes of participation can be contrasted by assigning a percentage of we tend to remember after two weeks after our experience. Although he never tested these percentages and they seem exaggerated, they serve as rules of thumb for teaching. Nonetheless, education involves a range of experiences, some of which are direct, some iconic and others symbolic.
As explained in Chapter 2, teachers have to move their students from direct experiences, procedures and facts to concepts, laws and rules of thumb and eventually strategies and theories (Fig. 6.10). The Cone of Experience invokes a bi-directional movement from the concrete to abstract and from the abstract to concrete. Our theory of practice in technology studies merely turns the cone into a cycle which involves the doing, feeling and knowing dimensions of experience, or the technical-empirical, ecological-natural, ethical-personal and socio-political dimensions of technology. Whereas Dewey and Kolb overlook objects and material culture in their theories, the Cone of Experience accounts for "things." However, Dale's theory suggests that objects and the material culture of technology are mere augmentations or media to be used in the learning process. To fully empower teachers with a theory of practice in technology studies, technologies and physical settings have to play a more active role in cognition, emotion and action.
Modes of Learning with Technology

As indicated, there are three general modes of learning: **Enactive** (direct experience), **Iconic** (pictorial experience) and **Symbolic** (abstract experience). Some theorists prefer to be more specific and refer to conditioned, imitative, trial and error, investigative or expansive learning as six possible modes of learning. **Conditioning** refers to learning by pre-design or control via a series of punishments and rewards. **Imitation** refers to learning tasks by observation or modeling. **Trial and error** refers to learning via a series of successful and unsuccessful trials and deliberations. **Investigation** refers to learning via a series of informed hypotheses and inquiries into problems. **Expansive learning** refers to the questioning of the validity of tasks and problems of a given context to the transformation of the context itself.

However, this is a different way of looking at learning than is typically the case. Each of these modes involves technology in some way, shape or form. However, in the way that that the three general modes and five specific modes are defined and used, technologies are seen to merely augment or amplify the learning process. This is the use in Dale's cone of experience. This is the instrumental view of technology: technologies are instruments or tools to enhance the learning process. Of course, this grossly simplifies the activity of technologies in the learning process. This masks the power that technologies have to shape our actions, feelings and
thoughts. In order to interpret the role of technology in the learning process in a sophisticated way, we have to acknowledge the range of possible modes in which technology penetrates our being. There are six different possible modes of learning with technology.

<table>
<thead>
<tr>
<th>Modes of Learning with Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tacit Learning- Technology operates in the background as infrastructure. Technology backgrounds and foregrounds the learning process. We are immersed in a world and always learning. We learn through observation, association, socialization and immersion in established routines. We learn when we least expect we are learning.</td>
</tr>
<tr>
<td>Augmented Learning- Technology augments, enhances, extends or magnifies our senses. Technology augments the learning process. The world is given a boost through technology and made more decipherable or perceivable to our senses. The world is merely amplified, magnified or clarified in the process of augmentation, somewhat like a prosthetic. This was McLuhan’s notion of media.</td>
</tr>
<tr>
<td>Mediated Learning- Technology mediates between our senses and the world. Technology mediates the learning process. The world is transferred to us and changed through some medium or intermediary (technology). We are once removed from reality, which is distorted or changed in the process of mediation. Our experiences and learning are mediated by some person (i.e., mother, teacher) and technology (i.e., book, internet, radio, television).</td>
</tr>
<tr>
<td>Distributed Learning- Technology distributes our actions, feelings and thoughts. Technology distributes the learning process. We are fragmented and made complete by metaphorically plugging into technologies (i.e., books, computers, tools). We project parts of ourselves into and onto our technologies (More or less the same as mediated learning).</td>
</tr>
<tr>
<td>Automated Learning- Technology models, automates and simulates our senses and the world. Technology automates or simulates the learning process. The world is imperfectly modeled and completely changed for our perception. The lines between the artificial and real are blurred.</td>
</tr>
<tr>
<td>Cyborgenic Learning- Technology is embodied and literally a part of us. We embody technology, technology embodies us. We are a hybrid of human and technology, or cyborg. As cyborgs, we program and are programmed in a learning process. Beyond projection and plugging into the circuit, we are in the circuit and the circuit is within us.</td>
</tr>
</tbody>
</table>
In each of these six *possible* modes we are in some way dependent on or interdependent of technology. The degrees of distance from our technologies change across the six modes. If it were only so simple that we could pick the mode of learning that we preferred, the problem of embodiment and freedom would be easily solved. The fact is that we are involved with our technologies in all six of these modes—at once. If we are to understand how we learn with and about technology, we have to account for technology in the learning process. We cannot merely say that technology is instrumental to cognition or that technology merely augments the senses. We know that technology operates on much deeper levels that implicate our agency and freedom.

