Reforming Industrial Design Education in Mainland China for Sustainability

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ABSTRACT

Industrial Design in China seldom addresses the issue of sustainability in mass production. Failure to incorporate sustainable design as a core principle will result in long term environmental and economic loss for both business and society. This research studies the current Industrial Design educational system in Mainland China and proposes a new educational framework to engage sustainability as a design objective.

This study adopts the philosophical perspectives of constructivism, sustainable design theory, critical pedagogy, and systems thinking. Literature related to sustainability is collected and organized and overlaid with educational constraints identified through the interviews with educators, students, and practitioners of Industrial Design in four major cities of Mainland China. Using the grounded theory approach, from these two sources a new educational framework is proposed. The educational framework categorizes courses in a four year undergraduate Industrial Design educational program into four domains: ecological literacy, artistic, technological, and professional. Suggestions for the appropriate timeline, content, and pedagogical approaches for curriculum are also provided. The proposed framework was then critically reviewed Chinese educators that served as feedback for the final proposition.

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Chapter One: Introduction and Background

The demand for college-educated design professionals in the Peoples' Republic of China is exploding. According to a report from the National Instructional Committee of Industrial Design Education (China) of 2003, as an attempt to meet this demand, over 230 universities and colleges are currently offering degrees in Industrial Design in China. In the 2006 academic year, enrollment figures for one such institution, the School of Design of the Beijing Institute of Technology, were 125 undergraduate students and 108 master students for the coming academic year. To put these figures into perspective, consider that only six years ago, there were estimated to be only 500 Industrial Design graduates per year in the entire Mainland China. With the typical size of a class in Chinese universities at around 30 students, it is expected that more than 6,000 students will graduate with an Industrial Design degree every year from these 230 universities and colleges.

However, quantity does not necessarily mean quality. Mainland China has only 25 years of experience in Industrial Design education. Though Chinese Industrial Design education and the profession itself are gaining more and more attention, neither has earned an international reputation for originality or vision. Chinese Industrial Design education will require major reform if it is to compete with established industrialized nations on the global stage to produce industrial designers who can serve both local and international clients with professional skills and vision for the future. This is all the more true if the Chinese Industrial Design profession is to address issues of growing global importance, such as resource conservation and sustainability.

In this chapter, a background of the accelerating growth of Industrial Design education in Mainland China is presented. The inherent problems due to the current educational system and Chinese Industrial Design education as they relate to sustainable design principles are examined. Subsequently, a proposed research plan

is presented.

1.1 The Centralization and Expansion of the Chinese Higher Education System

The rapidly accelerating growth in the number of Industrial Design students and departments in Mainland China must be understood within the larger context of the rapid changes occurring in Chinese society and in particularly the response of the Chinese government and its educational institutions to these changes.

In Mainland China, education has to adhere to the centralized general regulations. As a consequence, when compared with its counterpart in North America, China's higher education system is highly structured. Chinese higher educational institutions may be categorized as shown in Table 1.1:

Table 1.1 - Chinese Higher Educational Institutions

Classification	**Regular Higher Education Institutes (abbreviated as Regular HEI)**	**Research Institutes**[1]	**HEI for Adults**	**Private HEI**
Number	1,792	316	481	252
Administration	Public institutes[2] are established by the government and administrated by the Ministry of Education.	Are usually administered by the joint effort of the Ministry of Education and other ministries in the government.	Most of these HEI for adults are affiliated with Regular HEIs and are administrated by the Ministry of Education.	Private institutions, regulated by the Ministry of Education[3].
Degrees	Full range of degrees including associate's, bachelor's, master's, or doctoral degrees.	Master's or doctoral degrees	Associate's and bachelor's degrees	Associate's and bachelor's degrees

Table 1.1 continues on the next page.

[1] The most influential one among them is the Chinese Academy of Science, which currently has more than 30,000 graduate students across the country.
[2] Regular HEIs receive the majority of the financial and political support from the government.
[3] This means that private institutes have to be approved and certified by the Ministry of Education if they intend to offer any kind of degrees or certification.

Table 1.1 continued

Educational Characteristics	Admit high school students who have passed the National College Entrance Exam; are considered to have higher educational qualities.	Highly prestigious institutions that only admit graduate students.	Provide short-term courses for part-time adult students and offer certificates for vocational training.	It is difficult to evaluate these private institutions since no governmental agency could ensure the authenticity or validity of the graduation and market employment statistics released by these institutions.
Industrial Design Education	Major providers of Industrial Design educational programs.	Do not provide Industrial Design education[4].	Many offer courses in graphic design and Interior Design, but few offer Industrial Design courses.	Many offer Industrial Design programs.

Source: statistics from the reports of the Ministry of Education of the People's Republic of China, 2005.

Table 1.1 shows that the higher education in Mainland China is administrated almost exclusively by the government. The Ministry of Education of the People's Republic of China (PRC) provides services and supervises all the educational institutions in China. It plans the educational development of the country as a whole, distributes funds, and advises on curricula. As a result of the heavy use of centralized planning, the increasing number of college students in Mainland China is

[4] Most of these research institutes focus their efforts on the "hard" or fundamental scientific research. As it is considered an applied professional education, degrees in Industrial Design are not offered at these research institutes.

not entirely determined by the increasing market demand for graduates.

The Chinese government had specific social and political motives when it announced a national policy in 1998 to increase the percentage of college-educated citizens of the Chinese population to improve the overall education level and to stabilize the rapidly changing society[5]. Since that time the government has invested millions of dollars into higher education to help raise its enrollment thresholds (both the number of students and entry requirements). This explains the sudden increase in enrollments and expansion of departments. In 2005, the rate of increase of freshmen enrollment in higher education was 12.77% over 2004 enrollment level. As of 2005, there are over 23 million students in the Chinese higher education system (statistics from the Ministry of Education of the PRC, 2005), which makes it the largest higher educational system in the world.

Another distinct character of the Chinese educational system is that admission is dominated by standard tests. For 50 years, there has been only one means to compete for admission to a higher education institute in China: the National College Entrance Examination. This standard test is taken at the end of the high school senior year, much like the SAT in the United States. The Ministry of Education of PRC has held this national examination in the summer every year for the last 28 years and it has determined the career paths of millions of Chinese high school students. The examination covers three essential subjects: Chinese, math, and a second language (usually English or Japanese). In addition, attendees must choose additional subjects depending on what major they want to apply for. These can include such subjects as physics, chemistry, politics, biology, and geography. Though the content of the exam and scores might vary from province to province, the exam committee tends to implement the same academic standards for the entire country.

[5] As in other places in the world, more and more job positions in Mainland China require higher education. Additionally, traditional blue collar jobs are not attractive to young people any more because the blue collar workers are considered as having lower social status. Higher education creates more career opportunities for people, subsequently there would be less criticism of the government and its policies.

The score on the national examination has been the most purport criterion of a student's competency. Universities admit students almost exclusively based on their scores in the national examination. Naturally, the better an educational institution is and the more popular a major is, the higher the required scores are for acceptance. Chinese HEIs normally do not consider the overall academic or extracurricular achievements of a student in high school unless the achievements are recognized nationally or internationally. If a student has a high overall Grade Points Average (GPA) from his or her three high school years, but does poorly in the national exam, he or she would most likely be rejected from the major or school they desire. Though it is easier to enter a college today than only a few years ago because the numbers of Chinese higher education institutes and enrollment are growing, due to the large population base, the competition among high school students to enter better higher education institutes is still intense.

In recent years, private schools and colleges have emerged as alternatives to Regular HEI (shown in Table 1.1 as the major component of the Chinese higher education system). Lacking governmental funding, these schools have to be market-oriented and vigorous to compete with nonprofit HEIs, focusing on particular majors and courses. Private HEI typically can adjust their curricula or even school policies much quicker than other educational institutions. Since Industrial Design, and other design majors in general, have become popular in the vocational market, these private institutions currently provide a great number of design courses. The admission standards are typically lower for private HEIs and therefore they are a popular choice for those who are not qualified for Regular HEIs. Nevertheless, private schools still have to gain license from the Ministry of Education and the degrees and certifications they offer need to be approved by the government as well.

Another notable change to this highly centralized system is that the Chinese government has gradually opened the education market to private and foreign investment. For instance, Raffles Design Institutes, established in several large

Chinese cities since early 2000, offer courses in many design disciplines. They are part of the Raffles Education Corp., an international organization that offers design education throughout the Asia Pacific region. In addition, since some Chinese families now can afford studying abroad, more and more overseas education institutes join the competition for talented Chinese students. For example, the British Council, the United Kingdom's agency responsible for cultural relations that operates as the cultural and education section of the British Embassy, aims to connect young Chinese people with learning opportunities and the latest creative ideas from the United Kingdom. It holds annual education expos in selected Chinese metropolitans, such as Beijing, Shanghai, and Guangzhou, to promote its education industry. In 2004, nearly 60 educational institutions from the United Kingdom participated in this expo. One notable new event in this expo was that aside from the traditionally popular majors, such as marketing and computer science, the British Council focused on promoting its educational capacity for arts and design[6]. The diversification of the Chinese educational market effectively encourages the Chinese educational system to change.

1.2 The Centralized Educational System and the External Problems Faced by Chinese Industrial Design Education

The discussions about the highly centralized Chinese educational system not only explain the sudden expansion of the Chinese Industrial Design education, but also provide the background of two major systematic problems that Chinese Industrial Design education is facing.

A. The structure of the educational system in China hinders art education in general.

Since the standard test has become the primary focus of K-12 education in China,

[6] In recent years, a large number of the designers who are educated in these foreign institutes have come back to Mainland China. While they help enhancing the overall level of design, local companies might not benefit as much because these designers tend to favor working for international companies. Therefore, local industry still relies heavily on Chinese educational system to provide qualified designers.

this examination system has been continuously questioned and criticized. Many researchers of the Chinese educational system argue that China should develop a more comprehensive system to evaluate students' overall abilities. The need to excel in the national examination inevitably forces K-12 education to focus on preparing students to achieve high scores in standardized exams rather than teaching them how to learn on their own or providing them with a holistic educational experience designed to equip them to be citizens.

Many Chinese high schools have canceled creativity and aesthetics classes, such as art and music to ensure a high college entry rate. This, of course, prevents the development of the very artistic abilities that are essential to prepare students for Industrial Design education at the college level. Under these circumstances, the only means to gain artistic training available to the aspiring design students is to either start early in their education (usually before primary school), or work extra hours outside of school. Most Industrial Design departments have additional drawing ability tests at admission to counter the effects of the standard tests. Nevertheless, because the artistic and creative abilities are not tested in the standard test, despite high potential ability in these areas, the entrance scores for artistic majors in higher education, such as music, acting, painting, and design majors, etc., usually are lower than other majors such as engineering, languages, business, and medical majors. As a consequence, a great number of students choose Industrial Design not because of their interests or abilities but solely as a means to gain entrance to an institute for higher education. Moreover, students who have scores high enough for acceptance into a university but not high enough for admission to their selected departments, are at times assigned to the Industrial Design department that they have neither interest in nor talent for. This phenomenon is especially common in comprehensive universities. It is difficult to switch majors so Industrial Design education is forced to deal with these unwilling participants.

Regardless of the ongoing debate, at the present time, there are no plans to make use of any other admission criteria to supplement the national examination scores in

China. But there are new hurdles to be overcome. Students must adapt quickly to the new environment associated with Chinese higher education. The enormous pressure from the national exam is lifted from students once they are accepted into the universities. From the beginning, Chinese students can feel the huge differences between high school and university in study methods and learning styles. These differences include:

- Many students who are not interested in their majors lose the motivation to study.

- Students might need a few semesters to get used to new pedagogical methods and study styles that are drastically different from their previous educational experiences. There is a steep learning curve associated with unfamiliar subjects.

- Students need instructions to set new career and educational goals according to their personalities and abilities. They might be confused because achieving high scores in standardized tests was their only goal in K-12 education.

- Students are usually good at imitation and memorization instead of creation or critical thinking because of the standard test.

Thus, the standardized exams in K-12 education have ripple effects on higher education that educators have to manage.

Certainly, despite the centralized Chinese educational system, the growth in Industrial Design education presented above is in part a reflection of the expansive needs from the market: in 1999, 79.91% of graduates with an Industrial Design major found jobs immediately after graduating. Apparently, this statistic reflects the strength of the country's economic industrial base. From 1999 to 2002, the Industrial Design major was among the top ten majors to see the most rapid growth in

job placement rates for graduates. In the interview with a professor from Hong Kong University of Technology, he states that the 30 graduates from their Industrial Design department each year can easily find jobs and their department has never worried about employment for graduates[7]. However, it should be noted that these graduates may not necessarily work as industrial designers. Official data is not available but according to observation, many of these graduates move into other design professions, such as graphic design and interior design. In fact, to ensure a wide range of career options, many Chinese universities have included interior design and web design courses in their Industrial Design curricula. For example, Beijing College of Art and Design offers a webpage design software course as an elective for Industrial Design students. Students often demand such supplements to the core courses since normally they cannot participate in similar courses from other design departments because of departmental restriction.

B. The Quality of Education is Suffering from the Sudden Surge of Enrollment

As stated above, for the past five years the Chinese government has attempted to increase the proportion of holders of Bachelor's, as well as more advanced degrees in the Chinese population. However, the educational infrastructure requires decades to develop because scarce funds for education must be spread thin over a heavily populated country with limited resources.

The quality of education usually suffers when the number of students is increased too rapidly. Qualified teachers, campus space, equipment, and funding, all become inadequate. For example, at Guangdong University of Technology from 2002 to 2003, there were only five faculty members in the Industrial Design department, while there were over 200 students[8]. In Guangzhou Academy of Arts,

[7] These graduates can easily find jobs in the Pearl River Delta region, which is close to Hong Kong and the largest manufacturing base of Mainland China. Hong Kong used to have large manufacturing industry but recent years many factories were moved to Mainland due to the high cost and competition of the Mainland market.

[8] This ratio is low because students are seldom allowed to take courses in other departments. For instance,

the number of graduate students increased three fold from 1999 to 2003. The resources are so limited that many universities cannot even provide studio space, let alone modeling shops and other essential equipment. This problem is exceptionally severe in many small arts and design schools where the number of faculty is even smaller.

1.3 The Inherent Problems Faced by Chinese Industrial Design Education

Due to historical reasons, the Chinese Industrial Design education is facing two major inherent problems as discussed below.

A. Chinese Industrial Design Education Has Limited Scope that Includes Little Exposure to Social and Scientific Subjects.

Chinese design education is, on the whole, developed from the traditions of the Bauhaus in the 1920s. In contrast to the social tradition of the Bauhaus, Chinese educators usually avoid political and social issues in the classroom due to the political constraints. For practical and political reasons, Industrial Design curricula in China[9] are limited to only a few subjects: basic and professional design presentation skills with concern for limited "hard science" subjects, such as ergonomics, mechanics, structure, and materials. Social components of design are mostly ignored. Social criticism, environmental science, economics, ecology, etc, are seldom mentioned in the classes because these subjects, though they have great relevancy to Industrial Design, are not considered to be essential to a designer's knowledge-base. As a consequence, the social awareness of Chinese Industrial Designers is weak.

In addition, though Chinese design educators are constantly trying to add new courses into the curricula, their approach is typically to copy the Western educational practices instead of an extension of their own research agenda. The structures and content of these new courses, such as "Design Management", usually remain

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courses in architecture are not open to Industrial Design students.

[9] Please see the survey of curricula in Appendix B.

unaltered when compared to their foreign models to fit Chinese market and design profession's needs.

Based on the same pragmatic mindset, the importance of design research is seldom recognized in the profession or even the academia because design is viewed as largely practice-oriented instead of research-oriented. Research methods employed in design research in China are primitive when compared with many other countries. For example, at Guangzhou Academy of Arts during 1999 to 2002, there were no courses with emphasis on research methods or theory. Consequently graduate students' research skills were mostly self-taught. Thus, there were few discussions of how design research should be conducted. Graduate work could not be compared or examined side-by-side among students because of this lack of theoretical common ground. The lack of design research creates a vicious circle for the Chinese Industrial Design education: the less knowledge is produced in design research, the less improvement to the design curriculum; the more limited the curriculum becomes, thus less research is conducted.

The limitation in scope results in a high level of homogeneity for Industrial Design educational programs in China. This reality not only restricts design education, narrowing its platform, and limits its engagement of social issues such as sustainability, but also limits the competency of industrial designers in China.

B. Contemporary Social and Cultural Structures in Mainland China Provide Insufficient Support to the Design Professions.

Dr. Penny Sparke of Kingston University, London, describes the role of design in contemporary society as below:

> Within the framework of industrial capitalism, which created it and continues to dominated it in contemporary society, design is characterized by a dual alliance with both *mass production and mass consumption* and these two phenomena have determined nearly all its manifestations…Design and designers are, and have been for many years, a *sine qua non* of the modern commercial

> system ensuring, through the activities of production and consumption, that people's needs and desires (whether consciously acknowledged or not) are met by the visual and material images and artifacts that enter the marketplace and help us define who we are (Sparke, 1987).

This statement stands in stark contrast to how design was viewed in Mainland China after the Communist government was established in 1949. The overall social climate for Industrial Design is different from that in the major industrialized countries. The Chinese did not usually associate Industrial Design with consumption or marketing, like Dr. Sparke suggests, because Consumerism was taboo in communist China before 1979. Such terms were synonymous with Capitalism. Between 1949 and 1978, products were not sold completely according to their own merits and market demand but according to the government plans. The pioneer designers did not want to create a negative image within the Chinese public for their profession. Therefore, designers tended to associate themselves with the traditional arts and craft professions, which at the same time limited the discipline. Many Industrial Design departments were restructured from former arts and craft departments. Faculty with an arts and craft education background dominated Chinese Industrial Design education in the 1980s until the first generation of Industrial Design educators graduated from Chinese colleges[10] after 1986.

This difficult situation for the Industrial Design profession is in fact changing as the value of design becomes recognized by industry and business as a result of the global competition and by the Chinese consumers pursuit of a higher quality of life. The public recognition of the roles of industrial designers has begun to shift more towards the capitalist conception in recent years. After years of economic reform, Mainland China has established a unique market economy system that started to bloom in the late 1980s, especially after China joined the World Trade Organization in 1997. The Chinese government has issued a series of policies to encourage

[10] Mainland China restarted the national university entrance exam in 1978 after over ten years of suspension due to the Cultural Revolution from 1966 to 1976. First generation of graduate students of Industrial Design graduated around 1986.

consumption in the internal market[11]. The Chinese started to identify themselves as "consumers". Design began to have greater impact on business decision-making in China as a result of these social and economical changes.

The shift in emphasis from reliance upon the manufacturing process as an end in itself to reliance upon design has not gone unnoticed by local governments. For instance, Dongguan city in GuangDong province, which is located two hours north of Hong Kong, is one of the newly developed Chinese cities that have the most active manufacturing industries[12]. Dongguan's ambitious local government has recently started a campaign to transform its manufacturing industry image from "Made in Dongguan" to "Designed in Dongguan" and "Created in Dongguan." It invited the faculty of GuangDong University of Technology to help Dongguan build an Industrial Design Center with a start-up investment exceeding one million U.S. dollars. This center will become the first local government sponsored Industrial Design Center in Mainland China. Described in the proposal of the project, the goal of this center is to build an integrated platform of information, technology, communication, and design, to improve the interaction among local government, industry, education institutes, and research institutes.

Despite these changes, Industrial Design still remains an obscure profession to the public. In 1999, in a random sample survey conducted in Guangzhou, only ten percent of the participating citizens had a general idea of what an Industrial designer does even when Guangzhou was among the first few major cities that launched Industrial Design educational programs. Needless to say, there are few Industrial Design companies or designers that are recognizable to the public.

[11] These major policies include allowing privatization of business and free market, focusing the governmental efforts on economic development instead of "the Class Struggle", and encouraging foreign investment, etc.
[12] In 2001, the whole city exported 10.499 billion US dollars of goods to Europe, the United States, and Japan, accounting for 55.5% of the City's total export (statistics from Dongguan government website).

1.4 Reforming Chinese Industrial Design Education for Sustainability[13]

As the brief discussion above suggests, Chinese Industrial Design education is facing four major problems. The problems caused by the centralized Chinese educational system constrain Chinese Industrial Design education. These problems need systematic solutions that are beyond the Industrial Design discipline. On the other hand, Chinese Industrial Design education can expand its scope to solve its inherent problems. One promising direction is to expand its curriculum to engage sustainability.

The reasons why Chinese Industrial Design education must engage sustainability are obvious. Design must adhere to the constraints of the eco-systems in which human society is embedded and intimately interconnected. In the past two decades, China has undergone a major economic reform and become an important player in the world economy. Unfortunately, this growth has created severe environmental problems: China produces a large proportion of world's commodities at a growing cost on its own environment. Pollution and its effects on public health, environment degradation, and wasteful energy consumption are dangerous side-effects of an economy with little concerns for sustainability.

In general, China's manufacturing industry falls into two categories: labor-intensive products (such as clothing, shoes, toys, and souvenirs) and energy-intensive products (such as chemical products, steel products, and mechanical parts). While energy-intensive products are not always accompanied by high pollution, in China it is all too often the case. Along with the growing demand for energy, coal energy still counts for 70% of China's total energy production. The use of coal, especially high-suffer coal is associated with a significant amount of pollution. Therefore, energy-intensive products almost inevitably result in higher pollution

[13] Sustainability is defined by the United States Environmental Protection Agency as the ability to achieve continuing economic prosperity while protecting the natural systems of the planet and providing a high quality of life for its people.

levels in China. In fact, 16 Chinese cities are among the top 20 most polluted cities in the world. According to the report of the State Environmental Protection Administration of the PRC in 2004, the economic impact caused by environmental pollution exceeded 520 billion USD, 3.05% of the overall GDP. To address this issue, in March 2006, the Chinese National People's Congress called for a 20% reduction in energy consumption per unit of GDP by 2010 in the 11th Five-Year National Planning Program[14] (issued in October, 2006).

The health effects of pollution are also costly. According to the report of the Ministry of Health of the PRC in 2005, currently 34% of the residents in Chinese rural areas do not have safe water resources. The World Bank estimates that after 2020, China will have to pay $390 billion, 13% of China's GDP per year, for illnesses related to coal source pollution.

The natural resources in China are rapidly being depleted. Five years from now, China will have to import 60% of the oil used by its industries. The energy crisis in China has reached a critical point and the increasing demand may be putting the rest of the world at risk.

From the world's standpoint, products designed and manufactured in China can be found almost everywhere. In 2004, China exported 593.4 billion U.S. dollars of goods, which made it the third largest export country in the world, following the United States and Germany. With such enormous quantity, the environmental impact of Chinese products should become a major concern of consumers everywhere. If all of these products were designed according to sustainable design[15] guidelines, it would definitely reduce waste and the undesirable impacts on our environment.

Given the gravity of these interrelated problems, appropriate Industrial design

[14] With an estimated 45% increase in GDP by 2010.
[15] In the Industrial Design field, it is referred to as a series of design philosophy and methods with the purpose of reducing or even eliminating environmentally destructive impacts of products. See Chapter Two for detail discussion of the concept.

strategies, especially sustainable design and green technology, are desperately needed to relieve the tension between China's fast growing economy and its environmental problems.

In addition, Industrial Design education engaged with sustainability would contribute the transition of the country's industry to comply with international environmental policies for sustainable development and avoid export penalties. With tightening environmental regulations, environmental friendliness is becoming an important concern affecting all parts of the product design chain and forcing more and more companies to seriously consider the environmental impacts of their products from manufacturing, consumption, and disposal/recycling process. The need for teaching and training of the next generation of designers concerning their responsibility in the sustainable development process is obvious. Industrial designers can help their clients as well as society as a whole in terms of mitigating environmental impact and subsequent social problems at a fundamental level, such as reducing waste of resources and energy, and the eliminating use of poisonous substances and materials. Sustainable design is a part of an all-around and systematic response to these needs.

