A NEW CONSTRUCTIVIST LEARNING THEORY
FOR WEB-BASED DESIGN LEARNING
WITH ITS IMPLEMENTATION AND INTERPRETATION
FOR DESIGN EDUCATION

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
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By

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*****

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ABSTRACT

With the current development of philosophical and educational theories, the computer technology makes it possible to realize new forms of education for the postmodern world, which are characterized as: connection, heterogeneity, flexibility and morphogenesis. However, the Web and other multimedia technologies are merely information resources and tools, unless we provide meaningful learning content and context. The idea of intertextualizing new design learning with the Internet in this study, therefore, is important to connect and integrate useful knowledge in ways that are suited to the design learning and its activities.

The purposes of this study were to reconstruct design education with a new epistemological approach, and to develop a constructivist learning theory for Web-based Design Learning (WBDL). The research processes of this study were: (1) to identify constructivist epistemology, and to investigate cognitive and social constructivist learning theories through literature review; (2) to build a conceptual framework for constructivist design learning; (3) to develop Web-Based Design Learning (WBDL) models as
knowledge construction tool, and to apply them in design education; (4) to analyze the effectiveness of WBDL with a case study; and (5) to present guidelines for applying the constructivist learning theory and the WBDL to design education for the future study.

The WBDL program was developed and analyzed on three factors of constructivist design learning: cognitive and meta-cognitive, social and collaborative, and technical factors. From the case analysis, the effectiveness of WBDL as a design learning tool was highly evaluated by its visualized learning pattern in cognitive and social learning contexts. Comprehension of the qualitative information such as the level of design process and time gives the rationale to study constructivist design learning for improving the quality of design education. Furthermore, the effectiveness of WBDL is not confined to the student’s learning achievement, but is extended to the students’ future work in the design industries where collaborative, communicative, and contextualized activities are strongly emphasized. The research findings support the theory of constructivist design learning that (1) conceptualizes the learner-centered, collaborative, and authentic learning theories, and (2) integrates them to solve the complex design problems emerging with the paradigm of postpositivism.
With my best wishes and love for my mother and loving family....
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On a glorious day full with love and hope, spring 2004….

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Industrial design is in the midst of a major paradigm shift developed from expanding its influence to new subject matter and exploring new ways of thinking about human life. The conventional thinking of design subject matter related to all forms of production for use has been expanded to the new paradigm, which is concerned with material and immaterial entities in which social service, cultural value, and virtual space are becoming important areas of design studies. Along with this expansion, the traditional boundaries within design studies such as visual communication, industrial design, and interior space design have been blurred. Holt (2000) remarked:

What was a rarity just a few years ago—a multitasked, multidisciplinary project bringing together print, virtual, and environmental aspects of brand, media, and product—is fast becoming the norm. If anything, the need for innovation is pushing designers into the next evolution of the profession, one likely to involve trans- or extra-disciplinary creativity. (p. 23)
Blurring of the boundaries between design and other disciplines has become a symbolic term illustrating current trends of design research. It draws attention to the multidisciplinary and collaborative approach to the design process that combines with other disciplines’ reasoning and reflection for technical, socio-economic, and socio-cultural progress. For cutting-edge design companies such as IDEO and Fitch, the multidisciplinary research and its working conditions are regarded as an origin and nature of their design competitiveness (Peters, 1992; Sanders, 1992). Therefore, design companies are now challenging to explore new design knowledge through multidisciplinary approaches, and turn that knowledge about how to enhance organizational performance into actions consistent with that knowledge (Nobak, 1998; Pfeffer & Sutton, 2000). It is believed that creating a company’s culture for enhancing knowledge management becomes a more important issue than any other elements for controlling design competitiveness. And the necessity of possessing expanded and cross-boundary knowledge and skills for designers represents an awareness that there is a multiple and pluralistic approach which recognizes the behavior and sensitivities of human beings. Industrial design is also in the midst of paradigm shift directed by the rapid progression of computer technology. Digital technology profoundly changes how
people work, how they learn, and what they produce. As Johnson (1997) explained, “The worlds of technology and culture are colliding” (p. 2). Especially, the Internet and the Web now serve as the most potential symbol of how the world may integrate together harmoniously in an information sharing environment. It brings a new socioeconomic system that realizes the unrestricted creation, distribution, and sharing of information and knowledge.

The development of new media and the explosion of the Internet has tremendously influenced the nature of design products by exploding new diverse categories of design such as e-products and Internet connected products. At the same time, the digital technology has revitalized the design problem-solving process effectively and efficiently, by allowing groups of people to work together concurrently in remote distant places. Because computer network technology has strengthened the non-linear flow of information and concurrent design processes, it uncovers totally different ways of understanding and exploring the design processes. The digitally connected communication channel between the users and the designers is a prime example of how digital technology provides new user-participatory design experiences to both designers and users during the whole design processes; designers continuously absorb users’
opinions during the design processes with the Internet, and users can actively participate in the design development process. Computer technology allows designers to work in the creative environment for managing design data with others simultaneously and efficiently.

Finally, the reason for change can be found and developed by a new way of utilizing digital technology in design learning. There is no question that the way of learning, creating, and using knowledge in schools and corporations needs to be changed as a consequence of the evolution of digital technology; it is predictable that a new model of design education is emerging. Unlike any technology that existed in the past, the computer and networked communication possess lots of possibilities and potentials to expand and challenge the philosophies of constructing design learning as well as design processes. For example, we are able to create a new design environment on the basis that the digital technology supports horizontal information sharing structure, where the learning process is simultaneously and collaboratively approached by groups of people, rather than by an individual. All these phenomena of change in the nature of design discipline, digital technology, and new ways of design learning indicate that this is one of the most difficult times to be a designer and an educator, but it is also one of the most challenging moments of being a designer for industry as well as an educator for academia.
1.2 Statement of Problem

In light of these shifting contexts, the design discipline and design education face the need of developing new ways of thinking about and creating design. In the midst of the design paradigm shift, the great idea enhancing the quality of design education in the Information era needs to take two aspects of the problem into consideration: (1) epistemology for design education; and (2) integrating computer technology in design learning.

a. Epistemology for Design Education

The first task on us is to conceptualize a useful and compelling basis for the construction of an epistemology of design knowledge and its learning process. Issues of knowledge and knowing are embedded in the area of epistemology, which concerns the basic assumptions of gaining knowledge of the world we are living in: What is knowledge? How does one come to know and understand design? How shall we decide what to teach?

Because the different epistemology provides a totally different understanding of design knowledge, it is very crucial and urgent for designers and educators to go back to
the fundamentals of epistemology, and find an appropriate perspective of constructing
design knowledge and the way of learning it. Reconsidering epistemology and identifying
the features of design knowledge, therefore, can be a good starting point for confronting
big changes or innovations in the midst of a design paradigm shift.

In considering epistemological change in teaching and learning theory,
objectivism and constructivism can be identified as comparative approaches
(Cunningham, 1992; Jonassen, 1992; Schwandt, 1994; Denzin & Lincoln, 2000). Unlike
objectivism, which is based on the notion of independent and objective reality,
constructivism develops a theory of knowledge in which “knowledge does not reflect an
objective ontological reality, but an exclusive ordering and organization of a world
constituted by our experience” (Watzlawick, 1984, p.24).

Since knowledge cannot be limited to a direct apprehending of reality,
constructivists focus on the transformation of knowledge and its development within
students. Constructivists, therefore, emphasize active learning rather than passive, for
participating in and interacting with the surrounding environment in order to create a
personal view of the world (Duffy & Jonassen, 1992; Perkins, 1992).
In this study, constructivism, as an emerging paradigm in education, is investigated to identify diverse possibilities of reforming design education with the support from its epistemological and pedagogical dialogues.

b. Integrating Computer Technology

Another important consideration of this study is the acknowledgement of the holistic approach of integrating computer technology into the design problem-solving context and its learning contents. With the radical evolution of computer technology, there exist fairly strong demands to reform the content and context of design curriculum (McCoy, 2001; Niederhelman, 2001). Considering the existing design curriculum, most computer-related courses are about useful functions of software programs such as Computer Aided Design (CAD) and Web design, and their applications to design problem-solving. But these courses are mainly dealing with the way of using cutting-edge software programs as the goal of learning; this kind of computer design course is not yet integrated into the philosophical base of constructing design knowledge and design learning. The problem encountered by design educators is to miss the link between the way of using computer technology as a learning subject matter, and the way of teaching
students about and with computer technology. With whenever new medium comes out, such as CD-titles and the Internet, it is easy to equate the new medium with a new pedagogy. However, it is not the delivery medium that creates and accomplishes the instruction; the delivery medium is very instrumental in the learning approach, and its capabilities can be exposed effectively only when it is integrated into the instructional design and concrete pedagogy (Verneil & Berge, 2000). For effective learning, there must be new ways of learning when using new media technology. Jonassen, Peck, and Wilson (1999) argue that, “technologies should be used as knowledge construction tools that amplify learners’ abilities to construct knowledge for themselves, rather than taught by preprogrammed lessons” (p. 152).

Therefore, it is hypothesized that computer technology can provide different frameworks for creating new design learning contexts when combined with the constructivist epistemology and cognitive learning theories; this creates new ideas for filling the current missing gap between using technology in learning design and learning to design with technology. Given these two problems, this study focuses on reconstructing design education with a new epistemological approach and re-addressing computer technology as a tool/environment for constructing new design learning. The
research questions for this study are summarized as follows: (1) What does a constructivist perspective in design education look like? (2) What do contextual features influence constructivist learning in design education? (3) How does Web-Based Design Learning (WBDL) function with a constructivist approach? (4) How is the quality of design education enhanced by a constructivist learning approach with Web-based technology?

1.3 Conceptual Framework

In order to investigate the research questions above, this study explores relevant theories in diverse areas: new design learning and design education, constructivism, and information technology and learning theories.

a. New Design Learning and Design Education

Design has traditionally been regarded as practice-oriented activity, which requires designers’ practical knowledge and intuitive skills. But, within the emerging paradigm of the knowledge-based post-industrial society, designers are required to
possess a broader perspective to deal with complex problems based on more expanded and cross-boundary knowledge and skills. This motivates design educators to consider a new way of learning design.

Buchanan (2001) defines new design learning as an opening pathway “to connect and integrate knowledge from many specializations into productive results for individual and social life” (p. 7). Donald Schön (1987) provides another aspect of new design learning as reflective practice. New design learning enhances reflective practice for perceiving the creative activity as well as for sharing experiences of the design process. This approach of new design learning has been developed in a series of conferences and publication throughout the 1990s in design studies (Cross, 2001). Compared with the old learning rooted in either engineering or art, the importance of new learning is given to the connective activity for integrating knowledge from many fields, and to the dynamic balance between theory and practice. There are several studies that reflect new design learning and new curriculum approaches in design education. For instance, Levy (1990) proposed that we needed a core design curriculum as “a carrier of value constructs, ethical ideals, technical and scientific know-how, social and political concerns, economic imperatives, environmental awareness, and historical consciousness” (p. 52). Buchanan’s
(2001) definition of new design learning comes along with Levy’s idea of core curriculum, addressing a comprehensive reconstruction of educational policies by integrating and interrelating ideologies, values, and other issues in human sciences. Both Levy and Buchanan suggest new curriculum establishment for better understandings of design learning and for enhancing human-centered practices in postmodern society; this makes new design education disengaged from the traditionally articulated and territorialized thinking about design education.

Another crucial point for understanding new design learning is the world of rapid change. Design students need to educate themselves to “a new competence when they don’t know yet what it is they need to learn” (Broadbent, 1995, p. 23). So, the question of “how do we know what we know” needs to be re-questioned to reform the content and context of design education. It is the fundamental epistemological question in this study.

Based on the idea of new design learning, design education models for this study focus on addressing new structures of learning by connecting and integrating design knowledge in new, useful, and meaningful ways to the student. By emphasizing boundless interconnectivities of knowledge and experience, creating the new education model is regarded as creating multiple possibilities within the situation, and addressing
certain problems for students and educators altogether. Therefore, design education needs to focus not only on the principle-oriented learning, but also on the expansion to learner’s generative and discovery-oriented learning. New design learning and design education emphasizes knowing how to learn rather than knowing what to learn.

b. Constructivism

The rapid changes in design education and in industry are the reasons why this study has started from investigating constructivism as an emerging paradigm in education and its epistemological dialogues. Constructivism has multiple roots in the psychology and philosophy of the 20th century, but constructivist learning theories reviewed in this study focus on two primary roots: cognitive constructivism and social constructivism.

Cognitive constructivists tend to draw insight from Jean Piaget and focus on individual constructions of knowledge discovered in interaction with the environment (Morf, 1998; Petraglia, 1998). They believe that “learning is a constructive process in which the learner is building an internal representation of knowledge, a personal interpretation of experience” (Bednar et al., 1992, p. 21). Cognitive constructivists emphasize the development of a rational model of cognitive activities of either an
individual or a group of individuals through the situated cognitive experiences. For instance, the Cognition and Technology Group at Vanderbilt University (1992) has developed a generative learning environment, which emphasizes “the importance of anchoring or situating instruction in meaningful, problem-solving contexts” (p. 78). Cognitive constructivists have generated the contemporary issue of learner-centered and authentic learning. Knowledge is not given to the student as an entity to be learned, and it is basically constructed by the continuous meaning-making procedure by the student (Hannafin et al., 1997). Meaning-making is at the heart of constructivist philosophy, and it emerges in the learner-centered concept emphasizing students’ activities within the context of their own experiences (Moll, 1990); it requires students’ engagement in active, constructive, intentional, authentic, and cooperative learning (Jonassen et al., 1999). The idea behind these studies is that if cognitive development proceeds through the construction of meaning from activities, we can support meaningful learning by understanding the ways where meanings evolve differently in different context. It makes learner-centered and authentic learning.
On the other hand, social constructivists rely more closely on Lev Vygotsky’s view of learning as connection with and from the socio-cultural context. In his book, *Mind in Society*, Vygotsky (1978) described the higher forms of human behavior and mechanisms by which culture became part of each person’s nature. He explained, “human learning presupposes a specific social nature and a process by which students grow into the intellectual life of those around them” (p. 88). From his perspective, knowledge is transferred among people by watching others work.

Based on Vygotsky’s extensive studies on cognitive psychology, pedagogy and sociocultural studies, the theory of social constructivism suggests that the fundamental role of education is to facilitate personal growth of individuals in the shared way of thinking about one’s self, the community, and the world (Jonassen et al., 1999); learning is driven by the desire to communicate (Selly, 1999), and cognition is itself a social construct (Moll, 1990). The concepts of knowledge-building community, learning community, and community of practice emphasize social and cognitive contributions of a group of learners to each other. Supporting each other for common goals in learning communities is recognized as the most important attitude that students and professional designers should possess in the highly competitive, complicated, and speedy environment.
Therefore, the idea of constructing cognitive and social learning in the socially interactive setting can provide an alternative perspective of enhancing quality of design learning and design practice.

c. Information Technology and Learning Theories

In addition to the epistemological and pedagogical dialogues in cognitive and social constructivism, this study includes diverse contemporary learning theories such as cognitive development theory with computers, computer as a knowledge construction and cognitive tool, and computer-supported collaborative learning. First of all, it is important to identify the relationship between constructivism and information technology. Since computer technology has been applied to many different areas of learning, the usage of computers in educational contexts has showed significant changes in perspectives on teaching and learning from a supplementary education tool for assessing students’ ability to Computer Assisted Instruction (CAI). At the same time, the ways of using computer technology in education have highlighted diverse issues regarding education systems such as curriculum changes or the integration of technology into learning as a cognitive tool (e.g., Jonassen et al., 1999; White et al., 2000; Jonassen & Carr, 2000).
What makes the computer a cognitive tool is still open for interpretation. There are, however, significant trends in cognitive approaches to instruction under the same theoretical perspectives. For example, in her paper of “Cognitive Approaches to Web-Based Instruction,” Sugrue (2000) explained four instructional elements performing a cognitive function in the learning process, which embodied instructional strategies: information organization and access, authentic activities, collaborative learning, and student modeling. These four elements are frequently discussed as cognitive functions/issues in Web-based learning.

Secondly, the cognitive skills and strategies for learning can be supported and enhanced by the computer (Jonassen & Carr, 2000; Harper et al., 2000). Because design learning with the World Wide Web (WWW) provides a new interactive structure and style of learning to support learners’ memories, to allow information access to any resource that serves explicit information about a topic, and to provide feedback regarding process and product, learning is enhanced with the Web. There are several studies providing a set of guiding principles to help designers and teachers create learner-centered and authentic environments that support students’ cognitive development and reflective thinking (Jonassen, 1999; Geer et al., 2000; Hung & Chen, 2001). The idea
behind these studies for a creating effective learning tool/environment is to change the meaning and value of computers to a cognitive and interactive tool with which students can manage new learning and meaning in a more constructive and collaborative way.

Finally, collaborative learning becomes one of dominant issues in both design education and professional practice. Collaborative learning is defined as a learning process that emphasizes cooperative efforts between instructors and students. Collaborative learning is an important cognitive strategy based on the social construction of knowledge, which leads to deeper processing and understanding than learning without collaboration. Supported by the Internet and the Web, collaborative learning can provide a new approach to integrating social, cultural, and practical issue into the design curriculum. The communication capabilities of the Web make it easier than ever before to support collaborative learning environments. Since Piaget promoted pedagogical practices, collaborative learning has been studied (Selly, 1999), but the realization of that learning theory becomes more meaningful with the development of the Internet and multimedia technology; the inherent features of the Internet such as flexibility and openness for many people have triggered the creation of horizontal and democratic learning environments (Hung & Chen, 2001; Sugrue, 2000).
Consequently, from the literature review, the emerging context of education in the development of digital information technology can be summarized and characterized by the key words of accessible, flexible, virtual, ubiquitous, connected, collaborative, authentic, and learner-centered. Furthermore, the constructivists’ approach to understanding the world and learning provides a conceptual frame for explaining the dynamic change in design discipline, and for supporting the multidisciplinary and flexible learning process for design students. This constructivist learning in education must be also continuously linked to design practice, where the idea of constructivist learning provides a more dynamic and affordable working environment to the designer in the Information Age. By sharing the same constructivist epistemology and technology as a communication channel, design education and professional practice become close partners for generating and distributing new knowledge and experiences in design. Therefore, both cognitive and social constructivist learning theories can provide a conceptual framework for new design learning, and the digital information technology has an important role of connecting two theories into one in an authentic learning context.
1.4. Design of Study

The overall goal of the study is to develop a conceptual framework of new design learning based on constructivism and Web-based learning. In order to achieve this goal, the objectives of study are: (1) to identify constructivist epistemology and its learning theories, and to investigate cognitive and social learning theories related to information technology; (2) to build a conceptual framework for creating constructivist design learning; (3) to explore the diverse possibilities of developing Web-Based Design Learning (WBDL) models as knowledge construction tools, and to apply them in design education; (4) to analyze the effectiveness of WBDL with a case study; and (5) to present guidelines for applying constructivist learning theory and WBDL to design education for the future study.

In order to support these objectives, the study uses diverse research methods: literature review, case study with Web-Based Design Learning (WBDL), and qualitative and interpretive data analyses to evaluate the effectiveness of WBI. The following Figure 1.1 illustrates the flow of research process, and the relationships between research content in each chapter and research methods used in the study. The detail of research design for the case study will be explained in Chapter 6.
Based on the literature review written in Chapter 2, 3, and 4, the conceptual model of new design learning and WBDL is developed in Chapter 5. The new design learning guidelines and WBDL models are applied to a case study at the Department of Industrial Design of KAIST (Korea Advanced Institute of Science & Technology) in Chapter 6. The purpose of conducting the case study was to investigate diverse possibilities of building WBDL with the support of constructivist theories. A WBDL tool, called “Product Design System,” was created and used during the sixteen-week course, in
which the face-to-face lecture was being held twice a week. The WBDL was created on
the server system of KAIST, and provided a venue for collaborative design learning
among students and between an instructor and students. With the subject matter of
“Wearable Computer Design,” thirty students were enrolled, and they were divided into
eight groups to accomplish team projects.

Based on the qualitative research methodology, this study follows the concept of
triangulation as a representative data gathering and analysis method to reduce the bias
produced by the researcher of one, and to improve the probability that findings and
interpretations would be found credible (Lincoln & Guba, 1985). For triangulation of
using of multiple and different methods, this study includes: interviews, analyses of
archival records such as group discussion logs and information posted, individual
student’s weekly journals, and the final design outcomes of each team. In this study, the
data collecting method itself represents the characteristics of Web at maximum: with
WBDL, each student’s contributions and activities were recorded and analyzed to create
a cognitive model of the students’ level of mastery of specific knowledge units and
learning experiences during the course. Data collected from the WBDL refer to the
frequency of participation, the willingness/motivation in participation, and the quality of
submitted design solution. This study finally assesses the cognitive, social, and cultural values of learning through the WBDL. For data analyses, the criteria for analyzing the effectiveness and value of WBDL are focused on three factors and their related six principles: cognitive and metacognitive factors (knowledge construction and cognitive & metacognitive strategies), social and collaborative factors (social interaction and constructivist mindset), and technical factors (technical competence and using computers in design learning). Through the data collection and analyses, the theoretical rationale of developing constructivist new design learning has been established. And finally, the questions, issues, and implications of developing WBDL are discussed in the end of this study in order to open more possibilities of exploring new design learning in the future.

1.5. Significance of the Study

The current development of philosophical and educational theories and educational technology makes it possible to realize new forms of education. However, the Web and other multimedia technology are only information resources and tools, unless we provide meaningful learning contents and context. The idea of intertextualizing new design learning with the Internet in this study, therefore, is very important to connect and
integrate useful knowledge in ways that are suited to the design learning and its activities.

This study investigates current theoretical and practical research on constructivist learning, and develops new design learning and its models with the Web. The significance of having such a computer-supported learning tool is that students can create new solutions of a higher order of design knowledge in an authentic and social learning environment. From Vygotsky’s (1978) perspective on tools and signs, tools are oriented outward toward the transformation of the physical and social reality; signs are oriented inward toward the self-regulation of conduct itself. As an effective learning tool and sign, therefore, the WBDL can be regarded as “the result of the internalization of social signs, and the internalization of culture and of social relationships” (Blanck, 1990, p. 44).

Finally, the importance of investigating constructivist theories and creating new learning contexts resides in educational implications and applications of constructivist ideas as a means for bridging design education and professional practice. For the case of WBDL, the effectiveness of cognitive and social learning with technology is not confined to the student’s learning achievement, but is extended to the students’ future work in the design industries where collaborative, communicative, and contextualized activities are strongly emphasized. The improvement in quality of design education, therefore, can be
assessed as to induce the desirable attitude to multidisciplinary research and continuous learning improvement as well as the development of intellectual, technical ability and creativity demanded in the society.
CHAPTER 2

DESIGN PARADIGM SHIFTS AND NEW DESIGN LEARNING

2.1. Issues for Changes in Design and Its Education

Industrial design has been changed dramatically with the development of economy, culture and technology. Since it was born as a new profession, designers have had to prepare and deal with all future changes. However, there is a huge difference between the early 20th century of industrial society and the current Information society in its magnitude and speed of the changes. It is likely that changes in the 21st century will be thousand times greater than they were in the 20th century (Tapscott, 1998; Taylor & Wacker, 1997; Nabarro, 2001). In the midst of these rapid and complex features of socio-cultural changes, this section will explore the key issues about design changes, and how these issues influence the design paradigm shift and design education.
2.1.1. Emerging and Expanding Design Areas

Industrial design has been changed in response to the broader socio-economic context. The conventional thinking of design subject matters based on the material entities has been expanded to include the immaterial entities such as experience, action, and services; product designs advance so quickly that they need the character of various kinds of experiences and services during and after they are purchased. This means that a user’s total experience with a product determines its success, and it forces a company to be more user-oriented in designing almost fully customized products and services (Gobe, 2001; Reedy et al., 2000). Therefore, if we consider the technological and economical developments, it includes a notion for designers to possess a larger body of knowledge and problem-solving skills, not only in the material-oriented product design, but also in the area of system, experience and service design.

Popovic’s (2001) study shows us how design areas and activities have been changed and expanded in the real world. She investigated the current and emerging industrial design practices from design websites around the world, and identified new categories of design expertise that have emerged. Those are: design research, experience design, scenario design, design leadership, industrial design strategy, strategy innovation,
technology and innovation management, user research, virtual visualization, and strategic planning (p. 151). The following Table 2.1 shows how diverse design expertise has emerged in the field of industrial design.

<table>
<thead>
<tr>
<th>Design Areas</th>
<th>Management and marketing</th>
<th>Design and Development</th>
<th>Materials</th>
<th>Other Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Aerospace</td>
<td>-Design leadership</td>
<td>-Aesthetic form studies</td>
<td>-Aluminum</td>
<td>-Copywriting</td>
</tr>
<tr>
<td>-Agriculture</td>
<td>-Design management</td>
<td>-Assembly drawings</td>
<td>-Composites</td>
<td>-Electronics</td>
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<tr>
<td>-Brand design</td>
<td>-Industrial design strategy</td>
<td>-CAID and CAM</td>
<td>-Die cast metal</td>
<td>-Engineering</td>
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<tr>
<td>-Capital good design</td>
<td>-Information management</td>
<td>-Conceptual design</td>
<td>-Material selection</td>
<td>-Ergonomics</td>
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<tr>
<td>-Consumer products</td>
<td>-Marketing</td>
<td>-Manufacturing</td>
<td>-Plastics</td>
<td>-Ergonomics evaluation</td>
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<tr>
<td>-Design research</td>
<td>-Marketing analysis</td>
<td>-Problem solving</td>
<td>-Sheet metal</td>
<td>-Illustrations</td>
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<tr>
<td>-Environmental design</td>
<td>-Marketing communication</td>
<td>-Product development</td>
<td>-Surface materials</td>
<td>-Model making</td>
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<td>-Exhibit design</td>
<td>-Program management</td>
<td>-Product layouts</td>
<td>-Wood</td>
<td>-Patents</td>
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<td>-Experience design</td>
<td>-Strategic planning</td>
<td>-Product semantics</td>
<td>-Glass</td>
<td>-Drawing</td>
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<td>-Furniture</td>
<td>-Strategy innovation</td>
<td>-Production documentation</td>
<td>-Finishing</td>
<td>-Renderings</td>
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<td>-Houseware design</td>
<td>-Technology and Innovation</td>
<td>-Prototyping</td>
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<td>-Software</td>
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<td>-Information design</td>
<td>management</td>
<td>-Stereo lithography</td>
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<td>-Technical illustration</td>
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<td>-Instrument design</td>
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<td>-Styling</td>
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<td>-User research</td>
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<td>-Interface design</td>
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<td>-3D modeling</td>
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<td>-Virtual visualization</td>
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<td>-Lighting</td>
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<td>-Tool design</td>
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<td>-Visualization</td>
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<td>-Medical equipment</td>
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<td>-Tool manufacture</td>
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<td>-Packaging</td>
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<td>-Value analysis</td>
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<td>-Product design</td>
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<tr>
<td>-Retail design</td>
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<td>-Scenario design</td>
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<td>-Sport goods</td>
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<tr>
<td>-Strategic design</td>
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<tr>
<td>-Scientific equipment</td>
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<tr>
<td>-Toy design</td>
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<tr>
<td>-Transportation design</td>
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</table>

Table 2.1. Expanding the field of design (adopted from Popovic, 2001, p. 152)
2.1.2. Blurring the Design Boundaries for Creating Knowledge

The above reflection on the expanded design areas is also understood from the perspective of blurring the boundaries between design and other disciplines. The rapidly changing environment has demanded designers to possess a broader perspective to deal with complex problems based on more expanded and cross-boundary knowledge and skills within the emerging paradigm of the knowledge-based society.

Blurred boundaries in design studies and design activities, therefore, are naturally characterizing the design process as the collaborative, dynamic, and team-driven activity that supports better interaction between designers and other members in the team. Ultimately, design becomes a wide spectrum of social act, and its process becomes “the social and cultural detailed attention, research, and analysis of all the various requirements and needs, in order to achieve accurate problem definition and the best solution” (Nabarro, 2001, p. 24).

From the perspective of the design industries, creating a company’s culture for enhancing knowledge management becomes a more important issue than any other element for controlling design competitiveness (Pfeffer & Sutton, 2000; Peters, 1992). As important aspects of creating and utilizing knowledge within the organization, the
design companies have turned their focus from having an efficient working environment to building a creative learning environment. For design companies like IDEO, “the tangible, physical, material aspects of knowledge acquisition and knowledge transfer, learning by doing, learning by coaching and teaching are crucial” for maintaining IDEO’s competitiveness (Pfeffer & Sutton, 2000, p. 250). IDEO is called as “a learning lab,” which promotes a learning environment from diverse viewpoints such as learning with clients, learning from outsiders, learning from each other, and learning from teaching (Peters, 1992). By capturing, distributing, and managing knowledge, design companies are now being changed to be other types of educational institutions.

The case of IDEO shows us that the design industries are now searching for their competitiveness by changing their attitudes toward education, which makes the organization a living organism of continuous and life-long learning. This attitude towards learning and knowledge makes a kind of relationship between the designers and their partners (i.e., other designers, users, and even products) successful and meaningful. The creativity comes from the multidisciplinary team approach as well as cross-fertilization of diverse knowledge and experiences among team members. Ultimately, blurring the design boundaries is not a simple term for describing the current phenomenological
changes in the design industries; it becomes a symbolic sign of changing designers’ attitudes toward creativity, learning, and self-esteem in the knowledge-based society.

2.1.3. Reforming Design Education

During the last two decades, there have been many ideas and studies of reforming and restructuring design education (Levy, 1990; Buchanan, 1993; Young et al., 2001). These studies argue commonly that the prevailing ideological framework of the industrialized world doesn’t support the rapidly changing features of post-industrial society.