**Agency, Embodiment, Technology and Determinism**

Are we free to use technology however we want or are we constrained by the technologies we use? Do our designs and technologies respond with fidelity to our intentions and will or do our intentions often go awry? Do we put a part of ourselves into our technologies? At the same time, do our technologies contain a part of us? Are we compelled and destined to follow the paths and passageways laid out by our technologies? These questions underscore four major problems in understanding and theorizing our relationships with our technologies: **agency**, **intentionality**, **embodiment** and **determinism**. What degrees of freedom do humans and their technologies have? What are the options in our deployment of technologies, their organization, and use? Agency refers to the degrees of freedom for either humans or technologies to act on desires, needs and wants. Do we or our technologies act or react? Intentionality refers to the degrees of intention or will that are realized in either our actions or within the actions and designs of our technologies. Are technologies neutral or do they embody certain intentions? Embodiment refers to the degrees of which we are part technology and technology is part us. Determinism refers to the degrees in which we are determined by our technologies to act and will in limited ways. Our fundamental premise is that material conditions and things matter.

In Chapter 3, we asked whether technologies can emote and act. We asked whether humans invest technologies with their desires, interests and values. We noted that individually, particular technologies may determine what we do on a small scale. But collectively, technologies gather more influence over our lives. Most theorists interested in our actions and
thoughts readily accept that we invest technologies with our desires, interests and values. Technology embodies us. Langdon Winner aptly summarized this in saying "artifacts have politics." Just as we delegate certain tasks to each other or our subordinates, we delegate certain tasks to our technologies. When we delegate tasks we also invest desires, interests and values, or politics, into technologies. Think of a stove. When we touched the hot stove and nearly burned our fingers when we were young, the stove suddenly took on awesome powers. After nearly getting burned, we invested the stove with all sorts of powers to be something fierce to be reckoned with. We need not have been burned or touched the stove to learn. We could have learned the powers of the stove through our mother or father. But from then on, the stove had powers. We could say this is a simple stimulus response situation. The hot stove or mother's warning caused us to act with fear and alarm. The stove caused us to approach it with caution from then on. We could say we merely projected the powers onto the stove, but the result would be the same. This simple behavioral example merely demonstrates that technologies can embody whatever we project into them. It demonstrates that technologies can direct our everyday actions.

Rules and procedures often emerge from material conditions to guide and limit our responses. A prime example of determinism and conditioning is the flow of vehicular and pedestrian traffic. In North America, we learn early on to pass people as we walk in hallways, shopping malls and on sidewalks left shoulder to left shoulder, or on the right hand side of the pathway. The custom issues from vehicular traffic. Our material culture of roads and traffic determines our behavior in malls, offices and schools. In Australia, you will find yourself walking right shoulder to right shoulder on sidewalks. Vehicular traffic, of course, flows right side to right side, the opposite of North American traffic. We embody the traffic system.

When we talk about technologies however, we are not just talking about objects. Technology has four different manifestations, as identified by the philosopher Carl Mitcham (1994). The most concrete manifestations of technology are in the form of artifacts or objects. This includes simple components and architecture as well as complex engineering projects, machines and electronic equipment. Mitcham outlined different types of tools and machines which typify technology as object or artifact (Table 6.1).
Table 6.1. Mitcham's Organization of Tools and Machines

<table>
<thead>
<tr>
<th>Analytic Elements</th>
<th>Immediate Source of Energy (Matter)</th>
<th>Immediate Source of Guidance (Form)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Kinds of Tools</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand Tools</td>
<td>Individual Human Beings</td>
<td>Individual Human Beings</td>
</tr>
<tr>
<td>Premodern Machines</td>
<td>Groups of Humans or Animals</td>
<td>Individual Human Beings</td>
</tr>
<tr>
<td>Modern Machines</td>
<td>Inanimate Nature (Wind or Water)</td>
<td>Individual Human Beings or Groups of Humans Assisted by Mechanical Controls</td>
</tr>
<tr>
<td>Modern Machines</td>
<td>and Technologically Controlled Nature (Steam Engine)</td>
<td></td>
</tr>
<tr>
<td>Power Tools</td>
<td>Technologically Controlled and Abstracted Nature (Electricity)</td>
<td>Individual Human Beings and Mechanical or Electrical Controls</td>
</tr>
<tr>
<td>Cybernetic Devices</td>
<td>Technologically Controlled and Abstracted Nature (Electricity)</td>
<td>Electronic Controls</td>
</tr>
</tbody>
</table>

The second manifestation is activity or process. This includes the process of smelting iron as well as activities such as designing, engineering, maintaining or building. Technology also takes the form of knowledge. Technology may be in the form of procedures for networking computers or the formulas in civil engineering for testing load bearing capacity. The last manifestation of technology, volition or will, is the most abstract. It is also the most important to grasp. Technology as volition refers to technological determinism. Figure 6.1 captures all four manifestations of technology (Mitcham, p. 160).

Figure 6.11. Manifestations of Technology
We exert a certain amount of energy and determination into our technological activities. Our compulsions or inclinations toward technology are directed by our technologies as well as our will. We are compelled, inclined or determined to act in certain ways.