Victor Papanek was among the first advocators for designer's social responsibility and a pioneer of ecological design. He states:

> There are few professions more harmful than industrial design, but only a very few… by creating whole new species of permanent garbage to clutter up the landscape, and by choosing materials and processes that pollute the air we breath, designers have become a dangerous breed… In this age of mass production when everything must be planned and designed, design has become the most powerful tool with which man shapes his tools and environments (and, by extension, society and himself). This demands high social and moral responsibility from the designer (Papanek, 1972, 1985).

Leading the way in education, and sustainable design research in the world, European countries such as Italy and Great Britain have developed prolific knowledge-bases in these areas. The British government released the

"Environmental Responsibility Report" in 1993, which defines the educational policy for sustainability in the UK. Its key recommendation states:

> After consultation with its staff and students, *every* higher and further education institution should formally adopt and publish, by the beginning of academic year 1994/95, a comprehensive environmental policy statement, together with an action plan for its implementation.

North America has also integrated sustainability issues into product design practice and education for more than three decades. Although there are diverse teaching models in different design schools, generally the academia in North America has developed an awareness for sustainability issues. These educational practices in developed countries could be adapted to the Chinese situation to help begin to reconstruct curricula engaged with sustainability concepts.

As a professional industrial designer and educator in the world's most rapidly developing country, the author's experience and early research on sustainable design in China led her to believe that very limited attention is being given to sustainable design education in China. Chinese designers are sensitive to current trends in design and technological development in the world. Many of them also have professional skills[16] equivalent to their Western counterparts. However, despite the interest in sustainability that has grown significantly in the past ten years, there are few Chinese designers who are knowledgeable concerning sustainable design principles, and fewer still who apply them in practice. The interviews with Chinese students, educators, and practitioners in the summer of 2005, which are discussed in depth in Chapter Four, suggest that the intense propaganda of sustainability from the Chinese government has in fact evoked emotional rejections from the audience because the system of Chinese higher education fails to offer practical curricula embedded with sustainability to help the Chinese Industrial Design community relate sustainability to design practice. This disconnection leads to frustration and

[16] Sustainable design skills are not considered as part of the professional skills sets of industrial designers in Mainland China. It is evidential in Appendix A, where the National Instructive committee of Industrial Design education (China) does not include sustainable design as part of the core course requirements.

indifference for both students and professionals. As a result, the design community is unable to use design to convince some short-sighted profit-driven local governments or clients to change their policies and practices for sustainable development. Sustainability becomes little more than political jargon that no designer can relate to in his or her practice.

Understandably, the reform of the Chinese higher education system is a complex process. The problems need systematic solutions beyond individual disciplines. This dissertation focuses on strengthening the Industrial Design educational system by integrating issues related to sustainability into its scope for long-term economic and environmental gain and offering a practical framework for implementation. The new framework should overlay sustainability concept on current courses to avoid overloading the system, introduce hands-on projects and successful cases using sustainable design guidelines, and adapt to different pedagogical settings.

1.5. Research Questions and Hypothesis

The main research question of this dissertation is:

Can a framework be developed to reform Industrial Design education in China to comprehensively include issues of sustainability?

The sub-questions include:

What efforts have been made in design education to promote engagement with issues of sustainability? What is the status of Industrial Design education in Mainland China? How would other countries' experience and practice help when reforming the Chinese design education system? When is the proper time to integrate sustainability concepts into product design education in a four-year higher education institute? What are the pedagogical methods suitable for sustainable design education? What are the barriers and constraints that must be overcome?

The hypotheses are:

1). An educational framework can be developed for Chinese Industrial Design education that translates and adapts Western models with emphasis on sustainability to the Chinese situation.

2). A comprehensive curriculum can be developed to induce changes in design practices.

3). In the current state of Chinese environmental education, there will be little use to only insert an isolated sustainable design course. There has to be a systematic approach to integrate sustainability into the whole curriculum.

4). This framework should be constructed by several interconnected categories of courses. Each category will include four to six courses.

1.6. Methodology Overview

The framework development relies on a grounded theory methodology. Its construction begins by analyzing literature related to sustainable product design and the current design education system in China. Interview data collected in China in the summer of 2005 assists with understanding the reality of the current Chinese Industrial Design education. It helps to identify the barriers and constraints for implementing the proposed framework.

The proposed educational framework identifies critical concepts and knowledge for Industrial Design according to commonly accepted Industrial designer's attributes while overlaying issues of sustainability. This framework also recommends course content and innovative pedagogical methods to improve Industrial Design education. For critical review and feedback, the proposed framework is evaluated by Chinese educators.

1.7. Summary

This chapter presents an overview of the Chinese higher education structure to provide a background for Chinese Industrial Design education. It discusses four problems that the current Chinese Industrial Design education is facing and the environmental crisis China is undergoing, then comes to the conclusion that Chinese Industrial Design education should expand its scope to include sustainability if it is to address issues of growing global importance. Based on these discussions, the researcher constructs the research questions and hypothesis to develop an educational framework to improve Chinese Industrial Design education for a sustainable future.

Chapter Two: Literature Review

This chapter summarizes the literature related to four aspects of this research:

1). Sustainability and its imperative for education

This part aims to define the main sustainability concepts that are included in this dissertation.

2). Systems theory

This part aims to understand how a system functions and how to change a current system to the proposed state.

3). Educational system for Industrial Design and related pedagogical theories

This part aims to understand the educational system and explore the suitable pedagogical theory for Industrial Design.

4). Learning and teaching in Mainland China

This part aims to understand the current educational system in Mainland China as it relates to learning and teaching in Industrial Design.

2.1 Sustainability and Sustainable Design

2.1.1 Global Environmental Movements

One must first look back to the international environmental movements beginning since the mid 1960s to trace the historical path of the development of the concept of *sustainability*. Before the 1960s, few industrialized people worried about the exponential industrial growth. However, the disastrous environmental impacts of

mass industrial production and explosive population increase quickly revealed themselves in a series of severe pollution cases around the world. Biologist, writer, and ecologist Rachel Carlson published her classic book *Silent Spring* in 1962 to "challenge the practice of agricultural scientists and government, raise the awareness of the consequences from using pesticides, and call for a change in the way mankind viewed the nature world." (Lear, 1997) As John Tillman Lyle concludes,

> (In the last two centuries,) where nature evolved an ever varying, endlessly complex network of unique places adapted to local conditions, human ingenuity has replaced it with a system of relatively simple forms and processes repeated with bold and consistent regularity over the face of the earth. Where nature evolved to a level of infinite diversity, humans have designed readily manageable uniformity. And most importantly, humans have replaced nature's endless cycling and recycling of materials, processes at the core of the earth's operating system, with an encompassing system of one-way flows, moving the materials that support life in vast quantities from source through consumption to sink (Lyle, 1994).

Scientists quickly realized that the environmental issues are complex and global in this postmodern world and that we should "protect individual rights while protecting the larger interests of the planet and our children who will live on it." (Orr, 1992) Above all, the environmental crisis is in essence caused by the social structure and psyche of our time. The crisis is interconnected with economic, social, and political issues. As David Orr states, "The environmental crisis is unique in its range and scope including energy, resource use, climate, waste management, technology, cities, agriculture, water, biological resilience, international security, politics, and human values"(Ibid).

The environmental movement fostered a school of green philosophical theories including social ecology, deep ecology, Eco-socialism, Eco-Marxism, and Eco-feminism[17]. In general, Green philosophies have a "relational" conception of humanity, where individuals are seen as intimately and inseparably connected to community and nature, such that the well-being of each depends on the well-being of

[17] See Appendix I for definitions of these theories.

the whole (Birkeland, 2002). As Gerald Weinberg (Weinberg, 1975) said, "[In man,] success comes from the power that knowledge gives to alter the environment. The problem is to bring that power under control." In general, green philosophies are for a sustained development that is beyond material economic development, that include both social and cultural development. They call for a holistic and systematic approach to manage both human society and nature.

2.1.2 Sustainability and Sustainable Development Concepts

German forester and scientist Hannss Carl von Carlowitz first introduced the concept of *sustainability* in his book *Sylvicultura Oeconomica* in 1712. In 1987, the term *sustainability* was adopted and further developed by The World Commission on Environment and Development, which the United Nations General Assembly charged with formulating an "agenda of the future". The Commission's report, *Our Common Future*, defines *Sustainable Development* as development that meets the needs of the current generation without compromising the ability of future generations to meet their needs. In 1992, as a result of the United Nations Conference on Environment and Development held in Rio de Janeiro, Brazil, the *sustainable development* concept is to be considered as the corner stone of a comprehensive plan of action for the 21st century known as Agenda 21. The 2002 World Summit on Sustainable Development expanded this definition identifying the "three overarching objectives of sustainable development" to be (1) eradicating poverty, (2) protecting natural resources, and (3) changing unsustainable production and consumption patterns. In short, sustainable development tries to deal with comprehensive issues related to environmental protection without compromising economic development or social equity as listed below (Hargroves & Smith, 2005):

- Dealing transparently and systemically with risk, uncertainty and irreversibility

- Ensuring appropriate valuation, appreciation and restoration of nature

- Integration of environmental, social, human and economic goals in policies and activities
- Equal opportunity and community participation/Sustainable community
- Conservation of biodiversity and ecological integrity
- Ensuring inter-generational equity
- Recognizing the global integration of localities
- A commitment to best practice
- No net loss of human capital or natural capital
- The principle of continuous improvement
- The need for good governance

2.1.3 Sustainability and the Traditional Chinese Philosophical Position on Environmental Issues

Many believe that by implementing the newest concepts of sustainable development, developing countries such as China, would leap to a sustainable society and avoid the ecological and social disasters caused by the excess industrial expansion model, especially in light of the traditional Chinese philosophical positions concerning the relationship between human beings and nature. In recent centuries, many Western environmental philosophers have borrowed concepts from ancient Chinese philosophies to express the understanding that human beings must maintain the integrity of the biosphere and our sense of connection with nature. There have been several ancient Chinese philosophers, among them Lao Tzu and Chuang Tzu of the sixth century, who have developed an extensive tradition in oriental philosophy to respect and coexist with nature.

Lao Tzu, the greatest thinker of his time, and one of the greatest philosophers in world history, established the concept of Tao in his *Book of Virtue (Tao-Te Ching)*. Another important philosopher in Taoism is Chuang Tzu who fully developed the Taoistic thesis. Tao, or Dao in other translation, has multiple meanings. Similar to the concept of sustainability, the meaning of Tao is abstract yet comprehensive. Lao Tzu considered Tao as "the Way." To be more explicit, it means a simple way of life, and a harmonious order. This order is the *Order of the Nature*. The meaning of Tao is deep and profound, and it has been described as subtle and elusive but rational. It is neither chaotic nor unpredictable, for it is the "essence" which is very real. Lao Tzu considered Tao as transcending heaven, earth, and all things. He extended his concern beyond the realm of human affairs to include the natural and the metaphysical. Lao Tzu insists that we avoid the extreme, the extravagant, the excessive, and do away with desires. He wants us to be "contented with contentment" and "know when to stop" (Laozi & Chan, 1963). All of these themes resonate with the present day call to reduce materialist desires and conserve energy as expressed by proponents of the modern environmental movements.

Of course while some might be charmed by these ancient philosophical ideas, many might argue that Lao Tzu's statements sound like primitivism and renunciation of civilization. His critics also oppose the idea that Tao exists beyond human beings. In fact, by studying Taoism, one may understand it is the simplicity and not renunciation that is desired. "Having no desires", as in Lao Tzu's word, means having no impure or selfish desires, not necessarily having no desires at all. While desires should be few, good ones are to be fulfilled. A popular Chinese saying explains: "Take from others with Tao." It means taking is allowed, but taking should be with methods, with principles, with ethics, and most importantly, with limits. Sustainable development intends to balance the needs of human development with nature. Development and sustainability are not rival. Therefore Taoism is perfectly consistent with the sustainable development concept. It is an ethical and philosophical argument for sustainable living.

In Chinese history, Taoism is more than a school of thought. It is woven into the fabric of the Oriental way of life. However, the recent political movements in Mainland China have greatly reduced the influence of the traditional beliefs on Chinese society. In the Cultural Revolution (1966 to 1976), Taoism and other traditional Chinese philosophies such as Confucianism were condemned as heresy by fanatic communists. Given that these traditional philosophical systems were discredited before, it will be difficult to convince most Chinese to use them to manage their modern developments.

2.1.4. Chinese Governmental Policy on Sustainability

Since the early 1990s, the Chinese government has adopted sustainable development as the fundamental national policy. However, the concept is still unknown or misunderstood by the average citizen. Marketing of the benefits from embracing concepts of sustainability has had little success in China due to the fact that the country has just struggled through many years of material shortage. In most cases, environmental issues are widely ignored in China in favor of economic development. The Chinese have expanded their materialistic appetite as the country's economy continues to grow (see Figure 2.1). Consistent with the western experience, according to "Chinese Environmental Protection White Book" published by the State Department of PRC, the governmental investment in environmental protection as a percentage of GDP has risen in the past 25 years (Figure 2.2). These figures show that the Chinese government is taking the environmental issues more seriously, but on the other hand, it may imply a rapid increase of environmental problems.

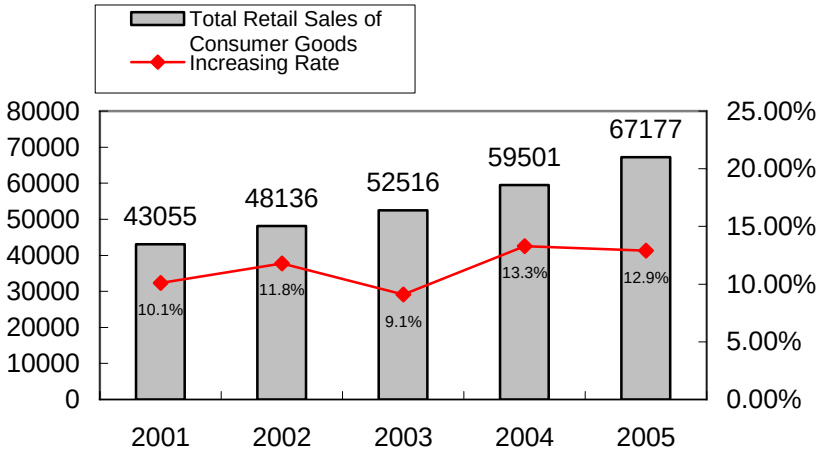

Figure 2.1 - Total Retail Sales of Consumer Goods Growth in 2001 to 2005[18] in China: Unit: 100 million RMB[19]; Source: National Bureau of Statistics of China

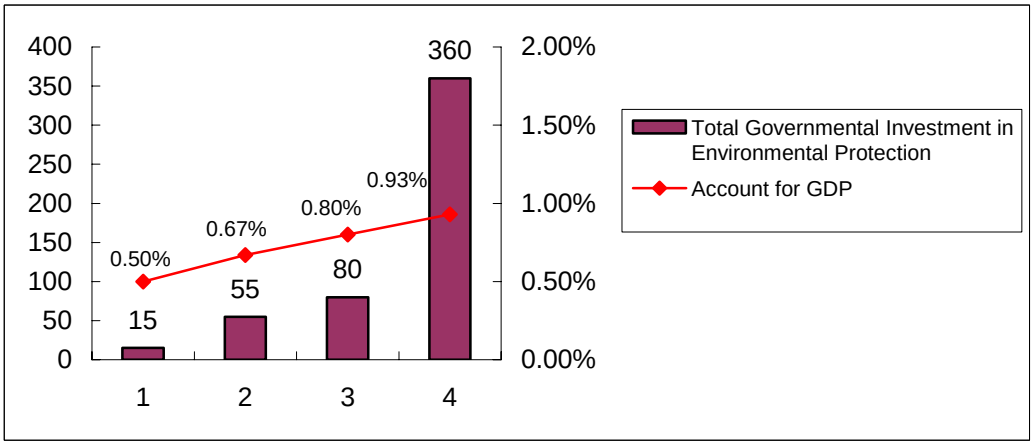

Figure 2.2 - The Total Governmental Investment in Environmental Protection in Mainland China from 1980 to 2000

Note: X coordinates: 1=1980-1985; 2=1986-1990; 3=1991-1995; 4=1996-2000; Unit: 100 million RMB; Source: National Bureau of Statistics of China)

Table 2.1 shows that although emission rates declined for a few major pollutants, the overall pollution rate has increased from 2000 to 2005.

[18] The decrease of increasing rate in 2003 was partially caused by the SARS outbreak in Mainland China.
[19] Approximately, 8 RMB equal 1 US dollar in 2005.

Table 2.1 - Major Pollutants Emission Statistics

			Unit: 10,000 tons
Item	2000	2004	2005
Emission of SO_2	1995.1	2254.9	2549.4
Industrial Emission	1612.5	1891.4	2168.4
Household Emission	382.6	363.5	381.0
Emission of Soot	1165.4	1095.0	1182.5
Industrial Emission	953.3	886.5	948.9
Household Emission	212.1	208.5	233.6
Emission of Industrial Dust	1092.0	904.8	911.2
COD Discharge	1445.0	1339.2	1414.2
Industrial Discharge	704.5	509.7	554.7
Household and Service Discharge	740.5	829.5	859.4
Ammonia Nitrogen Discharge		133.0	149.8
Industrial Discharge		42.2	52.5
Household and Service Discharge		90.8	97.3
Industry Solid Wastes Discharged	3186.2	1762.0	1654.7

Source: Chinese State Environmental Protection Administration

Figure 2.1, 2.2, Table 2.1, and the discussions in Chapter One show that despite the increasing funding in environmental protection, the environmental problems in China are still severe.

2.1.5 The Educational Imperatives for Sustainable Development

For a sustainable future, educators have the responsibility to cultivate environmental awareness. David Orr (Orr, 1992) defines education for sustainability in a broad sense:

- Education relevant to the transition to a sustainable society demands an uncompromising commitment to life and its preservation.

- Education for sustainability should help students and teachers understand the world of nature and develop competence in considering natural systems.

- Education for sustainability will connect disciplines as well as disparate parts of the personality: intellect, hands, and heart. A multidisciplinary approach and the aim of personal wholeness and transcendence are both essential in ecological design education.

- Education for sustainability must include an awareness of the tragic in human affairs: the limit of growth.

Sustainability education should be taught at all ages, cover all subject areas, and be woven through life. David Orr (ibid) states that there are six foundations of how to educate people to live sustainably at all levels:

- All education is environmental education.

- Environmental issues are complex and cannot be understood through a single discipline or department.

- For inhabitants, education occurs in part as a dialogue with a place and has the characteristics of good conversation.

- It follows that the way education occurs is as important as its content.

- Experience in the natural world is both an essential part of understanding the environment, and conducive to good thinking.

- Education relevant to the challenge of building a sustainable society will enhance the learner's competence with natural systems.

Sustainability must become the framework or integrating concept to deliver the core knowledge of the curriculum. These guidelines help to construct a general educational system to serve the goal of sustainability. However, they are insufficient for the specific needs of design education. More specific guidelines need to be further developed.

2.1.6 Sustainable Development and Design Education

The Industrial Design education has a long tradition of recognizing the interactions of design and the society. The revolutionary reform of modern design and architecture education started from Walter Gropius, the influential German architect and educator who founded the Bauhaus School of Design in 1919 in Germany. The Bauhaus' ideals were that the artist must recognize his social responsibility[20] to the community and likewise, the community must accept and support the artist. It strived to produce a new approach to architecture that incorporated artistic design, craftsmanship, and modern machine technology. The intention of the Bauhaus was to develop creative minds for architecture and industry and influence students so they would be able to produce *artistically, technically, and practically* balanced utensils.

As design became more integrated with the economy and mass production, it became more commercialized, and then the social responsibility of designers was largely ignored in the professional practice. The visionary architect R. Buckminster Fuller was among the first who raised the social responsibility issues for designers and architects in the later part of the 20th century. He urged the design community to examine global problems in the context of the whole system to anticipate the critical needs of humanity. The Oil Crisis in 1970s inevitably raised the question of the social responsibility in the design community again, and greatly encouraged the practice of environmentally responsible design. In his radical classic publication in the late 1970s, *Design for the Real World*, Victor Pananek brought forward the ethnics issues to designers and called for a major paradigm shift in design.

"Green design," "Design for the Environment," and "Ecological Design" are positive responses of the design professions to the environmental movement. Trends of styles in design, such as minimalism, also call for a radical reduction of material

[20] Social responsibility is a doctrine that claims that an entity whether it is state, government, corporation, organization or individual has a responsibility to society.

use in design. The development of design for the environment can be described by the table (Table 2.2) below.

Table 2.2 - Four types of Eco-Design

	Product improvement before 1990	**Product Redesign since 1990**	**Product innovation since 2000**	**System innovation starting 20??**
Approach	End of pipe: Reduction of emissions by using filters Material recycling: Recirculation of material into the production process	Redesign of existing product concepts according to environmental criteria, e.g. Modular systems aiming at easy disassembly, improved distribution	New Product concepts with increased eco-effectiveness and with well-known product functionality, e.g. cyclone vacuum cleaner (Dyson^{TM})	Design of Products or services to fulfill customer's needs by systematic change, e.g. exhaustive introduction of fuel cell technologies in the automotive industry.
System boundary	Impact of hazardous substances to the environment. Use of raw material along the life cycle.	Single manufacturing processes and supply parts	Whole product life cycle, explicitly including use phase and end of life	Whole product life cycle, explicitly including all global environmental interactions
Reference	-emissions, hazardous substances -raw material	Additionally -energy consumption	Additionally -process -product	Additionally -service -value

Source: (Abele, Anderl, & Birkhofer, 2005)

The development of these design theories resonates with the rising ecological awareness of customers since the 1980s. After the wide discussion of sustainability in the early 1990s, many researchers started to integrate this concept into systematic design and planning of the industrial structure. In *Natural Capitalism* (Hawken, Lovins, & Lovins, 1999), Paul Hawken and his colleagues put forward strategies to engage business and industry to becoming part of the solution. An emerging

generation of designers who are deeply concerned about environmental impacts of design was inspired by new theories in sustainability and the public attitudes towards environmental issues. Much literature has been published during the last two decades to fuse an ongoing discussion engaged with sustainability issues among designers and architects. In recent years, the emphasis of Ecological Design has shifted to a more systematic approach. One of the most important advocates for sustainable design in North America, architect William McDonough, suggests a new model for industry that will imitate the natural cycle of materials flow. He calls this model the "Cradle-to-Cradle" model, which will eliminate the concept of waste by discarding the old linear model in industrial growth.

As Abby Mellick of the "Change Design" organization of Sydney, Australia stated, sustainable design needs "an intuitive sense", a sense that gives immediate cognition of the potential environmental impacts of design. It comes from thinking comprehensively about the entire life cycle of products, services, and design process. This intuitive sense can be cultivated by integrating systems thinking and critical thinking (discussed later in this chapter).

These discussions generated a new model for environmentally responsible design practice: "Sustainable Design." In the Industrial Design field, it is referred to as a series of design philosophy and methods with the purpose of reducing or even eliminating environmentally destructive impacts of products.

Another significant move of sustainable design in the United States is the establishment of rating tools for sustainable design in architecture and building construction such as LEED. The U.S. Green Building Council developed the Leadership in Energy and Environmental Design (LEED) rating system and standards to recognize the achievements in high-performance and sustainable buildings nationwide. LEED sets a standard for architects who are vigorously pursuing sustainable design.