Firstly, in a white paper of the Department of Design in Carnegie-Mellon University, Buchanan (1993) brought up hot issues that design education has faced: (1) the vision of design education; (2) the nature of design thinking and learning; and (3) the educational leadership making the equal partner between the practice and theories. All three are very fundamental as educational issues, and he reconsidered them to enhance the quality of design education and to create the new design curriculum within the contemporary socio-cultural context. Because most design schools have continued to teach students in the manner of the traditional way, the learning contents and the teaching
methods in design education are limited for achieving the skills and the formation of
design knowledge. In order to meet the currently changed world, Buchanan emphasized
the acquisition of integrative disciplines of design thinking and the formation of the
intellectual character of designers, which will make designers stir and change
circumstances and lead the design professions. Buchanan (2001) implemented a new
design curriculum at the Carnegie Mellon University by “moving away from the
foundation course and creating new introductory courses that cultivate the new
perspective among students” (p. 13). This new perspective and new learning expands and
focuses on human experiences with design problems/projects instead of limited
foundation courses of teaching materials, tools, and techniques of design as the primary
subject matter.

Levy (1990) proposed a minimum curriculum for design education maintaining
ten major concerns: inquiry systems, paradigmatic perspectives, system theoretics,
communication competence, value constructs, ethical awareness, cultural conscience,
historical consciousness, epistemics of science and technique, and environmental
responsibility. To summarize, several major concerns of Levy are as follows: (1) Inquiry
systems promote knowledge of how to investigate problems with multiple inquiry
systems; (2) Possessing paradigmatic perspectives connect four interconnected fields of study (cognitive aspects of design, the scope of material and immaterial entities, heuristic imperatives, and choice from multiple methods), and help students construct a general conceptual framework of design in a coherent and interrelated manner; (3) System theoretics is a pragmatic perspective to construct the structural and existential web of being of perceived complex phenomena; (4) Communication competence is essential for the understanding and communication of complex phenomena with the triangulation of literacy, numeracy, and graphicy; (5) Value constructs help designers make decisions and assume responsibilities; and (6) Ethical awareness begins to embody new ontological claims in which the concrete and virtual constructions of individual, social, and cultural experience provide the basis for a reconstituted understanding of existential being (pp. 48-50). Finally, environmental responsibility provides a balance to integrate and interrelate personal and social ideologies, values, intentions, and notions of existence.

Both Levy and Buchanan suggest new curriculum establishment for better understandings of design learning and for enhancing human-centered practices in postmodern society, which makes new design education disengaged from the traditionally articulated and territorialized thinking about design education.
Recently, Young et al. (2001) pointed at strongly the needs of creating new forms of design education. They argued, “although the Bauhaus pioneers’ out-of-orthodoxy thinking created the base for design education today, the social, economic context in which they operated is totally outdated and inappropriate today…It’s time to move on” (p. 29). Escaped from the context in which the Bauhaus predecessors operated, they proposed “the creating of a new form of design practice in order to help differentiate its aims and methods from those of existing forms of practice” (p. 31). Figure 2.1 explains their educational challenge for design integrating the material aspects of designing within the immaterial challenges of context and beyond to redesigning the context itself.

Figure 2.1. Expanded role of design within society (Young et al. 2001, p. 30)
All the above issues related to changes in the design industry and in education show that designers in the post-industrial society are required to possess expanded and cross-boundary knowledge and skills beyond traditional designers in the industrial society. The goal of design education is, therefore, to educate students to be able to get accustomed to the dynamic changes in design discipline, and to possess the flexible learning capabilities, which can be expandable and applicable to the postmodern context.

Under this circumstance, I think what we need under the midst of change is to possess a new vision for design and design education as a whole by taking new paradigm. The following chapter discusses the paradigm shift and epistemology to get to know about the nature of knowledge and the way of organizing knowledge.

2.2. Design Paradigm Shift and Epistemology

2.2.1. New Design Paradigm

Design is in the midst of a paradigm shift. Modern design had been led by a positivist paradigm, which is defined as “a family of philosophies characterized by an extremely positive evaluation of science and scientific method” (Lincoln & Guba, 1985, p. 19). Generated from the Newtonian approach, positivism has sought and promoted
absolute and universal truth with objective and scientific methods (Linn, 1996; Slattery, 2000). As a dominant paradigm, positivism has been remarkably pervasive in design studies as well as in design developments in the context of industrialization, functionalism, and internationalism. The desire to build design process objectively and rationally brought “the 1960s heralded as the design science decade” (Cross, 2001, p. 50), and developed design methodology continuously till the 1980s.

Generally, modern design has been identified as positivistic, rationalistic, and universal with the belief in rational planning of ideal social orders, and the standardization of knowledge and production. These conventional design thoughts and methods based on positivism, however, are not adequate to deal with the rapid and fundamental changes in the post-industrial society (Levy, 1990; Buchanan, 2001; Findeli, 2001; and Jonas, 2001). Design requires a new paradigm—a new way of seeing the world.

Postpositivism, naturalistic inquiry, or postmodernism is an emerging and alternative paradigm that guides inquiry in different ways from positivism. For comparing certain sets of basic beliefs between positivism and postpositivism, Lincoln and Guba (1985) characterized the paradigm shift from positivism to postpositivism as the following movement and change. These characteristics of paradigm shift focus more
on an attitude rather than a cohesive set of principles or practices; it deconstructs “modern notions of metanarratives that attempt to explain a universal and unalterable truth for all people in all circumstances” (Slattery, 2000, p. 134).

- Movement from simple to complex realities
- Movement from hierarchic to heterarchic concepts of order
- Movement from mechanical to holographic images
- Movement from determinacy to indeterminacy
- From linear toward mutual causality
- From assembly to morphogenesis
- From objective to perspectival views (Lincoln & Guba, 1985, p. 51-56)

The differences between positivist and postpositivist paradigm are compared in Table 2.2. Because any inquiry is value-bounded, postmodern researchers have produced a revised justification for knowledge. Unlike the modernists’ thought on knowledge as a value-free and context-free entity, the postmodernist believes that knowledge is not value neutral and that knowledge is the result of a way of knowing. The relationships of the knower to the known are not independent, but interactive. Many design scholars, who believe that designing is nonscientific or more than scientific, apply the postmodern approaches above to overcome the positivist boundaries of the restricted and articulated perspective (Margolin, 1989; Buchanan, 2001; and Findeli, 2001). Under the new design
paradigm of postpositivism, we believe that “design does not occur in a neutral field in which the designer’s contribution is universally recognized and accepted; rather it is a contradictory intervention into a society that demands objects with use-value on the one hand, but is preoccupied with converting them into ephemeral simulacra on the other” (Margolin, 1988, p. 11).

<table>
<thead>
<tr>
<th>Axioms About</th>
<th>Positivist Paradigm</th>
<th>Postpositivist Paradigm</th>
</tr>
</thead>
<tbody>
<tr>
<td>The nature of reality</td>
<td>Reality is single, tangible, and fragmentable.</td>
<td>Realities are multiple, constructed, and holistic.</td>
</tr>
<tr>
<td>The relationship of knower to the known</td>
<td>Knower and known are independent, a dualism.</td>
<td>Knower and known are interactive, inseparable.</td>
</tr>
<tr>
<td>The possibility of generalization</td>
<td>Time-and context-free generalizations are possible.</td>
<td>Only time-and context-bound working hypotheses are possible.</td>
</tr>
<tr>
<td>The possibility of causal linkages</td>
<td>There are real causes, temporally precedent to or simultaneous with their effects.</td>
<td>All entities are in a state of mutual simultaneous shaping, so that it is impossible to distinguish causes from effects.</td>
</tr>
<tr>
<td>The role of values</td>
<td>Inquiry is value-free.</td>
<td>Inquiry is value-bound</td>
</tr>
</tbody>
</table>

Table 2.2. Comparing positivist and postpositivist paradigm (Lincoln & Guba, 1985, p. 37)
Therefore, the postpositivist paradigm provides a different perspective of understanding the nature of design and its solving process, which the positivistic paradigm cannot produce. One of dominant research attempts is to redefine design. For example, Jonas (2001) described, “design as anticipative, generative, use-oriented, illustrative, integrative, and context-sensitive” (p. 66). From his point of view, design is a discipline having a context-oriented and systematically integrated approach, and pursuing natural inquiries for solving complex human problems.

It is important to understand how Jonas’s definition about design is carefully reconstructed on the basis of postpositivism. He started his argument by positioning that design was not art, not technology, and not science; instead, he emphasized, “it should be conceived as an expert discipline of a special kind for integration, relation, and meaning” (p. 66). Jonas’ status of understanding the origin of design is controversially juxtaposed from the positivist researcher, who refer design science “to an explicitly organized, rational, and wholly systematic approach to design; not just the utilization of scientific knowledge of artifacts, but design in some sense as a scientific activity itself” (Cross, 2001, p. 53). Jonas’s redefinition of design is symbolic, because it represents phenomenological changes in design paradigm, design studies, and practices.
The paradigm shift toward postmodernism has also opened a new debate on design knowledge and education. Like what Slattery (2000) emphasized, postmodernism “contributes to school reform by reconceptualizing the very nature of debate and allowing educators to challenge assumptions and envision alternative possibilities for change” (p. 143). The importance of understanding the paradigm shift is here to open a new pathway to design learning, and to build a new design education model in this study.

2.2.2. Epistemology

Generally, the paradigm shift is deeply related with epistemology. As a subdivision of philosophy, epistemology concerns itself with the basic assumptions of our way to gain knowledge of the world we are living in. Epistemology deals with the basic questions: What is knowledge? How does one come to know and understand design? How shall we decide what to teach? What kinds of knowledge and techniques shall be taught to design students, and how shall it be taught?

Why do designers and design educators need to understand the paradigm shift, and to build a new epistemological base related to the paradigm? It is because all aspects of understanding “design education is linked to its epistemological roots, i.e., the origin,
structure, method, and validity of design knowledge” (Levy, 1990, p. 42). The epistemological problem—how we acquire knowledge of reality, and how reliable and true that knowledge might be—comes up with new turns in the theory of knowledge. Therefore, the differences between the epistemological views have provided different ways of understanding the nature of knowledge and the way of organizing knowledge with its origin, nature, and limits.

Escaping from the positivistic epistemological structure, the current studies on design education have emphasized the postpositivist approach to deconstruct and to reconstruct the nature of design knowledge. Within the emerging postpositivist paradigm, design is now understood as the constructive, non-neutral, and context-bounded axioms. Findeli (2001) reconsidered design education and research “within a non-materialistic, non-positivist, non-agnosticist, and non-dualistic worldview” (p. 6). The content and context of design studies are also to be recreated in a time- and context-bounded working environment in order to “develop highly effective educational programs to both fulfill the requirements of producing adequately trained personnel and to advance the growth of knowledge in the profession” (Gysler et al., 1971, p.2).
Another significance of seeking active discussions about epistemology lies on exploring concrete development of knowledge that will combine theory with practice in education. Schön (1987) challenged the positivist belief, and offered a new epistemology of practice as a re-thinking of education through reflective practice. He explained that professional practice throughout design and technology and elsewhere has to face and deal with problematic situations. He proposed an epistemology of practice implicit in the artistic and intuitive processes, which some practitioners bring to situations of uncertainty, instability, uniqueness, and value conflict (Broadbent, 1995; Cross, 2001). Schön’s idea was supported by Rorty who claimed all knowledge is a social construct. As a postmodern pragmatist, Rorty believed that “thought can only be justified in the realm of action, and that it can only be justified by successful action in a democratic society” (Linn, 1996, p. 43). His main concern is focused on self-creation, not on self-discovery.

One of goals of this study is to identify how important it is to have a concrete epistemology to understand the complex and uncertain world around us, and to cope with all problems in design. Having a different epistemology will finally make a huge difference in the way of understanding the world, and the designers’ attitude toward design and learning itself. Along with postpositivism and the new epistemology of action,
this study will, therefore, focus on constructivism; an epistemology which believes that knowledge comes from the constructive learning process of an individual, not from the transmitted and passive learning process. Constructivism is an umbrella term covering diverse theories based on postpositivism, and primarily centered on the nature of knowledge and the cognitive subject (Schwandt, 1994). The origin and diverse theories of constructivism will be discussed in Chapter 3. The following section will discuss how the changed contexts of the design disciplines and new epistemology can bear meanings for the formation of design knowledge and its learning process.

2.3. Design Knowledge and Design Learning

2.3.1. Design knowledge

The questioning toward new epistemology continues to identify design knowledge and designing. There are many discussions about various forms of design knowledge. Several studies (Heylighten & Neuckermans, 1999; Morf, 1998; Dorst & Kijkhuis, 1995; and Giard & Gilles, 2001) present different categories of knowledge: explicit or tacit knowledge, and declarative or procedural knowledge. Explicit knowledge is knowledge we can easily show or explain to others, whereas tacit knowledge is one
that we build up over our lifetime; tacit knowledge comes only when the knower and the knowing become one. Declarative knowledge is described as knowledge of some object, event, or idea; it is also understood as knowledge of “knowing that.” Procedural knowledge is regarded as “knowing how” (Novak, 1998).

There are two knowledge modes and two ways of knowing. Firstly, most knowledge practice is focused on collecting, distributing, re-using, and measuring existing codified knowledge and information; it is called knowledge creation and managing/developing mode. This is a passive mode of considering knowledge as a matter of the observed object alone. For this knowledge, the way of knowing becomes a definitive type requiring an additive process of learning, which is a similar process to assembling mechanical objects. Another mode of knowledge is a generative type that considers knowledge to grow through the incorporation of new experiences and differentiation; it can be explained as naturally grown trees. The generative model of creating and utilizing knowledge has strong relations with constructivist approaches to context-based and learner-centered learning. The constructivist type of knowing is both embedded in and developed through the activities of designing.
Concerning the importance of understanding different knowledge modes related to teaching and learning, Morf (1998) described, “if it is allowed that different categories of knowledge function according to different modes and that different types of human activity require different types of potential for action, it is certainly possible to elaborate a basis for theorizing teaching objectives” (p. 40).

It seems to be reasonable to consider creating design as “a dynamic balance between two ways of knowing two kinds of knowledge, i.e. between passive knowledge and active knowing of components and concepts” (Heylighten & Neuckermans, 1999, p.217). What is needed for learning design is a harmonious and continuous integration of “knowing that” and “knowing how.” This uniqueness of perceiving and acquiring design knowledge needs to be discussed as pragmatic and practical ways with studies as follows.

Under the theme of reflection-in-action as a new epistemology, Schön (1987) tried to integrate the separations between subject and object, research and practice, and knowing and doing. He sees design as a reflective conversation with the situation and emphasizes the practitioner’s reflective conversation, which can integrate harmoniously the oppositions between theory and practice, knowledge and action. Schön called this professional knowledge as the artistry of design practice (Dorst & Kijkhuis, 1995;
Valkenburg & Dorst, 1998). From his view, conversation at design studio courses is regarded as a form of reflective conversation. The instructor and the student speak both the language of design and that of doing design, which involves sketching and talking. When we speak language about design, it becomes a kind of meta-language describing the design process and the diverse activities of designing by making it explicit.

Along with Schön’s reflective practice, Giard and Gilles (2001) promote design as Delta knowledge. They explain Delta knowledge is the knowledge of doing, and part of the knowledge of design. As the fourth category of knowledge, Delta knowledge is different from the well-established knowledge counterparts in the humanities, sciences, and social sciences, Alpha, Beta, and Gamma knowledge respectively. The importance of understanding Delta knowledge in design is “knowing how the knowledge of techniques and procedures that apply to collecting, evaluating and interpreting data, creating, proposing, evaluating and selecting idea, making design decision… and communicating its design to technical and commercial interests” (Giard and Gilles, 2001, p. 166).

Understanding Delta knowledge and Schön’s reflective practice can be used as appropriate operational devices and pedagogical vehicles for constructivism, as design educators create, teach, discuss, and evaluate design learning. Although the studio design
projects have proceeded with lots of reflective discussions and evaluations, the lens of Delta knowledge can provide new way of perceiving how design is learned. For example, Giard and Gilles (2001) suggest writing a learner’s report. The learner’s report is used as a co-operating tool between the instructor and students. By writing a learner’s report, the student begins to reflect the process of designing, and enhances and reinforces the design experience. Through this cognitive experience, “students become aware of inconsistencies, misinterpretations, and gaps in information…the learner’s report is a tool that assists the student in learning to learn” (p. 167).

2.3.2. New Design Learning

No matter how differently categorized or named such as reflective knowledge, Delta knowledge, or the 3rd discipline (Archer, 1979), there has been a common denominator in that design is referred to as a unique learning activity different from other disciplines. This uniqueness of acquiring design knowledge comes generally from knowing by doing with practical knowledge and intuitive abilities.

In addition to this practical and pragmatic aspect of design knowledge, Buchanan (2001) suggested a term of new learning as an opening pathway to “the neoteric
disciplines that we need if we are to connect and integrate knowledge from many specializations into productive results for individual and social life” (p. 7). Because the contemporary nature of the design discipline “brings together knowledge from so many other disciplines and integrates it for the creation of successful products that have impact on human life” (p. 17), design needs to move away from old learning, which “was theoretical and oriented towards subject matters, marked off from each other by principles and causes that were in the nature of Being” (p. 5).

Borrowing from Buchanan’s idea, this study uses a term of new design learning as an integrated concept of constructivist design learning for educating and making students/designers to be translators and interlocutors solving increasingly complex design problems in the Information Era. In this study, therefore, the meanings of new design learning are; (1) to deconstruct the traditional boundaries of design learning contents or methods; (2) to reconstruct the nature of design and its activities by integrating knowledge from many disciplines; (3) to produce meaningful interpretations within a postmodern design context; and (4) to implement design knowledge that comes from knowing by doing.
2.4. Epistemological Links with Design Education Model

2.4.1. Epistemology and Reforming Design Education

Related to the issue of reforming design education, there have been several studies reflecting new curriculum development from epistemological perspectives. Levy (1990), Buchanan (1993), and Handenhoven (2001) suggest changing design curriculum as a new form of intelligence and thinking structure including Humanities and other areas. Based on the minimum requirements for design education, Levy (1990) suggested design curriculum would be “a carrier of value constructs, ethical ideals, technical and scientific know-how, social and political concerns, economic imperatives, environmental awareness, and historical consciousness” (p. 52). His suggestion of design curriculum is closely related to Buchanan’s new design learning. As long as design serves as an intellectual crossroads where diverse knowledge meets, design education needs to be changed “to become an integrative educational field, a liberal art for the next century” (Handenhoven, 2001, p. 164).

Another reforming model is Pearce and Toy’s (1995) education model for architecture education today. As a semiotic approach, their education model is generated from the idea of biological dialectical model “with certain growth, mutation and
transformation in a boundless and mapping field of possibility” (p.7). This model “loses
the definition of what is and what is not architecture and in this inherently creates both
the diversity and accompanying anxiety/paranoia of architectural education today” (p.7).
Pearce and Toy’s model perceives that the design learning itself is generative.

Although this study does not deal with curriculum development, discussing Levy
and other researcher’s studies provide strong evidence on how important it is to
understand different epistemological perspectives and their influences to the
contemporary educational changes. With a new epistemology, contemporary design
researchers either position the Humanities as a new core curriculum in design learning, or
emphasize generative learning by emphasizing boundless interconnectivities of
knowledge and experience. They believe that these kinds of epistemological approaches
can reform and reconstruct the field of design to cope with the complexity.

2.4.2. Concept for Design Education Model I

Based on these premises of design knowledge and new design learning, this
study needs to illustrate a way of developing a new design education model linked with
new epistemology. First of all, for the development of a design education model, we need
to reconsider four contextual features in the postmodern world, which are captured from the previously explained changes in both design industries and education. These four ideas are: connection, heterogeneity, and flexibility and morphogenesis. The three ideas of connection, heterogeneity, and flexibility are repeatedly emphasized in the previous studies as key elements of emerging design paradigm in the postmodern context. The fourth concept of morphogenesis is rooted in Pearce & Toy’s (1995) generative design learning. It represents living organisms, and deals with the natural and generative features of design learning. The idea of morphogenesis comes from the notion that the knower and the known are interactive, and the learning itself is very generative (Lincoln & Guba, 1985).

The four contextual features of learning illustrate a conceptual framework in the postmodern context, and we need some propositions to describe the way of creating a design education model for this study. Based on the previous literature review, three propositions for developing the new design education model can be selected as: (1) Learning how to learning is more important than learning that. It is hypothesized that constructivist philosophy and theories can provide a balanced integration of theory and practice for designers; (2) Design education models ought to link the theory and practice
continuously from a perspective of a person’s lifelong learning. And design knowledge communities are to be seriously developed for enhancing the quality of learning without any boundaries. For instance, the design schools and companies should acknowledge each other as an equal partner in creating and exchanging design knowledge; and (3) It finally provides a dynamic reinforcement to the student and the designer for shaping their attitudes fitting well to the present and future knowledge-based society.

<table>
<thead>
<tr>
<th>Four Contextual Features of Learning</th>
<th>New Design Learning Propositions &amp; and Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Connection</td>
<td>(1) Learning how to learning is more important than learning that. → Constructivism, Learner-Centered and Generative Learning</td>
</tr>
<tr>
<td>(2) Heterogeneity</td>
<td>(2) It ought to link the theory and practice continuously throughout the lifelong learning. → Build and use design knowledge communities, Equal partnership between design school and companies.</td>
</tr>
<tr>
<td>(3) Multiplicity</td>
<td>(3) It provides a dynamic reinforcement to the student and the designer for shaping their attitudes fitting well to the present and future knowledge-based society. → Reflective knowledge and action Cognitive and meta-cognitive learning</td>
</tr>
<tr>
<td>(4) Morphogenesis</td>
<td></td>
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</table>

Table 2.3. Four contextual features and propositions for developing design education model
Table 2.3 summarizes four contextual features of learning and propositions for developing design education model, which emphasizes learner’s generative and discovery-oriented learning. Based on these features and propositions, this study suggests two design education models: The first design education model I, in Figure 2.2, expands the infrastructure of design education from the formal educational institutions to the lifelong learning and cultural education. Design education has been developed mainly for higher education, and the higher education-oriented system has contributed to serve its main role in developing design as a discipline and to confirm the social status of design as a specialized profession. However, the 21st centuries’ design education can be no longer confined to higher education-oriented system only producing professional designers. With four contextual features of connection, heterogeneity, flexibility, and morphogenesis, the design education model I draws a learner’s generative learning through his/her lifelong learning process.
Figure 2.2. Design education model I (modified from Kwon, 2001)

The expandability of design education model I is multi-lateral and multi-layered. Interdisciplinary design curriculum needs to be expanded to educate those who are not designers but understand and support design, such as marketers, engineers, and politicians. As an expansion of life-long leaning, the professional designers in industry are highly demanding re-education system to continuously learn the rapidly progressing technology and the design knowledge. Another expansion is K-12 education, where creative ideas and qualifications to design need to start by emphasizing design-based learning. In addition to these institutional educations, the design education in culture for the public should be considered as important in building up its infrastructures of design.
education; such as museums, art centers and design councils can be crucial parts for constructing design culture as a third-part of education. Design and culture maintain a special relationship because design can naturally connect the daily life with the discipline under the original characteristics of pluralism, practicality, and applicability. In this sense of possessing a big structural frame, the quality of design education can be enormously enhanced through interactive connections among various kinds of knowledge and experiences through its multi-lateral and multi-layered learning.

In summary, this study will develop two design education models and several design learning models in later chapters on the basis of the emerging epistemological perspectives. The design education model I in Figure 2.2 emphasizes on: (1) the inclusion of diverse learning possibilities in educational boundaries for deeper understanding and bridging diverse knowledge areas in new design learning; and (2) the expansion of the breadth of design knowledge communities through life-long learning.

Similarly, the design education model II, discussed in Chapter 5, can be realized and promoted by the development of digital technology. The computer and networking technology expand and challenge the philosophies of constructing learning in a classroom or a design studio. Because communication and interactions in the Internet are horizontal
rather than vertical, learning in networked environment becomes more democratic and learners have more control of their learning (Lai, 2000). Therefore, the development of digital technology can radically reform the role and the boundary of design education with the four contextual features of connection, heterogeneity, flexibility, and morphogenesis.

This technology-mediated education model will be discussed after reviewing constructivist theories (in Chapter 3) and the cognitive aspects of computer technology (in Chapter 4).
CHAPTER 3

CONSTRUCTIVIST LEARNING THEORIES

3.1. The Nature of Constructivism

The previous chapter reviewed how different epistemologies provide different perspectives about the nature of knowledge. It is also discussed that constructivism is acknowledged as an appropriate epistemology to deal with the complex, uncertain, and changing features of design knowledge in the postmodern world. This chapter will discuss epistemological and pedagogical characterizations of constructivism, and investigate how constructivist learning theories are associated with new design learning.

3.1.1. Constructivists’ Landscape

The dominant character of the constructivists is committed to question of knowing and being. This constructivist thought owes a great deal to research and theory
in diverse disciplines of psychology, linguistics, anthropology, neurosciences, computer science, education, and philosophy. Although constructivism becomes a currently dominant word in these disciplines especially in the second half of 20th century, the way of using the term “constructivism” are diverse and it covers a wide range of thought; for instance, different research groups understand “social constructivism” with different meanings. Therefore, in order to specify the research boundary of this study, it is very important to create a map of the terrain where diverse constructivist thoughts have developed.

The term constructivism has been referred to two different things, (1) social constructivism/social constructionism; and (2) psychological/cognitive constructivism. Although both of them have the same epistemology for rejecting foundationalism, each of them is significantly different in its own attitude. The first constructivism “embodies a thesis about the disciplines or bodies of knowledge that have been built up during the course of human history” (Phillips, 2000, p. 6). The constructivists in this area believe that knowledge is not determined by the objective reflections of an external world, but by things such as politics, ideologies, values, and religious beliefs. This broad area of constructivism is named as social constructivism or social constructionism. Social
constructionism attempts to break away from traditional Western dualism “by viewing the knower as part and parcel of socially constituted knowledge” (Petraglia, 1998, p. 111). Social constructionism, therefore, reflects an anti-foundationalist epistemology based on a social theory of knowledge. The extreme version of social constructivism was developed by a group called as the “Edinburgh School” of sociologists of knowledge (Phillips, 2000), and their approach was entirely accounted for knowledge out of social relations within sociological contexts. This extreme version of social constructivism is recognized as radical, and another version of social constructivism led by social psychologist George Herbert Mead as less radical. Mead said, “all objects are open to creative reconstruction” (Garrison, 1998, p. 50) in the pragmatic construction zone, where the relationship between the self and the world is mutually transformed in the transaction. As pragmatic social constructivists, the scholars like him possessed progressive positions in which radical and moderate ends of the constructivist spectrum are bridged.

Another constructivism refers to a set of views of how individuals learn. The constructivists in this area believe that knowledge is actively made and constructed by the learners; and it is called psychological/cognitive constructivism. Phillips (2000) named
this area “as psychological, because the center of interest is the psychological understandings of individual learners” (p. 7). No matter whether we name this area of constructivism as psychological or cognitive, it has been explored in two basic areas: cognitive and social constructivism. The cognitive constructivism focuses mainly on individual learning and his/her meaning construction. The constructivists in this area tend to draw insight from Jean Piaget and focus on individual constructions of knowledge discovered in interaction with the environment (Morf, 1998; Fleury, 1998). Ernst von Glasersfeld (1984) explained that constructivism began with the assumption that all cognitive activity took place within the experiential world of a goal-directed consciousness. The meaning of ‘goal-directed’ in his assumption involves the following reason.

A cognitive organism evaluates its experiences, and because it evaluates them, it tend to repeat certain ones and to avoid others. The products of conscious cognitive activity, therefore, always have a purpose and are, at least originally, assessed according to how well they were that purpose. (p. 32)

Based on this philosophy, Glasersfeld (1984) called this cognitive version of constructivism as “radical constructivism.” From his viewpoint, the cognitive constructivism is radical “because it breaks with convention and develops a theory of
knowledge in which knowledge does not reflect an objective ontological reality, but exclusively an ordering and organization of a world constituted by our experience” (p. 24). However, his advocacy of radical constructivism seems to be not accepted well by most researchers in the field of psychology and education; they prefer the term cognitive or psychological constructivism to radical constructivism.

The second psychological constructivism focuses not only on individual learning, but also on social influences into the story to account for how it is that individuals construct the knowledge that they do (Moll, 1990). Based on Lev Vygotsky and his Soviet colleagues’ studies, these socially oriented psychological constructivists are called “social constructivists.” In spite of having the same name, this socially oriented psychological constructivist is totally different from the social constructivist described previously as the first category of constructivism. Vygotsky’s social constructivism highlights the influences of social and interactive culture on individuals’ learning, rather than promotes social theories of knowledge radically.

The diversity of extreme and moderate variants of constructivism generates a great deal of confusion unless we do not successfully identify the differences among them. Petraglia (1998) emphasized a tension between the two social constructivists’ account of
knowledge and implications for the education: “the social/psychological constructivist’s ultimate interest is in the individual learner and the social constructionist’s attention is to the social forces that act on individuals” (p. 111). The psychological constructivists’ attempts to understand and to support individual learners are pragmatic and applicable as pedagogy, while the social constructionists’ understanding often seems incapable of addressing issues of individual agency.