In all learning theories, there are questions of agency, intentionality, embodiment, and determinism. Marx argued that economics and technology largely determine the way that knowledge is constructed and acted on, or the way we behave. Freud argued that the unconscious Id and the subconscious Super-Ego together largely determine the way that the conscious Ego constructs knowledge and guides behavior. Constructivists suggest that knowledge is much less determined than Marx and Freud argue. In other words, we construct knowledge pretty much as we please. Activity theorists and theorists of distributed cognition help us rethink determinism and free-agency or self-actualization. Agency and intentions are present, but mediated and somewhat or sometimes determined. Learning theories also have to take Mitcham's four manifestations of technology into account in some way, shape or form. The following five sections deal with different learning theories that take technology into account, some more adequately than others. In other subjects, it may be all well and good to merely consider technology to be instrumental in augmented learning. Nevertheless, for the subject of technology, more sophisticated theories of technology are necessary.

Learning Theories

Just as the development of cultures over time cannot be accounted for without taking technologies into account, learning theorists during the 1920s and 1930s noted that human development from children to adults cannot be accounted for merely by biology or growth. Technologies are essential in any account of cultural or human development. In fact, psychologists prior to the 1920s suggested that human development repeats the patterns of cultural development. This genetic development model held that humans, like cultures, begin in the rather "primitive" stage of childhood and advance through progressively sophisticated stages. People and cultures develop through progressively sophisticated tool use. This was recapitulation theory. Ontogeny (individual development) recapitulates phylogeny (species development), theorists once said. However crude this developmental theory of progress now seems, the important point was that it acknowledged the centrality of technologies to both cultural and human development. Theorists of industrial arts, such as Lois Mossman (1938, p.
combined recapitulation theory with the disclosive power of technology. "Genuine social appreciation is furthered if one understands the simple hand processes and the steps in the evolution to the complex machinery processes," she observed. Teaching how to weave a simple rug "provides a bit of detailed experience in a process—a detail that is fundamental in appreciating the weaving industry of the world of all time." The simple act of weaving could disclose the craft basis of the complex machinery of the modern weaving industry.

Learning theories have generally focused on how individuals organize their behavior, but at the neglect of material conditions and technology. Learning theories generally grant near total freedom to humans to act and will, neglecting the powers that technologies possess to act on humans. Most current learning theories are reactions to behaviorism, which reduced human freedom and granted determinant forces to culture and the environment. In many ways, the issue of freedom and determinism is analogous to the old nature-nurture debate. Does the environment make the person and the personality, or is it biology? If the answer is both, then when is one more influential than the other? Nature and culture must somehow work together. This of course, is a concession that technologies do play an active role in everyday affairs. This notion of balanced interplay is a challenge to learning theories. Learning theories must recognize the interplay between agency, intentionality, embodiment and determinism or between motivated individuals and groups, material culture and material forces. In the learning process and theories of practice we have to account for agency, intentionality, embodiment and determinism. This is the main criterion for technology educators to judge learning theories. Our fundamental premise is that material conditions and things matter.

Behaviorism

Behaviorism and neo-behaviorism are primarily associated with the work of psychologist B. F. Skinner. However, behaviorism began in the early 1900s and was elaborated on during the 1920s by the American psychologist John Watson and Russian psychologist Ivan Pavlov. Watson defined behaviorism as the prediction and control of behavior. He basically responded to dominant learning theory of his times, which was based on biology and the notion that students' abilities were limited by heredity or genetic inheritance. Against this, Watson claimed that people (e.g., abilities, personalities, etc.) were made not born. We are conditioned through the control of environmental stimuli and systems of punishments and rewards, said the
behaviorists such as Watson. Through repetitive uses of punishments and rewards, we can be conditioned to act consistently over time. Behaviorists observed that learning could not be accounted for without accounting for technologies in the process. Behaviorists theorized that technologies establish the conditions and more or less determine the results of the learning process. Learners are not passive vessels; nor is the environment passive. Rather, learners actively respond to stimuli in their environment as an adaptive strategy and the environment acts on the learners by stimulating select responses. As Skinner wrote, "the environment determines the individual even when s/he alters the environment" (1953, p. 448). Behaviorism reiterates Marx's observation that as we work in and transform the world we also transform ourselves.

Skinner turned these premises into a learning theory of radical behaviorism. He argued that behavior should be manipulated and produced by design, or according to a plan simply by arranging conditions and technologies. "With the help of devices and associated techniques," he wrote, "we change the behavior of an organism in various ways, with considerable precision. But note that the organism changes our behavior in quite as precise a fashion" (1961, p. 543). For this reason, he looked at educational, economic, religious and therapeutic institutions as "behavioral technologies." They are in the business of producing and shaping particular behaviors. He noted that teachers most often produced certain behaviors by merely maintaining a system of punishments rather than by dishing out punishments. Skinner advocated a deliberate manipulation of conditions and technologies to bring about desired behaviors. In behaviorism, technologies are essential to the learning process. Technologies are both active and malleable, responsive to the task of controlling and shaping behavior. As Skinner and behaviorists asked, how conditioned are we by our technologies? The problem is not if we are conditioned and determined, but how.