Industry also began responding to the increasingly rigorous environmental regulations. Thus, business and industry started to show more interest in minimizing the environmental impacts of their products and services by adopting "design for the environment" methods such as Life Cycle Assessment (often abbreviated as LCA, see Figure. 2.3). LCA is defined by the U.S. Environmental Protection Agency as a technique to assess the environmental aspects and potential impacts associated with a product, process, or service, by:

- compiling an inventory of relevant energy and material inputs and environmental releases;
- evaluating the potential environmental impacts associated with identified inputs and releases;
- interpreting the results to help you make a more informed decision.

However, most of these early practices were marginalized and failed to gain wide acceptance by the design professions, especially in developing countries such as China. Consumers also often found these design outcomes much less desirable than traditionally designed products because of their crude appearances and high prices. Many designers believed that these first attempts at sustainable design were superficial movements that could not significantly influence consumers' attitudes or behaviors. Some even considered environmentalism as an extreme and unrealistic fanaticism that would ultimately lead to the degeneration of modern civilization. In China, these stereotypes of "green design" are still possessed by large numbers of people as confirmed by the interviews with the Chinese Industrial Design community later described in Chapter Four. Promotion of sustainable design has to change these perceptions first and education is an effective means to tackle this problem.

2.2 Systems Theory and Design Education

2.2.1 General Systems Theory and Sustainability

One needs to adopt a systems approach to thinking of the world to comprehend the complexity of environmental issues facing humanity. As a poet might say, systems thinking is a point of view. Historically, the "systematic view" has been referred to as a "holistic worldview." According to general systems theory, a system is "an entity that maintains its existence and functions as a whole through the interaction of its parts" (O'Connor & McDermott, 1997).

One does not need to look far for examples of complex systems. Humans and their activities constitute a subsystem of a system of the Earth, the interconnected dynamic geophysical, geochemical, and biological processes that collectively serve to make our planet a living world. On the contrary, the reductionist worldview slices the world into small pieces then analyzing these pieces to understand the world. It was effective at discovering new knowledge in closed systems[21] at the micro scale where external environmental conditions could be controlled by the experimenter. This technique could not be applied to open systems[22] and large scale systems because the external conditions were beyond control of the scientists. Furthermore, it cannot predict the emergent properties[23] in the systems that are not found in their parts.

In addition, systems theory also contributes to our understanding of how and where changes in the systems might occur and how these changes might interact with the current system to produce a new system with new behaviors. When changing systems such as educational systems, dynamic complexity always arises because systems have these characteristics as shown in Table 2.3:

[21] Closed system and isolated systems are systems that do not interact with their surroundings.
[22] Open systems can be affected by events outside of the actual or conceptual boundaries of the systems.
[23] For example: personality is one of the emergent properties of a human biological system.

Table 2.3 - Dynamic Complexity of Systems

Characteristics	**Symptoms**	**Implications for the reform of the Industrial Design educational system**
Dynamic	Changes in systems occur at many time scales.	Interventions occur at many scales.
Tightly coupled	The participants in the system interact strongly with one another and with the natural world.	Changes can have far reach and unanticipated consequence and responses.
Governed by feedback	All dynamics arises from the interaction of just two types of feedback loops, positive (or self-reinforcing) and negative (or self-correcting) loops.	Feedback from all the actors in the system constantly reinforces or weakens the changes.
Nonlinear	Effect is rarely proportional to cause.	Significant effects of reform might take generations to emerge. But well-positioned interventions in the system with high leverage[24] can affect large and rapid changes.

Table 2.3 continues on the next page.

[24] Leverage points in the system means places where policy resistance is lower and small changes will be amplified.

Table 2.3 continued.

History-dependent (path-dependence[25])	The path-dependence of any institution determines that changing a system must consider the historical evolution and the current state of the system. When introducing policy intervention, it is expected to have resistance, the tendency for interventions to be delayed, diluted, or defeated by the response of the system to the intervention itself (Meadows, Richardson, & Bruckmann, 1982).	The current state of the Industrial Design educational system needs to be examinined. Elements that will effect the changes in the system must be identified and their relationships with the intended changes have to be understood to ensure the policy resistance can be minimized.
Self-organizing	The dyanamics of systems arises spontaneously from their internal structure. There are constant renegotiations within the system.	Systems react to interventions and adjust themselves internally.
Adaptive	The capabilities and decision rules of the agents in complex systems change over time.	The actors in the system learn new ways to achieve their goals in the face of interventions over time. This might weaken or reinforce the intervention.
Counterintuitive	Cause and effects might be distant in time and space in a complex system.	The reform of the system has to be proactive and beyond the current events, sometimes counter-intuitive.
Policy resistant	Policy resistance arises because we often do not understand the full range of negative feedbacks operating in the system.	Strategy has to be constructed to counter the policy resistance.
Characterized by trade-offs	Time delays in feedback channels mean the long-run response of a system to an intervention is often different from its short-run response.	There will be trade-offs when implementing interventions. These trade-offs have to be taken into consideration.

Source: adopted from John Sterman's table of "Dynamic Complexity" (Sterman, 2000)

[25] Path-dependence means the self-reinforcement mechanism of institutions or systems (Pierson, 2004). In a broader conception, it also means "history matters" in the development of institutions and systems.

Systems theory uses system dynamics models to understand the behavior of a complex system. These models deal with the feedback loops and stocks and flows of the systems. In this research, building these models will help understanding the system and facilitate formulation of policy interventions to change the current system. A basic feedback loop in the Industrial Design educational system is shown in Figure 2.3.

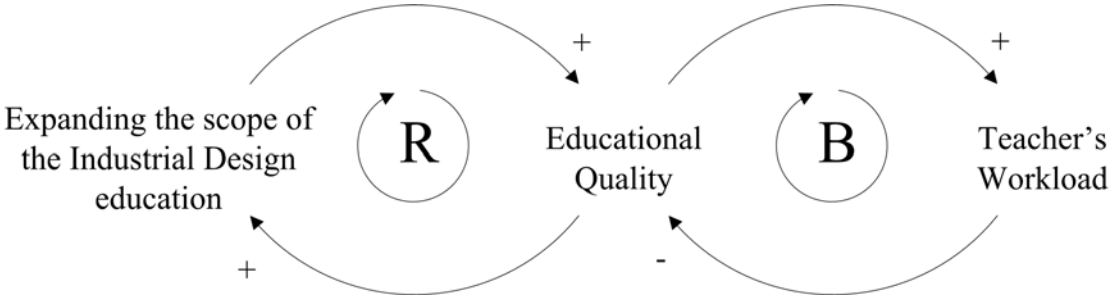

Figure 2.3 - A Basic Feedback Loop in the Industrial Design Educational System
Note: "R" means reinforcing loop; "B" means balancing loop (negative loop).

Figure 2.3 shows that by expanding the scope of the Industrial Design education (i.e. discussing more social and cultural issues in the curriculum) will presumably enhance the educational quality, but also increases the teachers' workload. Therefore, educators might resist the expansion and the educational quality might in fact decrease and act to resist the demand for expansion. This resistance is always caused by balancing loops. A system with a strong balancing loop seeks its emergent goal. Changes to the system are not permanent because once the pressure is off, the system returns to its original goal. Hence, to change a system, one has to create or strengthen reinforcing loops and weaken or remove balancing loops. In addition, often a short-run gain leads to a long-term decline. Similarly, a short-run loss can lead to a long-term gain. Predictably, when the goal of an educational system is long-term, it is difficult to sustain support for new policy interventions.

General systems thinking is a holistic approach to the solution of complex problems well-suited to analyze the complexity of sustainable design. Using this approach, The Club of Rome, which was formed in 1968 at the instigation of Italian

industrialist Dr. Aurelio Peccei, undertook an ambitious project “to examine the complex of problems troubling men of all nations: poverty in the midst of plenty; degradation of the environment; loss of faith in institutions; uncontrolled urban spread; insecurity of employment; alienation of youth; rejection of traditional values; and inflation and other monetary and economic disruption” (Meadows, Club of Rome, & Potomac Associates, 1974). The report by the World Commission on Environment and Development (World Commission on Environment and Development., 1987) concluded that, “[Sustainability is to be attained by] more rapid economic growth in both industrial and developing countries, freer market access for the products of developing countries, lower interest rates, greater technology transfer, and significantly larger capital flows”. Their missions confirm that sustainability encompasses all aspects of human society and needs systematic analysis for its scale.

2.2.2 Design and Design Education as a System

From the discussions above, one can propose that reforming Chinese Industrial Design education could benefit from a systematic approach and strategy. This system includes the administrative structure of the universities, students, faculty, job market, and social requirements, etc. As a part of the greater educational system, the educational framework proposed in this dissertation is mainly concerned with the courses, content, and pedagogical approaches of the Industrial Design higher educational program. Understanding the dynamics in the current Chinese Industrial Design educational system is crucial for the success of this educational framework because it is intended to be implemented. It is not intended to constitute a mere conceptual model. Therefore, an investigation of the current Chinese Industrial Design educational system is the preliminary stage of this study.

Though also following certain principles, design[26] and design education cannot

[26] Design, usually considered in the context of the applied arts, engineering, architecture, and other such creative endeavors.

be simplified as mere mechanical systems[27]. Design and design education are human activities. Hence, their behaviors are much more complex and often unpredictable. Design can however be conceptualized as "soft systems" that have fuzzy boundaries that are not easily defined and are characterized by complex dynamic interaction and feedback among the designer, the objects of the design, and other members of the society who affect and are affected by the design. Bela H. Banathy (Banathy, 1996) explains the problem situation in design systems as below:

> In designing social systems we are confronted with problem situations that compose a system of problems rather than a collection of problems. They are embedded in uncertainty and require subjective interpretations. Above all, design problems are ill structured and defy straightforward analysis. In design there is a continuous interaction between problems and solutions.

Soft systems thinking is more appropriate in fuzzy and ill-defined situations involving both human beings and cultural considerations for a lateral design process (Checkland, 1999). As designers can attest from experience, the design process cannot always be described in rational and mechanical terms. In fact, architect Botund Bognar (Seamon & Mugerauer, 2000) believes that the tendency of "rational" design reduces architecture "to measurable effects and results…which seriously limits architecture's primary grounding in human experience." Peter Green's "Design Process" diagram (Green, 1974) vividly demonstrates that the design process is multidisciplinary and non-linear, fundamentally a system of many interacting elements.

Design education can likewise be conceptualized as a soft system. Educational experiences involve almost every aspect of life. They are not restricted to classrooms or textbooks. Using systems thinking, educators can understand and explain the correlations of multiple disciplines in education. At the scale of the individual learner, systems thinking can greatly enhance the learner's ability to comprehend the enormous amount of knowledge involved with design and

[27] A mechanical system is a system whose behaviors can be successfully described and predicted in mechanical terms.

sustainability. For the reasons given above, systems thinking is important to design education.

2.2.3 A Survey of Current Industrial Design Curricula

Courses convey knowledge to students by subjects and are foundational modules of educational systems. Categorizing existing courses demystifies Industrial Design education, clarifies the cultural attributes of each course, and makes it easier to weigh their importance and arrange them into a curriculum sequence. More importantly, it exposes the deficiencies in current curricula. Appendix B presents a survey of the better-known Industrial Design curricula in several universities around the world. A comparison of these curricula reveals that there are many similarities and differences in both the content and the knowledge-building sequence in these curricula. The current knowledge base of Industrial Design education in China can be generalized into three skills sets: technological skills, artistic skills, and professional skills. The courses have been categorized according to these skill sets in Table 2.4.

Table 2.4 - Categorizing Courses by Three Skill Sets in Existing Chinese Industrial Design Education

Categories of Skills	**Technical**	**Artistic**	**Professional**
Courses	• Mechanics • Materials • Manufacturing • Ergonomics	• Design History • Design basics • Design Literacy • Communication Skills: drafting, drawing, computer aided design, etc.	• Design Theory and Methods • Design Research & User Studies • Product Design Strategy • Design management • Design Studio

In recent years, reforms of Industrial Design curricula in Mainland China have sought to emphasize the artistic and creative skillsets. This notion is reflected in the curricula survey by the large proportion of courses emphasizing artistic skills. Every university has a different focus that greatly influences the course content. When compared to universities abroad, the curricula of Chinese universities are relatively simple, with little content beyond professional training. The courses listed indicate that the current Chinese Industrial Design education curricula do not directly address the importance of social, environmental, or economic issues. In countries with longer histories of design and design education, such as Great Britain, the curriculum tends to provide an all-around knowledge-base for the students. That is to say, it introduces a wide-range of cultural, social, artistic, and technological knowledge to help students understand the complex nature of Industrial Design. Inevitably, as the discipline matures, it will encompass more knowledge because industrial designers are always trying to explore new questions.

Sequence of courses is another important issue in curriculum building and it is fundamentally determined by students' cognitive development (discussed in pedagogy section). The knowledge-building of the surveyed curricula usually builds on sequential difficulty from introduction to professional practice; from basic concepts to comprehensive subjects; and from broad subjects to more specific studies, and so forth. Curriculum has distinct regional characteristics, mirroring the requirements that product design varies in different parts of the world.

2.2.4 Past and Current Practice of Sustainable Design Education

In response to environmentalism and movement toward sustainable development, many design educators have realized the responsibility of design and have devoted themselves to advocate for sustainable design. Among them is David Orr from Oberlin College in Ohio, who has contributed important literature for sustainable design such as *Ecological Literacy* and also has led the design and construction of Oberlin College's teaching facilities to provide an example of a "Living Machine." British architect and educator Antony Brown is another example. He founded the Ecosa Institute in Arizona with the sole mission to restore the health of the natural environment and the health of the human environment through education in design. In Europe, educators like Ezio Manzini of Italy, have built upon the sustainability concept. They have suggested the concept of "immaterial design", which focuses design on the production of shared services instead of physical products.

As Victor Papanek (Papanek, 1995) states in *Green Imperative*, the future of design is bound up with the key role of synthesis between the various disciplines that make up the socio-economic-political matrix within which design operates. He suggests:

> Perhaps there should be no special category called "sustainable design". It might be simpler to assume that all designers will try to reshape their values and their work, so that all design is based on humility, combines objective aspects of climate and the ecological use of materials with subjective intuitive processes, and relies on cultural and bio-regional factors for its forms (Papanek, 1995).

Papanek (Papanek, 1995) lists some examples of how an ecological world-view could change design in these dimensions:

- Goal of design

There will be a greater emphasis on *quality, permanence and craftsmanship* in designed products, as people and designers come to understand that obsolescence

or bad workmanship waste natural resources that can't be replaced, and contribute to shortages on a global scale. The style of the future will be based on products that age gracefully, and will be more timeless than the quickly changing fads, trends and fashions of the late 20th century.

- Awareness of consequence

Designers and manufacturers will need to question the ultimate consequences of a new product being introduced. Questions of profit balances and production quotas are not enough.

- New green technology

New products will appear, especially in areas such as catalytic converters, afterburners, scrubbers for factories, air, water and soil-quality monitors.

- Systematic view of design

It will be understood that no design stands on its own: all design has social, ecological and environmental consequences that need to be evaluated and discussed in a common forum.

- Ecological literacy

There must be a greater concern for and a deeper understanding of nature, and this will be a preserving and healing force for the global environment.

Because many people are intimidated by the complexity of sustainable design, when selecting concepts and knowledge in other disciplines, the researcher suggest that these questions should be asked to ensure the relevancy of the knowledge to the discipline: *what can industrial designers do about this impact of design? How can industrial designers use their knowledge and skills to deal with social, environmental, and economic issue?* While this can be regarded as a pragmatic approach, it would

keep the students interested and bind the broad knowledge of sustainability in the scale that designers can comprehend.

Apart from the subject specific content, design education should also encourage the building of research skills and enhance mental capacities to process information so that students can turn it into knowledge. Victor Papanek (Papanek, 1995) has sorted out a list of the *general abilities of designers* to achieve the "green imperative" (Table 2.5)

Table 2.5 - General Abilities of Designers for Sustainability

Research skills	● The ability to research, organize and innovate ● The capacity to develop appropriate answers to new or newly emerging problems
Technological and social considerations	The talent to combine form-giving with rigorous technical considerations and with a sense of humane and social factors and aesthetic enchantment.
Communication	● The skill to test these answers through experimentation, computer modeling, working prototypes or real world test runs. ● The training to communicate such developments through drawings, models, mock-ups and feasibility studies, video or film, as well as through verbal, computer-generated or written reports ● The ability to work with people from many different cultures and different disciplines
Ecological sensibility	The wisdom to anticipate the environmental, ecological, economic, and political consequences of design intervention

Papanek provides a vivid portrait of a designer who is well educated in the environmental consequences of design. A design educational system embedded with sustainability must strive to cultivate these general abilities.

There have been many educational practices to try to integrate sustainability with design education. One recent example is that since 2002, Philip White, Steve Belletire, and Louise St. Pierre, as a team for the ecological design interest group of Industrial Designers' Society of America (IDSA), have developed The Okala Ecological Design Course Guide. The guide provides relevant information about

design and ecology as an introductory course for university level students (see Table 2.6). It offers methods to stimulate the generation of Ecodesign ideas as well as scientifically grounded methods to evaluate the environmental performance of product concepts.

Table 2.6 - The Okala Course Overview

Phase	**Modules**	**Class Activities**
FOUNDATION (Covers the role of design in creating and resolving the ecological crisis. It outlines principles of ecology and explores attitudes that have lead to the destruction of the natural world.)	1. Design in the ecological crisis 2. What is Ecodesign? 3. Evolution of our biosphere 4. Principles of ecology 5. The Natural Step 6. Environmental impacts 7. Challenging our beliefs 8. Meeting stakeholder needs	Reading; Videos; Pre- and Post-course Discussions; Visualizing a product that can solve an environmental problem
LIFECYCLE STRATEGIES (Describes the product lifecycle and provides practical ecodesign strategies)	9. Product lifecycle 10. Ecodesign strategies 11. Process tree 12. Eternally Yours 13. Balances & tradeoffs	Reading; Pre- and Post-course Discussions; Redesign a product using strategy and strategy diagram.
ASSESSMENT (Instructs how to model environmental impacts of a product.)	14. Lifecycle impact assessment 15. Impact factors 16. Comparing impacts	Reading; Videos; Pre- and Post-course Discussions; Redesign and make a LCA of a new product
PRACTICE (Explores marketing, business planning and ethical challenges)	17. Green marketing 18. Ecodesign business planning 19. Practicing ecodesign	Reading; Videos; Pre- and Post-course Discussions;

Source: adopted from Okala Guide.

The Okala course categorizes ecodesign issues into four modules and it is highly practical. However, to single out sustainable design as a course is helpful but

insufficient especially in developing countries demanding balance between environmental protection and economic development. Sustainability must become the core value of the philosophical foundation of the educational system.

2.3. Educational Framework Building

2.3.1. The Elements of an Educational Framework

This dissertation aims to present a new educational framework for Industrial Design in Mainland China. This framework has the main components shown in Figure 2.6 (figure is further developed in Chapter Five):

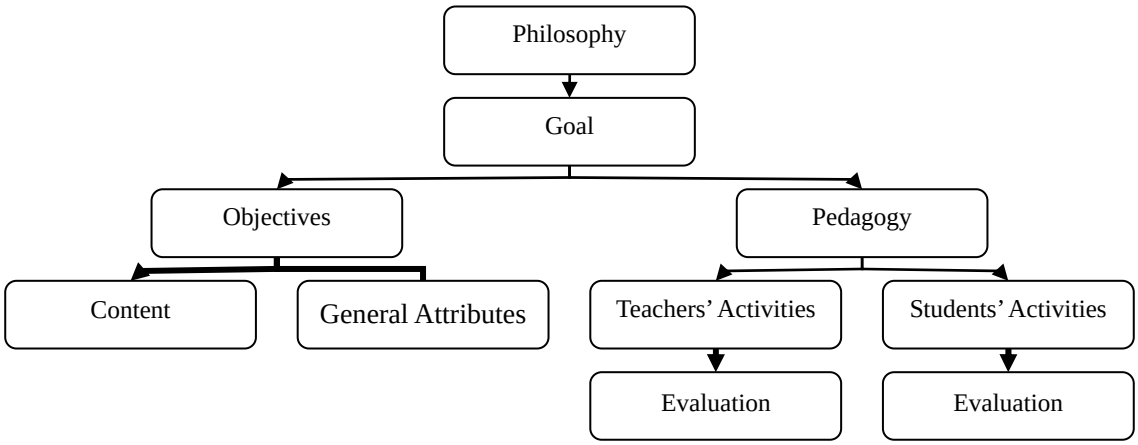

Figure 2.4 - The Components of an Educational Framework and Their Relations

An educational framework encompasses curriculum but relies on a systematic approach to provide solutions toward the intended learning objectives. It is concerned with the overall structure of the educational system as well as the content selection. The components of the educational framework are discussed below as they are related to the Industrial Design educational system in China.

2.3.2 Philosophical Foundation and Goals for Education

Philosophy lies at the center of the educational framework. It determines the following aspects of the framework:

Table 2.7 - Philosophy of an Educational Framework[28]

Philosophical dimensions	**Actual aspects**
Ontology	The purposes and goals of education
Epistemology	The knowledge that is relevant and should be included
Axiology	The ideal of an educated citizen
Methodology	The organization of the curriculum and the pedagogical approaches

Different philosophical positions create different educational systems. As Peter Hlebowitsh concludes, there are three traditions of philosophy in education as shown in Table 2.8.

[28] Please refer to Appendix I for the definitions of these philosophical terms in this table.

Table 2.8 - Three Traditions of Philosophy in Education[29]

Philosophical tradition	**Isms**	**Characteristics**	**Ideal of the Learner**	**Knowledge base**
Conservative tradition	Perennialism and essentialism	Subject-centered, aims to preserve and transmit a core culture	A disciplined and rational mind immersed in traditions, values, wisdom, and academic disciplines	A set of subjects of "permanent virtue".
Progressive (liberal) tradition	Experimentalism, romantic naturalism, social efficiency	Aims to change the culture by critical evaluation for the sake of the betterment or improvement	A socially conscious, democratically inspired, and intellectually empowered problem solver	A foundation of values, attitudes, and general competencies required for informed participation in democracy
Radical tradition	Social reconstructionism, postmodernism	Explicitly designed to revolutionize the existing system	An emancipated individual seeking an authentic meaning and identity in an ideologically layered world	Criticism of the existing systems and knowledge base

Source: (Hlebowitsh, 2005)

Conservative tradition is based on the assumption that there are subjects of "permanent virtue." Such subjects do exist in Industrial Design such as design history and universal esthetic principle. Progressive disposition is more suitable for sustainable design education because it invites social issues into the curriculum. Radical disposition aims at social change and might prompt objection from the government in a centralized educational system.

Based on the investigation of the different philosophical dispositions and practical reasons, only a combination of the conservative and progressive

[29] The definitions of the philosophical terms in this table are included in Appendix I.

philosophical dispositions seems viable for an educational system in today's Mainland China. This combination of philosophical dispositions defines the **goal** of the proposed educational framework to educate citizens who are **socially conscious, intellectually empowered, and professionally competent**.

The proposed educational framework adopts a constructivist philosophy. In epistemological terms, the constructivist worldview holds that the learners build their own knowledge in response to sensory inputs from authentic experiences[30]. In educational practice, the constructivist paradigm considers the social experiences and cultural backgrounds of both educators and students in constructing knowledge. It challenges the idea of *didactic teaching* (lecturing, teacher talks to students) thus rejects the "banking" model[31] of education. Educators embracing constructivist pedagogy invite and welcome students to join the process of knowledge construction. The Constructivist paradigm is the foundation for critical-thinking development and intellectual stimulation in education. As Ina Clair Gabler and Michael Schroeder (Gabler, Schroeder, & Curtis, 2003) conclude, a constructivist teacher recognizes the following behaviors of learners and teaching strategy:

- Knowledge is relevant to learner's experience

  Learners of any age make sense of new experiences by relating them to their own previous experiences. Making ideas understandable from the learner's point of view is not merely a motivational ploy or nice when possible, but essential.