Table 3.1 summarizes the diverse spectra of constructivism from its radical approach to the psychological. This classified map is important to identify the scope of this study; within the broad constructivist’s landscape, this study focuses only on the area of psychological constructivism. Both the radical and moderate social constructivism are not included, because they take into account the epistemological dimension of a constructivist metatheory rather than offering an alternative theory for design learning.
<table>
<thead>
<tr>
<th>Theoretical Framework</th>
<th>Social Constructivism</th>
<th>Psychological Constructivism *</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Radical</td>
<td>Moderate</td>
</tr>
<tr>
<td>Anti-foundationalism,</td>
<td>Anti-foundationalism,</td>
<td>Anti-foundationalism,</td>
</tr>
<tr>
<td>Social theory of knowledge</td>
<td>Pragmatic Social psychology</td>
<td>Cognitive psychology</td>
</tr>
<tr>
<td></td>
<td>Edinburgh School</td>
<td>George Herbert Mead, John Dewey</td>
</tr>
<tr>
<td>Ancestors</td>
<td>Karl Marx</td>
<td>Kant</td>
</tr>
</tbody>
</table>

Table 3.1. Constructivist landscape (* means the research boundary in the study)

3.1.2. Constructivist Epistemology

Basically, constructivism has multiple roots in the psychology and philosophy of the 20th century. Constructivism is not prominent in the field of philosophy, but philosophers provide constructivist thought to epistemology as the branch of philosophy that deals with theory of knowledge and knowing. In order to characterize epistemological constructivism from historical context, Howe & Berv (2000) outlined Kantonian constructivism and post-Kantonian constructivism from their perspective on positivism. Based on Kant’s theory of synthesizing empiricism and rationalism,
Kantonian constructivism ushered in the true sense of constructivist epistemology. Post-Kantonians, led by Wittgenstein, denied having a dualistic view such as dividing mind and language, and emphasized that knowledge is conceived as inter-subjective. According to Howe & Berv (2000), the response of epistemological constructivists was not “to provide a solution to the question of how the world hooks up with mind and language. Rather, they reject this question as fruitless and misguided because based on untenable dualism between the world and human’s construction of it” (p. 25-6).

From its historical debate on positivism and postpositivism, the constructivists have refused old separations between mind and language and between subject and object (Greene, 1994; Fleury, 1998; Denzin & Lincoln, 2000). The historical progress of constructivist epistemology relocates our epistemological stance to an individual’s representation of the world rather than to objective reality.

Unlike in the field of philosophy, constructivism has been prominent in the field of education. Constructivist epistemology is more clearly identified in the field of education, when we compare it with different epistemology, objectivism. Objectivism is the most frequently used term by many educational psychologists and technologists as the antonym of the constructivist theories (Duffy & Jonassen, 1992; Petraglia, 1998;
Noddings, 1998). The important metaphysical assumption of objectivism is that the world is real, and the learning consists of assimilating that objective reality (Jonassen, 1992). The objectivist’s goal of understanding is to know the entities, attributes, and relations that already exist; in other words, it is to know the independent existence of information and acquisition of that information. The content of “what is to be learned” is considered to be a stable entity that can be organized into a structure involving a series of learning steps. The objectivist view that the role of the teacher is to transfer or transmit knowledge to a student, and the student is passive for their learning.

Constructivism provides an alternative epistemological view to the objectivist’s tradition. Constructivism claims that reality is more in the mind of the knower, and that the knower constructs a reality, or at least interprets it, based on his/her experiences (Jonassen, 1992). The constructivist’s approach incorporates the notion that learners build knowledge through personal experience and apprenticeship into the real-world contexts. This approach is radical, because constructivism refigures the relationships among the object, the knowledge, and the knower. Meaning is imposed on the world by us, rather than existing in the world independently of us (Duffy & Jonassen, 1992). Since knowledge cannot be understood as a direct apprehending of reality, constructivists focus
on the transformation of knowledge, instead of transmission of it. For the development of learning theory, constructivists become aware of the importance of experience in which an idea is embedded, and emphasize the way of situating cognitive experiences in authentic activities. This authentic learning, one of the most frequently cited features of a constructivist education, views “education as an extension of national economic and social policy, and the applicability of learning to the world” (Petraglia, 1998, p. 4), which decontextualizes learning from the objectivist base. In the situated learning context, constructivists emphasize each student’s active learning rather than passive, and encourage his/her participating in and interacting with the surrounding environment in order to create a personal view of the world. The following Table 3.2 summarizes the comparative features of objectivism and constructivism.

At the end of Table 3.2, two education models are compared as a representing model of each epistemology: “knowledge transmission model,” and “knowledge transaction model.” Acknowledging the constructivist’s landscape and its different epistemological view promotes a knowledge transaction model as an alternative education model. This transaction model has generated an emerging educational issue of “student-centered learning,” which brings students to the center of the education, and requires
design educators to develop new teaching methods or tools through which students’
internal and cognitive developments can be enhanced. The transaction and learner-
centered model of education is the epistemological base for this study.

<table>
<thead>
<tr>
<th>Reality</th>
<th>Objectivism</th>
<th>Constructivism</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Externally mediated reality</td>
<td>Internally mediated reality</td>
</tr>
<tr>
<td>Contents</td>
<td>“What to be learned”</td>
<td>“Learn how to learn”</td>
</tr>
<tr>
<td></td>
<td>as a stable entity</td>
<td>learning by problem-solving</td>
</tr>
<tr>
<td>Learning</td>
<td>Linear and sequential</td>
<td>Non-linear and Collaborative</td>
</tr>
<tr>
<td>Environment</td>
<td>Experimental</td>
<td>Authentic</td>
</tr>
<tr>
<td>Instructor</td>
<td>Transfer or transmit knowledge</td>
<td>Build knowledge through personal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>experience</td>
</tr>
<tr>
<td>Learner</td>
<td>Passive</td>
<td>Active</td>
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<tr>
<td>Education Model</td>
<td>Knowledge Transmission Model of</td>
<td>Knowledge Transaction Model of</td>
</tr>
<tr>
<td></td>
<td>Education</td>
<td>Education</td>
</tr>
</tbody>
</table>

Table 3.2. Comparative features of objectivist and constructivist views

3.2. Two Constructivism and their Learning Theories

Generally speaking, constructivist’s learning theories have been primarily
originated from the work of Jean Piaget and Lev Vygotsky during the first half of the
20th century, whose research founded cognitive constructivism and social constructivism, respectively. This chapter reviews these cognitive and social approaches of constructivism.

3.2.1 Cognitive Constructivism

Petraglia (1998) explained, “European psychologists such as Piaget, Bartlett, and Vygotsky focused on individuals’ mental processes, the way in which individuals actively pieced together meaning from information in accordance with prior experiences and understanding” (p. 42). Piaget insisted that we couldn’t study knowledge without studying the knower, because all knowledge is constructed, neither received nor innate. In keeping with Kantian roots, Piaget posited cognitive structures that described mental activities in each stage of development. Thereafter, contemporary cognitive constructivists tend to draw insight from Piaget and they believe that “learning is a constructive process in which the learner is building an internal representation of knowledge, a personal interpretation of experience” (Bednar et al., 1992, p. 21).

Piaget’s perspective on constructivist learning can be identified as two important features: “schema theory” and “developmental theory.” Firstly, Piaget investigated the way in which learners use schema to construct meaning and developed the
constructivist’s process to thinking. A schema functions as a type of memory unit that stores information in associated webs and assists to interpret incoming information by judging what seems to be relevant and what can be ignored as irrelevant (Petraglia, 1998).

Piaget also identified the structure of mind underlying cognitive behaviors of each stage of mental development, and developed the theory of cognitive assimilation, accommodation, and adaptation of schema. This is an extended thought of how schema functions. The schematic development leads each individual’s ability to assimilate and accommodate, and act on new information. As an example, he related “the structures of mind to abstract structures of mathematics, biological structures to cognitive structures, and structures of the intellectual development of the race to those of individuals” (Petraglia, 1998). Based on his theory, Piagetians believe that cognitive development proceeds in stages and that each stage is characterized by a distinctive cognitive structure. “This fundamental structure acts as a mechanism to assimilate knowledge and to build substructures” (Noddings, 1998, p. 17).

Piaget’s cognitive constructivism has been also confronted with objections. For example, it is criticized that Piaget’s work concentrated too heavily on the individual child’s interactions with objects. Schema theory is constructivist in nature, but “its
emphasis on the individual’s active learning process omits consideration of the social context of learning and leaves unchallenged the assumption that an objective social reality exists about which to actively learn” (Fleury, 1998, p. 169). Even inside of cognitive constructivist camp, many educators point out that most of learning come from one another than from the direct manipulation of objects. This social aspect of learning, neglected in Piaget’s work, has been heavily drawn on Vygotsky’s social constructivism.

3.2.2. Social Constructivism

Another approach of psychological constructivism is traced back to the work of Soviet psychologist Lev Semenovich Vygotsky. In the 1920s and 1930s, Vygotsky and his colleagues challenged the Pavlovian paradigm based on conditioning and reflex; Vygotsky’s sociohistorical psychology rejected conditioned reflex and behavioralistic approaches to learning (Moll, 1990; Petraglia, 1998). As an anti-foundationalist, Vygotsky denied the objectivist epistemology and emphasized social interaction rather than the subject-object interaction, which was so prominent in Piaget’s work. Vygotsky (1978) described the higher forms of human behavior and mechanisms by which culture became a part of each person’s nature. He explained, “human learning presupposes a
specific social nature and a process by which students grow into the intellectual life of those around them” (p. 88). Using Wetsch’s explanation, Petraglia (1998) summarized Vygotskian thought in three general assumptions as follows:

(1) A developmental approach to cognition is required to understanding human learning; (2) An individual’s mental functioning is derived from social interaction. A learner’s cognitive behavior is an internalization of the social practices he or she has experienced; and (3) Sociohistoricism is closely tied to the belief that social practices are mediated practices that are dependent on the physical and mental tools and symbols that the learner uses to engage in them (p. 43).

These three assumptions express that the basic assertion of the Vygotskian theory is in the social learning, “the result of interiorization of social signs, and of the internalization of culture and of social relationships” (Blanck, 1990, p. 44). Internalization is one of the most important of Vygotsky’s concepts relevant to social determination of learning. This concept can be explained in detail with Vygotsky’s famous constructivist learning theory: “interaction of social and psychological/cognitive planes,” and “Zone of Proximal Development (ZPD).”

Firstly, in Vygotsky’s theory, a child’s development appears twice on two planes: the social and psychological plane. At the social plane, children can perform certain tasks under social settings with the help of others. Later, the same functions appear at the
psychological level and can be activated by the child (Noddings, 1998; Blanck, 1990). The student’s development appears among people as an inter-psychological category, and then within the students as an intra-psychological category (Vygotsky, 1978; Tudge, 1990). At the interpersonal or inter-psychological level, a student’s construction of knowledge is preceded by his/her internalization of social relations. For the effective socialization, the social tools such as language and other sign systems play important roles in learning.

Secondly, Vygotsky created a concept of Zone of Proximal Development (ZPD) representing the distance between two conceptual levels of cognitive zone: the real level of development and the potential level of development. Vygotsky (1978) defined the ZPD as “the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers” (p. 86). As an example of child development, ZPD becomes the cognitive zone in which children can work with more knowledgeable peers to perform tasks that they can go on to perform independently. Within ZPD, “children can act as apprentices, guided toward greater proficiency in performing tasks by mentors who are more experienced participants in the
activity than the learner” (Petraglia, 1998, p. 45). One of significant contributions of Vygotskian sociohistoricism is its embedding of learning in everyday cultural practices. Vygotsky linked formal and informal learning environments by promoting social interaction, which connected the student with the student’s life outside the classroom.

Contemporary cultural-historical scholars have elaborated on Vygotsky’s ideas, adding the other contextual dimensions and expanding the concept of context in relation to cognitive activity. For example, Gallimore and Tharp (1990) presented an extended description of learning progress based on the ZPD theory, which was consisted of four stages: (1) where performance is assisted by more capable others; (2) where performance is assisted by the self; (3) where the performance is developed, automatized, and fossilized; and (4) where deautomatization of performance leads to recursion through the zone of proximal development. In Figure 3.1, Gallimore and Tharp’s model shows how ZPD can be extended to progress each student’s performance with four stages. Similarly, the design learning can be interpreted as the development of each student’s performance with inter-personal and intra-personal activities with ZPD. This learning is iteratively developed and has a recursive loop.
Figure 3.1. The genesis of a performance capacity: progression through the ZPD (Gallimore & Tharp, 1990, p. 185)

3.3. Contemporary Issues in Constructivism

Contemporary constructivism arrived after the late 1970s, and gradually progressed in the 80s and 90s. The educational psychologists and technologists who adopted constructivism have developed diverse learning theories and practical applications: the area of cognitive flexibility by Spiro and his colleagues (1992); and the
generative learning by Cognition and Technology Group (1992, 1998) at Vanderbilt
University. These learning theories will be discussed in detail in next chapter with a
theme of computers as knowledge-building and cognitive tools. Combined with computer
technology and the Internet, constructivism has become a center of creating new vision of
learning and developing new theories and its applications in the classroom. A big debate
between the leading instructional design researchers and constructivists appeared in the
May 1991 issue of *Educational Technology* journal provided a new perspective for a
richer and more meaningful understanding of constructivist learning and the way of using
digital technology in the Information Age.

From the literature review, the currently discussed issues and theories of
constructivist learning are collected and classified into four categories in Figure 3.2. This
study focuses on these four issues of contemporary constructivist’s theories: student-
centered learning/self-authorship, authentic/situated learning, collaborative learning, and
synchronous/on-line learning. The first three issues are discussed in this section, and the
last issue related to digital networking technology will be discussed in the Chapter 4.
3.3.1. Student-Centered Learning

Inspired by Piaget and Vygotsky, constructivists figured that learners must be active participants in the learning process because they are the ones who experience the activities with the learning materials for construction. This acknowledgement of the active nature of students’ learning is also found in diverse references with keywords as empowerment, student centeredness, self-authorship, and participatory education. The learning-centered approach focuses on students’ experiences as a context for introducing,
working with, and constructing knowledge whereas the teaching-centered approach focuses on knowledge acquisition and control (Baxter Magolda, 1999). Instead of emphasizing lecturing and telling by instructors, therefore, constructivists encourage the students to be engaged actively in establishing and pursuing their own learning objectives.

In 1995, the American Psychological Association (APA) announced “14 learner-centered psychological principles.” These principles have begun to provide a foundation for educational reform and transformation across age levels and organizations. Therefore, it is very important to understand the content and background of developing these principles for creation of a framework of new constructivist design learning to this study. The APA explains the importance of developing the ‘learner-centered psychological principles’ as follows.

The following principles, which are consistent with more than a century of research on teaching and learning, are widely shared and implicitly recognized in many excellent programs found in today's schools. They also integrate research and practice in various areas of psychology, including developmental, educational, experimental, social, clinical, organizational, community, and school psychology. In addition, these principles reflect conventional and scientific wisdom. They comprise not only systematically researched and evolving learner-centered principles that can lead to effective schooling but also principles that can lead to positive mental health and productivity of our nation’s children, their teachers, and the systems that serve them… Learner-centered psychological principles provide a framework for developing and incorporating the components of new designs for schooling. These principles emphasize the active and reflective nature of learning and
learners. From this perspective, educational practice will be most likely to improve when the educational system is redesigned with the primary focus on the learner (http://www.apa.org/ed/lcp.html).

Table 3.3 shows the 14 learner-centered psychological principles, where are classified into four factors: cognitive and metacognitive factors, motivational and affective factors, developmental and social factors, and individual difference.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Learner-Centered Psychological Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive and Metacognitive</td>
<td>1. <strong>Nature of the learning process</strong>: The learning of complex subject matter is most effective when it is an intentional process of constructing meaning from information and experience.</td>
</tr>
<tr>
<td>Factors</td>
<td>2. <strong>Goals of the learning process</strong>: The successful learner, over time and with support and instructional guidance, can create meaningful, coherent representations of knowledge.</td>
</tr>
<tr>
<td></td>
<td>3. <strong>Construction of knowledge</strong>: The successful learner can link new information with existing knowledge in meaningful ways.</td>
</tr>
<tr>
<td></td>
<td>4. <strong>Strategic thinking</strong>: The successful learner can create and use a repertoire of thinking and reasoning strategies to achieve complex learning goals.</td>
</tr>
<tr>
<td></td>
<td>5. <strong>Thinking about thinking</strong>: Higher order strategies for selecting and monitoring mental operations facilitate creative and critical thinking.</td>
</tr>
<tr>
<td></td>
<td>6. <strong>Context of learning</strong>: Learning is influenced by environmental factors, including culture, technology, and instructional practices.</td>
</tr>
</tbody>
</table>

Table 3.3 Learner-Centered Psychological Principles (http://www.apa.org/ed/lcp.html)
### Table 3.3 continued

| Motivational and Affective Factors | 7. **Motivational and emotional influences on learning.** What and how much is learned is influenced by the learner's motivation. Motivation to learn, in turn, is influenced by the individual's emotional states, beliefs, interests and goals, and habits of thinking.  
8. **Intrinsic motivation to learn.** The learner's creativity, higher order thinking, and natural curiosity all contribute to motivation to learn. Intrinsic motivation is stimulated by tasks of optimal novelty and difficulty, relevant to personal interests, and providing for personal choice and control.  
9. **Effects of motivation on effort.** Acquisition of complex knowledge and skills requires extended learner effort and guided practice. Without learners' motivation to learn, the willingness to exert this effort is unlikely without coercion. |
|-----------------------------------|-------------------------------------------------------------------------------------------------|
| Developmental and Social Factors  | 10. **Developmental influences on learning.** As individuals develop, there are different opportunities and constraints for learning. Learning is most effective when differential development within and across physical, intellectual, emotional, and social domains is taken into account.  
11. **Social influences on learning.** Learning is influenced by social interactions, interpersonal relations, and communication with others. |
| Individual Differences            | 12. **Individual differences in learning.** Learners have different strategies, approaches, and capabilities for learning that are a function of prior experience and heredity.  
13. **Learning and diversity.** Learning is most effective when differences in learners' linguistic, cultural, and social backgrounds are taken into account.  
14. **Standards and assessment.** Setting appropriately high and challenging standards and assessing the learner as well as learning progress -- including diagnostic, process, and outcome assessment -- are integral parts of the learning process. |

Combined with student-centered learning, self-authorship has become another key issue to help students construct knowledge effectively for themselves. Baxter
Magolda (1999) defines self-authorship as a complicated phenomenon: “It is simultaneously an ability to construct knowledge in a contextual world, an ability to construct an internal identity separate from external influences, and an ability to engage in relationships without losing one’s internal identity” (p. 12). Unless students are able to connect learning with their lived experiences, it is impossible to generate self-authorship. It is a cognitive, interpersonal, and intrapersonal matter. This is the reason why educators often highlight self-authorship for the learner-centered educational practice. Achieving self-authorship in higher education is also crucial to keep and extend students’ motivation and attitude toward lifelong learning, which makes keeping up with changes in technology, the economy, and the cultural norms.

Identifying individual differences in mental representations and cognitive processes such as learner-centered psychological principles is important for the accomplishment of learner-centered learning. There has been an assumption that “a learner’s cognitive process can be modeled, traced, and corrected in the context of problem solving” (Lajoie & Azevedo, 2000, p.262). Because the learning process is affected by the extent of the learners’ existing knowledge, “instruction facilitates adaptability by building on the learner’s existing knowledge, monitoring learner progress
and rectifying misconceptions when they arise, and fostering the development of metacognitive skills” (ibid, p. 263). Identification of individual differences is currently developed further because the state-of-the-art-of technology and information-processing theory allow educators to include learning-activity-tracing components in the individually customized computer learning system. This tracing component will be applied to the case study and its analysis in Chapter 6.

3.3.2. Situated and Authentic Learning

The second-wave constructivists after Piaget and Vygotsky addressed questions of authenticity as they are related to schooling for learning context. Based on Merleau-Ponty’s exploration of “participative perception” and “situatedness,” Greene (1994) pointed out, “the human being is an embodied consciousness, contextualized, situated in a landscape of an appearing world” (p. 437).

This basic concept of situatedness or “contextualization” focuses on the problem of transferability of knowledge across contexts and the effectiveness of abstract versus concrete instruction. Because human cognition is partially context-dependent and partially context-independent at the same time, we need a deeper understanding of the
circumstances that determine what is learned, when and how is needed, and where the issue learned should be used. The situated perspective operates a methodology for research on situativity relating both to the individual construction of knowledge and knowledge building within a community. In order to immerse learners in situated problem-based learning environments, new methods for how context and situations can be defined and formalized need to proceed. From a number of years of research, the Cognition and Technology Group (CTG) at Vanderbilt University (1991; 1992) has presented several studies on constructive or generative learning in nature. Their theory of learning emphasizes the different ways of thinking of an expert from that of a novice, which is based on Vygotsky’s ZPD theory: experts in any area have been immersed in phenomena, and use their familiar experiences for new theories and principles; novices have not been immersed in the phenomena being investigated, and they are unable to experience the effects of the new information on their own understanding. This difference explains why novices need help to achieve the overall learning goal.

A major goal of generative learning is, therefore, to create shared environments that permit students and instructors to sustain exploration and enable them to understand the kinds of problems and opportunities encountered by experts in various areas and the
knowledge used by these experts as tools. The design principles for creating generative learning environments are to motivate students and make them be immersed into a series of generative problem-solving activities. Related to the theory of situativity, the issue of authenticity becomes important to reconsider the fundamental questions about curriculum and its learning circumstances. Petraglia (1998) emphasizes the authentic as one clear sign of constructivist’s impact on educational discourse as follows.

Following up on constructivist insights into issues such as learner centeredness, the contingency of knowledge, and the importance of social, cultural, and material context, educators have rejected the sterility of transmission assumptions, untouched, by accounts of real people confronting problems in their day-to-day lives (p. 13).

Moll & Greenberg (1990)’s study of creating an authentic learning system with ZPD is another good example of understanding how Vygotsky’s ZPD concept and authentic learning influence the development of social learning and its supportive system. They discussed the importance of identifying various ZPDs and using them as funds of knowledge. Explained in Figure 3.3, they illustrated seven different sources of funds of knowledge, which could be utilized during the module implementation for studying families with a Hispanic working-class community in Tucson, Arizona. Based on the
concept of extended ZPD, the incorporation of funds of knowledge was accomplished by bringing the classroom and the community people who could be reached through the available social networks.

Figure 3.3 Various ZPDs for creating a research/teaching system (Moll & Greenberg, 1990, p. 336)
The social networks connect the classrooms to outside resources, and transform the classroom into a more advanced context of study. Moll & Greenberg added the benefits of their authentic approaches as follows.

There are various household zones of proximal development, manifested different ways depending on the social history of the family and the purpose and goal of the activity. These zones are clearly content- or knowledge-based and rarely trivial…They are authentic…It follows that it is by creating similar authentic activities in schools that we can access these funds of knowledge and investigate their relevance for academic instruction (p. 326).

As a conclusion of the study, they summarized “both the content and process of exchange of funds of knowledge are enormously useful in mediating instruction” (p. 344). This case study demonstrates that the necessary social relationship with outside classrooms can be established in systematic ways within the classroom to enhance the transaction of knowledge among participants, especially students.

3.3.3 Collaborative Learning

Collaborative learning is a cognitive strategy based on the social construction of knowledge, which leads people to deeper processing and understanding than learning without collaboration does. Collaboration becomes an important issue for the
constructivist’s learning and its processes. It is the social and psychological aspects of working conditions that are critical in understanding the concepts associated with partnered or peer learning. Saltiel (1998) defines, “collaboration is organizational or individual entities coming together to work toward a common goal or vision. In collaborative learning, the goal is the acquisition or construction of new knowledge” (p. 7). Vygotsky’s work stressed the benefits of collaboration with more experts or peers because what a student carries out jointly with others could be incorporated into his/her individual problem-solving process. Concerning the effectiveness of collaboration based on Vygotsky’s ZPD concept, Tudge (1990) explained:

In Vygotskian terms, the impact of the immediate social context has both a powerful and a lasting effect. Children who were led to think at a higher level through being paired with a more competent peer achieved that higher level in the course of collaboration and generally retained it in subsequent independent performance. The same, unfortunately, was true of children who regressed in their thinking (p. 163).

Engaging students in collaborative problem-solving projects has been recognized as a powerful method to motivate learners. However, in the field of education, “collaboration has long been a mainstay of fields such as writing, and collaborative pedagogy is still a new frontier of many fields outside the humanities” (Petraglia, 1998, p.
It is digital technology and networking service that open the possibilities of applying the theory of collaboration to the diverse learning situations. The advance of digital technology shows great potentials for changing the ways of students and their instructors to interact with each other in the learning processes. For instance, there are several research studies investigating the development of Computer Supported Collaborative Learning (CSCL) tools to identify how different tools and formats impact social interaction and learning. Bonk, Medury, and Reynolds (1994) categorizes CSCL into five levels of collaboration. These levels range “from electronic messaging to delayed-collaboration tools, to brainstorming tools, to real-time collaborative writing tools, to collaborative multimedia and hypermedia” (Bonk and King, 1998, p. 3). The currently developed electronic collaboration studies support Vygotskian views that “students internalize the scaffolding (students supporting each other’s learning) of more capable peers when collaboratively writing, as well as the cognitive supports or prompts provided by computer tools” (ibid, p. 5).

Contemporary cognitive constructivists emphasize the development of a rational model of cognitive activities of either an individual or a group of individuals through the situated cognitive experiences with digital technology. The linkage between learner-
centered instruction and collaborative learning with technologies is extremely strong to enhance both the cognitive and socio-cultural learning. Chapter 4 will explore diverse tools and research studies related to collaborative learning technologies, and its relationship with cognitive and metacognitive experiences.

3.4 Constructivist Pedagogy & Designing Its Learning

Constructivist pedagogy considers “a matter of creating the developmental conditions that allow students to generate their own ideas effectively, in essence to develop their minds, their voices, and themselves” (Baxter Magolda, 1999, p.8). Constructivist pedagogy incorporates two premises that parallel those of constructivist learning theories: (1) as its starting point, instruction must take the knowledge, attitudes, and interests which students bring to the learning situation; and (2) instruction must be designed to provide experiences that effectively interact with these characteristics of student and construct their own understanding.

Based on these premises, some studies investigate students’ learning processes with a curriculum development and some studies hold attentions on designing the infrastructure for learning and designing student activities (Palloff & Pratt, 1999; Brooks
& Brooks, 1993; Gagnon & Collay, 2001). Among diverse cases, I will discuss two examples of applying constructivist learning theories to curriculum design and students’ learning processes.

Firstly, Brooks & Brooks (1993) suggested a framework of planning constructivist learning as five tenets: (1) posing problems of emerging relevance to students; (2) structuring learning around ideas or large concepts; (3) seeking and valuing students’ points of view; (4) adapting curriculum to address students’ suppositions; and (5) assessing student learning in the context of teaching (Paulson, 2000). These five tenets of curriculum design process seem to be simple, but they include all the issues discussed previously such as student-centered, situated, and collaborative learning. With its emphasis on real-life themes and contextual application of knowledge, curriculum design needs to promote personal and social integration through the organization of curriculum around significant problems and issues. A constructivist curriculum is recognized as a network of ideas and a map. The five tenets of planning curriculum design and the idea of networked map will be applied to the development of constructivist design learning of this study with a case study.
Another example is Gagnon & Collay’s foundational study of constructivist learning design (CLD). Gagnon & Collay (2001) presented a pedagogical guideline for operating constructivist learning in the classroom. Their idea consists of six CLD elements of situation, grouping, bridge, questions, exhibit, and reflections: (1) the situation frames the agenda for student engagement by delineating the goals, tasks, and forms of learning episode; (2) groupings are the social structures and group interactions that will bring students together in their involvement with the tasks and forms of the learning episode; (3) bridge refers to the surfacing of students’ prior knowledge before introducing them to the new subject matter. Students need to refocus their energies on new content when they can place it within their own cognitive maps; (4) questions aim to instigate, inspire, and integrate students thinking and sharing information; (5) an exhibit asks students to present publicly what they have learned; and (6) finally, reflections offer students and instructors opportunities to think and speak critically about their personal and collaborative learning. It encourages all participants to synthesize their learning, to apply learning artifacts to other learning (p. 6).

The relationships among the six elements of CLD are simply summarized as Figure 3.4. Unfortunately, Gagnon & Collay’s proposal of CLD and their six elements are
not profoundly developed to address the cognitive and social constructivist learning theories related to each element’s development; the iterative connections among the six elements were not specified to demonstrate the inter-connective features of constructivism. However, the simple guideline to build CLD captures the essential elements of constructivism. The basic framework of CLD is useful for instructors who need to organize the curriculum and apply the basic process of constructivist learning to the course of a lesson. Their approaches to using six elements of CLD represent theoretical assumptions about constructivist learning, and draw these assumptions on a simple learning activity map.

Figure 3.4. The relationship among CLD elements (Gagnon & Collay, 2001, p. 9)
<table>
<thead>
<tr>
<th>Six Elements of CLD</th>
<th>Precedents &amp; Ideas</th>
<th>Practical Issues /Techniques</th>
</tr>
</thead>
</table>
| Situation (context) | - John Dewey’s situation  
- Maxine Greene’s local knowledge on specific situation.  
- CTG’s generative learning | - framing tasks as real-life experiences  
- situatedness, participative perception  
- authentic learning |
| Grouping (collaboration) | - Vygotsky’s social constructivism  
- Many studies related to cooperative grouping in classrooms | - Committing to using group process or cooperative learning  
- Random or ability grouping |
| Bridges (cognitive, metacognitive skills) | - Piaget’s developmental theory  
- Gagne’s instructional theories (ex: prior knowledge, internal control)  
- Visible materials creation such as Friedrich Froebel and Montessori | - bridging people (conversation, collaboration)  
- technology-supported tools (CSCL)  
- gaining perspectives from others in the process (index cards, journals, letters)  
- using materials to make thinking visible |
| Question (thoughts and thinking) | - Researches addressing hierarchies of questions.  
- Applying constructivist learning: asking students questions that encourage student thinking rather than asking students to recall specific answers. | - questions on problem solving in higher levels.  
- four categories of questions (cognitive memory, convergent questions, divergent questions, evaluative questions)  
- characteristics of questions (guiding, anticipated, clarifying, integrating questions) |
| Exhibit (critical thinking, authentic work) | - Donald Shön’s reflection in action  
- demonstrate student learning through portfolio, exhibition, and performance.  
- formative evaluation | - using the record of thinking  
- valuing and encouraging divergent thinking  
- presentation in the real world |
| Reflection (metacognitive skills) | - John Dewey’s reflective thinking  
- Vygotsky’s sociohistorical learning  
- Donald Shön’s reflection in action  
- a process for integrating new knowledge. | - thinking of individual and collective learning  
- writing a journal for connecting his/her experience to the issues dealt with in the class, gaining perspectives from others in the process  
- conversation with the situation  
- self-assessment, self-authorship |

Table 3.4. Summary of constructivist learning theories and practical issues of designing constructivist learning
To summarize diverse constructivist learning theories and contemporary issues discussed in this chapter, I classify the precedent theories and their theorists on the frame of six elements of CLD. The above Table 3.4 shows the summary of constructivist learning theories and its practical issues discussed in this chapter.