**Piaget and Cognitive Development**

In the 1930s, Jean Piaget set out to study the way that children and adolescents interact with their environment. Basing his studies on the educational environment designed by Maria Montessori, Piaget theorized that technologies were instrumental to development. He did not study technologies, *per se*. Whereas Skinner was interested in behavioral control, Piaget was interested in the way technologies impinge on cognition and intellectual development. He observed and tested hundreds of children to chart their cognitive development through their
encounters with language and manipulative technologies. In fact, Piaget established an entire developmental theory based on cognitive abilities to manipulate technologies and technological concepts. He identified four major stages in cognitive development:

### Stages of Cognitive Development

1. **Sensorimotor stage** (Infancy). In this period (which has 6 stages), intelligence is demonstrated through motor skills without the use of symbols. Knowledge of the world is limited (but developing) because it is based on physical interactions and experiences. Children acquire object permanence at about seven months of age (memory). Physical development (mobility) allows the child to begin developing new intellectual abilities. Some symbolic (language) abilities are developed at the end of this stage.

2. **Pre-operational stage** (Toddler and Early Childhood, 2-7 years). In this period (which has two substages), intelligence is demonstrated through the use of symbols, language use matures, and memory and imagination are developed. Thinking is done in a non-logical, non-reversible manner. Animism is popular and children develop the ability to use objects to symbolize other things or people. Egocentric thinking predominates.

3. **Concrete operational stage** (Elementary and early adolescence, 8-12 years). In this stage (characterized by seven types of conservation: number, length, liquid, mass, weight, area and volume), intelligence is demonstrated through logical and systematic manipulation of symbols related to concrete objects. Operational thinking develops (mental actions that are reversible). Egocentric thought diminishes.

4. **Formal operational stage** (Adolescence and adulthood). In this stage, intelligence is demonstrated through the logical use of symbols related to abstract concepts. Early in the period there is a return to egocentric thought. Only 35% of high school graduates in industrialized countries obtain formal operations; many people do not think formally during adulthood.

The key to what Piaget observed is how children and adolescents learn about their everyday world. Although not entirely novel, Piaget observed that knowledge about the world is not simply transmitted from teacher to students. He documented student after student actively constructing new knowledge by adapting it to what they already knew. They accommodate new experiences by assimilating these into their existing knowledge, or what Piaget called schemata. Children and adolescents learn about the world by actively manipulating technologies in the
world. Their development of language and symbolic thought is dependent on their manipulations of their technological world. While not always entirely accurate (e.g., taller means more), they build theories out of things. Basically, Piaget found that doing with things and images (concrete activity) makes symbols (abstract thought). Nevertheless, Piaget did not adequately theorize the role of the technologies in learning. Technologies were merely instrumental and pliable, or easily manipulated. Nor did he address the social nature of learning.

Constructivism

Constructivism, developed in the 1980s, is primarily based on the work of Montessori and Piaget. As Piaget found, we actively construct knowledge as an adaptive response to our environment and developmental growth. Learners are not passive, receptive vessels. Rather, learners are active participants in the construction of knowledge. The lesson here is that students do not learn exactly what we want them to learn; they reconstruct what we demonstrate, discuss and adapt it to fit their everyday life.

Within constructivism are two core premises. The first is that students actively construct meaning from what they learn, in ways that are consonant with and lend coherence to their experience. The second is that cognition is functional and adaptive, and allows us to cope with the world. This premise should not be new for technology teachers (see behaviorism). The meanings students derive from school or experience are personal. This knowledge is the product of complex intra- and intercommunications organized by the social roles the students consciously adopt for particular tasks. The child or adolescent takes the social role of student and develops knowledge that is characteristically student-centered (i.e., adaptive, dependent on authority, tentative). Knowledge in constructivism is an adaptation and a function of our personal history. What students come to know will likely be different from what the teacher intended. Teachers ought to pay attention to their students’ language to understand what they learn, how well it is understood and the process of cognition. Learning actually requires self-regulation and the building of concepts through articulation of thought, reflection and abstraction.

To understand students' thinking, Piaget suggested that we look at the world through their eyes. Attention shifts from a teacher's abstracted and pre-processed world to the students’ minds. Students’ thinking and prior understandings must be taken seriously in the design and implementation of instruction. A teacher's knowledge about teaching and the thinking of her or
his students evolves simultaneously with changes in the students’ knowledge. Among the most important insights from constructivism is the issue of paying attention to students’ language and their interaction with each other. The unit of focus is the individual. The emphasis is on the individual, active mind. In effect, the social nature of learning has been under-theorized in constructivism.