- Learning involves both memorizing and cognitive restructuring

  Memorizing facts and reproducing information on tests is not the path to developing a deep, flexible understanding of any subject. Although it may be necessary to memorize certain facts as part of a learning experience, deeper

[30] The paradigm of constructivism as an epistemology directing the research will be discussed in Chapter Three.
[31] Paulo Freire (Freire, 2000) defined the "banking" education mode in which students are treated like passive receptacles of learning into which teachers deposit knowledge.

learning involves active cognitive restructuring on the part of the student.

- Active learners

Learning is something that the learner does, not something that is done to the learner. Because meaningful learning involves active cognitive restructuring, students must be involved in the learning process, making their own inferences and experiencing and resolving cognitive dissonance[32]. The teacher is the stage setter and facilitator of this active learning process.

- Teaching by understanding students

Effective teaching involves continual probing of the nature of student understanding, that is, getting into students' heads to the greatest extent possible.

- Systematic view of knowledge and discipline

Deeper understanding includes gaining insights into the connections between disciplines and knowledge of the ways of thinking within them.

- Learning and teaching have to be planned systematically

Superficial, encapsulated information is the result of teaching and curricula that emphasize the coverage of content. This implies that learning must be a continuous process that involves building connections from lesson to lesson and from the classroom to the outside world.

- Educational system is an open system

Continual reflection on practice (i.e., thinking carefully about what we are doing and why) is a vital part of effective teaching, an activity that promotes the

[32] Gabler & Schroeder (2003) define *cognitive dissonance* as the discomfort from new information clashing with present beliefs of students.

learning of students and the empowerment of teachers as professionals.

Most educators of design disciplines might find the above statements familiar or even recognize them as unwritten underpinning of design education. Because art and design education has a long tradition with respect to the construction of knowledge through personal experience to enhance the connoisseurship of students, which eventually leads to their own creative work. Design education values the students' opinions and encourages them to learn from their peers. Students should never be the passive recipients of design education but the positive creators who participate in the knowledge generation process at all times.

The constructivist paradigm also brings democracy into the classroom. It empowers the students and builds a student-centered educational system. In *Art as Experience* (Dewey, 1934), John Dewey argues that the roots of aesthetic experience lie in commonplace experience, in the consummatory experiences that are ubiquitous in the course of human life. He says:

> Art is a product of culture, and it is through art that the people of a given culture express the significance of their lives, as well as their hopes and ideals. Because art has its roots in the consummatory values experienced in the course of human life, its values have an affinity to commonplace values, an affinity that accords to art a critical office in relation to prevailing social conditions.

Therefore, the process of constructing knowledge challenges the students' original beliefs, and their new knowledge might ultimately be shared with the people around them. Thus, the constructivist paradigm is the philosophical foundation of the proposed educational model that emphasizes the social context of design and design education.

2.3.3 Objectives of Education

Objectives are directed by the philosophy and goal of the educational framework. There are generally two dimensions of objectives in education as summarized by

Ralph Tyler (Tyler, 1949): to support the specific content mastery and the development of a set of pervasive behaviors, skills, and values. Peter Hlebowitsh identifies the particular skills and values associated with the two dimensions of objectives in Table 2.9 (Hlebowitsh, 2005).

Table 2.9 - Two Dimensions of Objectives

Objectives	**Skills**	**Values**
Pervasive behaviors (General attributes)	Systems thinking and critical thinking, communication, inquiry and study, interpersonal engagement, and personal development.	Common moral and ethical values.
Content mastery	Interaction with a body of knowledge (facts, principles, definitions, ideas)	Subject specific, discipline-centered combines with broad field

These two dimensions happen simultaneously and have to be synthesized into working objectives for administrators and teachers.

2.3.3.1 Thinking as Pervasive Behaviors

In the education of Industrial Design, two thinking abilities in the "pervasive behaviors" dimension are particularly important: critical thinking and systems thinking (discussed previously in *Systems Theory*). Critical thinking is defined as "not to find and execute a solution but to construct a plausible representation of the situation or issue that could be presented in a convincing argument" (Kurfiss, 1988, p.2). Kurfiss (ibid) also describes critical thinking as an investigation whose purpose is to explore a situation, phenomenon, question, or problem to arrive at a hypothesis or conclusion that integrates all available information and can therefore be convincingly justified. The most important attributes associated with critical thinking, as Gabler and Schroeder (Gabler et al., 2003) conclude, are:

- A desire to stay well informed.

- A driving curiosity, manifested by the willingness and ability to ask insightful questions.

- Open-mindedness and a willingness to suspend judgment until evidence can be carefully considered.

- Persistence, focusing on a problem situation that may be ill defined.

- A willingness to gather and consider evidence from a variety of sources, and the ability to assess the credibility (and possible biases) of these sources.

- Creativity in generating alternative perspectives and in viewing situations through the frames of reference of others.

- The ability to think about one's own thinking (metacognition), as well as the willingness to change one's ways of thinking as situations warrant.

Critical thinking and systems thinking will greatly enhance industrial designers' understanding of complex design issues such as sustainability and their connections with their profession. Once cultivated in a learner's mind, these thinking abilities will not easily fade away and can be applied across disciplines.

2.3.3.2 Content Selection in Industrial Design Education

The content of a specific course in an educational framework is subject-oriented and should focus on particular issues and knowledge concerning that specific course. This content is directed by the philosophy of the educational framework and influenced by the status quo of the discipline and profession. In the selection of content in sustainable design education, the educational framework must integrate the broad field in sustainability with the discipline specific courses.

Before selecting content for the courses in the framework, one must understand the nature of *knowledge*. Knowledge is our present moment awareness (*The*

American Heritage dictionary of the English language, 2000). All knowledge is comprised of concepts and propositions, including concepts and propositions that deal with learning strategies and methods of conducting inquiries and also including the affective dimension of experience associated with those concepts and propositions (Novak, 1998). All educational systems aim to lay theoretical bases of concepts and propositions for students before introducing them to the factual experiences of professional practices.

As Eric Wignall (Wignall, 2004) sums up, there are four general types of knowledge: *declarative knowledge* refers to shared recognition or shared definition of a concept, knowledge of "what"; *procedural knowledge*, as its name suggests, refers to knowledge of procedures: "how" to do certain things; *conditional/contextual knowledge* is the knowledge of environment and the context of issues; s*ynthetic knowledge* is the evaluation, estimation and creation of new knowledge.

Industrial Design has its specialized domain of knowledge. It is generally believed that Industrial Design educational system joins the knowledge domains of science, humanities, and design. Bela H. Banathy (Banathy, 1996) calls these three domains: "three cultures in general education." She said:

> They [three cultures] jointly constitute the wholeness of human intellectual affective and creative experience. A lack of any one of the cultures leads to a grave loss of substance and value, and a loss in the quality of human experience.

Banathy defines the focus, primary methods, and what is valued in "three cultures" in Table 2.10.

Table 2.10 - The Three Cultures in Education (Banathy, 1996)

	Science	**Humanities**	**Design**
Focus	The Natural World	The Human Experience	The Man-made World
	Problem Finding	Understand the Human Experience and	Solution Finding
	Describe What “Is”	Portray It	What “Should Be”
Primary Methods	Experimentation, Pattern recognition, Analysis, Classification, Deduction	Analogy, Metaphor, Criticism, Validation, Induction	Modeling, Pattern formation, Synthesis, Conjecture, Abduction
What Is Valued	Objectivity, Rationality, Neutrality, Concern for “truth”	Subjectivity, Imagination, Commitment, Concern for “justice”	Practicality, Creativity, Empathy, Concern for “goodness of fit”

Science gives designers the physical foundation to work with; design requires designers to be creative; and the humanities cover many disciplines, including philosophy, cultural studies, sociology, and economy, which are vitally important in helping designers understand sustainable design principles and ensure their creations to be beneficial to the individual consumers, the society as a whole, and nature.

The researcher further develops “four domains of knowledge” in Industrial Design education based on the “three cultures” in order to understand the structure of the educational system and categorize courses.

Table 2.11 - Four Domains of Knowledge in Industrial Design Education

	Social domain (Humanity)[33]	**Artistic domain (Humanity)**	**Technological domain (Science)**	**Design (Professional) domain**
Focus	The human experience; The relations between society, culture, and design;	The human experience and cultural definition of aesthetics;	The Nature World; Problem finding; Solution finding;	The man-made world; Solution finding;
Methods	Criticisms; Analysis; Analogy; Induction;	Criticisms; Analysis; Analogy; Induction;	Experimentation; Deduction; Analysis;	Criticisms; Analysis; Synthesis; Conjecture;
Main knowledge types	Contextual knowledge and declarative knowledge	Contextual knowledge and procedural knowledge	Declarative knowledge and procedural knowledge	Procedural knowledge and synthetic knowledge
Educational contents	Social issues; Cultural studies; Ecology & Sustainability; Economy; Human behaviors; History;	Aesthetics; Creativity; Visual communication;	Mechanics; Manufacturing; Physical Modeling; Computer skills;	Professional communication; Strategy and service;

The content of an educational framework of Industrial Design should strive to cover all four domains.

Sustainable design knowledge adds to the competency of industrial designers. They will not only have the commonly suggested attributes, but also the competitive edge of sustainable design knowledge and skills. When seamlessly integrated with the current curricula, sustainable design education will encourage students to use systems thinking and critical thinking to better understand design. Even when these

[33] In social domain, the concepts of sustainability are included.

students change to other professions (which is rather common in China), they will still process this knowledge and skills to help them excel. According to the literature review in Chapter Two and the *Roadmap for Sustainability Science Education* project proposed by researchers at Cornell University, an Industrial Design educational system engaged with sustainability should at the minimum include the knowledge and skills listed in Table 2.12. They are categorized by one category of general abilities (persuasive behaviors) and four knowledge domains (developed upon Table 2.9, Table 2.10, and Table 2.11). Courses that can deliver knowledge and skills are suggested.

Table 2.12 - The Knowledge Involved in Sustainable Design

Knowledge domain	**Relevant knowledge (content suggestion) for Industrial Designers**	**Courses**
General attributes	● Agency and self-determination (encouraged by constructivist pedagogy) ● Systems thinking ● The concepts and language of systems thinking and relational thinking ● Research and critical thinking skills ● Communication and team-building skills	Infused in all courses
Ecological literacy domain (social domain)	● A clear, concise, and scientific definition of sustainability and sustainable development ● The environmental crisis the human society is currently facing (e.g. climate change and global warming) ● The history of environmental movements, particularly post Carson (1968) and the Club of Rome (1972). ● The foundations of ecological philosophy (especially in Chinese philosophy) and environmental ethics. ● Stewardship, personal responsibility, social responsibility, civic engagement, political will, and participatory democracy ● A systematic view of the relations between human beings and the ecosystems we are living in. ● The importance of sustainability to the ecosystem and the continuance of our species. ● Bio-diversity of species (basic principles of biology) ● The three pillars of sustainability: the economic system, the social system and the environmental system. ● The economic (long-term gain) and psychological (Maslow's hierarchy of needs) incentives for sustainable development	Green philosophy, professional ethics & morality; society as a system; interactions of local and global cultures; aesthetics; ecological literacy; sustainability by design; environment and design as systems;

Table 2.12 continues on the next page.

Table 2.12 continued.

Ecological literacy domain (continued)	● The strategic steps towards reaching sustainability ● Corporate responsibility to sustainability policy (e.g., real cost accounting that integrates the costs of externalities, risks of inaction, how society can influence industrial impacts on the environment). ● Resource management, including ecosystem and resource assessment, the difference between renewable, nonrenewable, and consumable resources, the difference between resource conservation and resource preservation, and evaluating alternative resources ● The scale of environmental and socioeconomic processes, and how different scales of sustainability result in different solutions.	
Artistic domain	● Minimalist aesthetics ● Creativity with limited resources ● Traditional aesthetics	Visualization of design concepts; design theory
Technological domain	● The risks, benefits, and impacts of technology ● LCA and green GDP accounting: methods for critically analyzing resource use, embedded energy costs of products and services, and individual and institutional "footprints". ● Environmental friendly materials and manufacturing planning ● Measuring and evaluating sustainable performance (e.g. use of performance metrics and benchmarks that evaluate social impact, environmental impact, triple bottom line accounting, and longevity of project results).	Green technologies and chemistry; clean manufacturing and processing; quality control and Life Cycle Analysis; safe, recyclable, and reusable materials; structural improvement for disassembly;

Table 2.12 continues on the next page.

Table 2.12 continued.

Professional domain	● Design for the Environment: green design, eco-design, biomimicry, cradle-to-cradle model, and sustainable design. ● The principles, methods, and process of sustainable design ● Concrete examples of how to apply sustainability thinking and transition to sustainable living. ● Product life-cycle analysis; "full cost" analysis of products, which accounts for artificial prices due to government programs (subsidy), price supports, etc ● International and local environmental law and environmental justice related to mass production. ● Trade-offs in sustainable design practice including budget and the time required by Research & Development. ● Hands-on, experiential, place-based, and service learning; sustainability education through real-world demonstrations, examples, and action. ● Certification systems (e.g. LEED) ● Use and conservation of materials and energy resources (wood, coal, oil, etc.).	Green marketing; sustainability by design; sustainable product development strategy and planning; design analysis and critique; design culture;

Table 2.12 identifies the knowledge involved in the topic of sustainability that is relevant to the Industrial Design profession and suggests several courses to cover these subjects. These various topics can be categorized into four domains of knowledge: ecological literacy, artistic, technological, and professional. These domains cover the whole spectrum of Industrial Design education. Each domain is discussed below. The specific examples and course layout are included in Appendix H.

2.3.4 Pedagogical Theory

Pedagogical approaches, managing the activities of teachers and students, should

be carefully chosen to cultivate thinking abilities, as well as achieving other objectives. The researcher argues that pedagogical position is the philosophical foundation for instruction. It determines the style and effectiveness of one's teaching and students' learning. Design education should be built on innovative pedagogical theories to enhance the success of education.

2.3.4.1. Critical Pedagogy

The researcher suggests introducing critical theory and critical pedagogy into a new Industrial Design education framework engaged with sustainability for their relevance to sustainable development. Richard Cary (Weil et al, 2004) concludes the historical development of critical theory and its significance in arts and design as that,

> Critical theory emerged in Germany in the early twentieth century with the group of philosophers called the Frankfurt School, and continues today as an idealistic and often-confrontational discourse about power, democracy, social justice, culture, and other contemporary issues, including art, aesthetics, and art pedagogy…Critical consciousness accepts the duality of art: art itself is a force that shapes our lives and yet in turn, is shaped by all that influences our lives…A critical theory view of art and aesthetics includes the concept of art-as-praxis. Praxis is practice united with theory, the action of making or engaging with art in a context of human values.

Design education is more pragmatic than art education in many ways. Thus, all too often social and political issues are raised in design educational process, especially in sustainable design education. Designers need to be empowered by critical theory to analyze these issues.

From the cultural study perspective, pedagogy cannot be completely objective or universal to all cultures. Educational research should not be based on a positivist paradigm[34] because education has distinctive cultural characters and unique social values. Researchers who attempted to become actively engaged in promoting social change within the education system and the culture itself developed the critical

[34] Positivist paradigm believes that there are universal principles that could be applied under any circumstances.

pedagogy. Influential critical scholars include Paulo Freire, Michael Apple, Henry Giroux, and Peter McLaren. Critical pedagogy claims that educators and learners should examine the purposes and goals of our knowledge, and understand how various cultural contexts and social identities impact what constitutes knowledge. Great Brazilian educator Paulo Freire (Freire, 2002) said:

> Education either functions as an instrument which is used to facilitate integration of the younger generation into the logic of the present system and bring about conformity or it becomes the practice of freedom, the means by which men and women deal critically and creatively with reality and discover how to participate in the transformation of their world.

Freire expands the scope of education and stresses the social function of education. The characteristics[35] of Freirean critical pedagogy include:

- Critical literacy involves not only reading the *word*, but also reading the *world*.
- The importance of dialogic exchange between teachers and students, where both learn, both question, both reflect and both participate in meaning-making.
- The formation of critical consciousness, which allows people to question the nature of their historical and social situation and to affect change in their society.

Henry Giroux (Torres, 1998) summarizes that critical pedagogy attempts to achieve these goals:

- Create new forms of knowledge through its emphasis on breaking down disciplines and creating interdisciplinary knowledge (desirable for design education).

[35] As Dr. Shelli Fowler concludes in the "Contemporary Pedagogy" course in 2004.

- Raise questions about the relationships between the margins and centers of power in schools and is concerned about how to provide a way of reading history as part of a larger project of reclaiming power and identity, particularly as these are shaped around the categories of race, gender, class, and ethnicity.

- Reject the distinction between high and popular culture so as to make curriculum knowledge responsive to the everyday knowledge that constitutes peoples' lived histories differently.

- Illuminate the primacy of the ethical in defining the language that teachers and others use to produce particular cultural practices (desirable for sustainable design education).

Michael Apple (Apple, 1993) points out that the problem of education is part of a larger framework of social relations as it relates to cultural reproduction. Like many sociologists, he takes a systematic way of examining the educational system, which is essential for sustainable design education, especially in the Chinese setting. Because as the longest continuous civilization in the world, China is undergoing enormous changes in ideology, social structures, and political systems. Design education is pulled from every direction by these changes. These social relations are also important issues that an educational framework for sustainability must address or it cannot sufficiently discuss sustainable development.

Peter McLaren (McLaren & Giarelli, 1995) concludes that critical pedagogy is designed to serve the purpose of both empowering teachers and students and teaching for empowerment, which aims to build a democratic classroom.

Many terms that critical pedagogy theorist have used, such as *class*, *oppressed*, and *emancipation*, are in fact very familiar to Chinese people for those terms have been constantly used as Marxist and Maoist rhetoric of the Communist Party.

However, the Chinese government started to change the national rhetoric gradually but significantly after the Cultural Revolution (1966 to 1976). The terms with distinctive communist characteristics have been carefully avoided because they provoke negative feelings and memories from the anarchic era of the Cultural Revolution among Chinese people and deviate from the current governmental policies. Last year the Chinese government started to call for a "harmonious society," which means more tolerance and less conflict in the society, as well as a blurring of social class differences. This is significantly different from the firm and trenchant rhetoric the Party used before, which shows Chinese government's strong determination to participate in international affairs more effectively by abandoning typical communist terminology. This shifting political climate suggests that traditional communist terminology may no longer be desirable in Mainland China. Neither the Chinese government nor the Chinese people want social instability, unfortunately critical theory is often linked to violent social changes. Like in many countries, politics is still a sensitive issue in Chinese classrooms. Many educators argue that education should be neutral and one should avoid talking about politics in the class. However, it is almost impossible *not* to discuss politics in design education because politics is a vital part of a discourse on sustainable development. But it is also important not to politicalize design issues in a way that frustrates students. Instead, educators should concentrate on how understanding the dynamics of the political situation can improve the design capacity for students. As Freire said, education should give people hope, which means education should not only provoke new thought and help students analyze the political world they are in, but also offer them the tools to improve the situation if they identify problems, creating expectations while providing the means for their fulfillment. Cynicism is not a favorable outcome of education. Sustainability is complex and cannot be addressed within a single discipline. Everyone should utilize his or her talents to contribute to sustainable development.

2.3.4.2 Learning and Constructive-Development Pedagogical Approaches

Selecting among various pedagogical approaches also requires the understanding of the learning process and hence the cognitive hierarchy of learning where "cognitive" refers to thought or the process of thinking, and "hierarchy" refers to rank (Gabler et al., 2003). Benjamin Bloom (Bloom, 1956) and his colleagues created the Bloom's Taxonomy (Table 2.13) to categorize the level of intellectual behaviors that are important in learning. The previous discussion of four types of knowledge is also integrated into Table 2.13.

Table 2.13 - Bloom's Taxonomy

Questioning Category	**Bloom's Category**	**Student Activity**
Lower Level	Knowledge (content mastery/declarative knowledge)	● Observation and recall of information ● Knowledge of dates, events, places ● Knowledge of major ideas ● Mastery of subject matter ● *Question Cues*[36]*:* list, define, tell, describe, identify, show, label, collect, examine, tabulate, quote, name, who, when, where, etc.
Lower Level	Comprehension (declarative/procedural knowledge)	● understanding information ● grasp meaning ● translate knowledge into new context ● interpret facts, compare, contrast ● order, group, infer causes ● predict consequences ● *Question Cues:* summarize, describe, interpret, contrast, predict, associate, distinguish, estimate, differentiate, discuss, extend
Lower Level	Application (procedural knowledge)	● use information ● use methods, concepts, theories in new situations ● solve problems using required skills or knowledge ● *Questions Cues:* apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, experiment, discover
Higher Level	Analysis (conditional/contextual knowledge)	● seeing patterns ● organization of parts ● recognition of hidden meanings ● identification of components ● *Question Cues:* analyze, separate, order, explain, connect, classify, arrange, divide, compare, select, infer

Table 2.13 continues on the next page.

[36] *Question Cues* refer to the form of questions teachers might ask when testing this level of knowledge.

Table 2.13 continued.

Higher Level	Synthesis (synthetic knowledge)	● use old ideas to create new ones ● generalize from given facts ● relate knowledge from several areas ● predict, draw conclusions ● *Question Cues:* combine, integrate, modify, rearrange, substitute, plan, create, design, invent, what if?, compose, formulate, prepare, generalize, rewrite
Higher Level	Evaluation (synthetic knowledge)	● compare and discriminate between ideas ● assess value of theories, presentations ● make choices based on reasoned argument ● verify value of evidence ● recognize subjectivity ● *Question Cues* assess, decide, rank, grade, test, measure, recommend, convince, select, judge, explain, discriminate, support, conclude, compare, summarize

To many educators' surprise, application is in fact a lower-level category in Bloom's Taxonomy. Typically, "application" only involves using old ideas and techniques in similar situation. It does not normally require creative problem solving skills. Therefore it is not sufficient for Industrial Design that demands higher categories of knowledge and ability. The simultaneous learning of different categories of knowledge sometimes occurs. Understandably, the higher categories of knowledge and abilities are harder to nurture and evaluate.

Teachers' activities coordinate with students' activities in a constructivist and learner-centered learning environment. Educators have to be aware of these levels of learning to ensure that the learning curve in the entire curriculum is challenging while not intimidating. At the "literacy" level, memorizing is still essential for establishing a fundamental language and means of expressing ideas before innovative thinking could occur. However, the pedagogical approach for these concepts does not need to be rigid or static. Instead of preaching in the classroom, teachers could start new subjects with questions that students can relate to. In this way, the process of

analysis is brought to the beginning of the course. Deeper understanding of concepts is accomplished through application and analysis. On analysis, synthesis, and evaluation intelligence levels, learners combine pre-existing and new knowledge to find new solutions and ideas. The Industrial Design educational framework should aim to cultivate all levels of knowledge and thinking abilities.

As Marcia B. Baxter Magolda points out, students' epistemic assumptions also affect their learning process. Expectations of instructors, peers, and learners themselves change as assumptions about the nature of knowledge change and vary according to these assumptions (Baxter Magolda, 1999). She concludes that there are four types of epistemic assumptions about knowledge in college and post-college (Table 2.14).

Table 2.14 – Four Types of Epistemic Assumptions in Learning

Types	**Assumption on Knowledge**	**Characteristics of Learning**	**Student and educator interaction**
Absolute knowing	Knowledge exists in an absolute form and it is held by authority	Receiving knowledge, learning is a transaction process.	Minimum; passive learners
Transitional knowing	Uncertainty and certainty both exist in knowledge	Understanding requires more exploration than the acquisition of knowledge	Students are challenged to think. More interactions between peers and instructors
Independent knowing	Uncertainty of knowledge is the core assumption.	Learning how to think independently.	Authority is not the only source of knowledge.
Contextual knowing	Incorporates the relational pattern evident in other three forms of knowing through focus on accessing one's own and other's perspectives and experiences.	Contextual knowers look at all aspects of a situation or issue, sought out expert advice in that particular context, and integrated their own and other' views in deciding what to think.	Both peers and authority have valid knowledge if they can support their stance.