Based on the constructivist learning theories, the following Chapter 4 will discuss diverse characteristics of instructional media in the digital learning environment, and explore the cognitive aspects of digital learning tools and learning theories.
CHAPTER 4

CONSTRUCTIVIST WEB-BASED LEARNING

4.1. Computer-supported Learning Environment

4.1.1. Development of Instructional Media

With the advent of digital technologies, the nature of learning and its environment have been changed dramatically for the last two decades. Ever since technology has created new learning materials that simulate what is happening in the real world, learning with technology provides new learning experiences that are difficult to be realized in a previous learning environment.

Instructional medium has been defined as the physical means via which instruction is presented to learners. The history of using media for instructional purpose in the United States is longer than 100 years. In the early period of the 20th century, the increased interest in using media at the school was referred to as the “visual instruction”
or “visual education” movement (Reiser, 2001a, p. 55). With the technological advance in radio broadcasting and sound motion pictures during the 1920s and 1930s, the visual instruction movement became known as the “audiovisual instruction” movement. With the development of audiovisual media, media studies have been conducted on the attributes of media, media comparison studies, and instructional methods.

The terms “audiovisual instruction” began to be replaced by “educational technology” and “instructional technology” in the early 1970s. Currently, the term instructional technology means computers, videos, CD-ROMs, overhead slide projectors, and other types of hardware and software typically associated with the term instructional media (Reiser, 2001a). With the advent of the computers being used in education, instructional technology specifies diverse applications of media for its instructional purposes, such as Computer-Assisted Instruction (CAI) and Intelligent Tutoring Systems (ITSs). The term of CAI was widely used as an umbrella term for all usage of computers in education. With the advent of courseware building tools from the 1970s, CAI became a new learning (objectivist) paradigm reflecting a positive and programmed instruction, which “delivers the passive acquisition or absorption of an established body of information” (Koschmann, 1996, p. 5). CAI, the idea of programmed instruction, was
developed on the theoretical background of behaviorism and the systems approach of creating instructional design; instruction became a process of transmission and delivery.

Unlike CAI, Intelligent Tutoring System (ITS) adopted Artificial Intelligence (AI) research to apply various aspects of human cognition. However, in spite of applying cognitive aspects of learning, ITS has the same epistemological stance as CAI and reflects a positivist epistemology. Both of them reflect the notions of knowledge as given and of instructors as the final authority.

Generally speaking, the computer has had a major impact on education fields through CAI by the mid-1990s. But Reiser (2001a) argued that, “the impact of computers on instructional practices was minimal, with a substantial number of teachers reporting little or no use of computers for instructional purposes…Despite strong technological influences into the education fields, CAI and ITS were not successful” (p. 60). This slowness of technological adoption in education, however, has changed rapidly with the development of information technology and networking technology since the mid-1990s, especially with the Internet. As a high-speed electronic communication medium, the Internet creates a unified environment for connecting each site or location regardless of time and space. The idea behind the Internet is that every node or site is equal and
provides peer-to-peer communications as explained in Figure 4.1. The equitable accessibility to the information in the Internet provides lots of possibilities to reform the existing educational platform as well. The Internet provides the rich and collaborative learning environment that may exceed the traditional classrooms in its ability to connect students and provide course materials anytime. We can easily identify this uniqueness by comparing the Internet with other instructional media, and this will be discussed in detail in chapter 4.2.

Figure 4.1. Internet connectivity

A technical understanding of the Internet implicates various dimensions with its diverse usages such as e-mail, newsgroups, boards, chats, and the Web. Among these diverse dimensions, the development of World Wide Web (WWW) creates its explosive
expansion of using the Internet. As a method making the Internet accessible to the people, the WWW provides a democratic and easy way of organizing and sharing information on the Internet. Because communication and interactions on the Internet are horizontal rather than vertical, learning in the networked environment becomes more democratic and learners have more control of their learning (Lai, 2000). This enables the learning process to be more interactive among students, between faculties and students, and these interactions ultimately result in collaborative learning.

Therefore, it is assumed that the currently developed computer-supported learning tools can provide new learning opportunities and experiences to the student when combined with constructivist learning theories. The following section investigates the up-to-date computer-supported learning environments and their epistemological and pedagogical implementations.

4.1.2. A Variety of Computer-supported Learning Environments

The emerging paradigm of constructivism has led the development of the computer-supported learning tool and its environment in a totally new approach, which differs from positivistic approach of building CAI and ITS. Especially with social
constructivism, the collaborative and interactive aspects of learning activities are strongly emphasized in the development of computer-supported learning tools. There are a variety of newly emerging computer-supported learning environments; computer-mediated communication (CMC), computer-supported collaborative learning (CSCL), computer supported intentional learning environments (CSILE), open-ended learning environments (OELEs), and multi-user domains (MUDs).

Computer-mediated communication (CMC) refers to the use of networks of the computer to facilitate interaction among spatially separated learners (Jonassen et al., 1995, p. 16). Related technologies for CMC include electronic mail, computer conferencing, and on-line databases to support functions of conversation and collaboration. The most popular application of CMC supports both synchronous and asynchronous group communication (Palloff & Pratt, 1999). In CMC learning, asynchronous discussion is when students post comments to a discussion area on a website at a convenient time; and students read, proceed, and respond to the topic under discussion. Synchronous discussion or chat is a way that all participants log on to a course site at once and interact with each other in real time. Both of these communication methods have become popular with the emerging distance or remote education. In CMC learning, knowledge
construction is fostered through the intentional and goal-oriented behavior, and, at the same time, the database searching procedure “facilitates and strengthens connections between elements of information and that results in higher-order thinking and meaningful learning” (Jonassen et al., 1995, p. 17).

Computer-supported collaborative learning (CSCL) focuses on the way of using technology as a mediation tool with collaborative methods of learning. The idea of CSCL, explained in the Chapter 3.3, has been generated from Computer-Supported Collaborative Work (CSCW), a well-known subfield of research on Human-Computer Interaction. Along with CSCW, CSCL is designed to identify, exemplify, and examine problems with other people who contribute to the achievement of social and collaborative activities (Pea, 1996; Koschmann, 1996). It is the CSCL that brings socio-cultural issues into the foreground as the central phenomena for conducting computer-supported educational studies. CSCL tools help a group of students work with diverse functions such as group decision-making systems, project management tools, and electronic conferencing systems. Following Figure 4.2 is a scene captured from a CSCL course at the Univ. of Texas at Austin. This World Lecture Hall site is designed to provide a variety of courses on the Internet with the intention of providing students with easier access to course materials.
Contemporary constructivists have conducted research on CSCL to investigate how different tools and formats impact social interaction and learning (Bonk & Cunningham, 1998; Pea, 1996). For example, Pea (1996) emphasized the cognitive issues to achieve the objectives of CSCL. He argued that CSCL needed to be expanded from primarily text-only asynchronous electronic mail applications to “the use of complex symbolic representational systems in a discourse workspace between participants” (p. 100).
Multimedia such as shared video, drawing, and data spaces can provide dynamic media features of rich expressions to CSCL, and they increase communication capabilities of CSCL. Bonk, Medury, and Reynolds (1994)’s research further identified the cognitive aspect of CSCL. They categorized CSCL into five collaboration levels. These levels range “from electronic messaging to delayed-collaboration tools to brainstorming tools to real-time collaborative writing tools to collaborative multimedia and hypermedia” (Bonk & King, 1998, p. 3).

The computer supported intentional learning environment (CSILE, pronounced see-sill) attempts to reform student achievements through a variety of learning methods; it includes across-the-curriculum collaborative learning and focuses on group projects rather than lectures (Gilbert & Driscoll, 2002; Jonassen et al., 1999). Developed by Scardamalia & Bereiter at the Ontario Institute for Studies in Education (http://csile.oise.utoronto.ca/), the learning theory behind CSILE is embodied in the network software program used for entering, archiving, and retrieving student research.

CSILE is a comprehensive model for inquiry designed to help students conceptualize and research a problem area. In CSILE, knowledge building is the focus of student activity, and this can be achieved with the construction of new information stored
in the communal database associated with the formulation of research questions. For the university level of CSILE, a new software program called “knowledge forum” (see in Figure 4.3) is developed to support: (1) collaborating; (2) building idea networks; (3) constructing, storing, and retrieving notes; (4) referencing, quoting, and tracking notes; (5) identifying knowledge gaps or advances; and (6) publishing and viewing ideas at the knowledge forum to possess multiple perspectives. This program can be linked with local area network, the Internet communications, and a popular browser using the WWW.

Figure 4.3. Knowledge building features from Knowledge Forum
(http://www.knowledgeforum.com/University/)

Open-ended learning environments (OELEs) mean a learner-centered environment promoting interactive activities based on constructivism. Open-ended refers
to the fact that the students are encouraged to learn as much as they can about the topic, rather than simply to find answers to questions posed by the instructor (Jonassen et al., 1999). A departure from directed learning environments, “OELEs establish conditions that enrich thinking and learning and use technology to support thinking and problem-solving processes” (Hannafin et al., 1997, p. 94). Generally, in the OELEs learning, teams consisting of four or five students use the Internet or other resources such as CD-ROMs and Videodiscs to find information on the assigned subject, and demonstrate what they learned. The goal of OELEs is to immerse learners in rich experiences using various tools, resources, and activities with which they can argue and extend their ideas.

Recently, new forms of Internet-based multi-user environments known as MUDs (Multi-User Dungeon) and MOOs (Object-Oriented MUDs) are recognized as a new learning asset (Dickey, 1999). Originally derived from on-line Dungeons and Dragon environments, MUDs provide an authentic learning environment where students can enter and participate in. With recent developments in virtual reality and multimedia technology, some MUDs and MOOs offer alternative means of accessing information through experiential learning: students can enter the virtual environment and travel to different locations; they take control of a computerized persona/avatar/character, and
even participate in the construction of the environment by creating their own rooms. Although they were primarily originated from adventure games, some MUDs have educational focus and its role-playing aspects present strong effects on student’s self-confidence and sense of self (Jonassen et al., 1999). This is the reason why contemporary researchers recognize MUDs as a new learning asset. With the development of three-dimensional modeling and virtual reality technology, the high interactivity within the three-dimensional virtual world will, therefore, provide MUDs and MOOs more educational values in the near future.

4.1.3. Paradigm Shifts and New Instructional Technology

A history of instructional technology reviewed above suggests that there may be some correlations between the development of media technology and the educational paradigm shifts. Koschmann (1996) investigated the interrelationship between the educational paradigm and new instructional technology in the form of dialectical analyses: thesis, antithesis, and synthesis. These dialectical analyses allowed him to categorize instructional technology into four paradigm shifts: CAI, ITS, Logo-as-Latin, and CSCL. Research studies in the CAI and ITS traditions motivated a new group of
researchers to develop an entirely different philosophy in the use of technology for education. Influenced by Piaget’s cognitive constructivism, Papert (1993) at MIT developed a programming language named Logo and implemented a concept of “sets” from which programs can be made. This concept was developed for the “construction sets” using such as LEGO block products, which associated a learning environment as “sets” with which the construction that takes place in the head. The activity of programming computers with Logo was promoted to create a “knowledge machine” emphasizing mathetic skill (mathematic in use) of constructing concrete knowledge. The knowledge machine is recognized as a symbol of constructionism named by Papert with the connotation of construction set. Recently, constructionists’ pedagogy was realized through a new product, LEGO Mindstorms. Figure 4.4 shows an example of constructing Mindstorms sets.
Similarly, the CSCL paradigm has emerged from the clash of cognitive constructivism and information processing theories of learning. Based on social constructivism, CSCL emphasizes collaborative and authentic learning, and provides diverse collective and collaborative communication tools through multimedia and networking technology. Table 4.1 compares the characteristics of four instructional technologies and their relationships with paradigm shift.
<table>
<thead>
<tr>
<th>Emergence of case</th>
<th>Learning Paradigm</th>
<th>Model of Instruction</th>
<th>Research Issue</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAI</td>
<td>Instruction of Coursewriter I (1960)</td>
<td>Behaviorist</td>
<td>Programmed instruction/instructional design</td>
</tr>
<tr>
<td>ITS</td>
<td>Carbonell’s dissertation (1970)</td>
<td>Information processing theory</td>
<td>One-on-one tutorial, interactive</td>
</tr>
<tr>
<td>CSCL</td>
<td>NATO Workshop (1980)</td>
<td>Socio-cultural constructivism</td>
<td>Collaborative learning</td>
</tr>
</tbody>
</table>

Table 4.1 Comparison between research paradigms and instructional technology (based on Koschmann, 1996, p. 16)

4.2. Internet and the Web as an Emerging Context

4.2.1. Characteristics of the Internet

The history of instructional media and its paradigm shifts explains how the Internet has been apparent in the development of new ways of learning. The dominant feature of the Internet as an instructional medium can be achieved since the general accessibility to the Internet has been increased dramatically through the development of
the WWW. People are getting more and more comfortable with the Internet as a daily tool. For example, the results of a 1998 national survey in the United States revealed that the percentage of schools that had Internet access increased from 50% in 1995 to 90% in 1998. This increased access to the technology doesn’t mean the increased usage of the technology for instructional purposes. But Jonassen et al. (1995) asserted that the increase in the use of instructional media has significant influences on the development of learning in a variety of settings for the variety of instructional purposes. Their research identifies that “compared with traditional instructions led by an instructor up to 80% of verbal exchange, on-line computer conferencing shows instructor contributions of only 10-15% of the message volume” (p. 14). This expanded usage of the Internet addresses that it has changed the structure of communication in the learning process from the teacher-centered to the student-centered.

This changed structure of communication makes the Internet as high quality of instructional medium as well. The Web environment is easily transformed to personal or group exploration spaces where learners control their learning pace and construct knowledge bases by themselves. Students are able to not only access a variety of learning materials in the Internet, but also construct their knowledge through collecting,
organizing, and discussing the learning materials with other students or instructors. This cognitive and socio-cultural aspect of learning increases the value of the Internet in the education, which makes the Internet valuable as a knowledge-construction tool. (The later Chapter 4.3 will discuss the cognitive and knowledge-construction function of the Internet.)

The expanded and interactive communication capabilities of the Web make it easier than ever before to support collaborative learning environments. Although collaborative learning has been studied from the Piagetian pedagogy (Selly, 1999), people realize that learning theory more meaningful with the development of the Internet; the inherent features of Internet such as flexibility and openness have triggered the creation of horizontal and democratic learning environments.

In summary, the development of the Internet and the Web has apparently provided a new way of constructing learning. Digitally connected learning environments allow for: (1) flexible and individualized schedule for learning; (2) the customization and personalization of course and curriculum development; (3) easy access to a vast set of learning materials; (4) increased opportunities for collaboration with experts and with other learners; and finally (5) accessibility and openness from any location at all times.
4.2.2. Different Levels of Using the Internet as an Instructional Medium

There are several ways of adopting the Internet as an instructional medium: for example, a supplementary tool for classroom instruction, or an alternative means of delivery including the use of video, CD-ROMs, Internet websites, CMC, and etc. Generally, the use of technology shall be consistent with the pedagogic and academic judgment of the faculty members as to the appropriateness of the use of technology in the circumstances (Noble, 2001). Massy and Zemsky classified the levels of adopting information technology in higher education into three: (a) personal productivity aids; (b) enrichment add-ins; and (c) paradigm shift (Rogers, 2000). Personal productivity aids are the simplest applications, which allow faster and more effective performance of familiar tasks by the students. Enrichment add-ins provides new materials to the old teaching and learning without changing the basic mode of instruction. Finally, the paradigm shift means that educators and their institutions reform teaching and learning activities in order to take full advantage of new instructional technology.

In their analysis, Massy and Zemsky criticized that the technology adoption to higher education was mostly operated only at level (a) and (b). The role of Internet in higher education, however, can be more than the personal productivity aids and
enrichment add-ins that merely assist to achieve one’s individual knowledge. To achieve the (c) level of information technology adoption for higher education, the educational paradigm should be shifted to reforming the content and context of curricula based on the up-to-date learning theory and technology. The WWW can be a good example to demonstrate how diverse levels of adoption and applications are possible in higher education. Concerning the case of Web-Assisted Instruction (WAI), the Web can be used to supplement face-to-face teaching, and to provide students with easier access to course-related materials (Lai, 1999; Reiser, 2001b): using the Web-Based Instruction (WBI), the Web can deliver courses at a distance, in which the concurrent and dynamic learning with multimedia technology is possible in a hypermedia learning environment. Due to a variety of functions helping learners construct meanings through interactions with objects, events and other people, WBI in higher education requires more complex systems than WAI. The current WBI software such as WebCT provides a computer-mediated communication (CMC) platform, and supports synchronous and asynchronous conference assessment tool and class management tools.

The issue of adopting a high level of information technology in the university has been investigated by contemporary scholars. Gilbert & Driscoll (2002) investigated how
actively the instructional conditions implemented in a graduate course contribute to a collaborative knowledge-building enterprise. In order to identify and understand the learning conditions in the Internet that promoted knowledge building and learning communities, they used a case study of a 15-week semester at Florida State University.

As a conclusion of this study, they provided guidelines for designing collaborative knowledge-building environments with six design features. They are: use scaffolds, track the learning process, balance tension, promote relevance and motivation, promote a shared vision, and promote the acquisition of knowledge. Each design features and its related guidelines are summarized in Table 4.2. Their findings are empirical to assist in the design and development of collaborative, knowledge-building communities with the Internet based tool, especially in the higher level of technology adaptation.
<table>
<thead>
<tr>
<th>Design Features</th>
<th>Guideline</th>
<th>Teaching Strategies</th>
</tr>
</thead>
</table>
| (1) Use scaffolds | Use scaffolds at several levels to accommodate freedom and learning orientation; and that promote higher-order thinking and guide rather than drive the learning process to support students in self-regulated learning | - Reading reactions  
- Concept identification  
- Concept mapping |
| (2) Track the learning process | Use self-report techniques to measure the quality of the individual learning experience and use the information to guide intervention as appropriate | - Self-report measure |
| (3) Balance tension | Promote productive discomfort leading to growth without overloading the student | - not giving too much stress and overload to students |
| (4) Promote relevance and motivation | Analyze motivational levels and establish strategies to measure relevance and motivation relative to class activities by evaluating confidential reports and class discussion as well as using other instruments that might be useful for gathering this type of information | - Self-report measure (confidential)  
- Collaborative community activities |
| (5) Promote a shared vision | Use instructional strategies and technological tools that promote a buy-in from the students, across group collaboration, and quick interchange of ideas at the group and community levels | - promoting collaboration through quick interchanges of ideas |
| (6) Promote the acquisition of knowledge | Teacher and students identify key concepts or ideas in the content domain and use generative learning strategies and discourse to promote their acquisition | - Targeting key concepts in learning activities |

Table 4.2. Design guidelines for developing collaborative knowledge-building Environments (summarized from Gilbert & Driscoll, 2000, p.76-77)
4.2.3. Internet and Pedagogy

The Internet and virtual environment not only increases the complexity of a learning situation but also provides a wealth of learning options. This makes learning with technology extremely challenging. In spite of the positive and challenging side of computer-supported learning, however, it is recognized that not all computer-supported learning environments are successful. In order to achieve the constructivist learning goals, the technology must be easy for the students to master and transparent in the learning process by people. Besides technology, student’s participation as well as instructors’ are important factors for achieving successful learning in any computer-supported learning environment. Therefore, we need to discuss more on the factors of the student and the instructor for successful constructivist learning in Web-based learning environment.

Firstly, based on the constructivist theory, the role of the student in the learning process needs to be understood as knowledge generation, collaboration, and process management (Paloff & Pratt, 1999). As the students acknowledge the learner-centered process, they will begin to progress actively with the understanding of how much this type of learning differs from that of the face-to-face learning. Even collecting information from the Web requires a student’s new set of information accessing and processing skills.
To make information useful and accessible at a later state, students have to be able to select the information needed, organize it into a structure, and link it to their existing knowledge structure so that it can be used to solve problems in other settings...Connecting information into a structure and giving it personal meaning is an individual as well as social process that requires a lot of reflection. Reflecting on the information selected is essential to create ideas and knowledge (Lai, 1999, p. 9-10).

The Internet becomes a cognitive and knowledge management tool beyond its unique technical features when the students are getting more active and centered in his/her learning. Brown (1999) highlighted a real strength of the Internet in the educational context as 3Cs: content, connectivity, and community. Firstly, the Internet provides an excellent learning content to the student and fosters each student’s generative learning based on his/her self-authorship for learning that content. Secondly, the connectivity of the Internet allows students and instructors to expand their ZPDs, the well-known Vygotsky’s concept, by providing a chance for them “to engage in thinking process that are of a higher order than the ones they would develop without this connectivity” (Brown, 1999, p. 35). From Vygotskyian perspective, Brown explained that the online-link to an expert allowed learning “to be scaffolded by an expert where students learned as apprentices working alongside a more experienced old-timer” (p. 35). As the final strength of the Internet, communities of learning are far more powerful than
those of connectivity alone. With the communities of learning, the Internet makes it possible for the learner to have multiple zones in different contexts that often intersect and overlap.

Secondly, the role of instructor is also identified from the pedagogical, social, managerial, and technical points of view. In many cases, the way of understanding the Internet or virtual university makes it easy for us to equate the new medium with a new pedagogy. But it is not the delivery medium that defines the instruction; the delivery medium is very instrumental in the learning approach, and its capabilities should be integrated in the instructional design (Verneil & Berge, 2000). The constructivist learning with the Internet can be successfully conducted only when the systematic and holistic pedagogy is planned and executed with a vast amount of instructor’s efforts. Paloff and Pratt (1999) asserted that not all electronic courses were active and constructive for supporting learning experiences; the inactive and malfunctioning learning environment were influenced by the role and attitude of an instructor as follows.

We have seen many distance education programs in which the instructor posts lectures and attempts to control the learning outcomes by directing and dominating the process. We have also seen many instructors who continue to use multiple-choice and true-false exams as measures of learning. Many of these instructors are forced to bow to pressure from their universities, which are unwilling to let go of old methods of pedagogy or not
do understand how that could be done... With further exploration, we usually find that either these instructors were posing closed questions that did not stimulate or the instructors were dominating the discussion, thus not allowing the process to be learner-focused. (p. 31)

Along with the participatory role of students in constructivist learning, the role of instructor needs to be emphasized on the constructivist learning before, during, and after the instruction. Without investing more time and efforts by the instructor, the learner-centered education cannot be successfully conducted. For the instructor, there are lots of uncovered problems related to financial, administrative, and time needed to implement technology-supported learning environments. Among these issues, Paloff and Pratt (1999) discussed the time issue through the comparison of offline and online education. The time needed to deliver the online course for the instructor’s activities was “two to three times greater than to deliver a face-to-face-class” (p. 49). The comparative Table 4.3 shows the time difference needed to conduct a graduate-level class as a case study.

Paloff and Pratt (1999)’s study illustrated the gap between the ideal and the real situation in adopting them in higher education by demystifying the computer-supported learning and its educational value. Therefore, we need to conduct more empirical research on the financial, administrative, and socio-cultural issues of building and
managing the computer-supported learning environment. Their research is important because it introduced the importance of investigating these areas to develop the Internet as a more realistic learning tool rather than merely an ideological pedagogy.

<table>
<thead>
<tr>
<th>Instructor Activity</th>
<th>Face-to-Face Class</th>
<th>Online Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation</td>
<td>2 hours per week to:</td>
<td>2 hours per week to:</td>
</tr>
<tr>
<td></td>
<td>- Review assigned reading</td>
<td>- Review assigned reading</td>
</tr>
<tr>
<td></td>
<td>- Review lecture materials</td>
<td>- Prepare discussion questions and lecture materials in the form of a paragraph or two</td>
</tr>
<tr>
<td></td>
<td>- Review and prepare in-class activities</td>
<td></td>
</tr>
<tr>
<td>Class Time</td>
<td>2 1/2 hours per week of assigned class time</td>
<td>2 hours daily to:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Read students posts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Respond to student posts</td>
</tr>
<tr>
<td>Follow-up</td>
<td>2 to 3 hours per week for:</td>
<td>2 to 3 hours per week for:</td>
</tr>
<tr>
<td></td>
<td>- Individual contact with students</td>
<td>- Individual contact with students</td>
</tr>
<tr>
<td></td>
<td>- Reading students assignments</td>
<td>Via e-mail and phone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Reading students assignments</td>
</tr>
<tr>
<td>Totals of the week</td>
<td>6 1/2 to 7 1/2 hours per week</td>
<td>18 to 19 hours per week</td>
</tr>
</tbody>
</table>

Table 4.3. Time comparisons of an online versus a face-to-face class for one week (Paloff & Pratt, 1999, p. 50)
4.3. Learning Theories for Computer-Supported Learning Environment

4.3.1. Computer as Cognitive and Knowledge Construction Tool

Cognition is defined as “the act or process of knowing,” and learning is “the act or process of acquiring knowledge or skill” (Webster, 1989). In the field of learning theories, one of the challenging problems is how to bring about improvement in cognitive strategies, so that every learner is working up to potential. About the meaning of cognitive strategies in learning, Gagné (1985) explained that they are “the skills by means of which learners manage their own internal processes of attending, learning, remembering and thinking” (p. 55). A learner must also possess sufficient metacognitive skills to be able to function in complex situations demanding variable and flexible actions. Metacognitive strategy refers to awareness of one’s cognitive processes.

What makes the computer or the Web a cognitive tool is still open for interpretation. But Solomon et al. (1991) viewed the computer as “a potential partner in cognition either extending the cognitive capabilities of the user temporarily or increasing the cognitive capabilities of the user permanently by leaving behind a cognitive residue in the mind of the user” (Sugrue, 2000, p. 134). As broader view of the term, Jonassen and Reeves (1996) use the meaning of cognitive tools to refer to any tools that “enhance the
cognitive powers of human beings during thinking, problem solving, and learning” (*ibid*, p. 134). Lajoie also uses the term cognitive tool as “any tool that can support aspects of learners’ cognitive processes” (*ibid*, p. 134).

Based on these definitions of cognitive tools, broad explanations about the cognitive tools can be investigated further with three dominant aspects of viewing computer as cognitive tools. The three aspects are: (1) intellectual partners; (2) authentic learning with multi-modal representation; (3) and externalizing students’ internal knowledge representations.

Firstly, from a constructivist perspective, computers can function as intellectual partners that share the cognitive burden of carrying out tasks (Lajoie, 2000). Jonassen and Carr (2000) simply define cognitive tools as computer software applications including databases, spreadsheets, semantic networks, expert systems, computer conferencing, multimedia construction, and micro world learning environments. Computers can facilitate cognitive processing for supporting knowledge-construction with these diverse software applications. In addition to the cognitive function, they describe computer tools as “mindtools” or “knowledge construction tools” that support, guide, and extend the student’s thinking processes. Their assumption on the role of computer is a mind-
extending cognitive tool rather than a teaching agent. What kinds of effects can computers have on the minds of learners; and what kind of cognitive skills will result from using technologies? To answer these questions, we can quote Jonassen et al. (1999)’s response as follows: “the effects include what a computer enables the learner to do while working, planning, writing, designing, or communicating with computer software” (p. 152). These cognitive activities make a computer become an intellectual partner in the Information Age.

Another advantage of using computers as cognitive tools is an occasion when computers provide effective multimedia functions, and support the manipulation of complex ideas, which can be represented in diverse visual forms. These cognitive aspects allow students to create multiple forms of understanding through multimedia representations such as text, video, and audio (Lajoie, 2000). Visualization helps students interpret and represent ideas visually and holistically. Jonassen and Carr (2000) assumed that “using visualization tools engages learners in the use of more creative thinking skills than most other mindtools” (p. 182). Multimedia technology makes computers more embedded cognitive tools and creates more authentic learning environments that facilitate learning, experiencing, and assessment altogether by using multi-modal representations.
Finally, computers become a tool for externalizing students’ internal knowledge representations by planning, making, and representing the consequences of their actions. The computer-supported learning environment helps students reflect on their actions in the context of their stated hypotheses. Students even compare their problem-solving processes with those of an expert (Lazorie & Azevedo, 2000). Identifying such differences is important to ensure that students assess their own plans and actions, and help them expand their problem-solving procedures to a model of expertise.

In summary, computers can function as cognitive tools from three aspects: intellectual partners, authentic learning with multi-modal representation, and externalizing students’ internal knowledge representations. Using computers as cognitive tools provides learners with engagement in a variety of critical, creative, and complex thinking processes, which finally enhance their analyzing, connecting, elaborating, synthesizing, evaluating, imaging, and decision-making capabilities. If these cognitive functions are well performed in computer-supported learning environments, the computer will become a cognitive and metacognitive tool.
4.3.2. Cognitive Strategies of Web-based Learning

Many studies have investigated Web-based learning with its cognitive processes and strategies (Sugrue, 2000; Spiro, 1992; Feltovich et al., 1996). How can computers be used to help learners gain better understanding of complex and difficult subject matters; and how can computers aid groups of collaborating learners when they are trying to understand subject material?