**Situated Cognition**

Situated Cognition (SitCog) takes Piaget and constructivism with a grain of salt and is primarily based on the work of Russian psychologist Lev Vygotsky from the 1930s. Vygotsky's theory of cognition is founded on three principles:

1. Learning is a social activity and is mediated by the student's social environment.
2. Learning is mediated by the student's physical environment and the tools that s/he has at her or his disposal, and
3. Learning takes place within a "zone of proximal development."

The zone of proximal development is the realm of the "almost understood," as opposed to the realms of the well understood and the completely unimagined. This concept is cited by theorists as the foundation of "scaffolding." Educational activities built around scaffolding attempt to encourage learners to build from concepts that are well understood to concepts that are almost understood. Vygotsky observed that learning is thoroughly social and that we learn when we are active. When we act however, we are *situated* in what Jean Lave & Etienne Wenger call a “community of practice” (1991, pp. 56, 98).

Lave, Wenger and other cultural theorists, such as Sylvia Scribner, built on Vygotsky's work and established situated cognition during the mid 1980s. They noted that cognition is distributed across time and across the individuals in our community—cognition is shared. Individuals enter into a community of practice (e.g., family, office, job site) by learning the language. The lesson in SitCog is that social arrangements are extremely important. SitCog theorists argue that constructivists under-theorize this extremely important point: learning is social. In a SitCog classroom, teachers model how success is established within the community. The technologies of these social arrangements are quite important.

Educational implications of situated cognition include an emphasis on the social and cultural *conditions* of learning, and on language. Teaching begins with students’ conceptual
understandings and relies on language as an entrance into a social system of expertise and acceptable performance. In SitCog, language is the single most important tool in knowledge construction. Problems are not solved by individuals, but within communities, through which students participate. The question is how to arrange complex, social environments. The constructivist question of "what is going on in a student’s mind?" is extended to a SitCog "what kinds of social arrangements provide the best context for learning?" Hence, what is going on in the teacher’s mind and the social relations between students and teachers are crucial. The intent of education in situated cognition is to recognize and nurture a thoroughly social environment through activity and discussion. Routine skills and knowledge for individuals are constructed in relation to the success of all participants in the community. Teachers, as authorities in the community, must demonstrate the means of success in this community of practice.

A spin-off from SitCog is enactivism, which expands on "enactive experience," one of Bruner's three modes of learning (i.e., enactive, iconic, symbolic). In enactivism, cognition is ecological and nested in "complex webs of experience" (Davis & Sumara, 1997, p. 115). Enactivism underlines the importance of recognizing that cognition is nested. Individuals are nested in communities and environments which are nested in societies and regions which are nested in nations and continents which are nested in races and hemispheres nested in a planet and so on. SitCog and enactivism are theories of the ecological, seamless interconnections between psyche, culture and nature. These theories allow for complex understandings of learning, where cognition is neither fully personal nor environmental, but situated in activity of individuals and their natural and cultural environment. Although SitCog and enactivism appropriately recognize the social over the individual in cognition, neither adequately account for technologies in the process. They address our practice of thinking through others but undertheorize our practice of thinking through things.

**Constructionism**

Long before the learning theory of constructivism was popularized in the 1980s, another theory of constructivism was developed during the 1920s. In Germany, Holland and Russia following the October 1917 revolution, constructivism was developed as an integration of art, architecture, engineering and design. Constructivism was a theory of practice for a new kind of technologist who would design new forms for the modern world. The premise of constructivism was that
through the systematic study of the organic and geometric form and physical nature of the material world, a new environment for social change could be constructed. Literally, constructivism referred to the activity of building, designing and constructing. The artist-engineer of constructivism was literally to construct artifacts and buildings that would teach the value of community, as simple forms without deceit and motifs. Maholy-Nagy (1922), a principal architect of the Bauhaus school of design, expressed the premise this way: The "reality of our century is technology— the invention, construction and maintenance of the machine. To be a user of machines is to be of the spirit of this century." The goal for students was the general study of technology, as opposed to specialized minutiae. "As soon as creating an object becomes a specialty and work becomes a trade," he wrote when he resigned from the Bauhaus in 1928, "the process of education loses all vitality… I can no longer keep up with the trade specialization in the workshops… The spirit of constructivism for which I and others gave all we had— and gave it gladly— has been replaced by a tendency towards application" (quoted in Naylor, 1985, p. 166).

In the 1960s and 1970s, Seymour Papert (1980) managed to merge the constructivism of Piaget with the literal notion of constructivism that referred to constructing and building. Papert called his theory constructionism to emphasize the doing and making aspect. Like his mentor Piaget, Papert observed that children do not get ideas, they make ideas. But he also noticed that students are likely to make new ideas when actively involved in designing and making an artifact— a robot, poster or computer program. Papert and his MIT Media Lab colleagues, such as Sherry Turkle, developed an interface between Apple IIs and a bunch of LEGO compatible motors, creating robots that could be programmed to manipulate LEGO building block sets. In their theory of constructionism, the Media Lab integrated motor skill manipulation with cognitive manipulation, building and design, with computers. Papert began to theorize exactly what technology educators did not theorize: the role of technologies in cognition and learning.