These assumptions of knowledge possessed by students evolve overtime. The shift of knowledge from certain to uncertain is accompanied by a shift from viewing oneself as a receiver to a constructor of knowledge, a shift central to the development of self-authorship. Absolute knowing and transitional knowing are prevalent in college but dissipate after college. Independent knowing and contextual knowing emerge late in college and develop further after college. Educators need to understand these students' epistemic assumptions of knowledge to design the curriculum that best suits their cognitive development.

2.3.4.3 Main Pedagogical Approaches: Problem-based Learning and Project-based Learning

The cognitive hierarchy of learning and the characteristics of the Industrial Design education suggest that problem-based learning and project-based learning are two main pedagogical approaches in the proposed educational framework. The principles of learning and components of problem-based learning instructional design are listed below (Brown & King, 2000):

- Anchor all learning activities to a larger task or problem.
- Support the learner in developing the ownership and control of the problem.
- Design authentic task and problem.
- Design the task and environment to reflect the complexity of the environment.
- Give ownership of the solution process to the learner.
- Design the learning to challenge, as well as support, the learner's thinking.
- Encourage testing alternative views.
- Ensure the reflection on both the content and the learning process.

Similar to problem-based learning but more comprehensive, project-based learning is a model that organizes learning around projects. According to the definitions found in problem-based learning handbooks for teachers, projects are complex tasks, based on challenging questions or problems, that involve students in design, problem-solving, decision making, or investigative activities; give students the opportunity to work autonomously over extended periods of time; and culminate in realistic products or presentations (Jones, et al, 1997; Thomas, et al, 1999). The five criteria of problem-based learning are centrality, driving question, constructive investigations, autonomy, and realism, elaborated as below:

- Problem-based learning is central, not peripheral to the curriculum.

- Problem-based learning focuses on questions or problems that "drive" students to encounter (and struggle with) the central concepts and principles of a discipline.

- Projects involve students in a constructive investigation.

- Projects are student-driven to some significant degree.

- Projects are realistic, not school-like.

Problem-based learning and project-based learning are desirable for design education which aims to cultivate the creative and critical thinking ability through practice. They have been adapted for many years in design education and have been proven to be effective in helping the students to integrate theories into design practices. It is a common practice in design education for the educators to propose a design task with a list of objectives to the students, and then assist them in discovering problems and solving problems. Problem-solving is often associated with deductive reasoning, with the learner assessing the situation, gathering information, and forming and testing hypotheses until the desired goal is reached (Gabler et al., 2003), sometimes in ambiguous situations multiple solutions to the problem can be

conceived. Thus, problem-based learning and project-based learning support an educational framework for Industrial Design.

2.3.5 Evaluation

Evaluation provides the feedback for the design of an educational framework to allow educators and researchers to examine if the framework has achieved its intended goals. Evaluation includes two aspects: evaluation of the content and evaluation of the implementation of the framework. First of all, when possible and practical, the researcher should use scientific methods to evaluate the validity and reliability of the content. For example, the content of the educational framework can be evaluated by the educator to see if it fulfils the requirements of the particular discipline and profession.

The implementation of the framework can be evaluated by the academic performance of the students and teachers. The instruments of evaluation include tests, interviews, surveys (questionnaires), observation, and portfolio assessment (Hlebowitsh, 2005).

2.4. Learning in Chinese Higher Education

Learning is greatly influenced by the assessment and evaluation methods. As discussed in Chapter One, the standardized exams in Mainland China have significantly influenced K-12 teaching and learning styles in China. As Antonia Darder (Darder, 2002) summarizes Paulo Freire's idea about learning and teaching to meet the needs of standardized tests:

> Teachers, besieged by the politics of expediency and the standardization of knowledge, feel little freedom to practice the flexibility to permit the learning process to emerge originally with students. Needless to say, public-school teachers are under tremendous pressure to "cover the material" and to move their students "successfully" through standardized tests – serious pressure that to one extent or another is constantly at work in the pedagogical decisions they make in their classroom…In direct conflict with a revolutionary pedagogy that seeks to

> engage students critically in unveiling the world, public schools are predominantly focused on the standardization of knowledge and authoritarian approaches to teaching content, with little regard for involving students critically or substantively in the process of knowledge production. Instead, the emphasis is on the sequential memorization of descriptive content, irrespective of whether the student comprehends what she/he is "learning".

Although many Chinese design educators recognize the importance of self-authorship[37] and encourage students' involvement in knowledge production, many Chinese students find it hard to depart from the "banking" education mode. In the United States, there are similar situations when students only care about the correct answers that would ensure their passing of the exams. However, design often starts with ambiguous settings and there could be multiple appropriate solutions to one design problem. Design education demands for more than just reading and memorizing the text. Thus, Chinese design students in higher education often experience frustration and uncertainty during this drastic shift of learning styles. Especially when Chinese undergraduate students must take Chinese (at university level), politics, a second language, basic law, and so forth and so on, of which typical rely on a "banking" method and consequently, they are confused by the two different learning styles. To help students with this transition, Chinese design curriculum usually arranges non-major classes in the student's freshman and sophomore years to avoid conflicts with the professional courses.

There is another important difference between learning styles of Chinese and American students: Chinese students are good at concept learning but bad at hands-on work, such as physical model building. It is understandable, as stated above, because the National Exams is over-emphasized. Chinese students have to be confined in classrooms and chained to the books, whereas American students have plenty of opportunities to develop their own interests, take on part-time jobs, volunteer for various organizations, and travel to see the world. The Chinese K-12

[37] Marcia Baxter Magolda defines *self-authorship* as "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" (Baxter Magolda, 1999).

educational system does not offer any incentive for students to work on anything other than preparing for the standardized tests. As a consequence, Chinese students are confused and nervous when thrown into design projects with rich social context, which poses a challenge for design education that has to be addressed by an innovative educational framework.

2.5. Summary

This chapter introduces the concepts and developments of sustainability, sustainable development, and sustainable design. It analyzes design education using systems thinking theory. It reviews the components of an educational framework and the relevant pedagogy theories. Finally, it discussed the reality of learning in Chinese higher education.

Chapter Three: Methodology

A research paradigm is a set of beliefs or assumptions, concepts, values, and practices that constitutes a way of viewing reality for the community that shares them, especially in an intellectual discipline (*The American Heritage dictionary of the English language*, 2000). The paradigm guides the methodology. Methodology is a body of practices, procedures, and rules used by those who work in a discipline or engage in an inquiry; a set of working methods (ibid). This chapter explains the research paradigm and the methodology of this inquiry.

3.1. Research Paradigm: The Philosophical Framework

This research locates in a constructivist paradigm. As discussed in Chapter Two, in short, constructivism is an epistemology that considers knowledge as constructed by individuals, hence has many varieties (multiple realities). Constructivism proposes individual reconstructions of realities coalescing around consensus (the common reality). Egon Guba and Yvonna Lincoln (Lincoln & Guba, 1985) describe the constructivist paradigm as a philosophy that assumes truth is a matter of the best-informed and most sophisticated construction on which there is consensus at a given time.

As a paradigm for learning and teaching, constructivism states that people construct their own understanding and knowledge of the world, through experiencing things and reflecting on those experiences. Constructivism is concerned with how knowledge arises, what concept of knowledge is appropriate and what criteria can be invoked in the evaluation of knowledge (Flick, Kardorff, & Steinke, 2004). It emphasizes on more informed and sophisticated reconstructions of knowledge and vicarious experience. Users of this paradigm are oriented to the production of reconstructed understandings of the social world (Denzin & Lincoln, 2003). In this paradigm, the research recognizes that knowledge is constructed in processes of social interchange and thus has social functions. In the light of this paradigm, design

education should also be a process of social interchange and has social functions. The philosophical framework of this research is presented in Table 3.1.

Table 3.1 - Philosophical Framework for this Research

Constructivist Paradigm		
Assumption	Characteristics	Implications for Practice
Ontological (The nature of being and reality)	Reality is subjective and multiple, as seen by participants in the study	Researcher uses quotes and themes in words of participants and provides evidence of different perspectives
Epistemological (The nature of knowledge)	Knowledge is constructed in processes of social interchange and it has above all social functions (Flick et al., 2004).	Researcher collaborates, spends time in field with participants.
Axiological (The role of value)	Researcher acknowledges that research is value laden and that biases are present.	Researcher openly discusses his/her own values that shape the narrative and includes own interpretation in conjunction with interpretation of the participants
Methodological (The process of research)	In grounded theory, researcher starts inductively, then the initial inductive logic of generating open coding and generating a theory evolves into the deductive process of examining the theory against existing and new databases.	Researcher revises questions from experiences in the field.

Source: constructed based on John Creswell's table on "philosophical assumptions with implications for practice" (Creswell, 1998).

3.2. Rationale for Applying Qualitative Research Methods

The constructivist paradigm determines that the research methodology of this dissertation should include qualitative research methods that study peoples'

interpretation of phenomena according to their experience and perspectives.

Within design disciplines, qualitative and quantitative research methods both play important roles. They are applied to solve different research questions. Quantitative research methods can help to build the foundation of knowledge by providing countable data on fundamentals, such as objects or entities that can be measured, or on conceptual quantities derived from a combination of such measurements. This may include such things as the physical performance of objects (e.g. materials), the demography of human subjects (age, gender, ethnicity, etc), the social and economical status of human samples, and scores of pretest and post-test used to evaluate the effectiveness of different design approaches, etc. However, quantitative research has many limitations. It does not lend itself to the understanding of how people perceive their reality and how people cope with reality differently.

Qualitative research methods are most effective when used to address these limitations of quantitative methods. Qualitative research methods represent the methodology of choice whenever any of the following conditions are met:

- the nature of the research question requires description of a process instead of a simple cause and effect relationship between variables;
- when the variables cannot be easily identified;
- or when the researcher wants to play the role as an active learner who tells the story from the participants' view (Creswell, 1998).

John Creswell (ibid) defines qualitative research in the following way:

> Qualitative research is an inquiry process of understanding based on distinct methodological traditions of inquiry that explore a social or human problem. The researcher builds a complex, holistic picture, analyzes words, reports detailed views of informants, and conducts the study in a natural setting.

Sharan Merriam lists the general characteristics of qualitative research as follows (Merriam, 1998):

- Qualitative researchers are interested in understanding the meaning people have constructed;
- The researcher is the primary instrument for data collection and analysis;
- It usually involves fieldwork;
- Qualitative research primarily employs an inductive research strategy;
- Qualitative research focuses on process, meaning, and understanding, the product of qualitative research is richly descriptive.

With these characteristics, qualitative research methods require a relatively lengthy period of time in conducting research, which is also a limiting factor. Linda Groat summarizes the strengths and weaknesses in qualitative research in Table 3.2. (Groat & Wang, 2002):

Table 3.2 - Strength and Weakness of Qualitative Research

Strengths	Weaknesses
Capacity to take in rich and holistic qualities of real life circumstances	Challenge of dealing with vast quantities of data
Flexibility in design and procedures allowing adjustments in process	Few guidelines or step-by-step procedures established
Sensitivity to meanings and processes of artifacts and people's activities	The credibility of qualitative data can be seen as suspect with the post-positivist paradigm.

The discussions of the characteristics of qualitative research methods above demonstrate that qualitative research is appropriate for design and design education research because they are both soft systems. As discussed in Chapter Two, soft systems approach is basically designed for use with a complex system involving the interaction of human beings with non-human systems. Many phenomena in design and design education cannot be explained in isolation (e.g. in a lab) because of the complexity of reality and phenomena. Even if measurable variables do exist, these variables often cannot be measured on the same spatial or temporal scale. A defining characteristic of a given design solution is that it represents an integrated response to a complex and multidimensional problem. Teaching and learning in design disciplines are also continuous processes that are interconnected and correlated with numerous social and cultural issues. Due to their richness and comprehensiveness, qualitative research methods are well suited to design research because they allow the researcher to interpret phenomena by the meanings people construct according to their experience and perspectives.

Qualitative research has five traditions of inquiries: phenomenology, grounded theory, biography, case study, and ethnography (Creswell, 1998). A grounded theory approach is used in this research.

3.3. Strategy of Inquiry

The Constructivist paradigm suggests that a grounded theory approach should be

implemented in this research. Grounded theory is a qualitative approach that generates theory from observation (Glaser & Strauss, 1967). The intent of grounded theory study is to generate or discover a theory, an abstract analytical schema of a phenomenon, that relates to a particular situation. This situation is one in which individuals interact, take actions, or engage in a process in response to a phenomenon (Creswell, 1998). In this research, the phenomenon is "sustainable design education in Mainland China." The research procedures intend to understand this phenomenon and generate a framework upon the analysis.

The procedures of grounded theory inquiry can be summarized in these steps (Flick et al., 2004):

a. Theoretical sampling

b. Data collection

c. Coding: open, axial, and selective coding

d. The formulation of theoretical memos: based on the coding notes and on broad interrelations that are gradually revealed by the investigator (ibid).

e. After the first phase of data collection, a framework is constructed, which is then tested with the aid of further data (validation phase). This leads to further questions and another round of theoretical sampling, data collection, coding, and analysis.

Ideally, grounded theory is an iterative process that involves repeated and rapid cycling between inductive and deductive reasoning such that emerging theory is constantly subjected to testing and further refinement and modification as it is being developed by the research. Hence theory development and its validation occur as part of a single process rather than as a two step linear process.

Through this iterative process, the researcher can understand the current status of sustainable design education in Mainland China. This understanding will then serve two purposes: it will act as a realistic foundation for the proposed educational framework, and it will allow potential opportunities and obstacles for implementing the new framework engaged with sustainability to be identified and explored.

Literature review and interviews were used to collect data in this research. Based on the literature review and interview data, the researcher constructed an educational framework engaged with sustainability as presented in Chapter Five, which were critically reviewed in follow-up interviews in Chapter Six. The procedures of inquiry are discussed in detail below.

3.4. Methods

3.4.1 Theoretical Sampling

In grounded theory, the term *theoretical sampling* means the researcher examines individuals who can contribute to the evolving theory (Creswell, 1998). In theoretical sampling, the researcher's goal is not the representative capture of all possible variations, but to gain a deeper understanding of analyzed cases and facilitate the development of an explanatory framework of mutually supporting concepts (Strauss & Corbin, 1998). The principle for theoretical sampling in this research is to achieve the widest possible range of viewpoints of those actively participating in the teaching, learning, and practice of Industrial Design. Literature review in Chapter Two also serves part of the sampling.

To gather opinions of Industrial Design education from multiple perspectives, the interviewees consist of students, educators, and practitioners in Industrial Design in China. Geographic location has a strong influence on perspectives of people in the Mainland with regards to design education and sustainability. Hence, it is logical to theoretically sample as many different regions as possible (see Figure 3.1).

Figure 3.1 - Four Locations the Research was Conducted

Note: the triangle shows the geographical relationship between these locations and Mainland China.

Beijing, Guangzhou, Hong Kong, and Chengdu are chosen for their representation of design education in China respectively. The rationales for selection of these locations are listed in Table 3.3.

Table 3.3 - The Rationales for Selection of Locations of Study

Cities	**Political, Economical, and Cultural Significance**	**Industrial Design Education Status**
Beijing (North-east)	The political and cultural capital of People's Republic of China; International business center; East-Asian headquarters of multinational companies in Beijing have created jobs for local designers, including Motorola, Nokia, and Lenovo.	Has the largest number of Industrial Design programs.
Guangzhou (South-east)	Capital of Guangdong province; Among the top three cities in Mainland China that have the fastest industrial growth and strongest economic performance; International manufacturing center	Among the first in Mainland China to provide Industrial Design education in the late 1970s.
Hong Kong (South-east)	Special administrative region; One of the most important economic and industrial centers in Asia for decades.	Industrial Design educational programs begun in early 1970s and have become an example for many universities in Mainland because of its close connection with the international design community and its fast reaction to the global market.
Chengdu (North-west)	The capital city of Sichuan province, the city exhibited strong economical growth in recent years. It has been an important strategic city in Chinese history for thousands of years due to its defensive topography, fertile farm land, and significance of being the origin of three major rivers in China. Thus it has abundant and interesting cultural traditions	Industrial Design education has just started in the late 1990s.

Design education in these four cities can represent the design education status in northern, central, southern China, and the special administrative region.

Secondly, the participants were chosen on the basis of the characteristics of the universities where they attend, teach, or have recently graduated. As shown, different universities use different pedagogical approaches.

Table 3.4 - The Rationales for University Selection[38]

University	**Type**	**Industrial Design Program**
The University of Science and Technology Beijing	Prestigious comprehensive university with emphasis on science and engineering	Industrial Design program was established around 1998, offering bachelor's and master's degree.
Beijing Institute of Technology	Prestigious comprehensive university with emphasis on science and engineering	Industrial Design program was established in 1978 and evolved from mechanics and manufacturing department, offering bachelor's, master's, and doctoral degrees
Beijing Institute of Art and Design	Small art and design school	Industrial Design program was established in early 1980s and mainly provides vocational education, offering associate's and bachelor's degrees.
Guangdong University of Technology	Comprehensive university with emphasis on science and engineering	Industrial Design program was established in early 1990s, offering bachelor's degrees.
Guangzhou Academy of Arts	Prestigious art and design school	Industrial Design program was established in 1978, one of the oldest in Mainland China, offering bachelor's and master's degrees.
The Hong Kong Polytechnic University	Comprehensive university that uses English as the main language in teaching and has strong ties with the international community	Industrial Design program was established in early 1970s, offering bachelor's, master's, and doctoral degrees.
Sichuan University	Newly formed comprehensive university	Industrial Design program has not yet been established.

[38] See Appendix C for additional information of these universities and departments.

Table 3.4 shows that the selected universities can represent different types of Industrial Design programs in Mainland China because of their sizes, program history, and program orientation.

The actual participants of the initial interviews are listed by their institutions and types in Table 3.5.

Table 3.5 - The Actual Participants of the Initial Interviews

University	**Type**	**Number**	**College Year or Teaching Experience**	**Interview Structure**
The University of Science and Technology Beijing	Students	Around 30 (group interview)	Junior	Formal
	Teacher	3	From 2 years to 10 years	Informal
Beijing Institute of Technology	Teacher	1	Over 30 years	Formal
Beijing Institute of Art and Design	Students	4	Sophomore	Formal
	Teachers	6	From 6 years to 20 years	Formal
Guangdong University of Technology	Teachers	2	From 5 years to 20 years	Informal
Guangzhou Academy of Arts	Students	1	Master student	Formal
	Teachers	2	From 2 years to 10 years	Formal
The Hong Kong Polytechnic University	Teacher	1	Over 10 years	Formal
Sichuan University	Students	Around 30 (group interview)	Sophomore	Informal
Other	Professionals	2	N/A	Formal

3.4.2 The Purpose of the Initial Interviews

Interview is a method used to collect data in this research. The improvement of any educational system is a complicated and non-linear process. It is also path dependent[39] for that it has to be built on or replace an existing paradigm. Hence, the aim of the initial interviews is to map the range of cognitions and perceived realities of design education and sustainable design within the Industrial Design community in China. The questions are intended to disclose if there has been any effort to incorporate concepts related to sustainability into the design curricula and practice. The interviews aim to provide answers to these main research questions:

- Have there been any efforts made in Industrial Design education to integrate sustainable design?
- What is the structure of a four-year curriculum in design in a higher education institute in China?
- What knowledge building strategies are included in the current Industrial Design education curriculum?
- What attributes should an industrial designer as the Chinese Industrial Design community possess?
- What challenges and opportunities does the current Chinese Industrial Design educational system present?

New questions emerged during the interview process. The analysis of interview data, in addition to literature review, provides answers to the following research questions:

- How does the structure of the Chinese educational system influence

[39] The concept of "path dependent" is discussed in the section of "Systems Theory", Chapter Two.

sustainable design education?

- How might the domains of knowledge influence sustainable design education?

- How do the attribute requirements perceived by the Chinese Industrial Design community influence Industrial Design and sustainable design education?

The analysis of data provided insights on the current status of sustainable design education in Mainland China and informed the construction of a new educational framework. The procedures of interview are discussed below.

3.4.3. Data Collection Using Interviews

The strength of interviews as a methodology is that it is a powerful tool for successfully probing and capturing how the interviewee thinks, feels, and acts toward an idea, thing, or experience. The interview allows behavior to be put in context and provides access to the cognitive mechanisms underpinning people's action (Seidman, 1998). Hatch (Hatch, 2002) concludes that,

> Qualitative researchers study the lived experiences of real people in real settings. *Qualitative research seeks to understand the world from the perspectives of those living in it.* It is axiomatic in this view that individuals act on the world based not on some supposed objective reality but on their perceptions of the realities that surround them. Qualitative studies try to capture the perspectives that actors use as a basis for their actions in specific social settings. *Qualitative researchers use interviews to uncover the meaning structures that participants use to organize their experiences and make sense of their worlds.* These meaning structures are often hidden from direct observation and taken for granted by participants, and qualitative interview techniques offer tools for bringing these meanings to the surface.

Lincoln and Guba (1985) identify five outcomes of interviewing, abstracted as follows:

- Here and now constructions: participant explanations of events, activities, feelings, motivations, concerns
- Reconstructions: explanations of past events and experiences
- Projections: explanations of anticipated experiences
- Triangulation: verification or extension of information from other sources
- Member checking: verification or extension of information developed by the researcher.

This research requires a comprehensive understanding of the opinions, attitudes, and knowledge level of sustainable design concepts within the Chinese Industrial Design community. Since there is little literature on the design education system in Mainland China, the richness of required information must be gathered through interviews. Moreover, interviews create thick descriptions of the participants' experiences relating to design education in China that show the challenges of integrating sustainability.

Interviews conducted for this research included informal and formal interviews. Formal interviews were conducted in a structured manner to prompt the interviewees to give the information the researcher hoped to obtain through the questions. The interviewees read and signed the consent form then answered a list of questions. Informal interviews were conducted in casual conversations that were loosely structured. The form of interviews was chosen according to the interviewees' preference. There was no sequence to the interviews or their forms.

3.4.4. Major Weaknesses of the Interview Method

Validation is a major concern when applying the interview method. First of all, the questions in interviews have to be pertinent to obtain the information the research

needs. Secondly, the responses to the questions change from participant to participant during the interviews. Bias, the design of the questions, and interview skills of the researchers influence the success and validity of the interview approach. With the informal approach, the line of questions may change from interview to interview which in turn might lead both the inquiry and the respondent in an undesirable direction. Chiseri-Strater and Sunstein (Chiseri-Strater & Sunstein) describe interviewing as an ironic contradiction:

> You must be both structured and flexible at the same time. While it's critical to prepare for an interview with a list of planned questions to guide your talk, it is equally important to follow your informant's lead. Sometimes the best interviews come from a comment, a story, an artifact, or a phrase you couldn't have anticipated. The energy that drives a good interview - for both you and your informant - comes from expecting the unexpected.

The transcription work of interviews is tedious and time-consuming, especially in this research because the interviews were conducted in Chinese and later translated into English. Consequently due to translation, some portions of the conversations might lose their precise meaning. In such cases, the word-by-word data analysis method does not always apply.

The social settings of the interview might influence the outcome of the interview as well. Although in many cases this influence could be an interesting observation useful for the research, in some cases its impact could be confounding. For instance, the interviewee might try to guess what the researcher wants to hear. She or he might quickly pick up on non-verbal hints of agreement or disagreement (e.g. the researcher's facial expressions). Taking these as a sign of approval or disapproval, the interviewee may change her or his answers to latter questions. In such cases, it is doubtful that the researcher will be aware that the interviewee is not really expressing their true opinions. If not detected by triangulation, this could introduce bias into the research. The researcher should make every attempt to avoid this inaccuracy. In the interview analysis, the researcher compared the answers of the interviewees from the same institution to corroborate the data.