A variety of types of information resources are provided by the hypertext functions of the Web, which can support the internal cognitive processes involved in the acquisition of declarative and procedural knowledge. The Web environment where the learner can be exposed to a set of information originated from different conceptual perspectives results in the acquisition of flexible knowledge; this is called as “Cognitive Flexibility Theory (CFT)” developed by Spiro and his colleagues. The central tenet of CFT is “the improvement of learner’s understanding and their transfer of information through exposure to the same material, at different times, in rearranged contexts, for different purposes” (Spiro, 1992). For this purpose, researches on CFT emphasize the ways called internal collaboration to produce an individual ability. Feltovich et al. (1996) proposed that instruction based on CFT should help individual learners “think like a
group” while, at the same time, preparing individuals to participate more effectively in collaboration (p. 26). In order to achieve this capability, Web-based learning derived from CFT is designed to consider alternative stances and interpretative ways so that interpersonal and group-based deliberations on a topic might be encouraged. This is why hypermedia capabilities of the Web are enhanced by researchers in CFT that reflect the cognitive characteristics necessary for knowledge construction, and the production of flexible knowledge representations in learners.

In her paper of “Cognitive Approaches to Web-Based Instruction,” Sugrue (2000) used the term cognitive as a variable attribute of any Web-based instruction. She promoted that the Web has become “a universal metaenvironment for learning” (p. 133). Based on the understanding of cognition and the Web, she selected four instructional principles performing a cognitive function in the learning process: (1) information organization and access; (2) authentic activities; (3) collaborative learning; and (4) student modeling. These instructional principles support each cognitive process involved in learning, respectively: (1) acquisition of declarative knowledge; (2) connecting knowledge to situational conditions that trigger application and proceduralization of knowledge; (3) refining and constructing shared understandings of knowledge; and (4)
the metacognitive monitoring of knowledge acquisition to ensure accuracy and efficiency (Sugrue, 2000, p. 135). For this study, Sugrue’s instructional principles are applied and used many times to categorize the diverse learning effects and to develop the complex database structure for building Web-based design learning environment. For example, Table 4.4 summarizes the relationship among cognitive process, related functions of the Web, and learning theories, based on Sugrue’s four cognitive instructional elements.

<table>
<thead>
<tr>
<th>Cognitive instructional elements (Sugrue)</th>
<th>Cognitive Process in Learning</th>
<th>Functions of the Web</th>
<th>Related learning theories</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Information organization &amp; access</td>
<td>- acquisition of declarative knowledge</td>
<td>database hypertext links</td>
<td>- CFT</td>
</tr>
<tr>
<td>2. Authentic activities</td>
<td>- connecting knowledge to situational conditions</td>
<td>Immersing technology to create simulated situation.</td>
<td>- theory of situativity (video and audio)</td>
</tr>
<tr>
<td>3. Collaborative learning</td>
<td>- refining and constructing shared understandings of knowledge</td>
<td>Boards, discussion room, CMC, CSCL</td>
<td>- externalizing ideas</td>
</tr>
<tr>
<td>4. Student Modeling</td>
<td>- metacognitive monitoring of knowledge acquisition - identifying individual difference</td>
<td>Self-report Personal database</td>
<td>- CFT’s internal collaboration</td>
</tr>
</tbody>
</table>

Table 4.4. Identifying the relationship between cognitive instructional principles, process, and its related functions of the Web
In summary, it is necessary for us to review again the fundamental questions we considered in the domain of the computer-supported learning and its cognitive-psychological approach to learning theories. What kinds of theories and practices are effective to conceptualize Web-based learning environment? What do we learn about learning with technology? All learning theories we discussed previously in both constructivism and computer-supported learning environment emphasize the cognitive process as well as the knowledge-construction function of the Internet. One of the important things we need to emphasize is that the diverse theories discussed so far grow out of another rather than being in opposite direction to the other. The following Table 4.5 summarizes constructivist learning theories and guidelines for building constructivist learning discussed in Chapter 3 and 4. This table illustrates that there are common denominators in cognitive instructional principles and constructivist learning design proposed by different researchers. This study focuses on these common denominators, and includes them as major and minor principles for building Web-based Design Learning in next chapter.
<table>
<thead>
<tr>
<th>Learner-centered psychological principles (APA)</th>
<th>Cognitive Instructional Principles</th>
<th>What makes Computer as Cognitive Tools</th>
<th>Constructivist Learning Design (Gagnon &amp; Collay)</th>
<th>Five Tenets for Constructivist Learning (Brooks &amp; Brooks)</th>
<th>Design guidelines for collaborative knowledge-building environment (Gilbert &amp; Driscoll)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive &amp; Metacognitive Factors</td>
<td>-Information organization &amp; access</td>
<td>-Intellectual partners</td>
<td>-Situation (context)</td>
<td>-Posing problems of emerging relevance to students</td>
<td>-Use scaffolds (concept mapping)</td>
</tr>
<tr>
<td>Motivational &amp; Affective Factors</td>
<td>-Authentic activities</td>
<td>-Authentic learning with multi-modal representation</td>
<td>-Grouping (collaboration)</td>
<td>-Structuring learning around ideas</td>
<td>-Track the learning process (self-report)</td>
</tr>
<tr>
<td>Developmental &amp; Social Factors</td>
<td>-Collaborative learning</td>
<td>-Externalizing students’ internal knowledge representation</td>
<td>-Bridging (cognitive &amp; metacognitive skills)</td>
<td>-Seeking and valuing students’ point of view</td>
<td>-Balance tension</td>
</tr>
<tr>
<td>Individual Factors</td>
<td>-Student modeling</td>
<td>-Questions (critical thinking)</td>
<td>-Exhibition (authentic work &amp; externalizing knowledge)</td>
<td>-Adapting curriculum to address students’ suppositions</td>
<td>-Promote relevance and motivation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Reflections (metacognitive skills)</td>
<td>-Assessing student learning in the context of learning</td>
<td></td>
<td>-Promote a shared vision</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-Promote the acquisition of knowledge</td>
</tr>
</tbody>
</table>

Table 4.5. Summary of constructivist and cognitive learning theories in Chapter 3 & 4
4.3.3. Examples for Designing Computer-supported Learning Environment

There are important studies in building learner-centered and collaborative computer-supported environments to be applied to this study. This section discusses two of the most appropriate and useful studies conducted by Jonassen and his colleagues. As the first case, Jonassen (1992) proposed the basic four characteristics of constructivism to create effective learning environment: context, construction, collaboration, and conversation. Context includes features of the real world setting where the task to be learned may naturally be accomplished. Construction of knowledge is the end result of an active process of articulation and reflection within a context. It includes the features of physical, organizational, cultural, social, political, and power issues related to the application of the knowledge being learned. Collaboration among learners occurs throughout the learning processes. Entailed by collaboration, conversation is an essential part of the meaning-making processes because knowledge is language-mediated. Conversational interaction provides a means for students to gradually construct relational meanings.

As a further step, Jonassen et al. (1999) presented a conceptual model of designing Web-based learning environment. Their onion-shaped model in Figure 4.5
binds diverse learning components around the problem/project space; at the center of the model, the problem/project space consists of “problem context,” “problem presentation/simulation,” and “problem manipulation space.” The problem context includes the social, cultural, and physical context in which a problem or a project occurs as the nature of the problems. The problem presentation/simulation provides rich information about all aspects of the problems or projects that should be interesting, appealing, and engaging. The problem manipulation space provides students with diverse activities to manipulate the problem and to experiment for solving the design problem.

Figure 4.5. A model of constructivist learning (Jonassen et al., 1999, p. 195)
Jonassen et al. (1999) discussed that the problem/project space and its cognitive learning skill supported students to possess “higher-order thinking and to provide ample opportunity for evaluating student performance” (p. 196). Their constructivist approach to positioning the problem/project space at the center of learning environment is well connected with the design problem solving, which occurs from ill defined to well-defined problems in the design processes. The constructivist learning environment provides flexibilities to the student by defining and modifying the problem itself; the diverse learning occurs with the collaborative knowledge community by situating the problem within the real context. Figure 4.5 presents Jonassen et al.’s concept of instructional layers, which enlarges its learning boundaries with information resource, cognitive and conversation tools, collaboration tools, and social/contextual support. All layers are constructed to support and explore constructivist knowledge construction and negotiation.

Based on the literature reviews in three chapters (design paradigm shifts and new design learning in Chapter 2, constructivism and its learning theories in Chapter 3, and Web-based learning as cognitive and learning construction tool in Chapter 4), the next chapter will develop a series of conceptual models for building Web-based Design Learning, which fit to the outlining picture of Design Education Model I and II.
CHAPTER 5

THEORETICAL FRAMEWORK: CONSTRUCTIVIST APPROACH OF
CREATING WEB-BASED DESIGN LEARNING (WBDL)

5.1. Design Education Model with Computer Technology

5.1.1. Challenging Design Education Model II with Computer Technology

As computer technology and the epistemological changes in education have been
developed rapidly, education has been required to be more flexible and redundant; the
dominant features of educational change were characterized in Chapter 2 by the
keywords of accessible, flexible, connected, virtual, ubiquitous, heterogeneous, and
learner-centered. Among the flexibility of education concerned researches, the future
college model suggested by Collis and Gomers (2001) could be one of the most ideal
and desirable ones for its social and political arguments. They proposed a scenario
consisting of four possible profiles for the university in the year 2005, which were
characterized by two large axes of “flexibility in organizing and operating education curriculum” and “the possibility of virtual education.” Figure 5.1 explains the characteristics of four profiles A, B, C and D: Back to Basics, the Global Campus, Stretching the Mold, and the New Economy, respectively.

Figure 5.1. Future college model in digital technology (Collis & Gommers, 2001, p. 10)
Profile A represents the present higher education which is considered to be suitable for the entry-level students with very little specialized knowledge and less self-motivation. Those students expect well-structured curricula and the content of subject matters to be explained in a precise way. This is a typical traditional education administered in physical space. Profile B is for students with intermediate level of knowledge obtained from the basic courses and contribute to a distant education. Although they prefer to have well-structured curriculum, they tend to extend learning as a part of daily life as well, and need options of selecting time and space where they would learn without the traditional confinements of time and space.

Profile C is for learners with intermediate level of specialty; they prefer to select the contents of learning and its operation rather than to select the space of learning. Expansion of the flexibility of learning such as interdisciplinary curriculum development and integrated learning on the local campus becomes possible with introduction of this profile. Profile D is suitable for professional students who can make decisions in overall education by themselves: students can select proper curricula, time, space, materials and even assignments for them; the overall learning process becomes totally learner-centered.
Collis & Gommers’s scenarios for future higher education are focused on how present higher education can be changed within the emerging paradigm of information technology; it also reflects the limits and problems of the present education system. Acknowledging these educational problems has led an increasing number of colleges to shift their system from profile A to B and C during the last decades. For instance, the curricula using software such as WebCT, Lotus Learning Space, and TopClass, which make virtual education possible and popular, has developed new types of education by integrating profile A and B. Typically, in on-line classrooms, the student has access to course materials, tests, bulletin boards, and chat room, which provide various learning experiences to the student. More radical developments are found in profile D, which are currently being developed in the name of Virtual University and expanded all over the world.

Addition of a wealth of options that have been available via the Internet connection increases the possibility and complexity of learning. Therefore, it is not easy for us to draw a outlining picture of design education. Collis & Gommers’s scenario is useful, because it helps to project design education today and in the future. Design education model II in Figure 5.2 is created on the basis of their scenario to represent the
expanded and possible features of design knowledge and learning with the Internet technology. Four profiles are named as: traditional design education, world design education, personalized design education, and virtual design education.

Figure 5.2. Design education model II

Four profiles in the design education model II are divided by two axes of “local vs. global system” and “cohesive vs. personalized learning.” Profile A (traditional design education) and C (personalized design education) are categorized as local system because
they use physical space; their design learning is based on material-oriented and face-to-face contacts. The increasing connections and flexibilities in curriculum create profile C, and transform the curriculum as student-centered and personalized one with other disciplines or industries. Some interdisciplinary degree programs such as Design MBA or PhD in Design are categorized as profile C, because they afford customized and personalized learning opportunities. Design students and designers pursuing continuing education are also associated with profile C; they construct more interactive and practical learning context through the extended but locally enclosed connections.

The transition from profile A to B (world design education) had been made in a small scale in design schools before the Internet was introduced. For example, the “Design and Innovation” program provided by Open University in United Kingdom was one of the first institutions providing distance education for the last 30 years. Enrolled students are connected to the nearest regional center and allocated a personal tutor who provides guidance and assessment at regular base; textbooks, CD-ROMs, TV and audio programs are provided to the student to study at home or at work. This open-learning system has been initiated in United Kingdom, and expanded to Europe as main study area; the worldwide education is now available in a limited number of courses with the
Internet. The information technology is also included in a half of all courses to support learning with multimedia DVD, online conference, using the online library, and other instructional activities. Over 100,000 students are currently studying entirely on-line with the support of online conferences guided by experienced tutors (www3.open.ac.uk).

Profile B and D (virtual design education) are categorized as “global system” for sharing its time zone; their design learning is based on the immaterial and data-oriented. The development of computer technology has been pushed to overcome the limited speed and capabilities of hardware and software, and it helps to provide graphic-oriented multimedia instructions that were previously restricted to text-base only. Sessions.edu is a good example of a currently developed multimedia on-line design education program. This school of “design and new media” offers certified programs and courses especially in graphic design, web design, digital design, multimedia, and new media marketing. This kind of private and non-traditional type of school promotes and pushes the high quality of education. Although this kind of school doesn’t focus on the epistemological considerations for students’ learning, it demonstrates possibilities of building a personalized design learning program within the global context.
Combining design education models I and II provides a frame of understanding and analyzing design education for the present and the future. The design education model I in Figure 2.2 illustrates how diverse learning possibilities are linked and interrelated to provide the better and diverse knowledge in new design learning context. This model becomes a map of new design learning guided by variables of when, where, and with whom the learning can occur; the expanded knowledge communities through life-long learning support a student/designer to keep up with changes in technology, science, the economy, and cultural norms.

The design education model II in Figure 5.2 challenges the philosophies of education by including different time and spatial dimensions through the Internet technology. It illustrates a wide range of curricula establishment for learners to have flexibility to select an appropriate learning type for their demands and situations. Four profiles of education system are symbolic to present new design learning contexts by composing the variables of where and how education can be accomplished. Design education model II is linked to any educational activity in the design education model I to explain how that kind of learning can be provided in time and spatial dimension. We can find the usefulness from the way combining design models I and II in solving the
problems with diverse approaches of connecting and expanding the learning communities based on the Internet and multimedia technology. For example, there are several possible ways of creating multidisciplinary programs for the advanced level of design education. By the design education model I, we can develop the content of design learning either with other disciplines related to design or with the participation of industries. A few of the possible ways of building the curriculum can be developed by the design education model II: a case of profile B includes local industries with other disciplines on the same campus; a case of integrating profile B and C provides more expanded learning opportunities to the student by including experts around the world; profile D can be another possibility of implementing online for only multidisciplinary curriculum. The following Figure 5.3 shows an example of developing the possible design curricula in higher education, which provides a vision and directions to facilitate educational resources including knowledge communities from the industry and cultural institutes.
Figure 5.3. A case of developing possible design curriculums with two design education models

Constructing design learning in the real-world context where the diverse knowledge communities are included as learning partners eventually narrows the gap between design knowing and doing; it provides a higher level of knowledge in an authentic and social learning environment. Therefore, it is assumed that design education models I & II are useful for understanding and enhancing cognitive and collaborative
learning based on constructivism. Proposing two models and introducing the way of using them so far can be one example of solving design education problems confronted at the emerging paradigm of postpositivism, which is represented symbolically with the four contextual features of education: connection, heterogeneity, flexibility, and morphogenesis. This one example of constructing new design learning with design education models I and II, however, can blur the boundaries of education types, disciplines, and even nations; and it will strengthen the discipline of design and its education, as various kinds of knowledge and experience will be exchanged and piled up among professional and non-professional designers. Design education models I & II are useful for predicting the educational change in content and context, and making the schools and design organizations as living organisms of continuous and life-long learning. It is also important for design students and working designers to acknowledge design education models and to plan his/her personalized design learning continuously.

For this study, the design education model II is used for positioning the development of a Web-based learning program (in Figure 6.5). Identifying the position of Web-based learning within a holistic map is important to analyze its learning effects, and to explore its future expandability in a big picture of creating new design learning.
5.1.2. Principles and Conceptual Models of Building Constructivist Design Learning

New design learning involves a complex and active process of reflective, reinforcing, and constructive learning. The three propositions of new design learning, proposed in chapter 2, emphasize the learner-centered and generative learning as follows: (1) learning how to learning is more important than learning that; (2) it ought to link the theory and practice continuously throughout the lifelong learning; and (3) it provides a dynamic reinforcement to the student and the designer for shaping their attitudes fitting well to the present and future knowledge-based society. We have also discussed that constructivism has become an alternative epistemology and pedagogy for new design learning, which matches to the three propositions and provides a variety of cognitive and social learning theories to be associated with the contextual features of learning in the postmodern world.

Therefore, it is conceptualized that the procedure of new design learning is established on the basis of cognitive and social constructivists’ learning theories and integrates them to solve the complex design problems emerging with the paradigm of postpositivism; it is named “constructivist design learning” in this study. In order to create constructivist design learning, therefore, the key elements of cognitive and social
constructivism are captured and categorized as learning factors and principles. Based on
the two constructivists’ learning theories, ‘cognitive & meta-cognitive’ and ‘social &
collaborative’ learning are selected as dominant factors for establishing new design
learning, and each factor consists of major and minor principles to support constructivist
design learning. As explained in the Table 5.1, four major principles are selected as a sub-
group of two learning factors: (1) knowledge construction; (2) cognitive and meta-
cognitive strategies; (3) social interaction; and (4) constructivist mindset. Mindset
represents the students’ and educators’ epistemology. Because the things we do and the
way we act depend a great deal on what we perceive learning to be, we hypothesize that
if the students and educators have the same epistemology as a constructivist approach,
then the enrichment levels of learning will be increased. The constructivist mindset is,
therefore, selected as the fourth major principle to identify the students’ and educator’s
attitude toward learning through their epistemological attitude, assessment of learning,
and self-authorship. Table 5.1 explains the relationship among four major and seventeen
minor principles. Minor principles are carefully selected from the literature review
(cognitive and constructivist learning theories in chapter 3 & 4) and field research (design
industries and academia in chapter 2) to meet the needs of accomplishing the
constructivist learning as well as the design problem solving. These principles create a framework to establish conceptual models of constructivist design learning and Web-based design learning later.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Major Principles</th>
<th>Minor Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive &amp; Metacognitive Factors</td>
<td>1. Knowledge Construction</td>
<td>1. prior knowledge &amp; experience</td>
</tr>
<tr>
<td></td>
<td>. knowledge acquisition &amp; utilization</td>
<td>2. questioning &amp; exploration</td>
</tr>
<tr>
<td></td>
<td>. nature &amp; goals of learning process</td>
<td>3. conceptual framing</td>
</tr>
<tr>
<td></td>
<td>2. Cognitive &amp; Metacognitive strategies</td>
<td>4. visualization</td>
</tr>
<tr>
<td></td>
<td>. thinking about thinking</td>
<td>5. present &amp; exhibit design works</td>
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<td></td>
<td>. strategic thinking</td>
<td></td>
</tr>
<tr>
<td></td>
<td>. context of learning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(culture, technology, practices)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>. individual differences &amp; personalization</td>
<td></td>
</tr>
<tr>
<td>Social &amp; Collaborative Factors</td>
<td>3. Social Interaction</td>
<td>1. information access &amp; organization</td>
</tr>
<tr>
<td></td>
<td>. social influences and interactions on learning</td>
<td>2. individual exploration</td>
</tr>
<tr>
<td></td>
<td>. learning &amp; diversity</td>
<td>(usage of language, numbers, and images)</td>
</tr>
<tr>
<td></td>
<td>. intrinsic motivation to learning</td>
<td>4. assessment (portfolio, performances)</td>
</tr>
<tr>
<td></td>
<td>. motivational &amp; emotional influences on learning</td>
<td></td>
</tr>
<tr>
<td>Social &amp; Collaborative Factors</td>
<td>4. Constructivist mindset</td>
<td></td>
</tr>
<tr>
<td></td>
<td>. intrinsic motivation to learning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>. motivational &amp; emotional influences on learning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. self-authorship</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. reflection &amp; assessment (collaboration, group</td>
<td></td>
</tr>
<tr>
<td></td>
<td>. group progressing, team work)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. attitude toward learning</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.1. Major and minor principles for constructivist design learning
Finally, a conceptual model of constructivist design learning environment in Figure 5.4 is created on the basis of Jonassen et al. (1999)’s model (see Figure 4.5); this onion-shaped model is divided by cognitive and social constructivism, and each constructivism consists of major and minor principles of constructivist design learning, which are embedded as key elements to create constructivist design learning. These major and minor principles are integrated to support design learning as reflective, social, and interactive. Positioning the design problem / process at the center of the model, in Figure 5.4, emphasizes that constructivist design learning is situated and grounded within the real context of the design problem from the beginning phase of the design process. It means that design learning becomes intertextualized as design problem solving proceeds. Around the center area of the design problem/process, minor and major principles of constructivist design learning make layers of cognitive and social learning activities. All these learning activities are influenced by the contemporary educational and design issues such as learner-centered, practical, cultural, and technological.
For practical and preferable functioning of this constructivist design learning model, it is important to focus on the ways of activating and empowering the learning
activities. Because the constructivist design is generative, the students’ learning activities are deeply related to their dynamic interactions among people and feedback received from the instructors or other students. This kind of learning is not developed in a linear process, but in more complicated formats of spiral, iterative, or multi-linear processes. Therefore, Figure 5.5 includes representative examples of the dynamic interactions generated during the learning process: circular interactions in the layers of major and minor principles, and iterative feedback among layers from the core of design problem to the peripheral layer of constructivism, and vice versa.

When the students’ learning activities are generated, the process of their interactions can create a pattern; this learning pattern is interpreted as the process of the internalization of social signs, and the internalization of culture and of social relationships. Based on this internalized learning pattern, the conceptual model of constructivist design learning is transformed to a three-dimensional one in Figure 5.6.

Combining Figure 5.5 and 5.6 represents as a top view and a side view of three-dimensional form such as a mountain. A student’s learning activities can be interpreted as a metaphor of mountain climbing; identifying/searching the context information of the mountain (time & geographical information), being familiarized with the routes of
mountain, reaching the top of the mountain and documenting the achievements, and reflecting them from a distance after the walking and climbing processes are completed.

Figure 5.5. Interactions and feedbacks among the major and minor principles of constructivist design learning.
This three-dimensional approach is useful to identify how a student’s design knowledge and experiences are constructed with Vygotsky’s ZPD theory. Based on Vygotskian perspective, design problems and ideas are considered as mediators between the social-community and the individual levels of cognition. Ideas are powerful psychological/cognitive tools that can be recognized as “aids for developing higher order functions and behaviors from the social level, and subsequently influencing the individual
level” (Hung, 2002, p. 207). The Figure 5.7 illustrates the two ways of interpreting Vygotsky’s theories in the constructivist design learning: (1) the Zone of Proximal Development representing the distance between a student’s potential level of development and actual/real level of development; and (2) the internalization process from the social level to cognitive/psychological level. Students’ collaborative interactions and instructors’ feedback support the internalization of design knowledge and experiences, and it finally determines the actual development of new design learning.

Figure 5.7. Internalization of new design learning based on Vygotsky’s ZPD theory
5.2. Creating Web-Based Design Learning

5.2.1. Conceptual Model of Web-based Design Learning (WBDL)

The constructivist design learning model can be developed further with the support of computer and networked technology. As a cognitive and knowledge construction tool, the computer and the Web challenge the conceptual model of constructivist design learning to overcome its restricted view of managing a classroom or a design studio, and proposes a new perspective on what can be accomplished in design courses such as previously discussed profile C or D (see Figure 5.2).

As the first step of integrating computer technology to the constructivist design learning, a conceptual model of Web-based Learning (WBL) is created on the same basis of Jonassen et al. (1999)’s model for constructivist design learning. Because of the consistency of understanding and interpreting the epistemological standpoint provided by this same idea, it is useful to apply it to the development of a series of learning models. Jonassen’s (1992) other work, four characteristics of constructivism to create an effective learning environment, is also applied to define the basic structure of WBL. Four characteristics of context, construction, collaboration, and conversation were previously discussed in Chapter 4.3.3. Related to the four characteristics, the learning context for
WBL is web-based and it defines WBL’s physical, organizational, cultural, social, and political features. The three other characteristics represent how the Web functions as knowledge construction, conversation, and collaboration tool. It is considered as the most fundamental factors’/issues’ for creating WBL. The Figure 5.8 illustrates how the four characteristics of constructivism are applied to the layers of WBL.

The major and minor principles of developing WBL are also selected from the literature review. Sugrue’s (2000) four instructional principles performing cognitive functions in Web-based learning are recognized as the most appropriate and reliable theories to be interpreted as major principles for building WBL. Those are: (1) information organization and access; (2) authentic activities; (3) collaborative learning; and (4) student modeling. These four cognitive instructional principles were summarized in chapter 4.3.2, specifically in Table 4.4. The minor principles of WBL function as methods for collecting data, and reinforcing or evaluating the learning activities related to the higher-level of major principles. Considering the Web-based context, this study selects a limited number of minor principles as follows: (1) visualization (video & audio); (2) database & Hypertext links; (3) situated context; (4) grouping & group processing; (5) collaboration & negotiation; (6) attitude toward learning; and (7) self-reflection.
With the same metaphor of constructivist design learning model, the conceptual model of WBL is developed with several layers of major and minor principles for facilitating learning activities within the Web-based learning context. Figure 5.8 shows the conceptual model of WBL.

![Figure 5.8. Conceptual model of WBL](image)
Because both conceptual models of constructivist design learning (Figure 5.6) and WBL (Figure 5.8) share their epistemological backgrounds, these two models can be created with a similar format and similar interactions between layers. However, each model functions in a different way. The constructivist design learning model is focused on the design content development, and the contents are created by the processes of knowledge accessing, and managing, building, distributing and assessing them iteratively. On the other hand, the WBL model emphasizes the way of supporting the design content development with diverse computer functions that utilize a variety of data formats such as video, audio, graphic simulation, hypertext links, and others.

Having the same epistemological stance but with different purposes of achieving constructivist design learning requires the drawing of a new concept to connect the learning methods and activities between the two models. This becomes a conceptual model of Web-based Design Learning (WBDL) in Figure 5.9. Based on the design problem at the center and peak of two models, the constructivist design learning model can be connected to the mirrored image of WBL; major and minor principles of each model are positioned to match the similar contents of learning activities; and connecting the related activities altogether constructs a larger and deeper dimension of WBDL. To
link layers at the same hierarchical level of two models provides a better understanding of the relationship between design learning and its supportive computer functions. For instance, the systematic controls facilitated by WBL support and reinforce the students’ learning and knowledge construction processes effectively and efficiently.

Figure 5.9. Conceptual model of WBDL
However, the advantage of creating the WBDL model does not lie in the visible linkage of two models by simple connections, but in the reconstruction of managing design learning to include more dynamic flows that even take the invisible aspects of dimension in WBDL into consideration. For instance, the learning content of design problems/ideas can flow naturally back and forth between two models, like an hourglass by rotating the WBDL model. This three-dimensional interpretation of WBDL by connecting cone shapes of constructivist design learning and WBL represents more flexible and expandable features of design learning. This three-dimensionally visualized model will be used as an analysis tool to assess the effectiveness of WBDL in the next chapter.