Papert took Piaget to his logical conclusion: If cognition is dependent on the manipulation of the world, then why not give students things to design and manipulate in school? The premise is that when students construct things in the world they simultaneously construct knowledge and theories in their mind. As they construct things in their mind, they reconstruct the world. Although generally ignored by technology educators and learning theorists alike, constructionism offered a key piece to the inadequacies of learning theory to that point.
Technologies are essential to learning, not merely essential to learning about technology. This echoed an undercurrent in education since at least the 19th century.

In the 1830s, the German educator Friedrich Froebel designed a series of wooden blocks and geometric shapes intended to program the play of young students. The "Froebel gifts," as they were called, were initially merely intended to facilitate the intellectual development of children. The blocks, like the erector sets of the 1910s, actually programmed children into thinking geometrically and spatially. In the early 1900s, Maria Montessori combined Froebel's gifts with her notion of a multi-sensory environment to develop an entire educational theory. Anticipating Piaget, she theorized that manipulatives were essential to cognitive development. There was a moral side as well. She observed that the environment and manipulatives were essential to the development of responsibility in her students. But it was not just any environment and manipulatives. She designed manipulatives that programmed and stimulated intellectual thought. She designed environments that structured the independence of her students. The important change from Montessori to Piaget to Papert was that Papert recognized that students need to design and construct, not merely manipulate, artifacts and their environment. But despite Papert's interest in constructionism, neither he nor his MIT colleagues adequately accounted for technologies or social interaction. Technologies, or manipulatives, were merely instrumental to cognitive development.

**Activity Theory**

Labor is a process going on between man [sic] and nature, a process by which man, through his own activity, initiates, regulates, and controls the material reactions between himself and nature…. By thus acting on the external world and changing it, he at the same time changes his own nature. (Karl Marx, *Capital*, Volume I, p. 283)

The key to understanding the role of technologies in learning is Marx's assertion that as we work in and transform the world, we also transform ourselves. Marx was most interested in how industrial work and the proliferation of material goods acted on human nature. He theorized that humans, individually, and human nature, collectively, were changed under the ever-expanding reaches of capitalism and commodities. He argued that qualitatively different technologies produce qualitatively different people. In other words, the technologies prior to the 1750s were qualitatively different than those of the 1800s, and in effect, so were the people of the urban centers. Marx theorized the relations between humans and technologies by reasoning that...
economics and technologies generally determine human behavior and nature. Material culture and tools affect the entire life and nature of individuals.

Working from Marx's fundamental observations, Vygotsky noted that individuals never directly react to their environment. Nor are they ever removed from their environment. He took Marx's observation that the unit of analysis for understanding people was labor, activity or practice, rather than merely their heads. The key to learning theory is activity. According to Vygotsky, the relation between the human and the environment is mediated by cultural artifacts (Fig. 6.12). The basic types of these artifacts are signs (language) and tools. Through education and other forms of socialization, individuals internalize the means of culture by participating in common activities with other humans. They internalize language, theories and norms and modes of behavior as well as how to use and adjust to technical artifacts. Thus cognition and consciousness do not exist inside the head of the individual but in the interaction— realized through material activity— between the individual and practice or labor of humankind. Activity is also socially mediated: cognition, consciousness and meaning are always formed in joint, collective activity.

Vygotsky and his colleagues, Leont'ev and Luria, created a theory to account for activity. Human activity, they observed, was nearly always artifact-mediated and object-oriented. Humans rarely act on their environment merely with inborn instincts and reflexes. The relationship between humans and objects of their environment is nearly always mediated by cultural artifacts (e.g., knowledge, language, symbols, tools). This was a breakthrough. Technologies ceased to be just raw material for cognitive development, or augmented learning. Activity or learning is always situated within an activity system (Fig. 6.13). An activity is undertaken by a human agent (subject) who is motivated toward a task (object), and mediated by tools (artifacts). The activity is constrained by the mediating artifact as well as cultural factors including conventions (rules), social groups (community), and social relations (division of labor) within the context. Learning is mediated by technologies and at the same time mediated socially. As Vygotsky and Luria (1994, p. 116) reasoned, "the road from object to child and child to
object lies through another person." We act on the environment through social means, through people surrounding us in the form of rules, communities and a division of labor. Hence, we do not act individually. Individual activity is not divorced from collective activity (Engestrom, 1999).

Activity theory, as suggested in the model of an activity system, accounts for the range of technologies that Mitcham identified (activity, artifact, knowledge and volition). At times we are free to act with intention or will on our environment. However, as Leont'ev noted, we are also constrained. There are times when our actions are automatic and not of our own free will. There are other times when we are directed either by our mediating artifacts or by the cultural rules, communities or division of labor which we embody. This is a point that is easy to overlook.
Activity theory also accounts for consequences and results that are not intended. Consequences can be quite other than those intended. Intentions and objectives can be distorted by mediating artifacts, rules or divisions of labor. In other words, there are always forces acting in and on us as we act in and on our environment.