3.4.5 The Instruments for the Interviews[40]

3.4.5.1 Procedures

The interviewees were invited to participate in the research by emails and phone calls. The researcher explained the purpose of the research project, the risk and benefits of participation, confidentiality and anonymity of participations in the invitation. Participation was voluntary. If a person agreed to participate, she or he was asked to sign a consent form (the form and the letter of invitation are included in Appendix F). The interviews took place in an environment that was mutually agreed upon and comfortable to both participant and researcher, and was guaranteed to protect the participant's privacy.

The interview questions were structured, and designed in advance by the researcher. Each formal interview was tape-recorded and transcribed by the researcher. Transcripts were coded to identify emerging themes.

3.4.5.2 Risks and Benefits for the Interviewees

Participants in interviews were asked to describe their experiences in education or practice. These experiences occasionally might be described as being unpleasant. This could possibly cause feelings of discomfort if an unpleasant or a private experience is being described. Participants might also feel embarrassed or confused while encountering unfamiliar subjects that emerge from the questions. The researcher agrees to follow the Institutional Review Board procedures and protocols to take all possible measures to eliminate risks to participants during the course of the study. Researcher agrees to provide adequate description of the goals and expected outcomes of the research. Participants had full freedom to stop the interview or withdraw from the study at any point. Each participant has full access to his/her case of the study as well as the opportunity to provide feedback to the researcher.

[40] The section of 3.5.5 is developed upon an example document distributed by the Institutional Review Board of Virginia Tech.

Participants in this study will benefit from the opportunity of reflecting upon their personal experiences with regard to sustainable design. They might evaluate their perspectives and knowledge with the research subject. Participants whom are educators might benefit from the findings of this study by utilizing them to modify their curricula. It is expected that this will increase the awareness and knowledge level of sustainable design for the participants. No promise or guarantees of benefits is offered from the researcher to any of the participants.

3.4.5.3 Confidentiality and Anonymity

Participants will remain anonymous and are only identified by their universities or locations in this document. The information collected from the participants will be confidential. Tapes and transcriptions of interviews and journal entries will be stored in secure locations by the researcher. Those materials that are confidential will only be accessible to the researcher, her advisors, and the corresponding interviewees. Tapes and transcriptions will be destroyed when the research involving these items is deemed complete by the researcher. The researcher will be forced to break confidentiality if any abuse incidents are known or strongly suspected or if the participant is believed to be a threat to himself or herself or others.

3.5. Coding

After the interview data is collected and transcribed, the research continues to the analysis stage: coding. Coding refers to the process of naming or labeling things, categories, and properties (Merriam, 1998). There are three basic steps in data analysis for grounded theory: open coding, axial coding, and selective coding.

- Open coding

Open coding is the analytic process through which concepts are identified and their properties and dimensions are discovered in data (Strauss & Corbin, 1998). In this process, the researcher uses their background knowledge to identify and

categorize concepts in the data. Concepts and categories are both abstract representations of phenomena that are identified as significant by the researcher. They are the building blocks of theory (ibid). Within each category, the researcher finds several properties or subcategories about how the phenomenon might be further investigated.

- Axial coding

Axial coding reassembles the data and creates sub-categories from the categories developed during open-coding. As Strauss and Corbin summarize, the axial coding process places emphasis on causal relationships, and fits things into a basic frame of generic relationships (ibid).

- Selective coding

Based on the previous analysis, selective coding selects a core category and creates the theoretical framework. The relationships of categories and sub-categories are formulated to test the hypotheses in this process.

The process of theory generation in grounded theory research is iterative. The theory generated from the first set of interviews is provisional. It is tested by the later interviews and application.

3.6. The Modeling of an Educational Framework

An educational framework is part of a greater educational system that is constantly interacting with culture, society, administrative structure, industry, economy, etc. Interview data and analysis support the modeling of the current educational system. By using systems theory, the dynamics of the current educational system provide the possible paths to improve the current system to the proposed ideal state.

Based on the literature review and interview data analysis, an educational framework engaged with sustainability for Industrial Design education in Mainland China has been constructed in Chapter Five. The framework initiates in these categories (Table 3.6 expanded from Figure 2.6):

Table 3.6 - The Initial Construction of the Framework

Category	**Proposed Framework**
Philosophical foundation	Constructivist paradigm
Goals and objectives	Educational goals and objectives for sustainable design education
Content selection: knowledge and Learning (competency and abilities of industrial designers)	Industry's requirements; The imperatives for sustainability; The vision for the future; Knowledge required to gain the competency and abilities; The domains of knowledge; The skill sets; The structure and content of courses
Pedagogical approaches	Constructivist pedagogy Problem-based and project-based learning Issue-based learning Critical pedagogy
Evaluation	Innovative evaluation methods

This framework is discussed in detail in Chapter Five.

3.7. Evaluation of the Framework

To evaluate the framework presented in this dissertation, two methods should be employed: follow-up interviews and actual testing of the framework. The first step of validation of this conceptual framework was to invite Chinese educators who are either interested in or have experience practicing sustainable design education to critically review the conceptual framework. They were asked to answer a set of questions by email or be interviewed by phone. Their feedback would allow the researcher to further refine and improve the framework.

Since this framework is intended to be implemented, the final validation should come through the implementation. However, the long-term effects of education usually take years to emerge and they are difficult to qualify or quantify. Such a longitudinal study would be useful but it is unrealistic to include the full implementation process as part of this dissertation. The researcher plans to publish the research as a handbook or textbook first to start discussion in the Chinese educational community, and then contact interested parties about implementing all or part of this framework. Further research involving surveys, interviews, and observations should be conducted for validation.

3.8. Researcher's Bias

As J. Amos Hatch (Hatch, 2002) suggests, the researcher's bias in qualitative research is acknowledged in a statement explicating the researcher's ideological positioning and identifying ideological issues she or he sees in the context under investigation. He states:

> Qualitative research is as interested in inner states as outer expressions of human activity. Because these inner states are not directly observable, qualitative researchers must rely on subjective judgments to bring them to light... Most qualitative researchers would deny the possibility of pure objectivity in any scientific endeavor. Most would argue that all their findings, including interpretations, are grounded in empirical evidence captured in their data. Instead of pretending to be objective, the stance of qualitative researchers is to concentrate on reflexively applying their own subjectivities in ways that make it possible to understand the tacit motives and assumptions of their participants.

In qualitative work, it is understood that the act of studying a social phenomenon influences the enactment of that phenomenon. Researchers are a part of the world they study; the knower and the known are taken to be inseparable (ibid). For Hammersley and Atkinson (Hammersley & Atkinson, 1983), "this is not a matter of methodological commitment, it is an existential fact. There is no way to escape the social world in order to study it; nor, fortunately, is that necessary."

Therefore, a brief biography of the researcher would identify the social background of the research and define his/her ability and bias in analyzing the subject s/he intents to study. It also helps to establish the credibility of the researcher in the subject area. The researcher's brief biography is as follows: the researcher was born and raised in Guangzhou, China. She witnessed the downfall of the environmental qualities of the country in the past 25 years. She started to become interested in environmental issues at a young age due to family influence. She was educated as an Industrial Designer in two Chinese universities as well as in an American university with different pedagogical approaches. Her master's research is a survey of both sustainable design practice and Industrial Design education. She had practiced in multiple design fields and taught Industrial Design at the higher education level for a year in China before she came to the United States and started to construct an educational framework for Industrial Design education engaged with sustainability for Mainland China. She uses a constructivist pedagogical approach in her teaching and strives to provide a learner-centered learning environment.

3.9. Summary

This chapter states the research paradigm and methods used in this research. It explains the sampling, interview procedures, and other issues in the initial interview process, of which results will be presented and coded in Chapter Four. It suggests using follow-up interviews to validate the proposed educational framework, of which results will be presented in Chapter Six. Finally, it acknowledges the researcher's bias.

Chapter Four: Initial Interviews and Results

This chapter presents the questions, results, and analysis of the initial interviews to establish a foundation for the educational framework proposed in Chapter Five. This data provides a systematic view of the educational system in China to explain how the proposed educational framework should interact with the current system to create change.

4.1. Interview Questions

Educators, practitioners, and students of the Chinese Industrial Design community are participants in this research. The interview questions can be categorizes by their purposes in Table 4.1.

Table 4.1 - Interview Questions and Their Purposes

Purpose	Questions
To know the interviewees' educational background and how those influence their response to latter questions;	Main Question: *Could you tell me briefly about yourself as an educator/practitioner/student?* Sub-questions: What is your educational background? Which discipline were you educated in? How long have you been teaching/studying/practicing Industrial Design? What courses have you taught/taken? What courses are you currently teaching/taking? What was your incentive and motivation of choosing Industrial Design as a major/career? How do you evaluate yourself among your peers? Do you view yourself as successful, above average, or average teacher/student/practitioner?

Table 4.1 continues on the next page.

Table 4.1 continued.

To know the pedagogical approach/learning style of the interviewees	Main Question: *Could you describe your teaching/learning style and pedagogical approaches?* Sub-questions: What are your goals as an educator/student/practitioner? How do you normally arrange the time of your class? What atmosphere do you try to build inside the classroom? Strict or casual? Do you strictly follow your syllabus? How do you grade your students? How would you describe your learning/pedagogical style? Are you an active learner[41]? Do you learn better by listening or participating?
To examine the pedagogical approach of the interviewees' department and school; to examine the differences among educational programs.	Main Question: *What is the educational goal of your department and school?* Sub-questions: How would you describe the focus of your department's curriculum? Is there an educational paradigm that your department or university follows? Are there any significant pedagogical differences between your approach and that of your department/school? How will you manage the pedagogical conflicts?
To examine the interviewees' willingness to improve their educational practice or experiences;	Main Question: *What would you improve in the current curriculum or the educational practice in your department if given the chance?* Sub-questions: Do you think your department should have a shift of educational focus? If so, to what? What content do you think should be added or reduced from the current curriculum? Do the market's needs, social changes, or your educational practice inform you about your proposed changes? How or how not does the academic atmosphere of the department/school encourage changes or alternative pedagogical approaches?

Table 4.1 continues on the next page.

[41] An active learner takes the responsibility of learning in his/her own hands. S/he is aware of his/her study strategy and learning habits and plans his/her learning accordingly with minimum amount of guidance from others.

Table 4.1 continued.

To examine the interviewees' knowledge level of sustainable design	Main Question: *What comes to your mind when you hear the term "sustainable design"?* Sub-questions: Could you describe the concepts of "sustainability" and "sustainable design"? What issues do you think are related to these concepts? Do you think Industrial Design education should engage sustainability? If so, how?
To examine the current state of sustainable design education in Mainland China	Main Question: *How do you evaluate sustainable design in current Chinese Industrial Design education and practice?* Sub-questions: You can use these standards to evaluate: Does your department have a clear statement or policy to teach sustainable design? Does your department or school offer a course on sustainable design or related topics (Green Design, Design for Environment, Eco-design, etc)? If such course exists, could you describe it? For example, what was taught in the course? What is the time span for this course? How is the attendance? What were the students' reactions to this course? What textbooks are used? If such course is not offered, can you gain access to such educational resources easily in other higher educational institutions? Does any other course touch on sustainable design issues? Have you taught/practice or do you plan to teach/practice sustainable design? What obstacles do you perceive in teaching/learning/practicing sustainable design?

The interview data are analyzed using an open coding method in grounded theory. The results are presented below.

4.2. Decoding of the Interview Data

There are four steps of building a theory using an open coding method in grounded theory:

1). Conceptualizing;

2). Defining categories;

3). Developing categories in terms of their properties and dimensions;

4). Relating categories through hypotheses or statements of relationships.

Interview data analysis began with the conceptualizing of the current Industrial Design educational system in China. The researcher identifies a series of concepts in the interviews associated with sustainable design in Industrial Design education and practice, and then categorizes and analyses these concepts. The analysis provides a range of different perspectives of the status quo of the current Industrial Design system in Mainland China.

Table 4.2 - The Constraints of the Current Educational System

Educators	Students	Practitioners
Educational goals; Teaching materials; Student quality; Pedagogical approach; Peer pressure; Lack of systematic planning; Workload; Governmental restrictions; Pressure from the society; Resource limitation; K-12 education influence; Attempts;	Confusion; Motivation; Attention span;	Ability and requirement gaps; Market acceptance for sustainable design; Relevance of educational materials and practices;

The actual interview excerpts to support these conceptualizations are categorized and analyzed below.

4.3. Categories and Dimensions

In the open coding process, categories emerge from the interview data.

According to the concepts summarized above and the research questions, the researcher categorizes and analyzes the concepts.

4.3.1 The Current Educational System

Many interviewees criticized the current educational system because it restricts the development of design education. Their criticism focus on two categories: dissatisfaction of the current educational system and demand for systematic changes.

Table 4.3 - Dissatisfaction of the Current Educational System

Concepts	**Interview Excerpt and Analysis**
Resource limitation	My advisor has sixteen graduate students! He is also the chief administrator of the College of Design. He is so caught up in clerical work. I really can't expect much from him. You know we don't have any courses after the first year. I have job offer from universities but I'm not sure if I want to be a professor after I graduate. (Graduate student and practitioner from Guangzhou Academy of Arts)
Analysis	The lack of qualified teachers leads to the decline of educational quality. The lack of resources damage both graduate and undergraduate education qualities.
No systematic planning	[Japanese design is successful because] the designers have been trained in their basic trainings to work thoroughly and pay attention to details. (Instructor of Beijing College of Arts and Design)
Analysis	The Chinese design education is still crude because there is little research on educational reform in Industrial Design. The education focuses too much on quantity instead of quality. The schools only plan their curricula to "produce" more graduates as fast as possible. The graduates only know how to do "quick and dirty" design. This working attitude will eventually force them out of the market because the industry is more and more concerned about the quality of design and manufacturing. This problem also suggests that Chinese society has the eagerness and anxiety for quick success regardless of social or environmental cost. This mentality presents a major obstacle for sustainable design.

Table 4.3 continues on the next page.

Table 4.3 continued.

Lack of sustainability education.	Our curriculum doesn't really have much information on sustainability. I think it has a lot to do with the educational system of our country. There is not much we can do in our design school. We shouldn't wait till college, or even high school to teach our students about sustainability. I think we should begin in kindergartens. When students have that mentality from a very young age, they don't need to think about it while designing. It would be very natural to them. (Instructor of Beijing College of Arts and Design)
Analysis	Although it might seem to be shifting responsibilities, the educators' complaints about the K-12 education are mostly legitimate. Nevertheless, higher education can foster critical thinking and systems thinking and provide professional training to solve environmental problems. Hence, higher education still has the great responsibility to engage sustainability at a comprehensive level.
Limitation of liberal arts education	Our education in primary schools and high schools fails to provide students with good communication skills. Some of the students have very poor writing skills that their theses are full of solecism. How could you expect them to communicate with the clients effectively? How could you expect them to be the leaders of our culture and society? Education is indeed a systematic problem. (Professor of Guangzhou Academy of Arts)
Analysis	A major part of industrial designers' job is to communicate design idea to clients and consumers. Because of the standard tests, Chinese students have difficulties to express their own ideas creatively.

The interview data confirms the problems of Industrial Design education in Mainland China stated in Chapter One. It also confirms that there is little content on sustainability in this system. It is both a challenge and an opportunity for an educational reform.

When asked about the possible reform of the Chinese Industrial Design education as they see it, Chinese educators pointed out that design education needs a systematic reform (Table 4.4).

Table 4.4 - Systematic Problems of Chinese Industrial Design Education

Concepts	**Interview Excerpt and Analysis**
Chaos (Lack of scientific instruction on curriculum building)	Our design education studied from Japan in the first 10 years, to analyze, so forth and so on. But after that, I feel our design education system became chaotic. There is no lead. For example, students want to learn design, teachers will teach whatever the students want, but not how to think. (Instructor of Beijing College of Arts and Design)
Analysis	Because Chinese Industrial Design started several decades later than its Western components, it learns from them. This is a shortcut to establish design programs quickly. However, there is little scientific research and instruction in curriculum building based on the unique needs of Chinese Industrial Design. Hence, the educational system appears to be chaotic and confusing to students and faculty.
Lack of cultivation of systems thinking	I think Chinese design education is still too crude, not systematic. For example, teacher gives students a topic and asks them to return with [product] design, but not teaching them to research systematic…Students don't discuss or research, they don't think about methodology of design. They want to have fun, play, no more system. But industrial design has to be systematic, has to be precise…(Instructor of Beijing College of Arts and Design)
Analysis	Not only the educational system itself is chaotic, it does not teach systems thinking to the students either. This reveals another fundamental problem in design education in China: the lack of cultivation of systems thinking and critical thinking.

Table 4.4 continues on the next page.

Table 4.4 continued.

Pragmatism (Focus on skill training instead of holistic educational experience)	[Our system] aims to train draftsmen, not designers. My former students mostly established their own successful companies because they were well trained in the old systematical way [referring to the previous system modeled solely after the Japanese design educational system]. Students who are not trained like that can still work as designers, but it is difficult for them to achieve anything. Interesting enough, some students said that what they had learned in the school was useless, some appreciate the school education very much. This huge difference is caused by the different educational systems. (Instructor of Beijing College of Arts and Design)
Analysis	Educators have realized the negative effects of a chaotic educational system. Of course, as a profession, Industrial Design needs both draftsmen and highly creative designers. But design education should provide multi-levels of educational experience to cultivate both creative thinking and professional skills. The educational system must have this flexibility to satisfy different needs. Therefore, elective courses are an indispensable part of the educational system. The subjects the students can choose from should be relevant to the educational goal of the department and diverse.
Governmental support	Moreover, we need strong support from our government. Designers can't do it all on their own. (Instructor of Beijing College of Arts and Design)
Analysis	Several other educators also mentioned the support from the government is crucial for the reform of the educational system because the higher education system in China is supervised by the government.

As discussed in Chapter Two, David Orr has pointed out that all levels of education have the responsibility to educate future citizens about sustainability. Compared to other levels of education, higher education has more responsibility on fostering critical thinking and preparing students for their future professions. Chinese design educators should initiate changes instead of waiting for support from the government. The proposed educational framework gives educators the flexibility to use new educational materials and pedagogical approaches without major conflicts with the guidelines of the directive board of Industrial Design education of China.

4.3.2 The Current Problems of the Chinese Industrial Design profession

The limitation of the current practices in the Industrial Design profession in Mainland China leads to negative effects on society and the profession. These effects reflect the problems of the current design education. Some interviewees, especially those educators who also practice, are concerned that the Industrial Design profession in China contributes to the wasteful and excessive consumption of natural resources because of repetitive and low-tech design (Table 4.5).

Table 4.5 - The Limitations of the Industrial Design Profession

Concepts	**Interview Excerpt and Analysis**
Encourages wasteful consumption	I believe Industrial Design has negative effects on our society in some way. Industrial Design encourages mass consumption. For example, we use design to encourage consumers to exchange old models for new ones, while the old ones can still work fine. We do that simply because we want to sell more. It is a waste… The mass media creates such an atmosphere that the new design becomes too tempting for consumers to resist. (Instructor of Beijing College of Arts and Design)
	Frankly I feel guilty as a designer. I think designers, in a lot of ways, add fuel to the fire in wasting energy. New styles, new fashions, do we really need that many things? I've been to Europe, I was shocked to realize that China has been overwhelmed by American consumerist life style in the past few decades. This is terribly wrong. It made us shortsighted. (Professor of Guangzhou Academy of Fine Arts)
Analysis	Chinese industrial designers were not well prepared neither for the rapid growth of the economy, nor for the impact of consumerism. After a frantic race to satisfy the seemingly infinite market needs in the last 20 years, industrial designers started to reflect on their practices and realize that Industrial Design sometimes encourages wasteful and excessive consumption. This endangers the sustainable development of China. His comments also imply that he is concerned that it will be difficult to teach sustainable design if the young generations worship Western consumerism, which has been viewed as a destructive force to the environment and society by many criticizers.

Table 4.5 continues on the next page.

Table 4.5 continued.

Shell design = Product similarity	Frankly I am tired of being an industrial designer. Yes the design market seems prosperous, but it is a false impression. I feel that designers are producing trash by repeating themselves on a very low-tech level. Mostly industrial designers are only designing the shells for the products. The core technology is similar everywhere. Design does not seem matter to many companies. They care only about marketing. I believe that innovative concepts should be the center issue for business. This meaningless repetition has wasted resources and caused pollution. (Instructor of Beijing College of Arts and Design)
Analysis	Industrial Design helps products to distinguish themselves from their competitors. In many cases, the Industrial Design profession in China can only provide services for visual improvement instead of innovative concepts that will revolutionize the business. Therefore, the business world does not value design as much as marketing in China. Design education should strive to foster visionaries, instead of short-sighted blind followers of popular trends.
Globalization endangers local business	International enterprises target our young generation, like the McDonalds and KFC, they pour huge amount of money on advertisement to win loyal consumers from the age of 1 to 18. This severely damaged our local cuisine culture. I'm very concerned about this. (Professor of Guangzhou Academy of Fine Arts)
Analysis	If local industrial designers blindly follow the international trends instead of finding inspirations in their local culture, design will contribute to the destruction of local culture.

It took several years of practices for these interviewees to realize these problems, when they did, they realized they have already done damage to the environment and they felt guilty about it. Furthermore, they are discouraged and tired of their profession. If students become aware of these problems in their education, they will be more prepared to find solutions when they entered the workforce. Therefore, these problems of the profession should not be ignored. This data shows that Chinese educators who are searching for ways to limit Industrial Design's negative impacts to the environment need an educational framework engaged with sustainability.

4.3.3 Constraints for Teaching Sustainable Design

There were few interviewees who could articulate the complete concept of sustainability, but most of them have heard of “Green Design”. There are mixed feelings towards sustainability and sustainable design in the academia and among the practitioners (Table 4.6 and Table 4.7).

Table 4.6 – Constraints for Teaching Sustainability in the Academia

Concepts	**Interview Excerpt and Analysis**
Breadth and depth of sustainable education	This issue is so complicated. Many researchers have conducted research on the use of recyclable materials in product design. But if you focus on development, there could be more to explore. I think it might involve political issues for it is not just a design issue, but also a political, economic, and human development issue. This research topic could be difficult to write. It could be overwhelming and exceed our ability as designers. You have to read books from many disciplines, including philosophy, politics, and economics. (Instructor of Beijing College of Arts and Design)
Analysis	Complex and multidisciplinary were usually how the interviewees described sustainable design. Her comments reflect the scope and breadth of sustainable design. Their responses show that they have a vague idea of sustainable design. But this vague understanding prevents them from investigating the subject because the concept seems to be distant from design and too vast to grasp. This confirms that the current educational system does not provide sufficient knowledge on sustainable design.
Mindset towards dependence on technology	Some of them [students] still argue with me about environmental issues. They still believe that technology will solve all these [environmental] problems in the future. I asked them to think about this: mankind only exists for such a short time compared to the history of nature, if consider the history of nature is one year, we’ve only existed for a few seconds. Modern technology only existed for 1/10 of a second. You just can’t depend too much on it. (Professor of Guangzhou Academy of Fine Arts)
Analysis	Technology is an effective means to solve some but not all of environmental problems because technology is only a tool. Industrial designers have to make the conscious decision to employ green technology and beware of the potential negative environmental effects of some new technology.

Table 4.6 continued.