As another example, the conceptual model of WBDL is useful to illustrate the interrelationships among diverse design contents and its authentic learning contexts; Figure 5.10 shows how students, design problems (artifacts), and computer functions are interrelated and interacted. The interactions generated among them can be documented with the frame of WBDL, and summarized as a map of possessing lots of text and visual information to illustrate how diverse learning contents and context are interrelated through the learning process.
Figure 5.10. Example of connected and enhanced learning relationships in WBDL

5.2.2. Information Architecture of WBDL

Related to the issue of what constructivist perspectives and computer technology offer educational practice, Perkins (1992) suggested five facets (information banks,
symbol pads, construction kits, phenomenaria, and task managers) of information processing technologies that support the learning process. “Information banks” can be any resource that serves explicit information about a topic. “Symbol pads” are expanded concepts of constructing and manipulating symbols, which serve to support learner’s short-term memories as they record ideas, develop outlines, formulate, and manipulate it. “Construction kits” include prefabricated parts and processes with emphasis on modular things and actions. “Phenomenaria” is designated as an area for the specific purpose of presenting and making phenomena accessible to scrutiny and manipulation. “Task managers” are elements of the environments that set tasks to be undertaken in the course of learning, guide and sometimes help with the execution of those tasks, and provide feedback regarding process and product. Perkins’s idea of five facets provides a useful guideline for creating the information structure of WBDL; and his way of using computer technology to support learning activities is adopted and implemented in this study. His idea of five facets influences on building the information architecture of major and minor principles of WBDL; for example, Information Banks contains a database and a variety of hypertext links, and it supports information gathering and access activities.
Table 5.2. Information structure and learning activities related to four learning principles in WBDL

<table>
<thead>
<tr>
<th>Major Learning Principles</th>
<th>Applying Perkins’s Five Faucets</th>
<th>Functions of the Web &amp; Computer</th>
<th>Design Problem Learning Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Information organization &amp; accesses</td>
<td>Information Bank, Phenomenaria, Construction Kit</td>
<td>database Hypertext links</td>
<td>- a process of reaching a resolution by organizing information, and embedding data in the learning format - a process of solving a design problem.</td>
</tr>
<tr>
<td>2. Authentic activities</td>
<td>Task Manager</td>
<td>Immersing technology to create simulated situation. (video, audio, and text format)</td>
<td>- a well-formed story to create a meaningful context for problem-solving</td>
</tr>
<tr>
<td>3. Collaborative learning</td>
<td>Symbol Pad Task Manager</td>
<td>Boards, discussion room, CMC, CSCL (narrative and text format)</td>
<td>- It provides students with the opportunity to use concepts in a situated context, and work collaboratively as a group to transfer skills.</td>
</tr>
<tr>
<td>4. Student Modeling</td>
<td>Authentic Learning Task Manager</td>
<td>Self-report Personal database (narrative and text format)</td>
<td>- with the complexity of the problems, students learn to deal with complexity - provides many opportunities to introduce topics from other subjects.</td>
</tr>
</tbody>
</table>

To summarize, Table 5.2 discusses: how each major principle of WBL is related to Perkins’s five facets; what kinds of computer and the Web functions are available for
Perkins’s facets; and what kinds of learning activities are enhanced by the functions of the computer and the Web. One way of building information architecture is examined in Figure 5.11 to identify the relationship among the five facets and the learning activities of major and minor principles in WBDL. In this figure, Task manager is identified to manage the overall learning processes and to support all design problem-solving activities.
In summary, along with the ability to supply information resources using the WWW and manipulating design ideas with multimedia presentation explained in Table 5.2, the idea of WBDL provides a new perspective to what can be accomplished in design.
courses by enhancing generative and authentic learning with the use of video and hypermedia technology; it begins to blur the distinction between design learning and design practice by embedding cognitive and metacognitive strategies for solving complex design problems in a social learning environment. As a knowledge construction and integration tool, the WBDL supports the student to: (1) connect to diverse information and other students/experts; (2) integrate new knowledge with his/her prior knowledge and internalize them; (3) possess multiple perspectives to work with and learn from others; (4) have a positive attitude toward learning how to learn.

5.3. Principles of Building and Analyzing WBDL

The conceptual model of WBDL is designed to manage a one-semester course, incorporates a database of articles that learners can easily access from the Intranet server, and provides a new learning environment for students and the instructor to build links within the environment to resources outside of it. Perkins’s idea of five facets provides key elements for accessing or connecting to the outside and inside of the resources.

The fundamental menu structure of WBDL, therefore, is developed with the Perkins’s idea that connects and reflects the progressive concept to build the conceptual
model of WBDL from constructivist design learning and WBL. Constructivist learning theories for the development and application of WBDL in education are assumed to play a major role in students’ achievements in design problem solving and their cognitive developments. In order to analyze the effectiveness of WBDL, the major and minor principles of building WBDL in Table 5.1 are also used as fundamental criteria for the analysis of WBDL. Besides the knowledge construction and cognitive strategies, however, the analysis of WBDL needs to take the other factors related to IT infrastructure and technical supports into consideration. Benson Soong et al. (2001) recommended several critical success factors to measure the achievement in on-line education: human factors (high human-emotion-interaction skills and motivational skills), technical competence (computer literacy of its users), and IT infrastructure and technical support. In the case of human factors, they calculated the amount of time and effort dedicated to figure out at what regular base, the instructor and the student put their time and efforts to the web forum and other places. Through a collective and cross-case analysis, they found some qualitative implications for measuring success in on-line resources such as “high usage,” “enjoyment,” and “perceived helpfulness presence of higher learning.” (Benson Soong et al., 2001, p. 118) Technical competence on WBDL means each student should
possess computer and web literacy and apply the capability of using diverse digital media so as to develop design ideas with drawing, sound, and video manipulation. The knowledge and skills of using hardware and software will remove the obstacles of using WBDL and make learning enjoyable. Therefore, it is assumed that the level of technical competence and the participation of web-based education have a close relationship in analyzing the level of students’ technical cognition.

To analyze the effectiveness and the value of WBDL in this study, therefore, a technical factor is added to the research criteria of two factors and four major principles; the final research criteria for analyzing WBDL consists of three factors: cognitive & metacognitive factors (knowledge construction and cognitive strategies), social & collaborative factors (social interaction and constructivist learning), and technical factors (learner's technical competence and effectiveness of using computers for design learning). Table 5.3 is reproduced by adding the third factor with its subsets of major and minor principles to the previous one for building and analyzing constructivist design learning.
<table>
<thead>
<tr>
<th>Major Principles</th>
<th>Minor Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cognitive &amp; Metacognitive Factors</strong></td>
<td><strong>Social &amp; Collaborative Factors</strong></td>
</tr>
<tr>
<td>. knowledge acquisition &amp; utilization</td>
<td>. social influences and interactions on learning</td>
</tr>
<tr>
<td>. nature &amp; goals of learning process</td>
<td>. learning &amp; diversity</td>
</tr>
<tr>
<td>2. Cognitive &amp; Metacognitive strategies</td>
<td>3. Constructivist Learning</td>
</tr>
<tr>
<td>. thinking about thinking</td>
<td>. intrinsic motivation to learning</td>
</tr>
<tr>
<td>. strategic thinking</td>
<td>. motivational &amp; emotional influences on learning</td>
</tr>
<tr>
<td>. context of learning (culture, technology, practices)</td>
<td>. self-authorship</td>
</tr>
<tr>
<td>. individual differences &amp; personalization</td>
<td>2. reflection &amp; assessment (collaboration, group progressing, team work)</td>
</tr>
<tr>
<td></td>
<td>3. attitude toward learning</td>
</tr>
<tr>
<td></td>
<td>4. Constructivist Learning</td>
</tr>
<tr>
<td></td>
<td>. intrinsic motivation to learning</td>
</tr>
<tr>
<td></td>
<td>. motivational &amp; emotional influences on learning</td>
</tr>
<tr>
<td></td>
<td>1. Self-authorship</td>
</tr>
<tr>
<td></td>
<td>2. Reflection &amp; assessment</td>
</tr>
<tr>
<td></td>
<td>3. Attitude toward learning</td>
</tr>
<tr>
<td>3. Social Interaction</td>
<td>5. Learner’s technical competence</td>
</tr>
<tr>
<td>. social influences and interactions on learning</td>
<td>1. Computer/web literacy</td>
</tr>
<tr>
<td>. learning &amp; diversity</td>
<td>2. Software usage for design works</td>
</tr>
<tr>
<td>4. Constructivist Learning</td>
<td>6. Effectiveness of using computers for design learning</td>
</tr>
<tr>
<td>. intrinsic motivation to learning</td>
<td>1. Accessibility, flexibility</td>
</tr>
<tr>
<td>. motivational &amp; emotional influences on learning</td>
<td>2. Manageability</td>
</tr>
<tr>
<td></td>
<td>3. Relationship between the content of design and WBI</td>
</tr>
</tbody>
</table>

Table 5.3. Major and minor principles for constructivist design learning for case analysis.
In this study, a theory of developing a constructivist learning model with WBDL is investigated for supporting new design learning as cognitive, psychological, pedagogical, technological, collaborative, cultural, and pragmatic. Table 5.4 summarizes the learning tasks and design problem solving processes that are related to each of six major principles. The possibilities and effectiveness of building and using the WBDL in design studio course are experimented and analyzed in next Chapter 6 and 7.

<table>
<thead>
<tr>
<th>Major Principles</th>
<th>Minor Principles</th>
<th>Related Tasks/Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. knowledge construction</td>
<td>. prior knowledge &amp; experience</td>
<td>- searching information to solve problem, and utilize available learning resources</td>
</tr>
<tr>
<td>. knowledge acquisition &amp; utilization</td>
<td>. questioning</td>
<td>- clarifying design concepts, and procedures</td>
</tr>
<tr>
<td>. nature &amp; goals of learning process</td>
<td>. exploration</td>
<td>- reflecting on interconnections</td>
</tr>
<tr>
<td></td>
<td>. conceptual framing</td>
<td>- utilize prior knowledge to understand new experiences, and apply course experiences to build new knowledge</td>
</tr>
<tr>
<td></td>
<td>. visualization</td>
<td>- testing his/her understanding through examples, cases, and illustrations</td>
</tr>
<tr>
<td></td>
<td>. present &amp; exhibit design works</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.4. Major and minor principles of WBDL and its related tasks / learning outcomes
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>. thinking about thinking</td>
<td>. group making &amp; common interests</td>
</tr>
<tr>
<td>. strategic thinking</td>
<td>. group processing &amp; reflection</td>
</tr>
<tr>
<td>. context of learning</td>
<td>. collaboration &amp; negotiation</td>
</tr>
<tr>
<td>(culture, technology, practices)</td>
<td>. social dialogue</td>
</tr>
<tr>
<td>. individual differences &amp; personalization (personalized knowledge representation.)</td>
<td>. leadership, maturity, self-esteem</td>
</tr>
<tr>
<td>. metacognitive knowledge (awareness of one’s cognitive processes)</td>
<td></td>
</tr>
<tr>
<td>. information access &amp; organization.</td>
<td>. setting, allocating teams and monitoring tasks</td>
</tr>
<tr>
<td>. usage of language, numbers, and images</td>
<td>. listening, explaining, and questioning skills to ensure clear communications</td>
</tr>
<tr>
<td>. individual exploration &amp; generating connections</td>
<td>. supporting, encouraging, and engaging in conversation with group members</td>
</tr>
<tr>
<td>. self-regulated learning</td>
<td>. presenting and defending a position clearly, and offering constructive criticism</td>
</tr>
<tr>
<td>. assessment (portfolio, performances)</td>
<td>. setting agendas, scheduling meetings, directing and leading tasks</td>
</tr>
<tr>
<td>. self-reported awareness of cognitive process</td>
<td>. leading by knowledge/skill or personality</td>
</tr>
<tr>
<td>. learning how to solve design problems</td>
<td></td>
</tr>
<tr>
<td>. questioning diverse issues related to the design problem</td>
<td></td>
</tr>
<tr>
<td>. displaying divergent thinking and views from multiple perspectives</td>
<td></td>
</tr>
<tr>
<td>. identifying gaps in understanding and role of self within group</td>
<td></td>
</tr>
<tr>
<td>. enhancing his/her capacity for logical reasoning and formal argument</td>
<td></td>
</tr>
</tbody>
</table>

continued
Table 5.4 continued

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>. intrinsic motivation to learning</td>
<td>. computer literacy</td>
<td>. accessibility, flexibility</td>
</tr>
<tr>
<td>. motivational &amp; emotional influences on learning</td>
<td>. software usage for design works</td>
<td>. manageability</td>
</tr>
<tr>
<td></td>
<td>. self-authorship</td>
<td>. relationship between the content of design and WBDL</td>
</tr>
<tr>
<td></td>
<td>. attitude toward learning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>. engagement with learning activities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>. assessment (collaboration, group progressing, team work)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- developing in self-confidence and self-esteem</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- clarifying attitudes on learning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- accepting challenges</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- evolving a sense of responsibility and commitment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- managing their study time and effort and evaluating their own work and progress as learners</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- using computer system</td>
<td></td>
</tr>
</tbody>
</table>
6.1. Research Design

6.1.1. Research Questions for the Inquiry

This study has four research questions that have led the development of WBDL models and the theory of constructivist design learning discussed in Chapter 5. Before initiating a case study of WBDL, it is important to recognize the relationships among the four research questions and their research processes/outcomes to identify what we can anticipate to investigate further in the case study to cover those questions. The relationships of the research questions and their outcomes are summarized in Table 6.1.
<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Research Process &amp; Outcomes</th>
</tr>
</thead>
</table>
| **1. What does a constructivist perspective in design education look like?** | - Design education model I provides a constructivist perspective on design education focused on a person’s life-long learning and creating knowledge-building communities. (Chapter 2)  
- The Constructivist design learning model below provides an integrative ground for combining cognitive and social constructivist learning theories. Vygotsky’s ZPD theory is adopted to explain the importance of recognizing learning communities including peer group members and experts during the process of design learning. (Chapter 3, 4, and 5) |
| **2. What contextual features influence constructivist learning in design education?** | - The literature reviews and field researches for the rapidly changing design society illustrate the four contextual features of learning in the knowledge-based postindustrial society: connection, heterogeneity, multiplicity, and morphogenesis. It emphasizes the contemporary issues in constructivism such as learner-centered, generative learning, and knowledge communities. (Chapter 2)  
- The contextual features above drive design education to the new profiles in the Information Age, and this study proposes the major and minor principles for establishing constructivist design learning and computer-supported learning environment. (Chapter 3 and 5) |

Table 6.1. Relationship between four research questions and the development of research processes/outcomes
Table 6.1 continued

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
</table>
| 3. How does WBDL function with a constructivist approach?                | - The conceptual model of WBDL provides the students the constructivist learning environment where design learning is enhanced by its cognitive, social, collaborative, and reflective learning procedures. (Chapter 5 and 6)  
- The WBDL program functions as a knowledge construction and social interaction tool. It provides a venue for encouraging students to use diverse cognitive strategies and to be involved in diverse ZPDs among students and experts. (Chapter 7) |
| 4. How is the quality of design education enhanced by a constructivist learning approach with Web-based technology? | - The interactive learning among students and experts is assumed to enhance the quality of design learning. Design problem-solving is also enhanced by the support of Web-based computer technology. The case study explains the possibilities and effectiveness of applying WBDL for the quality of design education. (Chapter 6 and 7) |

Among the questions, the first two questions can be answered by the literature reviews concerning the development of design education models and the constructivist design learning model in chapter 2, 3, 4, and 5. Conducting a case study will support the other two questions, which requires identification of the effectiveness of the WBDL
program as a knowledge construction tool, and the appropriateness of applying the theory of constructivist design learning with WBDL: How does WBDL function with a constructivist approach? How is the quality of design education enhanced by a constructivist learning approach with Web-based technology? These questions, therefore, are the research goals of a case study discussed in next section.

6.1.2. Research Design

With the paradigm shift toward postpositivism, the field of qualitative research has undergone quantum leaps in 1990s (Lincoln & Guba, 1985; Denzin & Lincoln, 2000). The word “qualitative” implies the qualities of entities and processes. Qualitative research is understood as a “situated activity” that produces a wide range of interpretive practices (Denzin & Lincoln, 2000), based on the belief of postpositivism that there is no value-free and context-free research. Janesick (2000) characterized qualitative research as follows:

- Qualitative research is holistic; it is not constructed to prove something.
- Qualitative research is focused on understanding given social settings.
- Qualitative design demands time in analysis equal to the time in the field.
- Qualitative design requires the researcher as human-instrument.
- Qualitative design requires the construction of an authentic and compelling narrative of what occurred in the study (p. 385-386).
Lincoln and Guba (1985) proposed a flow of qualitative inquiry in a natural setting/context (see Figure 6.1) based on these characteristics of qualitative research. According to their flow, the natural setting demands the qualitative researcher to be a human instrument, because it is believed that “only the human instrument has the characteristics necessary to cope with an indeterminate situation” (p. 193). Concerning the field studies of sociology and anthropology, the concept of using humans as instruments is not a new one and it has been recognized to be nearly as reliable as objective means. The humanly implemented methods such as interview, observation, and data interpretation are supported by “triangulation,” a well-known qualitative inquiry concept, which uses multiple and different sources and methods “to clarify meaning, verifying the repeatability of an observation or interpretation” (Stake, 2000, p. 443). Lincoln and Guba’s flow of qualitative inquiry adopts the concept of triangulation to the four forms of inquiry steps; purposive sampling, inductive data analysis, grounded theory, and emergent design. The inquiry takes a form of successive iterations of four forms of inquiry until redundancy is achieved and the theory is stabilized (Lincoln & Guba, 1985, p. 188). As the final outcome of the inquiry, a case report is produced with the analyzed data and its interpretations.
Figure 6.1. The flow of qualitative inquiry (Lincoln & Guba, 1985. p. 188)
Figure 6.2. Qualitative inquiry flow for the case study
Lincoln & Guba’s flow is adopted to develop the qualitative inquiry orientation and process of this study. Figure 6.2 illustrates the content and flow of qualitative inquiry for the case study; the tacit knowledge of constructivist design learning was established from the literature review, and a WBDL environment was developed simultaneously as a case study. A case study means a choice of what is to be studied. Stake (2000) explained, “case studies are of value for refining theory and suggesting complexities for further investigation, as well as for helping to establish the limits of generalization” (p. 448). As a way of conducting case studies, this study uses an “instrumental case study,” which examines mainly to provide insight into an issue or to redraw a generalization. Stake identified an instrumental case study as: “the case is of (the) secondary interest, it plays a supportive role, and it facilitates our understanding of something else. The case is still looked at in depth…but all because this helps the researcher to pursue the external interest” (p. 437).

For the case analysis, this study adopts a method of “purposive sampling,” which has a purpose “to include as much information as possible, in all of its various ramifications and constructions; hence, maximum variation sampling will usually be the sampling mode of choice” (Lincoln & Guba, 1985, p. 201). This study selects two groups
and two students from the purposive sampling, which will be discussed in next chapter.

In order to increase the validity and credibility of the data analysis, this study triangulates diverse data gathering methods: interview, questionnaire, on-line information posted on the WBDL menus, a student’s personal weekly journal/reports, the design problem solving process and its outcomes, and collaborative learning activities.

6.2. A Case Study Design

6.2.1. A Case Study of a Design Studio Course with WBDL

The goals of the case study are to investigate diverse possibilities of applying the theory of constructivist design learning, and to identify the effectiveness of applying WBDL as an alternative learning method and environment. For these goals, a series of cases were developed and conducted during four consecutive semesters at KAIST (Korea Advanced Institute of Science & Technology). Figure 6.3 outlines how a series of cases were designed and experimented with the theory of WBDL.

Among a series of cases, this study focuses on one design studio course, entitled as “Product Design System” in 2001. Based on the research questions discussed in Chapter 6.1.1, a specifically designed WBDL program for the senior industrial design
studio course at KAIST was used in the case study. The context and content of this design course are summarized as follows. Among a series of cases, the selection of the case in 2001 is appropriate, because this study focuses on group works in higher level of design problem-solving process.

Figure 6.3. A series of cases experimenting with WBDL
a. Outline of the Design Studio

The course was designed for senior industrial design students to investigate the emerging paradigm of design studies, and to develop a new design project with a subject matter of “wearable computer design.” Wearable computer design is a symbolic theme, which expands the design scope by blurring the boundaries between the discipline of design and other disciplines such as electronic, electrical, mechanical engineering, and fashion. The design project, therefore, has a goal to develop a meta-design concept, which integrates hardware and software, theory and practice, and a variety of knowledge from diverse disciplines; the course content covers multi-modalities of technology (vision, sound, olfactory, and tactile), history (wearable computer, fashion, and science), design (issues, trend, narrative, and scenario-based design), arts & aesthetics (new media, cyber novel, and digital aesthetics), and culture studies (self-identity, integration, and multiculturalism).

Since this course is established on the basis of constructivist design learning, the course objectives recognize each student's cognitive and social learning process as the primary goal; the ultimate wearable computer design is expected to be a part of the outcomes after constructing design knowledge through the course. The objectives of the
course are summarized as: (1) to establish cross-fertilized knowledge bases for solving technology-oriented design problems with a theme of wearable computer design; (2) to create social learning communities among students, experts, and instructors and to enhance their collaborative learning skills; (3) to investigate complicated design issues and contextualize them in the design problem; and (4) to demonstrate and evaluate design outcomes of wearable computer design and its problem-solving processes.

To accomplish the above course objectives, the constructivist learning activities and design processes were scheduled for 16 weeks as follows.

<table>
<thead>
<tr>
<th>Week</th>
<th>Activities</th>
<th>Design &amp; Learning Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction to new learning paradigm</td>
<td>Prior knowledge</td>
</tr>
</tbody>
</table>
| 2    | Team organization (8 groups) | - Understanding different paradigm  
- Construct knowledge base of fashion & history |
| 3    | Information gathering | Searching issues of wearable computer |
| 4    | Presenting group works | Analyzing wearability issues from technology, fashion, and design |
| 5    | Investigating design methods of Wearable Computer Design (WCD) | Defining design problem of Wearable Computer Design (WCD) |
| 6    | 1st Presentation (WCD concept) | Exploring design concepts  
Presenting multiple views of WCD |
| 7    | Developing design ideas | Ideation: scenario design (context of WCD) |

Table 6.2. Learning activities and design processes of the case study in 16 weeks
Table 6.2. Continued

<table>
<thead>
<tr>
<th></th>
<th>Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Midterm</td>
<td>Ideation: scenario design (user of WCD)</td>
</tr>
<tr>
<td>9</td>
<td>Invited Expert</td>
<td>Ideation: design metaphor, keywords</td>
</tr>
<tr>
<td>10</td>
<td>Developing design ideas</td>
<td>Experiencing five Senses of Design</td>
</tr>
<tr>
<td>11</td>
<td>2nd presentation (WCD scenario)</td>
<td>Developing best &amp; worst design scenarios</td>
</tr>
<tr>
<td>12</td>
<td>Invited Expert</td>
<td>Developing design solutions</td>
</tr>
<tr>
<td>13</td>
<td>Discussing and synthesizing design</td>
<td>Integrating hardware design</td>
</tr>
<tr>
<td>14</td>
<td>Discussing and synthesizing design</td>
<td>Integrating software design</td>
</tr>
<tr>
<td>15</td>
<td>Discussing and synthesizing design</td>
<td>Integrating interface design</td>
</tr>
<tr>
<td>16</td>
<td>Presenting final design solutions</td>
<td>Organizing &amp; presenting final design solutions &amp; its processes</td>
</tr>
</tbody>
</table>

b. Designing Learning Processes for the WBDL Program

The course provided a face-to-face class twice a week to extend its continuous meetings and discussions with the WBDL program. The WBDL program was used through the course, 24 hours and 7 days, as a venue for collaborative design learning among students or between an instructor and students. This program was run via the Intranet server at KAIST, and provided a supplementary learning and designing space for the students to share and construct diverse knowledge and information related to the wearable computer design. Figure 6.4 shows the login page of WBDL.
Figure 6.4 Login page of WBDL

The learning activities for 16 weeks that combine both face-to-face learning and virtual learning locate the WBDL at the middle of A and B and D altogether, as illustrated in Figure 6.5. Positioning a WBDL on the design education model II is useful for the instructor to develop the course content and the learning context, which directs the possible level of technology use and the desirable connections to industries or design communities as knowledge-building partners. It becomes a useful planner and director.
As a knowledge construction and collaboration tool, the WBDL program is designed to support six steps of design problem-solving process; (1) sharing information about wearable computer design and other related resources; (2) discussing the design problem and defining it with other students; (3) enhancing collaborative learning and creating a design solution as the result; (4) constructing communication channels among
students, and between an instructor and students; (5) presenting final design solutions to the class and criticizing them; and (6) reflecting the student’s learning process and constructing his/her attitude toward learning. These learning activities for the design process are required to be embedded in the basic information architecture of the WBDL program. Originally influenced by Perkins’s (1992) idea for creating WBI, the structure of WBDL menus in Figure 6.6 are designed to enhance the six steps of design process above.

Figure 6.6. Information Architecture of WBDL

The WBDL program consists of five main menus: Information, Design Kit, Communication, Design Table, and Gallery. Each main menu has diverse sub-menus...
which provide different learning functions and accessibilities. For instance, three sub-menus (Syllabus, Thinking Map, and Phenomena) under the “Information” menu are accessible by all, but the “Personal Room” under “Communication” menu is only for a student and the instructor; “Design Table” consists of separate group rooms which provide collaborative working spaces exclusively for the group members and the instructor. Table 6.3 explains the diverse learning activities supported by the sub-menus and their opened or limited accessibilities. The infrastructure of WBDL is explained in next section.

<table>
<thead>
<tr>
<th>WBDL Menu</th>
<th>Learning Activities</th>
<th>Accessibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syllabus</td>
<td>Sharing information about wearable computer design and other resources</td>
<td>All students and Instructor</td>
</tr>
<tr>
<td>Thinking Map</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phenomena</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Kit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>Discussing design problems and processes</td>
<td>All Students and Instructor</td>
</tr>
<tr>
<td>(Class Board)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>Communicating individually with the instructor</td>
<td>Individual Student and Instructor only</td>
</tr>
<tr>
<td>(Personal Room )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Table</td>
<td>Implementing design solutions with group members</td>
<td>Group Members and Instructor only</td>
</tr>
<tr>
<td>Design Gallery</td>
<td>Presenting final design solutions to the class and criticizing about it</td>
<td>All Students and Instructor</td>
</tr>
</tbody>
</table>

Table 6.3. The relationship between learning activities and information structure of WBDL
c. Infrastructure of WBDL

For the constructivist design learning, the WBDL program provides a cognitive structure that allows the students to construct meaningful information for solving design problems, and to visualize their concepts to produce appropriate design solutions. Among various menus of WBDL, Thinking Map, Phenomena, and Class Board provide open learning places for collecting information related directly or indirectly to the subject matter, and finally for establishing students’ cognitive structures to solve the design problem. Thinking Map is a knowledge construction menu that guides the students to collect explicit information about wearable computer design and guide students as to what to learn and think about it. It covers technological, historical, cultural, aesthetical, and design issues related to wearable computer design. The instructor designed the outline of thinking map, then the students became the centered persons who constructed the information nodes on the map; it is a part of their generative learning process. Figure 6.7 shows how the thinking map is organized as a horizontal structure, which students access voluntarily to add information on any node. The completed map is recognized as a grown-up tree as the natural result of students’ generative learning.
Figure 6.7. Information architecture of Thinking Map

Phenomena Menu is similar to Thinking Map for placing and sharing information, but the content covers diverse phenomenal information of senses and activities that relate directly or indirectly to the subject matter. Communication Menu is for connecting and promoting communications among students and between an instructor and students; it consists of “Class Board,” and “Personal Room,” which facilitates the out-of-class discussion. In Class Board, students post messages in correspondence to
other messages, or initiate new threads of conversation promoting others to respond in.

Another menu, Design Table, is an extended concept of a designer’s working table, where design ideas are developed, evaluated, and finalized. Each group occupies a cyber-table exclusively for the group members to support their short-term and long-term memories as they record ideas, develop design solutions, and manipulate and discuss them. The last menu, Gallery, is an online archive for reviewing the final design works. Each group posts the final design outcome and its problem-solving processes at the Gallery, which allows all students and the instructor to review them. Figure 6.8 shows a team’s project posted at Gallery.

![Figure 6.8. A group’s project presented at Gallery](image)

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6.2.2. Research Methods and Triangulation

The principal goal of data collection and analysis for the case study is to identify meanings from all materials, which is originated from the postpositivist paradigm. These meaning-making processes are accomplished by main tasks such as: (1) to understand how this type of education and the WBDL program works; (2) to show what rules of interpretation are operating, and (3) to illustrate the structure of interpretation of the study. For accomplishing these tasks, this study uses a method of triangulation with the following data sources: (1) analyses of archival records such as information board logs and Design Table participations; (2) a student’s weekly journals for reflecting the learning progress; (3) the design process and its final outcome as a group project; (4) interviews; and (5) questionnaire. Firstly, the data gathered from the archival records indicates the frequency of each student’s participations at the WBDL menus and the frequency of reviewing the posted information by the other students. These processes of information posting and reviewing activities require high-order rules as component skills of knowledge. In addition, a student’s way of constructing knowledge and cognitive skills can be inferred by tracking his/her procedure of creating and sharing information. Secondly, a student’s weekly journal is another important resource for identifying what the student does know and does
not. Triangulating the student’ archival records and the text of weekly journals explain the way each student has developed his/her understandings about the content and how he/she has constructed a personal interpretation from the learning experiences.

Furthermore, in this study, the data collecting method itself maximizes the characteristics of the Web. The WBDL program provides a database recording each student’s activities for knowledge construction and their diverse learning activities. For instance, each student’s learning activities recorded in the menus of WBDL are tracked and analyzed to identify how he/she learns, uses, and creates his/her meaning making process in 16 weeks. Students’ motivational states are also crosschecked by their weekly journals and the preference of data collection during the course.

In summary, the principles of analyzing the WBDL and inquiry resources in the menu of WBDL are compared in Table 6.4 based on the research questions for the case study. The effectiveness of the WBDL and its educational value can be evaluated and interpreted from these triangulated data in the next chapter.
<table>
<thead>
<tr>
<th>Research Question</th>
<th>Principles of Analyzing WBDL</th>
<th>Data Source in WBDL</th>
<th>Other Inquiry Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>How does Web-based learning function with a constructivist approach?</td>
<td>1. knowledge construction . access and utilizing information with WBDL . identifying design problem &amp; concept development . creating design scenario &amp; ideation from multiple perspectives . creative design solution</td>
<td>➔ Thinking Map, Phenomena ➔ Design Table ➔ Gallery</td>
<td>➔ Interview</td>
</tr>
<tr>
<td></td>
<td>3. social interaction . group making &amp; role in a group . well-managed group &amp; social dialogue . engagement of social interaction (size, frequency) . group processing &amp; reflection</td>
<td>➔ Design Table ➔ Thinking Map, Class Board</td>
<td>➔ Interview</td>
</tr>
<tr>
<td></td>
<td>5. Technical Competence - software usage for design works - computer literacy</td>
<td>➔ Design Table, Gallery</td>
<td>➔ Questionnaire</td>
</tr>
<tr>
<td>How is the quality of design education enhanced by a constructivist learning approach with Web-based technology?</td>
<td>2. cognitive &amp; metacognitive strategies . individual exploration &amp; generating connections (planning, comprehending, monitoring, evaluating) . self-evaluation, reflection (knowing, cognitive process, learning to learn)</td>
<td>➔ Diverse usage of WBDL menu ➔ Weekly Journal</td>
<td>➔ Questionnaire ➔ Interview</td>
</tr>
<tr>
<td></td>
<td>6. Effectiveness of Using Computers in Design Learning - manageability - relationship between the content of design and WBDL . structure of WBDL for increasing cognitive learning and social interactions</td>
<td>➔ Gallery</td>
<td>➔ Interview ➔ Questionnaire</td>
</tr>
</tbody>
</table>

Table 6.4. Research question, criteria for data analysis, data source, and methods
6.3. Data Gathering

6.3.1. Group Data Gathering & Purposive Sampling

The case study took place over 16 weeks in Spring Semester of 2001 at KAIST. A total of thirty students was enrolled for the senior design studio (14 males and 16 females), and they were organized into eight groups by themselves to accomplish the team project; six groups consisted of four students and three students were included in each of the remaining two groups. All students were aware of the Web, and able to use it for information searching, data creation, and distribution.