**Distributed Cognition**

Some theorists expanded activity theory and situated cognition to distributed cognition, to emphasize that cognition is *distributed* across people *and* things. We do not think outside our social group *or* our technologies. Cognition is distributed across community, environment *and* artifacts, rather than centered in the individual. Somewhat like behaviorism, distributed cognition suggests an active role for technologies in the learning process. Michael Hutchins, the primary theorist of distributed cognition, defines learning as "adaptive reorganization in a complex system" (1995, p. 289). Learning, or adaptive reorganization, involves the coordination of resources that are internal to individuals (memory, attention, skill) *as well as* those that are external (artifacts, objects, environment). Learners are not isolated. Instead, we are part of a system—"a system of person-in-interaction-with-technology" (p. 155). "Distributed cognition does not posit a gulf between 'cognitive' process and an 'external' world, so it does not attempt to show how such a gulf can be bridged. Cognitive processes extend across the traditional boundaries as various kinds of coordination are established and maintained between 'internal' and 'external' resources" (Hollan, Hutchins and Kirsh, 2000, p. 193).

Whereas activity theory places technologies *between* the subject and the object or intent of an activity, distributed cognition places technologies *with* the subject in the coordination of an activity. Cognitive abilities are *not* augmented or amplified. We delegate cognitive and physical tasks to technologies while these technologies transform the tasks for us. In this way, we offload tasks to technologies while they constrain our behavior at the same time. Constructivism reminds teachers to pay attention to language, SitCog reminds us to attend to social conditions, activity theory to culture, and distributed cognition to workflow. If we want to take advantage of what we know about distributed cognition, we have to help our students understand their place in human-technology interaction. We have to teach them how to coordinate their activity and behavior within complex systems.
Activity theory and distributed cognition turned our attention to activity, practice and systems, precisely the concerns of technology studies. These learning theories validate our theory of practice explained in the first two sections of this chapter. We absolutely have to embrace learning theories that take technology as a serious subject. Anything less invalidates our existence and the need to study technology in schools. If technology is dismissed or relegated to an incidental role in the learning process via a learning theory, then there is nothing in the theory to suggest that we have to study technology. We study technology not because it is a force to reckon with or instrumental to skills, but because technology is central to cognition and action. Where do we begin? We begin with technologies. We begin with what is mediating our encounters with our environment, goals and problems. We begin with our subject of study: technology.

Projects

Many so-called projects are of such short time span and entered upon for such casual reasons, that extension of acquaintance with facts and principles is at a minimum. In short, they are too trivial to be educative. (Dewy, 1931/1964, pp. 422-423)

What role do projects play in the process of learning with and about technology? For the most part, projects in technology studies refer to things to be designed, imaged or built. Projects are generally organized by a step by step instructional process that typically involves a toggling between teacher demonstrations and student practice. At times, especially in the upper levels of the schools, projects take on a more independent, self-directed form. In this independent form, students generally carry out the demands of design, imaging or construction virtually unassisted, using the teacher as a facilitator and resource. A logic is employed to suggest that the more complex or independent the project, the more complex the learning. However, as Dewey noticed in the early 1930s, the technical complexity of projects does not dictate their educational value. In fact, Dewey noted that there was a side of projects that was ignored by teachers. He reminded us that the project is not merely the thing. In addition to a thing, projects are a method for disclosing self-knowledge and feelings as well as the cultural and material conditions of subsistence, work and home life. Projects then, have two meanings. One is the notion of the project as a product or a challenge to be taken on. The other is the notion that the project is a method for disclosing meaning from everyday life. The methodology of projects is provided in Chapter 9. If we accept that projects are a method for disclosing a range of content, then we can
treat projects the way we treat technology in our theory of practice. We use projects and technology for their power to disclose content (Chapter 9). How do we do this?

Following the revolution of 1917, the Russians championed the project method precisely for this disclosive power. The entire school system of the USSR was oriented toward projects in the 1920s for their capacity to disclose the workings of socialist in industry and society and ultimately to transform the lives of the students. Projects, rather than subjects, were the principle means of organizing curriculum. Projects related to surveys of illiteracy, mortality or illness disclosed the applications of math to everyday life. Projects in agriculture disclosed the applications of chemistry to the fertility of soil, fertilizers and pesticides. Housing and transportation projects disclosed the applications of physics. Other projects disclosed the realities of labor and technology. This is the climate in which Vygotsky began to study the importance of language and the disclosive power of artifacts in the process of learning.

In our theory of practice, projects and technologies are used to disclose and provoke feelings and knowledge. Remember, when we speak of technologies we are referring to objects, activities, knowledge and volition. Technologies 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. How can technology teachers can draw knowledge and feelings from technologies? How does doing lead to knowing? Doing leads to knowing through projects and our methods of disclosive analysis outlined in chapters 5, 8 and 12.