Future needs	I predict, not before long Hong Kong design will return to a green design track because of the external reality and internal motivation of the society. Internally, Hong Kong should develop into a knowledge-intensive society and service economy. It will serve the Mainland first. Professional Assistant Engineering department of our university is researching Green Engineering. They could provide consulting for the Hong Kong factories in the Mainland to help them to pass international industrial standards (ISO1400). I believe this will be a good opportunity for Hong Kong to enhance its competitiveness. (Professor of Hong Kong Polytechnic University)
	Yes the situation is frustrating. However, there is still hope. Some companies in Dongguan and Shenzhen have already begun to invest money in advanced water treatment systems. Because the government has huge fines on the pollution produced by the textile and dye industry, these companies have to reduce their pollutant release by microbiological means. (Professor of Guangzhou Academy of Fine Arts)
Analysis	Sustainable design education is not perceived as urgent in current Chinese Industrial Design education. Despite the difficulties, some educators still believe the industry needs sustainable design. They predict the government and industry will demand sustainable design education in the near future.

Table 4.7 – Constraints for Practicing Sustainable Design

Concepts	Interview Excerpt and Analysis
No support mechanism	We both agree it [sustainable design] is very important. But there is no system or resource to support us even if we want to practice sustainable design. If only there was a system to help us teach sustainable design! We don't know where to start. Clients like TCL, will only have design requirements related to environmental issues while they need to export products to where there are such laws. While exportation is becoming the major part of the business for many companies, sustainable design might become a major concern for them. (Instructor and graduate student of Guangzhou Academy of Arts)
Low market acceptance	[The design project] was an air humidifier. I used vine, glass and bamboo as the main materials instead of plastics. The feedback from the market was not good at all, only a few thousands of them were sold. The product did not even make it to the market. Consumers like new and fancy things, but they rather have something to show off. Natural and organic materials cannot make a great visual impact to many people. (Instructor of Beijing College of Art and Design)
Analysis	The majority of Chinese consumers tend to consider natural materials as low-tech and cheap. Products using these materials have a very limited market.

Table 4.7 continues on the next page.

Table 4.7 continued.

Lack of incentives to implement sustainable design	I think [sustainable design education] is important and meaningful for China, but it is hard to preach sustainable design in this country. In the next 10 to 20 years, it might still be difficult. There are a huge number of medium and small size corporations in China, especially in the Pearl River Delta region. It is practically impossible to convince them to adopt sustainability concepts. First of all, there is no law to force them to make too much effort for a sustainable production. People like to take short cuts. And it is difficult to supervise these corporations. Besides, local governments in many places are terribly shortsighted. They might even indulge some destructive industrial activities to the environment if there would be economical benefits. Second, there is no apparent economic return or encouragement for them to do [sustainable design]. Thirdly, the complete cycle of a product is too complicated for a small company to manage. You cannot ask them to do sophisticated research. I have talked to the managers of a golf course project near LiuXi River. You know, LiuXi River provides the drinking water for the people in Guangzhou. So I am very concerned about it, it is about my family and my own well-beings. Many people are captivated by the appearance of a golf course. They think it is great to have a huge lawn. They think it is a good thing for the environment[42]. But what they don't know is that it requires tons of pesticides to maintain a golf course. And the vegetation with one single species will threaten biodiversity. I know it is impossible to have them moved the location of the golf course. So I suggested a microbiological treatment for the gray water. They can design the treatment ponds as part of the landscape. The technology is out there and it's not expensive at all. It is also very easy to maintain once it's built. The managers of the golf course politely listened to my concerns and suggestions. But they never did anything. Why? Because they don't want that much trouble! (Professor of Guangzhou Academy of Fine Arts)

Table 4.7 continues on the next page.

[42] Grass lawn is considered as a green beautification of the landscape in Mainland China.

Table 4.7 continued.

Analysis	The practitioners claimed that they recognize the importance of sustainable design but they all emphasized there are many difficulties in practicing sustainable design. The participant described a very typical case of why there is no incentives to implement sustainable design. The market and government do not provide substantial support. Even as an influential educator, he still could not convince his friends and clients to adopt even a minor design change for sustainability. His case is evident for the fact that sustainable design cannot rely solely on people's good consciousness: design practices must be regulated.

The Chinese market is so enormous that all kinds of products can be marketed with success. That is one of the reasons that many small and medium size Chinese companies are reluctant to improve their products. They focus more on building sales channels and networks than introducing a new design. Most companies do not have the capital to absorb the impact if new products fail. Independent designers have to rely on these companies, thus they cannot afford to take risks. Industrial Designers with green business knowledge can "educate" these companies for their own sustainable development.

More or less, most interviewees understand the importance of sustainable design. At the same time, they are skeptical about whether or not sustainable design could be successfully introduced to Chinese design market and design education. They worry that the shortsighted and chaotic Chinese market would not give sustainable design a try unless required by international laws and regulations. The interview data also confirms that sustainable design education should not promote "guilt" but provide solutions.

Few of the universities where the research was conducted offers sustainable design related courses, let alone interweaving sustainable design principles into the current educational framework. The educators who have taught sustainable design agree that it is difficult for the industry to accept this concept.

The constraints in practicing sustainable design shows that the design industry suspects that the complexity of sustainable design might compromise the professional skills of the students because they already have too much to learn in too short a period. This represents another major argument for sustainable design education: many educators argue that adding sustainable design content in the curriculum burdens the students and consumes their time, which might be better invested in other professional skills of greater needs. An educational reform for sustainability must provide clear and relevant knowledge and skill sets to clear these doubts.

Nevertheless, educators are still optimistic about the future of sustainable design education because they see the genuine need for it. They believe that the industry will recognize the importance of sustainable design and then demand the design community to provide this service. Therefore, design education should prepare students for this future need.

Comprehensive universities provide an ideal environment for sustainable design education for they have sufficient educational resources to cover many disciplines in sustainable design. There has been intercollegiate collaboration between small arts and design schools and comprehensive universities, which is crucial for sustainable design education especially in smaller universities in Mainland China. For instance, graduate students from Guangzhou Academy of Arts could apply for courses and use the library in Sun Yat-Sen University, and vice visa. However, even though these two universities are located closely to each other, students seldom take advantage of the other universities' resource. The cost and difficulty of transportation, though negligible, still contributes to the reluctance of using the intercollegiate programs. One effective means to encourage the use of these programs is to utilize the Internet platform. Online courses and electronic libraries can greatly improve the sharing of educational resources. Most universities in Mainland China have the computer network infrastructure but lack the management or motivation to share resources. Directors of Industrial Design programs and universities should make the efforts to

push for these collaborations.

4.3.4. The Students' Perspective

Students' perspective of the Chinese Industrial Design education helps to validate the theory that emerged from the interview data from educators and practitioners. Several educators also shared their concerns about the low quality of students in Industrial Design as this may represent an important constraint for teaching design or sustainability. Their comments are incorporated into Table 4.8 below.

Table 4.8 - Student's Perspective on Chinese Industrial Design Education

Concepts	**Interview Excerpt and Analysis**
The complexity of the discipline	[Industrial Design] covers so many things, there are so many things we don't know. (group student interview, p.11)
Analysis	Students realize the complexity of the Industrial Design discipline and are intimidated by it. This shows that the curriculum needs a more clear and understandable structure to help students to have an overview of the discipline as early as possible. The objectives and goals of the curriculum should be articulated and course content should be planned accordingly. So they will have a better idea of where the courses are leading. In this way, the curriculum encourages students to plan their college experiences themselves.
Motivation	Frankly most of the students don't feel the pressure of survival because their families can provide for them even when they are unable to find jobs long after their graduation. (Instructor of Beijing College of Arts and Design)
Analysis	Design majors usually cost considerably more than other majors in China due to the necessary purchase of expensive design materials and books. The motivation to excel professionally to find good jobs is not as strong for students in Industrial Design than those in other majors because many of them can rely on their families for financial support. The lack of such motivation becomes a challenge for the educational system. Innovative pedagogical approaches should be employed to motivate students.
Sense of loss	I am majored in Industrial Design and have been in this school for 2 years. I'll graduate next year. In fact, I feel at loss all the time…I feel…I think I'm not good at this…I don't know which direction to go. (student 2:2:1, p.1)
Analysis	Some students lack the confidence to enter the profession even in their sophomore year. This phenomenon might mean that the student does not have the motivation to pursue a career as an Industrial Designer so s/he is confused about his/her future plans. Or it might mean that the curriculum does not provide career advice or prepare the students well for professional practice.

Table 4.8 continues on the next page.

Table 4.8 continued.

School differences	You have to understand, there are many top universities in Beijing. This school [Beijing College of Arts and Design] is almost at the bottom of the list. Thus we cannot recruit the brightest students. This week I even have to drive to pick up the materials and models for the students myself! They just won't work that hard. (Instructor of Beijing College of Arts and Design)
Analysis	As discussed in Chapter One, there are different levels of higher education in China. However, there are complaints from all types of universities about the quality of the students nowadays, especially after the higher education expansion. This phenomenon may lead in two directions: the expansion decreased the quality of students; or the educational system is unable to motivate students according to their individual qualities and interests.

Note: coding example (2:1:3, p.55) means that the student is in his/her second year of undergraduate study (2), 1 stands for the university s/he is attending (list not shown in this document), 3 means that this interviewee is the third participants the researcher interviewed in this university, p.55 means this comment appears on page 55 of the interview transcript.

The pedagogical approach has to be adjusted to different student groups' needs to maximize the effect of education. Because sustainable design encompasses so many disciplines and "serious" social, cultural, and technological issues, the traditional lecturing method might be ineffective to motivate the students since their attention span is getting shorter and shorter in this information age. Educators nowadays have to learn to use entertaining elements in their courses. In addition, design students are notoriously known to loathe reading, while large amount of reading is crucial in understanding sustainability issues. However, *entertainment* does not equal *enlightenment* in education. It is a major challenge in sustainable design education to carefully balance attention-grabber materials and substantial knowledge. Class activities such as scenario building, game and role playing, discussions, and presentations should be used to encourage active learning.

4.4. Understanding the Current Industrial Design Educational System

The coding of the interview data and analysis provides concepts to understand the current educational system (Figure 2.6 provides the basic structure of this analysis).

4.4.1. The Philosophical Background of the Current System

The interview data indicates that there is no clearly articulated philosophy directing the current educational system of Industrial Design in Mainland China. Though sizes and types vary, Chinese universities are usually highly pragmatic. They closely observe the market needs and plan their courses accordingly. On the other hand, as discussed in Chapter One, the Industrial Design education has to face many barriers caused by the centralized educational system.

4.4.2. The Goals of the Current System

Guided by pragmatism, the interview data indicates there are two general goals of the current Chinese Industrial Design educational system:

- To fulfill the requirements of the administration
- To provide professional training to students that can ensure their competency for employment

4.4.3. Knowledge and Current Sustainable Design Education Practice

As Table 2.8 and Table 2.9 indicated in Chapter Two, there should be three cultures and four domains of knowledge in the Industrial Design education. The interview data and survey of the Chinese Industrial Design curricula (Appendix B and Table 2.4.) indicate that the Chinese Industrial Design education pays little attention to the social domain in which discussions of social and environmental impacts of design usually occur. Chinese Industrial Design education also focuses mainly on

the lower level of learning process and knowledge: content mastery (declarative knowledge) and comprehension/application (procedural knowledge).

There is limited practice of sustainable design education found in the current Chinese Industrial Design education system. However, most participants show some knowledge of sustainability concepts.

4.4.4. Understanding the Barriers and Constraints

The interview data and literature indicate barriers and constraints in implementing sustainable design education in the Chinese Industrial Design community (Table 4.9). These barriers can be categorized into four aspects.

Table 4.9 - Barriers and Constraints

Categories	Barriers and Constraints
Social/Cultural	● Standardized tests in K-12 education ● Lack of appreciation for design as a profession ● Little social pressure or concern for the environmental impacts of design
Institutional/Administrative	● Evolved out of arts/craft tradition with little science content ● Centralized curriculum decision-making ● Slow to change curriculum ● Limited educational resources ● Limited scope
Faculty	● Lack of knowledge concerning sustainability ● Lack of training ● Too few faculty ● Lack of incentives ● Lack of references
Students	● Low quality of students ● Lack of motivation ● High school to college shock

There is no simple solution to overcome these barriers and constraints in the social and educational systems. The proposed framework aims to create incentives to teach sustainable design, help selecting content, organize courses, and promote constructivist and critical pedagogical approaches.

4.4.5. Strategy for Interventions

The goals and barriers of the current Industrial Design educational system imply that for sustainable design education is to be considered as part of the agenda in this system, there are three strategies (are further discussed in Chapter Five):

- Governmental pressure: convince the educational policy makers that sustainable design education is necessary.

- External pressure: increase the market demands for designers with the knowledge of sustainable design.

- Internal pressure: convince the educators that sustainable design can enhance their students' competency in the near future.

Each strategy reinforces one another. When the need for designers with the knowledge of sustainable design increases in the market place, the educators will consider sustainable design knowledge as part of the essential attributes of the students and press the administration to arrange courses of sustainable design; when the educators start to emphasize about sustainable design, the industry and administration will start to take notice of the issue. The positive feedback loops are shown in Figure 4.1.

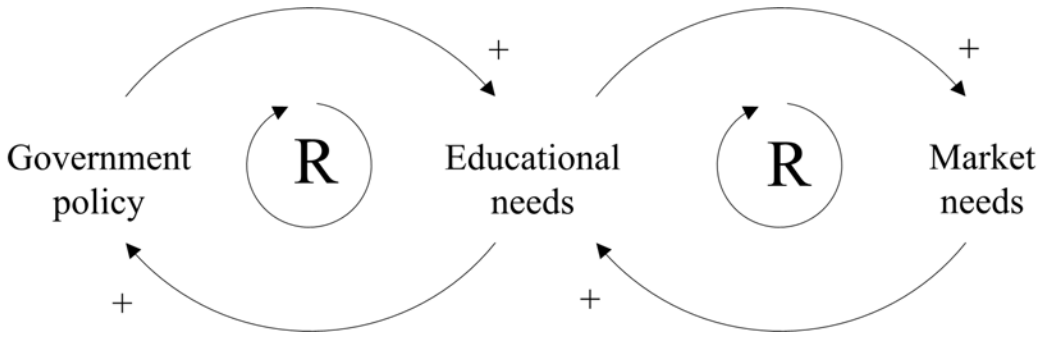

Figure 4.1 - The Positive Feedback Loops of Three Factors

Educators are the key players because they observe the market needs and

“translate” them into educational needs. They also contemplate the future needs for the profession and the society as a whole. Therefore, an educational framework saturated with sustainability concepts will provide them a toolkit to understand and teach the important issue of sustainability.

4.5. Conclusions

The interview data confirms the hypothesis stated in Chapter One. It confirms the following status of the current Chinese Industrial Design educational system:

- Chinese Industrial Design education needs to be reconstructed to promote sustainable design and limit the profession’s negative environmental effects.

- Chinese Industrial Design educators would encourage changes to the design educational system for sustainability if they have clear and pragmatic directions for implementing these changes.

- Chinese Industrial Design community is curious about sustainable design but their knowledge of the subject matter is far less than sufficient.

- Chinese Industrial Design practitioners realize the importance of sustainable design but they also need clearer guidance. A reformed design education system should be a good start to foster the commitment to sustainable design in Chinese Industrial Design community.

The interview data maps the landscape of Industrial Design education in Mainland China for a better understanding of the challenges and opportunities. Using this data, the educational framework presented in the next chapter has clear emphasis and structure that fit with the status quo in Mainland China and try to overcome the barriers of teaching sustainable design.

Chapter Five: A Proposed Educational Framework for Sustainability

5.1. The Overall Structure of the Proposed Educational Framework

This dissertation presents a new educational framework for Industrial Design in Mainland China that aims to promote sustainability. This framework is structured as shown in Figure 5.1 (based on Figure 2.6 discussed in Chapter Two):

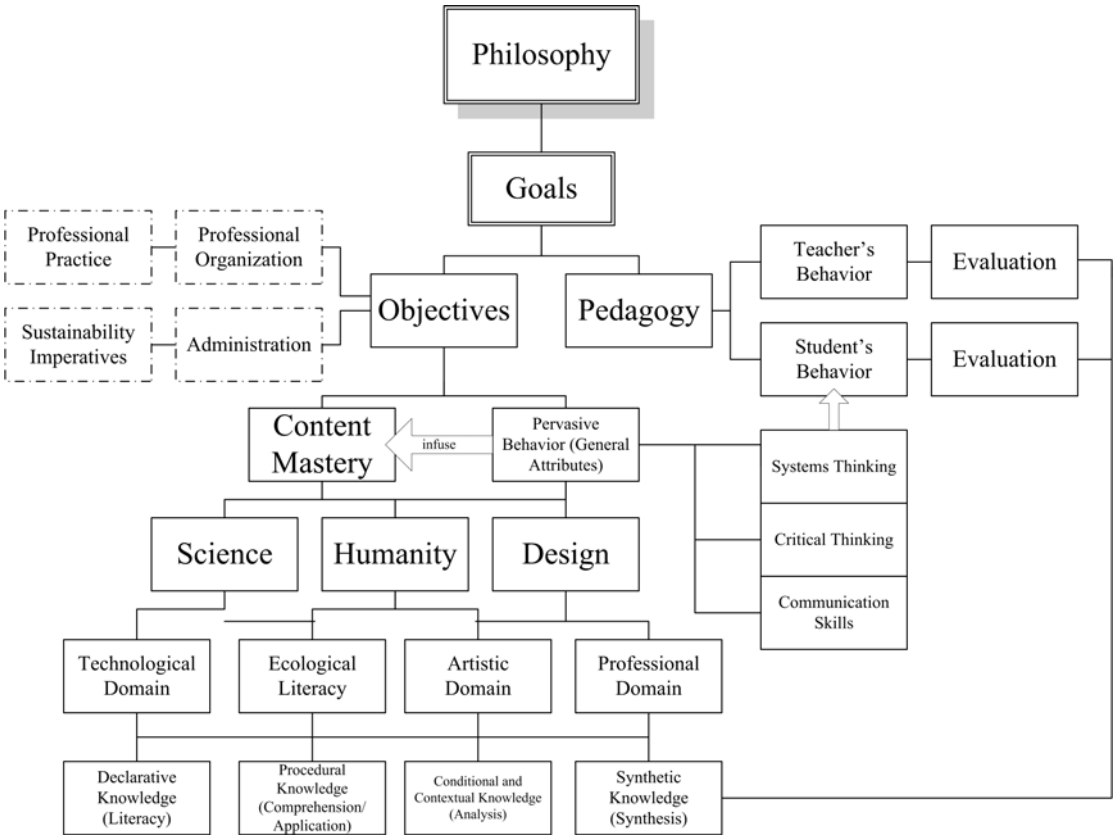

Figure 5.1 - The Overall Structure of the Proposed Educational Framework

Figure 5.1 is discussed in details below. This chapter is organized according to the flow of this structure.

5.2. Philosophical Foundation

Philosophy lies in the center of the educational framework. As discussed in Chapter Two and Three, the philosophical foundation of this research is constructivism. As a further development of Table 3.1, Table 5.1 presents the philosophical assumptions that the framework is founded on and their applications in

Industrial Design education.

Table 5.1 - Philosophical Assumptions and Educational Applications

Philosophical Assumptions	**Main Characteristics**	**Educational Applications for Industrial Design education**
Ontological (The nature of being and reality)	Reality is subjective and multiple, knowledge is constructed by individuals coalescing around consensus (the common reality).	Educational experiences are constructed by both the learners and teachers. Different people have different learning styles and needs, different schools also have different agenda. The framework should be flexible to accommodate these differences.
Epistemological (The nature of knowledge)	Knowledge is constructed in processes of social interchange and it has above all social functions.	Education must connect with the reality and serve the society.
Axiological (The role of value)	Educational framework is value laden and biases are present.	The framework considers *sustainability* as an important goal of Industrial Design in addition to creating good design.

5.3. Goals

The overall goal of this research is to promote sustainable design in the Industrial Design community in Mainland China. It proposes an educational framework that aims to honor the "social contract" between higher education and the society, while making meaningful and practical contributions to the development of economy in this highly pragmatic and practice-oriented discipline. The proposed framework strives to achieve the following goals:

- To provide instruction of curriculum building for Industrial Design educators in Mainland China according to the present and future needs of the profession.

- To provide a set of tools to teach sustainable design in Industrial Design education to generate responses to design problems.

- To foster systems thinking, critical thinking, and ecological understanding[43] among Chinese industrial designers.

- To encourage discussions about educational reform and professional ethics in the Chinese Industrial Design community.

These goals guide the specific objectives in content selecting and pedagogical approach in this framework.

5.4. Objectives

As a discipline that integrates knowledge from many disciplines, the extent of Industrial Design education is hard to define. The objective in content selection for the framework is to meet the requirements informed by the four references listed below:

- The current requirements in the *professional practices* for industrial designers because Industrial Design is mainly a practice-oriented profession

- The professional attributes listed by *professional organizations* (informed by practices and research)

- The requirements of the *administration*

- *Sustainability* imperatives

As discussed below, the requirements by these four references often overlap with each other. And as Table 2.7 suggests, there are two dimensions of objectives in

[43] Ecological understanding is defined as the expectation and awareness that human actions have consequences and that an intricate web of relationship connects patterns and processes in the physical, biological, and social environments (Johnson & Hill, 2002).

education: cultivating pervasive behaviors (general abilities) and delivering specific content (knowledge). These two dimensions are reflected in the requirements. An educational framework engaged with sustainability for Mainland China will emerge from the common requirements of the profession, the reality of Industrial Design education in China, and the vision for a sustainable future. The industry's requirements for designers, the requirements summarized by the professional organizations, the requirements from the Chinese administration, and the sustainability imperatives for design education are discussed next.

5.4.1. Industry's Requirements for Designers

One of the primary goals of higher education is to train qualified employees for professional practices. Therefore, requirements of professional designers influence the construction of design education. As early as 1983, the British Department of Education and Science in association with the Design Council commissioned a nationwide survey to investigate the requirements for professional industrial designers, which generated a set of quantitative data to describe the attributes from the professional point of view. Educators in the United States also conducted surveys of both professionals and educators. Their research has revealed the most important attributes of industrial designers as suggested by industry. According to the publications of the Industrial Designers Society of America, Industrial Design companies usually list these as the top five skills of industrial designers. Table 5.2 categorizes these skills in the dimensions of objectives (Table 2.7).

Table 5.2 - Top Five Skills of Industrial Designers according to IDSA

Dimensions of Objectives	**Skills**
Pervasive behaviors (General abilities)	Creative problem-solving skills
	Good verbal and written communication skills
Content mastery	Ability to convey concepts with quick sketches
	Computer proficiency in vector based or 3-D programs
	Mechanical aptitude and basic understanding of how things work

China's design industry also has many suggestions on how to improve design education. Alex Fung Shung-Yu and Alice Lo Choi Yuet-Ngor (Alex Fung Shung-Yu & Yuet-Ngor, 2001) conducted a market survey with 200 design and advertising companies based in Shanghai and Beijing in 1997 to seek their opinions and attitudes concerning design and designers. The results suggest the Chinese design education should:

- broaden the subject choice in Chinese design education to include Chinese and Western cultural study, marketing, consumer behavior, psychology, philosophy, aesthetics, sociology, history, literature, ethics, information technology, communication skills, and team work.

- have more interaction between design education and foreign design communities, and between design education and industry.

- promote more design education in K-12 education.

- encourage teachers to play a less interventionist role allowing students to make more creative and critical decision themselves; raise teachers' salaries to enable them to concentrate on teaching; invite experienced design teachers from abroad to introduce innovative teaching methods to local schools; introduce courses on creativity to develop students' lateral thinking skills; give student more choice in subjects allowing them to develop their own interests and strength;

- provide post-college education to practicing designers.