As the project proceeded, the individual students and the groups generated qualitative and quantitative data from their diverse learning processes. The electronically stored data in the WBDL program were basically qualitative in informing the students’ cognitive and metacognitive learning processes and their collaboration levels. At the same time, the data stored in the WBDL program were quantitative in referring to the student’s frequency of participation, time, and the subject areas of participation. First of all, this study uses the quantitative data in categorizing and sampling groups and individuals as follows.
a. Group Data Gathering

The social constructivists provide a perspective that the different levels of social communication and interaction influence the quality of learning. Therefore, it was assumed that each student’s frequency and level of participation in a group’s Design Table would impact on the quality of the final design outcome. In other words, there might be a distinct connection between the data constructed by team communications and the success of the final design output.

From the data referring to a group’s frequency of participation, it can be seen that there was a huge difference in participating and using the WBDL program among the eight groups. In the menu of Design Table, the frequency of posting information and exchanging ideas was analyzed; the most frequently participating group members had hit 108, while the least participating team had hit 21. Figure 6.9 shows the different levels of participation in the eight groups.
Figure 6.9. Different levels of group participation

For analyzing the quality level of design solutions, three experts were invited twice to share their knowledge and experiences from the disciplines of electronic engineering, virtual reality, and fashion design. Presentation of the design process to the experts afforded a lot of benefits to the students’ learning and their final design outcomes: not only the minimization of the bias produced by the individual researcher but also the maximization of the chances of collaborative learning with the experts are the typical benefits pursued. As a good example of building knowledge community, the fashion design expert, at her first attendance, played a role as an adviser as well as a critic.
The constructivist design learning theory would predict that the more frequently participating and communicating teams would draw more appropriate design outcomes at the level of accomplishment of design and the appropriateness of problem solving, than less frequently participating ones. Table 6.5 explains the relationship between the number of participations documented in Design Table and the quality of design outcomes from the eight groups. The experts and the instructor simplified the design evaluation process by categorizing the quality of design outcomes into three levels: higher than average, average, or lower than average. Through the comparison of the frequency of participations and the evaluation of design quality, this study selects two groups as maximum variation sampling for conducting the case analysis. It is the purposive sampling to be discussed in the next section.

<table>
<thead>
<tr>
<th>Group</th>
<th>Participations in Group’s Design Table</th>
<th>Quality of Design Outcomes</th>
<th>Purposive Sampling (O: selected, X: not selected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>73</td>
<td>Higher than Average</td>
<td>(O) The participation rate is high, and the quality of design outcome is better than average.</td>
</tr>
<tr>
<td>Group 2</td>
<td>49</td>
<td>Lower than Average</td>
<td>(O) The participation rate is high, and the quality of design outcome is worse than average.</td>
</tr>
</tbody>
</table>

Table 6.5. Group participation, quality of design outcomes, and purposive sampling

continued
Table 6.5 continued

<table>
<thead>
<tr>
<th>Group 3</th>
<th>21</th>
<th>Lower than Average</th>
<th>(X) The participation number is too low to analyze data.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 4</td>
<td>38</td>
<td>Lower than Average</td>
<td>(X) The participation number is too low to analyze data.</td>
</tr>
<tr>
<td>Group 5</td>
<td>63</td>
<td>Average</td>
<td>(X) The participation rate is high but lower than Group I within the same group of producing better quality of design outcome.</td>
</tr>
<tr>
<td>Group 6</td>
<td>45</td>
<td>Higher than Average</td>
<td>(X) The participation number is low to analyze data.</td>
</tr>
<tr>
<td>Group 7</td>
<td>25</td>
<td>Lower than Average</td>
<td>(X) The participation number is too low to analyze data.</td>
</tr>
<tr>
<td>Group 8</td>
<td>108</td>
<td>Higher than Average</td>
<td>(X) The participation number is the highest, but most of them are posted in wrong menu. They should be in Thinking Map and other menus in WBDL. One student didn’t keep the rule of using WBDL.</td>
</tr>
</tbody>
</table>

b. Group Sampling

Since analyzing the effectiveness of WBDL relies heavily on the quantity and quality of the student’s task management and decision-making process, the researcher needs to select groups and individuals having as much analyzable information as possible. For this purpose, the group sampling was done with the following criteria: (1) the total number of participations in Design Table needs to be higher than the average participation of eight groups; (2) the group needs to represent either higher than average
or lower than average on the design evaluation; (3) the process of posting and sharing
information should follow the general rule of managing the WBDL menu.

Based on these criteria, this study selects group 1 and 2 as appropriate samples
for the case analyses. In Table 6.5, group 8 showed the highest number of participations,
but one group member didn’t keep the general rule of posting information under the
appropriate menu of WBDL; a lot of information were posted in wrong places. Group 1
had the second highest participation, and was ranked as higher than average in design
quality; this group would be selected to represent “a group of good design quality.”
Group 5 had the third highest participation, but was evaluated as the same category of
design evaluation with Group 1. Group 2 had the fourth highest participation, and was
categorized as lower than average in design quality; this group would be selected to
represent “a group of poor design quality.” Therefore, group 1 and 2 were selected as
purposive samples and named as group A and B in the following case analyses. Table 6.6
shows the demographic data of two groups; both groups consist of two males and females,
and they have a similar range of age.
<table>
<thead>
<tr>
<th>Group</th>
<th>Student</th>
<th>Gender</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>A1</td>
<td>Female</td>
<td>0</td>
</tr>
<tr>
<td>(previously group 1)</td>
<td>A2</td>
<td>Male</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>A3</td>
<td>Female</td>
<td>-1</td>
</tr>
<tr>
<td></td>
<td>A4</td>
<td>Male</td>
<td>+1</td>
</tr>
<tr>
<td>Group B</td>
<td>B1</td>
<td>Female</td>
<td>0</td>
</tr>
<tr>
<td>(previously group 2)</td>
<td>B2</td>
<td>Male</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>B3</td>
<td>Female</td>
<td>+2</td>
</tr>
<tr>
<td></td>
<td>B4</td>
<td>Male</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 6.6. Demographic data of eight students in two groups

Both quantitative and qualitative data were collected from the WBDL in order to identify the cognitive processes used by the two groups to conduct the design research. First of all, each group member’s participation in the WBDL program was compared in Table 6.7. Group A showed higher collaborations and interactive communications among members than group B; specifically in Design Table, the number of participation in group A and B hit 72 and 49, respectively. The total number of participation in all WBDL menu indicated that there were huge individual differences among group members, for example, student B1 and B4 showed the largest discrepancy in participation as 60 vs. 9 times.

In spite of the different participation rates between the two groups, there is a similar tendency in participation that a student in each group showed a higher
participation than the rest of the students. Female students A1 and B1, of the same age, had huge amounts of collectable data relative to the others; therefore, they were purposively selected as two individual examples for analyzing the cognitive and social learning procedures in next section.

<table>
<thead>
<tr>
<th>Group</th>
<th>Group’s Design Table</th>
<th>Personal Room (journals)</th>
<th>Thinking Map</th>
<th>Phenomena</th>
<th>Class Board</th>
<th>WBDL Total Participation</th>
<th>Group Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>35</td>
<td>21</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>62</td>
<td>149</td>
</tr>
<tr>
<td>A2</td>
<td>18</td>
<td>11</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>15</td>
<td>12</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>A4</td>
<td>4</td>
<td>8</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>26</td>
<td>30</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>60</td>
<td>123</td>
</tr>
<tr>
<td>B2</td>
<td>9</td>
<td>10</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>B3</td>
<td>9</td>
<td>11</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>B4</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

Table 6.7. Eight students’ participation data documented in five menus of WBDL
6.3.2. Personal Data Gathering & Analysis

The student A1’s and B1’s personal data were collected from diverse sources: archival data within the WBDL menus, personal weekly journals, questionnaire, and interview. All these collected data would be analyzed and triangulated to understand and interpret their learning processes and problems as follows.

a. Student B1

Student B1 showed the highest participations in posting and sharing information among the group members, which covered almost half of the total participation of group learning with WBDL. She contributed to the development of group project on Design Table more than any other group member by as much as three to five times (see Table 6.7). The participation of the group she belonged to was low in all WBDL menus; furthermore, the frequency of participation of this group was very low. It is assumed that there would be a strong correlation between the total number of participations (amounts of time) and the frequency of participation (time points during 16 week) to the WBDL; the lower number of participations would pull the frequency of participation down. To provide the significance of connection and quantification, the data of frequency of
participation needs to be interpreted as more than the simple quantitative information: the
time data when each group members participated during the group project are enriched
by specifying the participation of 16 weeks in each menu of WBDL. The frequency data
of posting information in five menus of WBDL explains when, where, and how much she
put her efforts into different learning areas. For example, Figure 6.10 presents student
B1’s academic activity of 16-weeks with WBDL. Her high participation and active
learning in the beginning of the course had been reduced to nil by the fifth week. From
the second half of course, her learning pattern had been changed to focus on the group
project development and her personal journal writing, which limited her activities within
only two menus in WBDL, Design Table and Personal Board, respectively.

It is also important to notice that her total participation in Design Table for only
group members drops significantly down from 26 to 1 in other knowledge creation and
utilization menus opened to every classmate such as Thinking Map and Phenomena (see
Table 6.7). The reason of having this attitudinal difference was identified through the
interview after completing the course.

From all quantitative data described above, it is assumed that the one-way
contribution degenerated the motivation of student B1, and lessened her trust in group
members. To increase the validity and credibility, however, this assumption needs to be triangulated with other qualitative data sources such as weekly journals, questionnaire, and interview. Crosschecking among the qualitative data could illustrate her problems of cognitive and social learning process with the group members.

Figure 6.10. Student B1’s academic activity of 16-weeks with WBDL

**Weekly Journals**

The weekly journals were most useful resources for identifying her role and relationship with the other group members. Her first and second weekly journals revealed the good mood with initiating collaborative learning and the excitement for the new
design project. From the third journal, however, a good deal of discord had arisen in the group over the problems of “lack of communication skills and social dialogue,” “collaboration and negotiation,” and “questioning design problems and clarifying design concepts.” The following three journals extracted from her original writings explain chronologically her excitement and difficulties of learning with group members.

Weekly Journal 1 (03/24/01)
…So far I think our team is in a good shape since everybody has at least one role. And every discussion, two people were in charge of summarizing or making format. I am very content with team participation. Every member is voluntary and passionate. Hope this mood will continue to the end.

Weekly Journal 2 (04/01/01)
…I arranged brainstorming and user settings this time. And presented about our user definition in class…After the class we met again to decide the job…Our character is Mr. K…Hope it’s going to be a big fun!

Weekly Journal 3 (04/10/01)
…It was quite a harsh time for our group since we couldn’t clearly decide which part of Mr. K we would study for. Between job and life, all of us voted for job except one…I was mad for we couldn’t step forward at all to decide what to study for…But after a long talk and discussion, I could agree that job would be very challenging for us to make it in real product…I felt like making one product from life and the other from work. And this suggestion was instantly rejected…In this week’s work, I found one problem in our group that is we talk much on what to do but not how to do. When we work on each part, we never touch to do it for the respect of each member…From next discussion, we’d better clearly talk how to organize and how to precede our ideas. I believe respects and trusty on other team members are important, but other than that, we definitely need some common points in our works…In yesterday’s case, which was to develop detailed scenarios, I was
surprised seeing very different level of scenarios among mine and the other’s. It wasn’t a
team work but an individual work…I developed very detailed scenario while the other was
developing general idea…I guess our understanding of developing scenario were different
from each other.

Unfortunately, the group B was not successful in identifying the problems they
had confronted for several weeks; more psychological problems were generated among
the group members. Instead of solving the problem, student B1 had changed her active
and leading role for the collaborative learning toward an inactive and absorbing one. Her
fourth and fifth weekly journals explain her psychological emptiness, which was spread
to all members like “a plague,” from her description.

04/15/01 (weekly Journal #4)
This week wasn’t very good for our team since we were stuck before our idea banks…I was
totally exhausted. I really needed get back and take a little break…Instead of making idea,
we’ve talked much on process this week.

04/22/01 (Weekly Journal #5)
I confess I wasn’t voluntary working at anything. I took a rest left all works behind. I was, I
guess, like a plague since all our group members showed same symptoms…At the end of
the week, we met together with ideas developed…I first chose three favorite ideas. Other
members were for my choices. So my choices became group choices.

As the group members mistrusted each other, all discussions and collaborative
works had confused them, and finally led them to the wrong direction of conceptualizing
wearable computer design. The group members could not establish an appropriate and desirable cognitive strategy from the beginning phase of understanding and defining the design problem within the contextual boundaries; this fundamental problem continued to make all group members ambiguous on their problem solving process. The following journals from sixth and seventh deliver the chaotic moment the group members experienced.

04/29/01 (Weekly Journal #6)
We started to build up from the beginning. I said this and that but all rejected. Frankly speaking, I was in the very corner of my idea bank…Suddenly somebody questioned “by the way, how is this scenario related with our context?” Soon we all got calm. That was a little question we all had in mind but couldn’t answer clearly…We weren’t very sure if we were on right track. It seemed always a bit unclear.

05/6/01 (Weekly Journal #7)
It was a lucky week for our group…We knew something was missing in each of our scenarios. And that was the context. Then somebody suggested to combine all three scenarios together in one system. I thought that was a good idea…Wednesday’s class brought us in panic. We find out we don’t necessarily have to build working system for our ideas…We all got speechless. How foolish we were. We did put ourselves in prison named “working product.” After class, we get together and seriously talked…After knowing we do not really have to make actually working product, the clouds in my mind seemed got away. Feel energetic again to get into work. ^^

Student B1 was not the one who had such difficult times within the group. Weekly journals written by all group members revealed more tensions and discrepancies arising among the group members. The lack of communication and negotiation skills among the
group members evoked a need of a group leader as a decision-making person; student B1’s journal below shows that the necessity of leadership was still existing three weeks before the final presentation.

05/20/01 (Weekly Journal #9)
What we were going to do was clear. The last problem we have to go through is how we could work more efficiently…We talk much, we meet a lot, and we discuss actively. However, we are little passive to say “I will do this and you do that.” I think it’s good to have a leader-like person in our group…We just lack a decision-making person. I shall first try to be decision-making person.

The weekly journal functions as a student’s self-reflection and a cooperation tool between the instructor and the student. Student B1’s self-motivation to be a decision-making person kept her working hard during the last several weeks to complete the project. Her amounts of efforts and time devoted to participate in the WBDL were increased again during the last four weeks, especially on Design Table (see in Figure 6.10). Writing a personal journal/report is, therefore, recognized as a good cognitive strategy to enhance a student’s self-authorship and self-esteem by reflecting the process of designing and learning practices. It holds true with respect to the student B1’s case that she became aware of the problems of the group learning, and tried to find her way of solving the problem.
Questionnaire & Interview

The data of students’ mindset were gathered through questionnaire and interview with the student A1 and B1 after the completion of course. A warming-up step with a simple questionnaire was followed by the in-depth interview. Using a questionnaire allowed the student to overview and to reflect the learning activities she had completed; it worked as a thread to the interview questions later. This study adopted the general format originally developed by Benson Soong et al. (2001), in the paper titled “Critical Success Factors for On-line Course Resources” (p. 115). The newly created eighteen questions are for the familiarity of computer usage and the epistemology of constructivism. The questions were answered with five point scale from 1 to 5. Table 6.8 shows student B1’s answers for the questionnaire.

In the question of technical competence, she graded herself as high in both computer literacy and software competence used in design works of WBDL. For the questions of epistemology and mindset, she marked the highest for the comprehensibility, the value of collaborative learning provided by WBDL in constructivist approaches and in participation.
<table>
<thead>
<tr>
<th>Questions</th>
<th>5 point scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The on-line course encourages me to search for more facts and participate actively in the discussions than the traditional methods of teaching.</td>
<td>3</td>
</tr>
<tr>
<td>2. I contribute actively on the resources.</td>
<td>5</td>
</tr>
<tr>
<td>3. I reply to matters that my fellow contributors have raised.</td>
<td>4</td>
</tr>
<tr>
<td>4. The lecturer motivates me.</td>
<td>5</td>
</tr>
<tr>
<td>5. The lecturer is active in my learning of the subject.</td>
<td>5</td>
</tr>
<tr>
<td>6. I enjoy using the PC.</td>
<td>5</td>
</tr>
<tr>
<td>7. I use the PC for work as well as play.</td>
<td>5</td>
</tr>
<tr>
<td>8. I was comfortable with using the PC and software applications before I took up the on-line course.</td>
<td>5</td>
</tr>
<tr>
<td>9. My previous experience in using the PC and software applications helped me in the on-line course.</td>
<td>3</td>
</tr>
<tr>
<td>10. I am not intimidated by using the on-line course.</td>
<td>4</td>
</tr>
<tr>
<td>11. I learn best by absorption (i.e. sit still and absorb)</td>
<td>3</td>
</tr>
<tr>
<td>12. I learn best by construction (i.e. by participation and contribution)</td>
<td>4</td>
</tr>
<tr>
<td>13. I learn better by construction than absorption.</td>
<td>4</td>
</tr>
<tr>
<td>14. I do not read/participate in the discussion group.</td>
<td>1</td>
</tr>
<tr>
<td>15. I only read the messages posted in discussion group.</td>
<td>3</td>
</tr>
<tr>
<td>16. I read as well as participate in the discussion group.</td>
<td>5</td>
</tr>
<tr>
<td>17. The facilitator initiated most of the discussions.</td>
<td>2</td>
</tr>
<tr>
<td>18. Students initiated most of the discussions.</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 6.8. Questionnaire for student B1
However, she gave a moderate grade to the effectiveness of on-line learning than traditional learning. The question of epistemology didn’t show a significant difference between objectivism (learn by absorption, point 3) and constructivism (learn by construction, point 4) although she said she got better learning by constructivism than by absorption.

After the questionnaire, students had a one-hour interview individually. In the quasi-structured interview, students were asked holistic questions on problems in managing team projects and practical problems in WBDL learning. Interviews were based on the following questions in Table 6.9 and they were tape-recorded to be established as qualitative database. By the interview, student B1’s knowledge acquisition was found to be constructed not from her group's Design Table, but from other menus in WBDL opened to all students such as Thinking Map or Phenomena. However, she remained passive in these open areas for whole students in that she read what others have uploaded rather than gave them firsthand information. Her social knowledge construction was relatively passive and limited within her small group, which demonstrates her psychological conflicts between the intention to search for the construction of knowledge unattained by group project in open learning space, and the loss of the initiative to
actively participate in sharing and developing information with the whole class.

Following is her mindset toward the group project extracted from interview.

Q: About the group project, what was your role?
A: My typical role is like to be a leader. I usually worked as a leader…I tried to divide every work equally, but there should be one person who corrected every works I liked them. I got the role, which is the most difficult and hardest, and took the most time…It’s like the tear a group project has. I changed other people’s works and my own when they worked on my way. It was different from the way we should go.

Q: How did you manage the project? How could you be the leader?
A: It has a reason that I always am a hard worker. I can’t pass things easy. I just volunteered to get work more, and people started to rely on me. Not in this project…everybody had their own voice, and never tried to cooperate each other. That was very difficult time…. 

<table>
<thead>
<tr>
<th>Three factors for analyzing the effect &amp; value of WBDL</th>
<th>Questions</th>
</tr>
</thead>
</table>
| Epistemology & Knowledge Construction                | 1. How did you construct your knowledge and experiences during the course?  
2. What did you lean? What did you want to learn at the course?  
3. How do you know what you learn? What do you think of learning? What is it? |
| Cognitive strategies & Social knowledge Construction  | 4. We designers should work with other people. How did your group manage the team project?  
5. What is the advantage or disadvantage working as a team in design learning? Did you learn from other students? |
| Technical competence & Evaluation of WBDL            | 6. How do you think of Web as an instructional media? |

Table 6.9. Quasi-structured interview questions related to three factors of WBDL
b. Student A1

Another student A1 represented “a group of good design quality” and high participations in collaborative learning. She showed the highest frequency of participation among all group members. Similar to student B1 who had the number of 60 participations in WBDL, student A1 had the number of 62. However, the areas student A1 participated in WBDL was extended to be more diverse. Thus, in spite of the similar numbers of participation, the two students constructed different knowledge areas for wearable computer design and used different learning strategies. Student A1 performed academic activities with frequent motivation and feedback from group members and with ample content of communication from the situated and collaborative learning among group members; it is very comparable to student B1 who performed passive and closed activity with very few interactions between group members. Figure 6.11 illustrates student A1’s learning activity of 16-weeks with WBDL. This figure shows her consistent learning pattern with the number and frequency of participations, and learning areas in WBDL.
Comparison of frequency between the students’ and the groups’ in WBDL, therefore, enables us to illustrate the different learning contexts established by the group members; this socially and psychologically situated learning environment influences the development of each student’s psychological learning strategies.

**Weekly Journals**

Student A1’s weekly journals present the general characteristics of a well-managed group: positive interdependence, face-to-face provocative interaction, and
individual accountability. She took a leadership from the beginning of the project, and creating a good collaborative learning environment; it is well expressed in her first and second journal extracted as follows.

Weekly Journal 1 (03/26/01)
…In our team, I usually call my team member and conducted the meeting. First of all, I searched for reference books in the library…and the Internet. Our team exchanged URLs of good sites.

Weekly Journal 2 (04/02.01)
…we had three meetings in this week. We decided our design context as emergency medical system agent. We had a difficulty to determine the context. I think each team member has own perspective...therefore, we made a good team (construction).

Similar to group B, Group A also experienced difficulties in collaborative learning. But the cognitive strategies of accepting and negotiating the different opinions among group members were very different. Student A1 believed that cross-fertilization drew creative ideas in collaborative learning. Her seventh journal is a good example to understand how she and her group members managed the difficult task cooperatively, and kept their progress.

Weekly Journal 7 (05/06/01)
…I saw the presentation of other groups. I felt that the progress of our group was a little bit slow…I think our group have to make narrow our function, but other members like A2 thought all functions related to system. We spent much time to make scenarios, and it took
so much time to decide…We made morphological chart for contents vs. function, then we started idea sketching…I satisfied our process and our decision. Indeed before the Wednesday’s presentation we had a pride about our process.

It is also found that all group members developed social dialogue and communication skills to encourage each other’s learning progress. Her eleventh journal is extracted as a simple example of interpersonal communication and peer learning.

Weekly Journal 11 (06/04/01)
…I did some idea sketches. I was happy to hear a word of praise. A2 and A4 told me that my idea sketches were much better than before…

Questionnaire & Interview

From the questionnaire in Table 6.10, student A1 showed more positive attitude to on-line learning than B1. She also assessed herself to be the highest in participation. However, the questions on epistemology outlined her introspective nature. She estimated her contribution on knowledge building as very low regardless of her highest participation in the WBDL; it is comparable to the assessment for student B1 as the highest, although both of them participated equally.
Table 6.10. Questionnaire for student A1

<table>
<thead>
<tr>
<th>Questions</th>
<th>5 point scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The on-line course encourages me to search for more facts and participate actively in the discussions than the traditional methods of teaching.</td>
<td>4</td>
</tr>
<tr>
<td>2. I contribute actively on the resources.</td>
<td>2</td>
</tr>
<tr>
<td>3. I reply to matters that my fellow contributors have raised.</td>
<td>3</td>
</tr>
<tr>
<td>4. The lecturer motivates me.</td>
<td>4</td>
</tr>
<tr>
<td>5. The lecturer is active in my learning of the subject.</td>
<td>4</td>
</tr>
<tr>
<td>6. I enjoy using the PC.</td>
<td>3</td>
</tr>
<tr>
<td>7. I use the PC for work as well as play.</td>
<td>5</td>
</tr>
<tr>
<td>8. I was comfortable with using the PC and software applications before I took up the on-line course.</td>
<td>4</td>
</tr>
<tr>
<td>9. My previous experience in using the PC and software applications helped me in the on-line course.</td>
<td>4</td>
</tr>
<tr>
<td>10. I am not intimidated by using the on-line course.</td>
<td>1</td>
</tr>
<tr>
<td>11. I learn best by absorption (i.e. sit still and absorb)</td>
<td>3</td>
</tr>
<tr>
<td>12. I learn best by construction (i.e. by participation and contribution)</td>
<td>4</td>
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<tr>
<td>13. I learn better by construction than absorption.</td>
<td>3</td>
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<td>14. I do not read/participate in the discussion group.</td>
<td>1</td>
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<tr>
<td>15. I only read the messages posted in discussion group.</td>
<td>2</td>
</tr>
<tr>
<td>16. I read as well as participate in the discussion group.</td>
<td>5</td>
</tr>
<tr>
<td>17. The facilitator initiated most of the discussions.</td>
<td>4</td>
</tr>
<tr>
<td>18. Students initiated most of the discussions.</td>
<td>4</td>
</tr>
</tbody>
</table>
Students A1 also described her learning attitude as absorbing rather than constructing. Her overall preference for absorbing in learning could be found in her lower contribution to the open learning space for whole class than the group Design Table.

In her interview, she esteemed the collaborative design learning for its productivity such as a large amount of ideas and its diversities. At the same time, she defined the large amounts of time and efforts dedicated to arrange the schedule and discuss the design process as a disadvantage factor of collaborative learning; a lot of time and energy are required for calling a face-to-face meeting. Finally, she described her role in the group not as a leader but as a facilitator. She volunteered to make communication channels, and facilitated the efficacy and the effectiveness of her group’s human resources. She named each group member as strong areas (A2 and A4 for Humanities) and characteristics (A3’s fast absorption of learning and supporting character) which had made her team well-bonded and well-managed. Her strong contribution to the group was recognized as the establishment of the learning atmosphere and the summarization of the group discussion and task management.

In summary, five data-gathering methods were used in this study to collect valuable data based on the qualitative research design in Figure 6.2. Both quantitative and
qualitative data collected from the WBDL and other inquiry methods were triangulated through inductive data analyses, which strengthen the trustworthiness and increased the validity of this study. This data analyzing process provides the contextualized interpretation of data to create a grounded theory to be discussed in next chapter.
CHAPTER 7

FINDINGS OF THE CASE STUDY

7.1. The Effectiveness of WBDL as Constructivist Learning Tool

The constructivist learning theories recognize the computer and the Web as a useful and effective learning tool. Based on these beliefs, this chapter investigates the effectiveness of WBDL and evaluates its usefulness and value as: (1) a cognitive and knowledge construction tool in 7.1.1; (2) a social learning & collaboration tool in 7.1.2; and (3) a design learning tool in 7.2.1.

7.1.1. Cognitive and Knowledge Construction Tool

A constructivist tool for cognitive and metacognitive learning has a goal of supporting a student’s cognitive strategies such as managing his/her own learning, remembering, and thinking as his/her own internal processes. The cognitive strategy
influences the student’s psychological choice of personal actions, which was briefly identified in the case analysis in Chapter 6.3. The effectiveness of WBDL as a cognitive & metacognitive tool can be evaluated with the constructivist design learning model and web-based learning model developed in Chapter 5.

First of all, based on the constructivist design learning model, Figure 7.1 (Group B) and 7.2 (Group A) illustrate how individual students in each group managed their design problem-solving on Design Table within 16 weeks period; each student was coded differently and his/her learning sequence was numbered on it. Figure 7.1 illustrates a visual map created by the method of analyzing the content of information posted on Design Table based on the guidelines of major and minor principles of constructivist design learning in Table 5.3; the area of content and its related principle indicate the position of information on the map. At the same time, the position of information in the map is influenced by the level of design learning from the center of identifying design problem to the periphery of realizing the design learning.

Furthermore, the sequence of information posted on Design Table illustrates how learning occurs within the systems where people interact with each other and with material, informational, and conceptual resources for the subject matter of wearable
computer design. For instance, student B1 had a total 26 participations in Design Table, which were mostly in knowledge construction (major principle 1), and a little in cognitive and metacognitive strategies (major principle 2) and social interaction (major principle 3). Student B3 and B4 made their learning in the only limited area of knowledge construction; their correspondence rate to the other members was nil. The arrow sign in Figure 7.1 indicates a correspondence to previous information: it shows how interactive and collaborative discussion has been made in any thread of information. Unfortunately, the interactions/feedback generated by the members of group B were very small and limited, which did not make a correspondence among group members altogether.

On the other hand, group A generated an interesting learning pattern with total participation of 72 on Design Table. In comparison to group B, a wider spectrum of minor principles in constructivist design learning and deeper levels of design problem solving were covered by their learning pattern as illustrated in Fig 7.2 directed from the center to the periphery. Student A1 is a good example of showing expansion of her learning experiences in diverse content areas from knowledge construction towards self-regulated learning and assessing group’s performance; her learning experiences covered almost all principles of cognitive constructivism. Since group A had made several face-
to-face meetings in a week, the participation in major principle of social interaction was less important than other principles. However, as a facilitator of the group, student A1 applied important principles in social constructivism to promote collaborative works. She was involved in almost all communication activities generated by the group members. By possessing such a social and collaborative mindset, she covered the widest areas of constructivist learning and established the deepest level of design problem solving among the eight students sampled in the case study.