**Projection and Reflective Practice**

In chapters 2 and 3, we addressed the emotional, cognitive and sensorimotor dimensions of learning. In this chapter, we integrated action, cognition and emotion into learning theory. The challenge of contemporary learning theory is accounting for technology, or for technological artifacts, activities, knowledge and volition. Learning theories have to account for big "T" Technology as well as all the small "t" technologies that we confront on a daily basis. A theory of practice in technology studies was elucidated to provide a framework for understanding the role that materials and technologies play in action, cognition and emotion. Dewey and Kolb's theories of experience were described and tied to our mission to educate the head, hand, heart and feet about, through and for technology. Dale's cone of experience helped us to understand the roles of technologies in enactive, iconic and enactive modes of learning. We refined the of
modes of learning with technology by distinguishing among tacit, augmented, mediated, automated, distributed and cyborgenic modes of learning with technology. As Mitcham reminds us, technology is not just objects, but also activities, knowledge and volition or determinism. Theories of learning have to account for technology on all four of these levels. The learning theories that account for technology in some way, such as behaviorism, constructivism, situated cognition and constructionism provide a good backdrop with which to theorize practice in technology studies. Distributed cognition and activity theory are the most complex of learning theories when it comes to accounting for technology. This was an extremely theoretical chapter, and it is important to recognize that theory is power.

If in our theory of practice technologies disclose knowledge about the conditions of life, then how does this happen? We use the disclosive power of technologies and our methods of disclosive analysis as the best means we have at our disposal. The previous chapter dealt with disclosive analysis methods. In the next chapter, we will address the various ways with which we justify the study of technology in the schools. If doing leads to knowing, then what exactly is the content to be learned? The primary justification is the content of technology, disclosed through methods such as disclosive analysis and projects.

The following teaching maxims are derived from our theory of practice in technology studies. These maxims support a philosophy that links the technology educators of today to those of the past.

<table>
<thead>
<tr>
<th>Technology Teaching Maxims</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>If pedagogical movement is from doing and feeling to knowing and changing, then</strong></td>
</tr>
<tr>
<td>- Teach from concrete to abstract and back to concrete. From action to emotion and cognition and back to action.</td>
</tr>
<tr>
<td>- Teach from technical-empirical to ecological-natural, ethical-personal and socio-political dimensions then back to skills</td>
</tr>
<tr>
<td>- Teach from applications to implications and explanations and back to applications</td>
</tr>
<tr>
<td>- Teach from technologies to Technology and back to technologies (from concrete to abstract—known to unknown—familiar to unfamiliar—local to global)</td>
</tr>
<tr>
<td>- Teach from a position that to know how is to ask why (How things work toward who’s in charge?)</td>
</tr>
<tr>
<td>- Teach with the end(s) of technology education in mind (Have a clear view of the goals of technology studies)</td>
</tr>
<tr>
<td>- Teach technology with a theory of technology and material things in mind</td>
</tr>
<tr>
<td>- Cast technologies in larger and larger contexts—Begin with immediate contexts such as projects, labs and shops and work toward homes, cities, communities, farms, workplaces and global economics and environments. Situate technologies in contexts that extend from the local to global.</td>
</tr>
</tbody>
</table>

© Stephen Petrina. (in press). *Curriculum and Instruction For Technology Teachers*
Philosophies of teaching are historical as well as contemporary clarifications of what if means to teach at a certain point in time. These eight maxims help clarify the practice of technology studies and ought to help clarify your own philosophy of teaching technology.

1. **Essay on the philosophy of technology studies:** The intention of this essay is to encourage you to think clearly and critically about your philosophy of technology studies. Prepare a cogent statement of what you believe, and basically of your world view about education, people and technology. Include *statements and examples* to address the following questions:

   **Essay on the philosophy of technology studies:**

   **Definition:** What is technology studies? (Introduction)
   **Rationale:** What is technology and why should we teach this subject? Why should we teach it as we do? (Chapters 6-7)
   **History:** What differs technology studies from audio-visual education, industrial education, manual training, etc? (Introduction, Chapters 6-7, 12)
   **Values:** What is the end (goal) of technology studies? (Also address K-7, 8-10, 11-12 levels) (Chapter 2-3, 5-6)
   **Ethics:** What is the nature of the student (of people in general)?
   What is the nature of the teacher?
   What ethical stance do you take on essential educational issues (i.e., classroom climate, success, discipline, gender)? (Chapters 1, 3, 11)
   **Knowledge:** What is the nature of technological knowledge, and of knowledge in general? (Chapter 2)
   **Politics and Psychology:** What is the nature of society and the role of the individual and school in this society? What kind of society do you advocate for individuals and social groups? (Chapter 7)
   **Learning Theory:** What is your theory for how we learn about and through technology? What role do projects, tools and the material culture of your lab or shop play? (Chapter 6)

*Essay Length: 6-8 pages typed, double spaced

Criteria:
Content (Introduction, format, presentation, examples, substance, conclusion)
Grammar (Organization, sentence structure, paragraphs, spelling)