Furthermore, the effectiveness of WBDL can be identified with the conceptual model of Web-Based Learning (WBL). Because of the consistency of understanding and interpreting the epistemological standpoint and the same metaphor of applying principles to a visual map, the Web-based learning model can be used as effectively as the constructivist design learning model to interpret individual and group learning processes. For instance, group A’s and B’s learning activities of 16 weeks in Thinking Map, Phenomena, and Class Board were illustrated in Figure 7.3 and 7.4. Compared with the participation activity of students in the closed Design Table menu only for group members, they were not so active in the open learning menu for all students. Considering their attitude for learning and collaboration, participation of student A1 and B1 was
relatively low. In this quantitative analysis, student B2 and A2 showed the highest participation among the group members. Student A2 encompassed diverse content areas from visualization to the simulated context.

Figure 7.1. Group B’s learning activities of 16 weeks with constructivist design learning model
Figure 7.2. Group A’s learning activities of 16 weeks with constructivist design learning model
Figure 7.3. Group B’s learning activities of 16 weeks with Web-based learning model
Figure 7.4. Group A’s learning activities of 16 weeks with Web-based learning model
The accessibility of all students to the opened learning provides additional data usable to evaluate the function of WBDL as a cognitive and knowledge construction tool. One of the popular methods is to count the number of visits to the information. The administrative data such as date of information posted and number of visit saved in the menu of WBDL program were used as useful resources to evaluate the quality of knowledge construction shared by the whole class. For instance, in Class Board menu, the highest number of visits was 62, which meant statistically that all students might visit this information more than twice. As matched with the needs of knowledge for wearable computer, the information about the international wearable computer workshop was paid the highest attention and was recognized as valuable information by all students. The average visiting rate in Class Board was 27.3 and the lower one was 2.

From the point of view of the impact factor of the visiting number, the student’s participation data in Class Board can be interpreted differently. For instance, student B1 participated only once in this menu but her information was reviewed 42 times, which scored the third highest visit. Her data is very comparative to that of student B2’ who had four posted information segments that were visited 7, 2, 5, and 24 times, respectively. The impact factor of student B1 can be simply evaluated as 42, which is higher than
student B2’s impact factor of 38 as a total accumulation of four sites. This simple comparison represents the importance of triangulation as an inquiry method to crosscheck the reliability of data, and to interpret the meaning through the iterative induction.

The case of data interpretation above based on the constructivist design learning model and the web-based learning model shows the effectiveness of visualizing a student’s learning pattern with qualitative and quantitative data posted for knowledge construction. The importance of analyzing and interpreting data in this approach, however, is not in its visualization but in the possibility of identifying students’ personalized learning and its internalized learning process through the visualization. In summary, the effectiveness of WBDL as a cognitive and knowledge construction tool is highly esteemed in its fundamental functions of data collection and management. Because the process of information posting and its reviewing activities require high-order rules of knowledge management and cognition, it is reemphasized that learning with WBDL enhances students’ cognitive and metacognitive strategies. In addition, the case study of WBDL and its qualitative analyses signify future developments in a variety of applicable areas such as curriculum development and student advising; as an example, a student can use the visualized map of constructivist design learning (i.e., Figure 7.2 or
7.4) for self-reflection and self-regulated learning; a group can use the same map and method to manage group learning processes and to promote collaborative works.

7.1.2. Social Learning and Collaboration Tool

Constructivists emphasize that learners must be active participants in their learning process, which promotes the student-centered and participatory education. Through the case study of WBDL, it was assumed that social processes as well as cognitive processes played a major role in the change of the students’ academic performances and cognitive developments.

The effectiveness of WBDL as a social learning and collaboration tool can be discussed with Figure 7.1 and 7.2 again. One of comparative findings from the visualized map of constructivist design learning is how consistently group members managed the learning process with WBDL. All students in group A conducted their collaborative learning successfully from the beginning to the end of design process no matter how many and how frequently group members participated in Design Table; all group members reached the ultimate level of design learning at the periphery of constructivism in Figure 7.2 through keeping all members managing the project till the project was
completed. On the contrary, group B showed a different learning pattern in Figure 7.1 with a loose link of members in the learning process. It was found in previous data analysis that the one-way communication and the lack of social communication skills had lessened the trust among group members, which finally made the group members exhibit scattered to lose connections with the collaborative learning channels in Design Table. Therefore, this learning process left two members’ final participations in the middle of major and minor principles of constructivism in Figure 7.1. Even the instructor’s participation in Design Table with repeated encouragements of students was not successful. Consequently half of group B members failed to achieve the self-authorship of the group learning, which might be achieved when they reached the periphery of constructivist design learning model.

The importance of dynamic correspondence among group members is another finding in the visualized learning map. The dynamics and amount of correspondences signified a pattern, which is illustrated as a small pocket dotted in Figure 7.2. Each small pocket had at least four correspondences of different characteristics of student participations; group A had one example pocket of correspondence participated by all group members. From the constructivist’s theory, group members were expected to help
each other with the review process through dynamic correspondence. The correspondence visualized as small pocket can be interpreted as good evidence of collaborative learning with a level of understanding that the group work was performed socially and collaboratively: group A showed three collaborative evidences and group B nil.

An example of collaborative design learning which is symbolized as a small pocket can be interpreted by Vygotsky’s Zone of Proximal Development (ZPD) theory: how ZPD could extend each student’s performance progress assisted by the others and self was discussed in the literature review. The progress of each student’s performance with inter-personal and intra-personal activities with ZPD was emphasized in the zone of dynamic correspondences as a small scale. Through the design process of 16 weeks, three zones of dynamic correspondences were created to facilitate ZPD for the group A; the three zones of correspondence that were located consecutively from the center to the periphery of constructivist design learning model became evidence of the group’s learning progress from its potential development to the actual one based on Vygotsky’s ZPD theory.

Therefore, it is assumed that the generation of dynamic correspondence on a small scale facilitates the learning progress of ZPD from the beginning of design learning
by enhancing the mutual trust and social relations among group members. The more group members generate the zone of dynamic correspondences, the more their collaborative learning can be promoted.

Furthermore, as students understand the ZPD theory from a learning progress, they get more positive and active mindsets for the collaborative learning. For instance, student A1, with highest participations in Design Table exchanging all the projects related information, showed an easier and more effective process of sharing and developing the group project. The student’s weekly journal clearly demonstrated this kind of change in attitude; for example, the students of group A clearly described their roles and collaborative processes, and showed the joy of group learning based on mutual trust. However, what the students of group B described is mostly about a personal procedure of data collection or idea development in a very static way. Analyses of the collaborative experiences of these two groups reveals apparently that more successful groups were more aware of and more concerned with each other’s learning processes.

Analysis of these two case studies showed that when there was a group leader, the groups functioned more effectively. For the case of group A, the leadership was shared by all members of group, but more so with two female students, A1 and A3, who...
had participated in data organization and presentation preparation. Even though she defined herself as a facilitator, student A1’s role was intensified as a leader in that she participated in or initiated all three zones of correspondence. Through the triangulated data analyses, group A showed a good harmony of group members’ capabilities, an equal sharing of work responsibilities, no serious personality conflicts, and a group member having a strong leadership.

In summary, the WBDL as a social learning and collaboration tool is evaluated as high from the data analyses and its interpretation above. The accessibility and connectivity of the Web facilitates collaborative learning effectively by establishing an open learning context. The case analyses and their interpretations in this study show that the fundamental characteristics of communication, collaboration, and construction in Web-Based Learning (WBL) were highly influential and promising to the establishment of knowledge communities which can invite the experts in a variety of areas from the outside of campus. As an example, group A built two knowledge communities in medical service and fashion industry during the problem-solving process. The remote accessibility of the WBDL, therefore, can enhance the quality of design learning through the expansion of knowledge communities based on Vygotsky’s ZPD theory.
7.2. The Effectiveness of WBDL as Design Learning Tool

7.2.1. Design Learning Tool

This section analyzes the effectiveness of WBDL as a design learning tool: how effectively the WBDL program and its learning environment influences the design problem-solving process and enhances the quality of the design solution. The case study of wearable computer design requires several steps of design problem solving and its learning processes: (1) collecting resources on technology, fashion, history, and culture, (2) investigating users’ life styles by interviewing and observing, (3) developing user scenarios of wearable computer design and its contexts, (4) creating user-centered design, (5) integrating hardware & software design to provide the content of wearable computers, (6) presenting design outcomes and processes. In order to complete this process of learning, it was necessary to construct an effective communication system with which group members could assign their roles and share the work. Without having a communication tool of sharing information and experiences among the group members, they would have difficulties in managing all information resources and in solving design problems for 16 weeks, because wearable computer design deals with an ill-structured problem covering many research areas and issues.
Evaluation of the effectiveness of WBDL as a design learning tool can be accomplished by investigating the design content developed in Design Table, which reflects each group member’s design process and activities based on the system usage. Data were collected according to six predefined design processes, and students’ participatory activities were traced within those categories: collecting data, investigating lifestyle, developing user scenario, creating design, integrating, and presenting design outcomes. Table 7.1 summarizes the number of participations in the six steps of design process from the eight students in groups A and B.

<table>
<thead>
<tr>
<th>Step</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Presenting design outcomes</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
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<tr>
<td>5. Integrating H&amp;S</td>
<td>3</td>
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<td>0</td>
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<tr>
<td>4. Creating designs</td>
<td>9</td>
<td>8</td>
<td>6</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>1</td>
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<tr>
<td>3. Developing ideas</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>10</td>
<td>2</td>
<td>3</td>
<td>3</td>
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<tr>
<td>2. Investigating lifestyles</td>
<td>7</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
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<tr>
<td>1. Collecting Data</td>
<td>6</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Planning /Response</td>
<td>1</td>
<td>0</td>
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<td>0</td>
<td>3</td>
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<td><strong>Total</strong></td>
<td><strong>35</strong></td>
<td><strong>18</strong></td>
<td><strong>15</strong></td>
<td><strong>4</strong></td>
<td><strong>26</strong></td>
<td><strong>9</strong></td>
<td><strong>9</strong></td>
<td><strong>5</strong></td>
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</tbody>
</table>

Table 7.1. Students’ participation data for six design problem-solving process
The quantitative data in Table 7.1 informs the overview of the participation of the individual and the group in the six steps of the design process. For meaningful interpretation, we need to collect the time data for design activities conducted by each student. With time data added, Table 7.2 and 7.3 illustrate the group members’ learning process in Design Table; their contents were categorized into six different design steps at each time point during 16 weeks. The student’s activity was coded by abbreviation and prefixed to the student’s identification code. For example, “CoA1” means that information belongs to “Collecting Data” activity posted by student A1, and “Inst” means information posted by the instructor.

Besides the quantitative data of participation, additional data collected by the time point (variables) allow us to interpret the appropriateness of developing design solutions related to the time frame. For instance, group B spent more time in the beginning of the design process collecting and investigating data (steps 1, 2 and 3) than group A; it caused the significant shortage of time to produce design solutions of high quality for finalizing the design development (steps 4, 5, and 6).
Table 7.2. Group A’s design solving process in 16 weeks

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<tbody>
<tr>
<td>8. Presenting</td>
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<td>6. Integrating</td>
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<td>4. Creating</td>
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<td>3. Developing</td>
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<td>2. Investigating</td>
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<tr>
<td>1. Collecting</td>
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Table 7.3. Group B’s design solving process in 16 weeks

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<th>1</th>
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<tr>
<td>8. Presenting</td>
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<tr>
<td>6. Integrating</td>
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<td>4. Creating</td>
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The time- and content-based analysis of tracking a student’s learning process provides a visualized pattern to recognize the triangulated data holistically. As a comparative example, student A1 took even participation in the six steps of design process, but student B2 contributed only in the first half of the steps till the 11th week. Student A1’s iterative and parabola learning pattern widely covered six steps of design process, but student B2’s linear learning pattern limited his learning to the lower level of design process. The time-related design learning process affords highly valid and reliable data to interpret the quality of design learning and its outcome of design projects.

It is also useful to compare the time and project management tasks among groups; for example, group A started the fourth step of design process from the 9th week but group B did from 14th week; the learning pattern of group A was widely- and evenly-distributed in Table 7.2, but group B’s is represented as clusters in specific time zones and is unevenly distributed in Table 7.3.

In summary, the effectiveness of WBDL as a design learning tool can be highly esteemed by its cognitive and social learning contexts. Comprehension of the qualitative information such as the level of design process and time gives the rationale to study constructivist design learning for improving the quality of design education: as a design
learning tool, WBDL can include diverse multi-media applications of learning contents to create a high quality of design outcomes. At the same time, WBDL can promote collaborative and constructivist learning of the students and the designers as learning communities, which creates seamless and boundless design learning with the Web function of accessibility, connectivity, and flexibility.

7.2.2. Grounded Theory of Constructivist Design Learning

This study has developed a conceptual model of constructivist design learning by adopting multi-layered major and minor principles. It generates a fundamental base of creating WBDL, and the process of developing the WBDL program has built another conceptual model of WBDL from its two- to three-dimensional perspectives. These models have been used to identify the effectiveness of WBDL as a cognitive and social learning tool. As a next step, the qualitative research flow in this study leads to generating a grounded theory, demonstrated in Figure 6.2.

Considering the conceptual model of constructivist design learning to be a grounded theory requires critical thinking to answer the following questions: Does the theory of constructivist design learning stance serve adequately as far as design and its
learning activities are concerned? What does it mean to have students construct their own design knowledge? To answer the first question, this research shows that the theory of constructivist design learning serves adequately and desirably for the design process and its learning activities. It means that the theory of constructivist design learning can be useful in the different levels of learning and for the different purposes. For the beginning level, it is useful for students to identify the design problem and define it with the situated context. The issue of defining design problems has been discussed in the discipline of design but the necessity or the reason to do that as a learning action is not well investigated. Defining design problems with the group members or the whole class influences the establishment of the epistemology of learning as constructivist and student-centered.

Furthermore, the constructivist design learning model provides a visual map that can be used as a guideline for establishing knowledge construction with its minor principles such as prior knowledge and questioning. With cognitive strategies, students can realize what kinds of information need to be collected and gear up the knowledge construction process. The way of applying the theory of constructivist design learning to the beginning level, therefore, becomes appropriate and useful for students to facilitate
their learning processes through the awareness and usage of cognitive strategies. It supports new design learning that emphasizes knowing “how” is more important than knowing “that.”

For the intermediate level, the theory of constructivist design learning provides a similar methodology to the design process. Its interactive and iterative feedback occurring in the design process is simulated as the same way in constructivist design learning. The vertical and horizontal interactions between major and minor principles within the situated problem represent similarly that the dynamic feedback flows generated between design phases of design process within the context of the design problem. By understanding this similarity between design problem-solving and constructivist design problems, students and the instructor can create authentic, generative, and collaborative design learning. Applying diverse methods of constructivist learning theories to the design process makes the student’s learning and design-problem more integrated. For example, writing a journal/report can be a good method of enhancing students’ reflective thinking to review what is missing and what makes things better for their design processes. Figure 7.5 is an example of reviewing the individual and the group’s ZPD developments and the collaborative learning with WBDL.
Finally, the mindset of learners in WBDL is one of the most important factors to evaluate successful learning. It is estimated by students’ motivation and attitude toward learning. The mindset of learners is directly linked to the epistemology which she/he has
within. That is, the things we do and the ways we act depend a great deal on what we perceive learning to be. Benson Soong et al. (2001) hypothesized that “if the students’ and educators’ epistemology is that of a constructivist approach, then usage, as well as enrichment and enjoyment levels will be high” (p. 107). From the very first lecture of WBDL, therefore, I explained constructivist epistemology; its collaborative, active, authentic, and flexible characteristics were discussed in depth in order to share the same mindset with the students. Without sharing epistemology between an instructor and learners, it is difficult to construct knowledge together from the first design process of defining the design problem in the ill-structured condition of learner-centered education in Product Design System.

Ultimately, the pedagogy for constructivist design learning is based on student experience, self-authorship, or epistemological development. It considers a matter of creating the developmental conditions that allows students to generate their own ideas effectively, in essence to develop their minds and attitudes. The Web-based education established in constructivism allows both instructor and students to experience effective education under the same epistemology by suggesting the concept and the operating method of learner-centered education. From the data analyses, it was found that WBDL
supports high levels of collaboration via its emphases on collaborative project/works and discussions. In summary, the case study and its data analyses have fortified the development of grounded theory of constructivist design learning and WBDL. The grounded theory developed in this study can be summarized as: (1) the constructivist design learning enhances design learning by emphasizing its major and minor principles; (2) the WBDL functions effectively as a cognitive and knowledge construction tool, a social learning and collaboration tool, and a design learning tool; (3) the constructivist design learning with WBDL creates a new learning environment for the student-centered and collaborative learning, which provides diverse functions and methods of enhancing the quality of design learning; and (4) the constructivist design learning with WBDL provides a practical and pragmatic method of pedagogy to manage design learning effectively and to promote the student’ reflective thinking and self-authorship of learning.

7.3. Limits and Advantages of WBDL

7.3.1. Overall Course Evaluation and Limits of WBDL

For the overall course evaluation, students reported that their experiences with WBDL were much more learning-centered than teaching-centered. Students highly
valued the collective access that they had shared each other’s ideas throughout the semester. After the completion of the final design, there were overall commentaries on class works in weekly journals and Design Gallery, such as “hard but worthwhile” and “effective.” In the triangulated analysis of student B1, the general evaluation on WBDL seemed to be highly affirmative. The student B1 who always readily took the role of leader in design study in spite of her introspective personality, showed declined learning capability due to the difficulties and the troubles within group project proceeded in WBDL. Nevertheless, she assessed WBDL positively as “highly radical,” “very effective” and “new experience for learning.” And she clarified her standpoint on agreement to the continuation of such studies as WBDL.

The overall evaluation of WBDL needs to include the perspective of the instructor who is in charge of the development and management of WBDL. The effectiveness of WBDL as a teaching, administrating, and evaluating design course is extremely esteemed by the instructor. The educator’s general opinions of computer supported learning programs such as CAI and CSCL are evaluated highly in previous literature review. As we discussed previously, however, the instructor has to dedicate absolute effort and invest time from the planning and developing programs to the
management of WBDL. Therefore, the financial support and time management become another important factor to be investigated further to realize the benefits of WBDL. Increasing the implementation of technology and expanding virtual learning opportunities must be done in a way that is both educationally effective and acceptable to human and social values.

To provide the restructuring and reforming guidelines, the problems and limits of WBDL found in this study can be summarized as three issues of “intangibility,” “motivation,” and “instructor as the highest participant.” First of all, the issue of intangibility is connected to the nature of design work: industrial design, generally completed in physical format, tends to solve the design problem by considering sensible factors such as size, weight, and materials. Drawings and rendered products by computer are absolutely two-dimensional, and there is a serious discrepancy in scale between the real size and the size perceived on the monitor. Due to the problems above, it’s prevalent for design students to work with design mock-ups of identical size and shape to the actual form. Unless the subject matter wholly relies on the digitalized information, the design studio course such as Product Design System where all design works are completed in the Web space has problems in effective communication to exchange design information.
Accordingly, it is desirable to open the Web course only for the higher level learners with enough experiences of design problem solving procedure to convert their prior tangible experiences to virtual ones in the Web. However, it is assumed that the implementation of technology and the development of diverse contents for learning design with expanding virtual learning opportunities will solve these limitations of using WBDL for design education in the near future.

Secondly, the WBDL or distance learning may embrace several problems in provoking motivation of students from losing the physical or sensible relation between instructors and students, which is very rare in the traditional face-to-face design education system. For example, student B4 with very low participations in WBDL neither participated in Design Table for collaborative learning, nor showed any motivation to complete his personal weekly journal. Consequently, for achievements of successful education under circumstances like Virtual University, on-line education or distance education, it is essential to keep students motivated to take an active part in various educational activities.

Finally, the issue of instructor as the highest participant is a part directly linked to educational effects of WBDL. Due to the high risk of diminishing the motives of
students, the role of instructors should be emphasized as an adviser in work development, who reinforces the existence of connection between an instructor and students. The instructor frequently has to stay on-line to give students immediate response and help, because the time and the quantity of participation are learner-centered in constructivist perspective. Accessibility and flexibility which are regarded as the advantages of WBDL, now turn to be a burden to an instructor because they have to fulfill the ubiquitous demands from the students even after the class. The instructor should devote most of their participations in WBDL to attaining effective class works while supporting all demands from students. Interviews from the case studies revealed students’ response that they were motivated to participate more actively in WBDL when the instructor gave them feedback. Therefore, the instructor’s increased responsibility needs to be solved with some financial or human supports.

7.3.2. Advantages of Implementing Design Education with WBDL

Accessibility, manageability, interactivity and flexibility are considered as the big advantages of applying WBDL to design education. Firstly, accessibility represents not only the contextual accessibility as an access to an on-line space where students and
instructors share and create information, but also the content accessibility as all-time available access to the necessary information. Students and instructors upload the information and information is stored as permanent electronic data that can be accessed and supplemented at any time. After conducting the WBDL case study in 2001, the design course offered in 2002 included the design information collected in class of 2001 and opened their accessibility to the class of 2002 (see Figure 6.3). It increased the student’s motivation to review the previous data and add more updated information to their learning communities. Depending on how to use information available, the social and collaborative learning provides vast benefits to enhance the quality of the design learning process.

Secondly, the facility in access to information brings up the manageability issue that enables students and instructors to control the information on learning procedure and design outcomes. In case of design education containing ample visual and auditory information, it is easier and more efficient to maintain computers shared by networks and to control the outputs through them than any other recording media.

It links, thirdly, to the interactivity issue, which provides cognitive experiences with digital technology. Especially case studies like wearable computer design enable
students and instructors to do the interactive management of information that cannot be stored or retrieved in other media because they use videos or animations in the final outcome. The files stored in the WBDL network are available to access at any time and at any place. And it is facile to analyze and to follow up the procedures of projects either by team or by individual due to its support for non-linear information access. The information stored on the computer server, therefore, has the advantage of providing constant application for developing the related curricula, which was demonstrated in three consecutive courses at KAIST. Finally, all three issues of accessibility, manageability, and interactivity provide a variety of flexibility to the students to construct their design learning with the WBDL.

Compared with the individual, passive and closed ways of traditional design education, the Web-based educational environment originating from constructivism emphasizes collaborative, authentic, active, and learner-centered education: it considers the constructing process of knowledge and experience more important than producing design works. This means that WBDL regards the constructing process of knowledge and experience as more important, whereas traditional design education focuses on design outcomes. Accordingly, this design educational reform becomes an alternative model of
design education to improve or upgrade the quality of individual and closed education of
the past. The improvement in quality of design education can be assessed by a student’s
positive and desirable attitude toward the continuous learning improvement as well as the
development of his/her intellectual, technical ability and creativity demanded in the
society. The effectiveness of Web-based education and forming technology-supported
learning environments, therefore, are not limited to the students’ learning achievement,
but rather can be extended to the students’ future work in the design industries where
collaborative, communicative, and contextualized activities are strongly emphasized.

Consequently, the above constructivist theoretical and practical issues can also
be useful resources and methods to help both students and instructors integrate learning
experiences into the contextualized design learning environment. The constructivist
approach to learning and understanding the world provides an appropriate conceptual
frame to explain the dynamic change in design discipline, for supporting the
multidisciplinary team learning, and flexible learning process for designers. Moreover, it
will eventually form in its designers and users a desirable attitude toward the
multidisciplinary research and the continuous learning.
CHAPTER 8

CONCLUSION

Industrial design is in the midst of a major paradigm shift developed from expanding its influence to new subject matters and exploring new ways of thinking about human life. Modern design was identified as positivistic, rationalistic, and universal with the belief in rational planning of ideal social orders, and the standardization of knowledge and production. Within the emerging postpositivist paradigm, design is now understood as the constructive, non-objective, and context- and time-bound axioms; design learning, therefore, requires a new way of perceiving the change in the world by involving a complex and active process of reflective, reinforcing, and constructive learning.

This study characterizes this new design learning with three propositions as: (1) learning how to learning is more important than learning that; (2) it ought to link the
theory and practice continuously throughout the lifelong learning; and (3) it provides a dynamic reinforcement to the student and the designer for shaping their attitudes fitting well to the present and future knowledge-based society. We have also discussed that constructivism has become an alternative epistemology and pedagogy for new design learning, which matches to the three propositions and provides a variety of cognitive and social learning theories to be associated with the contextual features of learning in the postmodern world. Therefore, it is conceptualized that the procedure of new design learning is established on the basis of cognitive and social constructivists’ learning theories and integrates them to solve the complex design problems emerging with the paradigm of postpositivism; it is named “constructivist design learning” in this study.

With the current development of philosophical and educational theories, computer technology makes it possible to realize new forms of education for the postmodern world, which are characterized as: connection, heterogeneity, and flexibility and morphogenesis. This study hypothesizes that computer technology can provide different frameworks for creating new design learning contexts combined with the constructivist epistemology and cognitive learning theories.
Based on the research hypothesis, this study was designed to develop a theory of constructivist design learning and Web-based design learning. In order to achieve this goal, the study was: (1) to identify constructivist epistemology and its learning theories, and to investigate cognitive and social learning theories related to information technology; (2) to build a conceptual framework for creating constructivist design learning; (3) to explore the diverse possibilities of developing Web-Based Design Learning (WBDL) models as a knowledge construction tool, and to apply them in design education as a case study; (4) to analyze the effectiveness of WBDL with a case study based on qualitative research methodology; and (5) to present guidelines for applying constructivist learning theory and WBDL to design education for the future study.

For data analyses, the criteria for analyzing the effectiveness and value of WBDL are focused on three factors and their related six principles: cognitive and meta-cognitive factors (knowledge construction, and cognitive and metacognitive strategies), social and collaborative factors (social interaction and constructivist mindset), and technical factors (technical competence and using computers in design learning). Through the five data collection methods (archival data within the WBDL menus, personal weekly journals, design outcomes, questionnaire, and interview) and its qualitative data analyses, the
theoretical rationale of developing constructivist design learning has been established. The case study evaluated and interpreted the effectiveness of WBDL as: (1) a cognitive and knowledge construction tool; (2) a social learning and collaboration tool; and (3) a design learning tool. The effectiveness of WBDL as a cognitive and knowledge construction tool was highly evaluated in its fundamental functions of data collection and management. As a knowledge construction and collaboration tool, it is identified that WBDL supports the student to: (1) connect to diverse information and other students/experts which develops ZPDs; (2) integrate new knowledge with his/her prior knowledge and internalize them; (3) possess multiple perspectives to work with and learn from others; (4) have a positive attitude toward learning how to learn. At the same time, it provides a way to transform each student’s learning process into useful patterns of knowledge.

As a design learning tool, the effectiveness of WBDL is highly evaluated by its cognitive and social learning contexts. Comprehension of the qualitative information such as the level of design process and time gives the rationale to study constructivist design learning for improving the quality of design education. The significance of having such a computer-supported learning tool is that students can create new solutions of a
higher order of design knowledge in an authentic and social learning environment. The importance of investigating constructivist theories and creating new learning contexts resides in educational implications and applications of constructivist ideas as a means for bridging design education and professional practice. Furthermore, the effectiveness of cognitive and social learning with WBDL is not confined to the student’s learning achievement, but is extended to the students’ future work in the design industries where collaborative, communicative, and contextualized activities are strongly emphasized.

In summary, this study focuses on reconstructing design education with a new epistemological approach and re-addressing computer technology as a tool/environment for constructing new design learning. Based on the idea of new design learning, design education models for this study focus on addressing new structures of learning by connecting and integrating design knowledge in new, useful, and meaningful ways to the student. By emphasizing boundless interconnectivities of knowledge and experience, creating the new education model is regarded as creating multiple possibilities within the situation, and addressing certain problems for students and educators altogether. Therefore, design education needs to focus not only on the principle-oriented learning, but also on the expansion to learner’s generative and discovery-oriented learning. New
design learning and design education emphasizes knowing “how to learn” rather than “knowing what to learn.” Therefore, this study reemphasizes the goal of design education is to educate students to be able to get accustomed to the dynamic changes in design discipline, and to possess flexible learning capabilities, which can be expandable and applicable to the postmodern context.

For this reason, this study reframes design education models, and proposes a variety of assumptions of creating new design learning as a constructivist challenge. The idea of WBDL provides a new perspective to what can be accomplished in design courses by enhancing generative and authentic learning with the use of video and hypermedia technology. There is no doubt that the development of computer technology will provide continuously a new format of education, which has more flexible and more open learning features. However, this study emphasized that the adoption of the information technology in a higher level of learning, categorized as the level of paradigm shift is more important than applying information technology in lower levels of learning. This study also recognizes that the high quality of design learning can be achieved by integrating the epistemological and pedagogical foundation with the computer-supported learning tool.
More importantly, this study generates many issues to be investigated further as future studies: (1) the theory of constructivist design learning needs to be applied more to the design education to increase its validity. The major and minor principles of constructivist design learning can be developed to provide a foundation of learning guides for new design learning; (2) the models of constructivist design learning and WBDL need to be experimented with the diverse design course developments; (3) the interpretation of case data needs to be investigated further to establish the appropriate qualitative research inquiry for design education; (4) the design education models need to be applied to the different contexts of education. Since the two models have flexibility and connectivity as key elements, the application of two models in curriculum development will be developed with various formats of design education, which include different levels of design learning; and (5) the models of constructivist design learning and WBL in Chapter 6 and 7 should be embedded in the function of WBDL program for promoting the cognitive and social learning activities. Including the qualitative data analyses discussed in this study to the new WBDL program provides students and instructors with a useful tool such as the visualized analysis map to be reviewed in any time during the learning process; a visual tool for constructing knowledge. Reflecting the
individual’s and the group’s learning process/progress in real-time can enhance the quality of design learning and the development of constructivist learning activities.
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