Their suggestions not only reflect the industry's demands for Industrial Design profession, but also confirm the researcher's observation of the problems in design education discussed in the previous chapters. They also confirm that a constructivist pedagogical approach is needed in Chinese design education. As discussed in Chapter Four, the proposed framework can help solving some of these problems at the higher education level.

5.4.2 Professional Organizations' Suggestions for Design Education

According to these requirements and demands, the International Council of Society of Industrial Design (ICSID, 2003) suggests that a comprehensive Industrial Design education program should at least educate students in three categories of competency as listed in Table 5.3.

Table 5.3 - Competency of Industrial Designers according to ICSID

Generic attributes (pervasive behaviors)	problem solving, communication skills, adaptability to rapid changes, etc.
Specific industrial design skills and knowledge	design thinking and design process, design methodologies, visualization skills and knowledge, knowledge of product development processes, manufacturing, materials and processes, design management, environmental awareness, model making, etc.
Knowledge integration	strategies of system integration

ICSID also formulated an exit profile of a general design graduate as Table 5.4:

Table 5.4 - Exit Profile of a General Design Graduate according to ICSID

Primary cognitive abilities	Critical, innovative, lateral and creative thinking; motivation and curiosity; perception of design problems; conceptualization of new design solutions.
Secondary cognitive abilities	Oral, graphic, and symbolic communication; research and discovery; discipline of ethics and morality; psychology and philosophy of designing; competence in the design specialization;
Skills	Design methodologies; materials, processing and model making; computer-aided design and other software;
Social context	Grasp of the cultural heritage; teamwork, collaboration and leadership; entrepreneurship and continuing education;
Subject matter expertise	Knowledge of the subject matter and context for design; fundamental scientific principles and their application; basic laws, principles and design practice in the subject.

These attributes of Industrial Designers are widely accepted in the profession and are essential references for the objectives of Industrial Design education.

5.4.3 Requirements for Design Education in Mainland China

The National Instructive Committee of Industrial Design Education (China) commissioned by the Ministry of Education of the PRC supervises the overall academic activities of the Industrial Design discipline. It lists the basic requirements of courses in an Industrial Design department (see also Appendix A):

- Introduction to design
- Ergonomics
- Design history
- Computer aided design
- Design basics
- Product design and theory

- Engineering basics for Industrial Design
- Design expression
- Internship

This list is rather short and vague because as an instructive committee, this organization does not have the authority to interfere directly with the curriculum of any Industrial Design department. It serves instead as a platform of communication for schools. This makes it possible to have alternative educational approaches, which enhances the possibility for proposing an innovative framework to improve the existing Industrial Design educational system.

In addition, the Chinese government mandates college students to take courses in philosophy (mainly Marxism and Maoism), Socialistic economics, English, and law. Many comprehensive universities require their candidates for the Bachelor of Science degree to take physics and algebra. These requirements have to be taken into consideration while planning a curriculum because these courses consume a large amount of students' time and energy.

5.4.4 Sustainable Design Education in Mainland China

Should the design education be reactive, following the demands of the industry or should it be proactive, offering new visions? Educators have been debating this issue for years. Different positions taken might lead to completely different pedagogical approaches. Design education needs both great foresight and flexibility beyond submissions to the current requirements of the profession. As the discipline progresses, design education should not limit itself to mere professional training. Instead it should aim to broaden the students' horizon by introducing a wide range of issues into the design discipline. Engaging sustainability is a promising direction to achieve this goal.

As discussed in Chapter Two, the foundation of sustainable design education

should be an ecological world-view. However, having ecological literacy only solves the question of “why industrial designers should care about sustainability”, it is not sufficient to answer the question: how should educators teach sustainability issues?

David Orr states that achieving “knowing, caring, and practical competence constitute the basis of ecological literacy” (Orr, 1992). However, this competence only provides a general world-view for sustainable design. It is far from enough to solve environmental problems caused by irresponsible design. Sustainable design education has to focus on both systems thinking and professional practices. Thus, the professional competency of designers as suggested by industry and academia become the boundary for the diverse issues to be taught in Industrial Design education.

In Mainland China, the government has been promoting environmental education for over three decades. However, so far there is little incentive in Mainland China, either from the market or legislature, for many Chinese companies to require knowledge of sustainable design from designers. But predictably, the pressing need of sustainable development will push the Chinese government to legislate more strict environmental laws and regulations. To compete for overseas markets, Chinese companies that wish to conform to ISO 14000[44] have to make a commitment to improve their overall environmental performance. They also need to make their products more appealing to consumers who are environmentally aware. Thus, it is plausible to predict that in the near future, designers focused on sustainable design will fill in this market niche. Design education should provide sustainable design education for designers so they can educate their clients now and excel in the future.

[44] The ISO 14000 family is a set of standards issued by the International Organization for Standardization. It is primarily concerned with "environmental management". This means what the organization does to: minimize harmful effects on the environment caused by its activities, and to achieve continual improvement of its environmental performance.

In Chinese higher education, educators are just starting to integrate ecological knowledge into their courses. As discussed in Chapter Four, most Chinese Industrial Design educators are not well-equipped to teach ecological literacy courses because they were not trained properly and they are intimidated by the complexity of issues associated with sustainable design. Therefore, it is extremely important to educate the educators first. It calls for a strong leadership and commitment to sustainable design from the administration level. Training could be arranged as short-term workshops and seminars. Industrial Design departments should also actively seek assistance from other departments and schools to broaden their curriculum.

In addition, as literature review points out in Chapter Two, an educational system embedded with sustainability needs to cultivate systems thinking and critical thinking to enhance students' ability to comprehend complicated design problems involving social issues. These two thinking abilities are also essential for cultivating research skills for designers. Other essential general abilities as suggested by the design industry are communication skills, problem solving skills, interpersonal skills, etc (Table 5.3 and Table 5.4).

5.5. Content

A practical educational framework for Industrial Design should strive to foster designers who have all the basic attributes anticipated by the profession. Content selection adheres to the objectives of the educational framework. Literature review also guides the selection to include four domains and four types of knowledge.

5.5.1 The Taxonomy of Knowledge and Skills in Industrial Design Embedded with Sustainablity

Table 5.6 puts all the attributes and requirements into the taxonomy of learning perspective as summarized in Table 2.13.

Table 5.5 - The Taxonomy of Knowledge and Skills in Industrial Design Education Embedded with Sustainability

Ability Level	**Industrial Design Knowledge**	**Specific Skills**
Literacy Declarative knowledge	The concepts of ● Aesthetics and art history ● Philosophy ● Science principles (physics, chemistry, and biology) ● Design and design history ● Design and its social, economical, environmental impact (systems theory) ● Color theory ● 3D and 2D form perception ● Basic mechanics ● Ergonomics ● Materials (3R principles) ● Basic laws in design practice ● Cultural heritage ● Basics of business operation ● Professional behaviors: ethics and morality ● Design theory ● Writing and presentation	● Communication skills ● Sketching ● Drafting ● Literacy of design ● Literacy of ecology ● Critical thinking and systems thinking
Comprehension **Application** Procedural knowledge	● Clean manufacturing, processing, and structure ● Quality control ● Design methodology ● Product development process	● Model making ● Visualization: Rendering; CAD ● Portfolio building ● Oral communication
Analysis Conditional and contextual knowledge	● Design analysis: problem solving and critical thinking ● Design process, research methods, and solutions ● Product development strategy	● Teamwork, collaboration, and leadership ● Problem solving
Synthesis synthetic knowledge (evaluation, estimation and creation of new knowledge)	● User study ● Design management ● Design research and methods ● Interdisciplinary and multidisciplinary cooperation	● Design specialization ● Entrepreneurship and continuing education

Table 5.5 not only indicates all the required knowledge and skills in the

Industrial Design education, but also shows the progression of knowledge building in the discipline. An educational framework engaged with sustainability should at least cover these knowledge sets and skills.

5.5.2 Four Domains of the Sustainable Design Education

The literature (Table 2.11, Table 2.12, and Table 5.6) suggests that there are four domains of courses in Industrial Design education.

5.5.2.1 The Ecological Literacy Domain

Students, regardless of their discipline, need a certain level of ecological literacy to better serve society in the future. Students should learn how to perceive environmental issues using a systematic view and use their professional knowledge to creatively solve existing and potential new problems. In his book *Ecological Literacy* (Orr, 1992), David Orr points out:

> Literacy is the ability to read…*Ecological literacy*, according to Garrett Hardin, is the ability to ask "What then?"…The failure to develop ecological literacy is a sin of omission and of commission. Not only are we failing to teach the basics about the earth and how it works, but we are in fact teaching a large amount of stuff that is simply wrong… Ecological literacy also presumes an ability to use numbers, and the ability to know what is countable and what is not, which is to say the limits of numbers… Ecological literacy also requires the more demanding capacity to observe nature with insight, a merger of landscape and mindscape.

"What then?" is a question about the consequences of design, especially the long-term ecological and social consequences. Without systems thinking to consider multiple dimensions of design[45], one can hardly imagine, let alone measure these consequences. Industrial Design education has been rather linear because in most cases only the design process happens before the realization of products is discussed. How design affects the whole lifespan of products and their users during and beyond

[45] For instance, "natural capital", such as clean air and water, is an important dimension in measuring the environmental impacts of a product or service, which is usually ignored in design professions.

this period is usually ignored in the current curricula. Ecological literacy not only lays the knowledge foundation for sustainable design education, but also provides the grounds of arguments and methods for Industrial Design students to practice sustainable design in their professional lives.

The goal of ecological literacy education in Industrial Design is *not* to produce environmentalists or ecologists, but to ensure design students have an "ecological appreciation", thus have a holistic view of design and its consequences. This appreciation acts as a "mind filter" in the design process. It helps the designers to comprehend the enormous amount of knowledge that sustainable design encompasses.

The knowledge involved in this category is broad but bounded in the context of design, covering social and environmental subjects such as basic sustainable development concepts and green philosophy, sustainable design theory and practices, design ethics, etc.

5.5.2.2 The Artistic Domain

An important skill for an industrial designer is to convey design messages visually. Thus, industrial designers must have excellent communication skills. Sketching skill and the aesthetic sense are highly desirable in Industrial Design education.

In Mainland China, most Industrial Design departments still consider sketching, drawing, and freehand rendering as fundamental courses for the discipline, while their Western counterparts tend to place more emphasis on creativity development and art appreciation. Though the intense training of basic drawing skills enables Chinese Industrial Designers to express their ideas more efficiently, some argue that it also limits students' creativity to mere duplications and imitations of existing objects. This new educational framework proposes a set of courses to foster both creativity

and multiple levels of communication skills, particularly under the constraints required by sustainable design.

This category includes courses on creativity exploration, visual communication, design basics, introduction to design, design history, local determinants and culture, design critique, etc.

5.5.2.3 The Technological Domain

Technological understanding is important to industrial designers because the profession relies heavily on innovation to create breakthrough products and services. Industrial designers are expected to have knowledge of materials and manufacturing procedures and be acutely aware of technological developments and trends.

The proposed educational framework critically fosters technical skills to ensure that industrial designers understand that technological progress entails both benefits and risks. While technology plays a key role in solving environmental problems, in some cases, new technologies create more environmental problems than the ones they solve. For instance, new chemicals released into the environment sometimes cause unpredictable negative consequences. Also, certain traditional technologies that suit local needs should be reconsidered and re-introduced. For example, bamboo has been used for building construction in many oriental societies and it is proven to be economically viable and environmentally sound due to its fast growth rate. In recent years, Western architects and builders have discovered the benefits of bamboo and have started using it in their buildings. Therefore, this domain emphasizes on clean technology for mass production, quality control, and product life cycle analysis.

This category includes courses on materials and manufacturing, physical modeling, green technology, computer aided design (CAD) and rapid model prototyping, ergonomics, life cycle assessment, etc.

5.5.2.4 The Professional Domain

Students develop their basic skills in the first three domains of knowledge simultaneously. All three contribute to the final domain: professional knowledge. In this domain, students learn how to synthesize their skills by working on specific design projects, communicating with clients, and pursuing their career goals.

This domain includes three sub-categories:

- Courses for business and management that prepare students to understand the macro and micro dynamics between design and business so they will have a better understanding of industrial designers' value and role in the product development process;

- Courses for preparation for professional practice that allow students to experience the profession in near real world settings;

- Courses for design research to foster research skills and strengthen critical thinking and systems thinking abilities.

This category includes the following courses: design methodology and process, design research and user studies, collaborative studios, design strategy and planning, design management, internship, etc.

5.5.3 Course Suggestions and Domains

In conclusion, an educational framework engaged with sustainability for Industrial Design should include these courses (Table 5.7) to fulfill the requirements from the professional practices, ICSID (professional organization), the educational administration, and sustainable development. The relationship among the courses, the cognitive hierarchy of learning (Table 2.13), and the knowledge domains (Table 2.11, Table 2.12, Table 5.1 to 5.5) are also included in Table 5.6.

Table 5.6 - Courses and Their Coverage

Courses	Cognitive Hierarchy of Learning						Knowledge Domain					Requirements				
	Literacy	Comprehension	Application	Analysis	Synthesis	Evaluation	General Attributes	Ecological domain	Artistic domain	Technological domain	Professional domain	Governmental requirements	Professional attributes	Exit profile	Industry's needs	
a) Creativity exploration	√		√				√		√				√	√	√	√
b) Design literacy	√	√	√				√		√				√	√	√	√
(methods and history)													√			
c) Communication skills (basic	√	√	√				√		√	√	√					
to specialized)												√	√	√	√	√
d) Ecological literacy	√	√	√	√	√		√	√		√						
e) Basic mechanics	√	√	√				√	√		√	√	√	√			√
f) Design theory and methods		√	√	√	√						√	√		√		
g) Sustainability by design		√	√	√	√	√	√	√				√	√	√	√	√
h) Materials and		√	√							√	√					√
manufacturing												√	√	√	√	√
i) Ergonomics		√	√	√						√	√					
j) Design research and user		√	√	√	√	√	√				√	√	√	√	√	
study												√	√			√
k) Green technology and life		√	√	√		√		√		√	√					
cycle assessment																√
l) Professional ethnic codes	√	√	√				√				√					
and expectations												√	√	√	√	√
m) Product development		√	√	√	√	√					√					
strategy												√	√	√	√	√
n) Design management		√	√	√	√	√					√	√	√	√	√	√
o) Internship program	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

These courses can be expanded into several courses at different levels to accommodate different needs. For example, communication skills can be taught at basic, intermediate, and specialized levels. "Sustainable by design" can also be taught at introduction, analysis, and synthesis stages. The format of these courses can be as a traditional lecture course or as a project-oriented design studio.

5.5.4. Elective and Core Courses in Mainland China

Chinese universities have started the transformation to the credit system in the late 1990s. Due to limited resources and a large number of students, elective courses are still limited and typically are not taken seriously. To control the quality of education, core courses are carefully planned and usually quite extensive. Interdisciplinary studies are not encouraged and dual degrees are rare. Adequate elective courses are important for design education because they expose students to a variety of subjects, broaden their horizon as designers, and enhance their critical thinking and systems thinking abilities.

The proposed framework offers both core courses and elective courses. Each category offers elective courses on specific subjects that are not covered in detail in the core courses. For instance, students can choose photography as an elective course. The purpose of elective courses is to allow students to develop their specific skills and topics of personal interests. They serve the same educational goals as core courses (see Appendix H for detail course content).

5.5.5. The Timeline of Courses in the Framework

In the first year of undergraduate study, students must develop a good understanding of the fundamentals of design. They acquire fundamental communication skills and basic knowledge of the profession in these first two years. Students also need to fulfill the general requirements of courses in these two years.

In the third year, students have more liberty in choosing their courses. The courses become more specialized. The fourth year focuses on professional behavior cultivation. Students must also complete an internship program before they can defend their Bachelor's degree. Applying Table 5.7., Figure 5.2. shows the timeline of the courses.

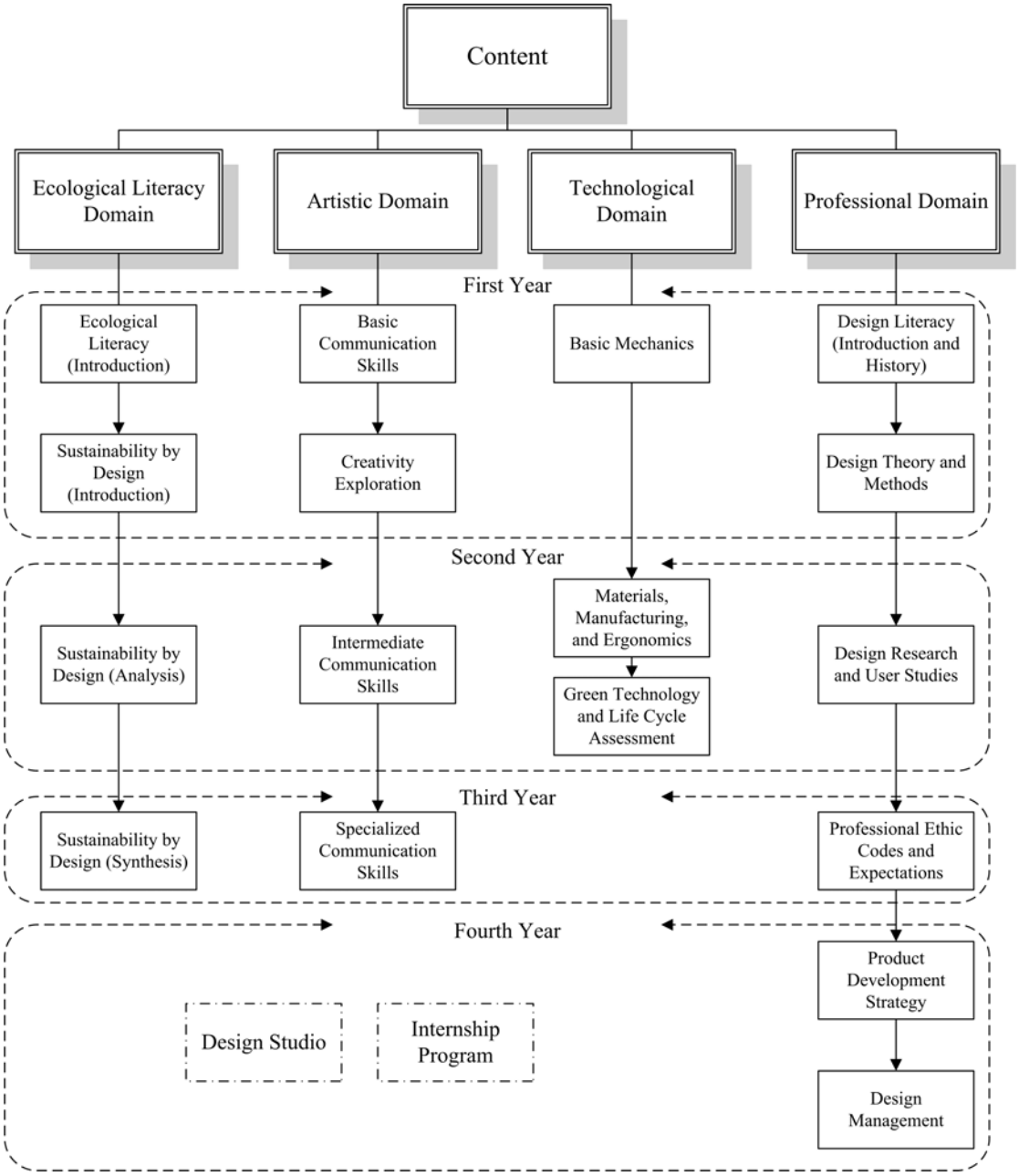

Figure 5.2 - Timeline and Courses

Note: design studio is a format that can be used for other courses.

5.6. Activities and Roles of Educators and Students

The implementation of an educational framework relies on the participants. An educational system has two main participants: educators and students. One could also argue that administrators/staff, students' families, and potential employers might influence educational experiences in some ways, however, it is assumed that only educators and students interact on a daily basis in the educational system, therefore

only these two are presented in the framework.

Managing the dynamics of educators and students is crucial for utilizing constructivist pedagogy to cultivate critical thinking. Developed upon the hierarchy of learning (Table 2.13 and Table 5.5), Table 5.7 describes the roles of educators and students at different learning levels in an active learning environment using a constructivist pedagogical approach.

Table 5.7 - Taxonomy of Educators' and Student's Roles in Active Learning

Ability Levels	**Educator's role**	**Student's Role**
Literacy	Lecturer[46]/ Facilitator[47]	Active learner who is critically learning
Comprehension **Application**	Facilitator	Active learner Participant Team player
Analysis	Facilitator	Active learner Participant Team player; Observer who observe others and give feedback.
Synthesis	Facilitator	Active learner Participant Team player
Evaluation	Facilitator and Observer[48]	Active learner Peer evaluator

Table 5.7 is based on the premise that the classroom setting begins as "teacher-directed and student-focused", and progresses to "student-centered" at the higher levels of learning. The "teacher-directed and student-focused" fits the needs of the lower level learning because in this setting, the teacher chooses the educational materials and topics while relating information to students' former knowledge (Gabler et al., 2003). The "student-centered" setting allows students to take initiative for

[46] Lecturer conveys knowledge to students by lecturing.
[47] Facilitators help students understand certain subjects through discussions and debates without taking any sides of the argument. Instead of leading the class towards what he or she thinks, the educator tries to encourage different opinions and avoid making judgments. Students are encouraged to provide facts to support their opinions so the class will learn from all sides.
[48] Observers give students total freedom to plan their learning activities and by observing their progress, evaluate their own teaching effectiveness.

their learning and choose their own topics. A teacher is essentially a resource who gives instructional rationales, instead of direct orders of how design projects should be done. Students may evaluate their peers using their own criteria when approved by teachers. Students are encouraged to provide their own interpretations and inputs in either setting.

The conventional “teacher-centered” classroom setting reinforces passive learning, which discourages the creativity development in Industrial Design. However, some materials related to sustainability and basic knowledge of design (literacy in design history and theories) may need to be presented as teacher-centered. Therefore it is recommended for introduction courses under the circumstance that the students are unfamiliar with sustainability issues.

5.7. Taxonomy of Learning and Evaluation

Developed upon Table 2.13, Table 5.5, and Table 5.7, Table 5.8 is created to describe the relations among ability levels, learning styles, and assessment methods using constructivist paradigm in Industrial Design education.

Table 5.8 - Taxonomy of Learning in Industrial Design

Ability Level	**Learning Style**	**Evaluation Methods**
Literacy	Memorizing, constructivist learning, critical learning.	Standard tests
Comprehension Application	Constructivist learning	Project, portfolio, and reports evaluation
Analysis	Social cognitive learning; self-regulated learning; peer-group learning	Self/Peer evaluation
Synthesis	Investigating learners' previous experiences and associating them with present experiences	Interactive presentation; reflective discussion
Evaluation	Self-authorship learning; self-evaluation	Interactive presentation; reflective discussion

This table shows that different evaluation methods are appropriate for different types of learning style and ability levels.

In general, Chinese students are required to submit homework as well as term projects which are often presented before their peers. Assessments generally are based on a zero to hundred points scale according to the quality of their works, the completion of the course work, attendance, and class participation. Oral presentation is usually not required in most cases due to the large class size. The grading standard varies according to teachers' preferences, the overall quality of students, and course requirements.

In this framework, an unconventional assessment method (Figure.5.3 as an example) is proposed. This graphical method uses a polygon with each corner representing a criterion for the work. The result is a spider diagram as shown in Figure 5.3. The center of the polygon represents the failure to comply with a given criteria, whereas the perimeter of the polygon represents the highest level of performance. In the example, multiple criteria are presented, such as effort (participation), creativity (originality and exploration), aesthetic, market value,

applicability (technical viability and usability), and environmental responsiveness. Students will learn the strengths and weaknesses of their own works by this visual assessment method.

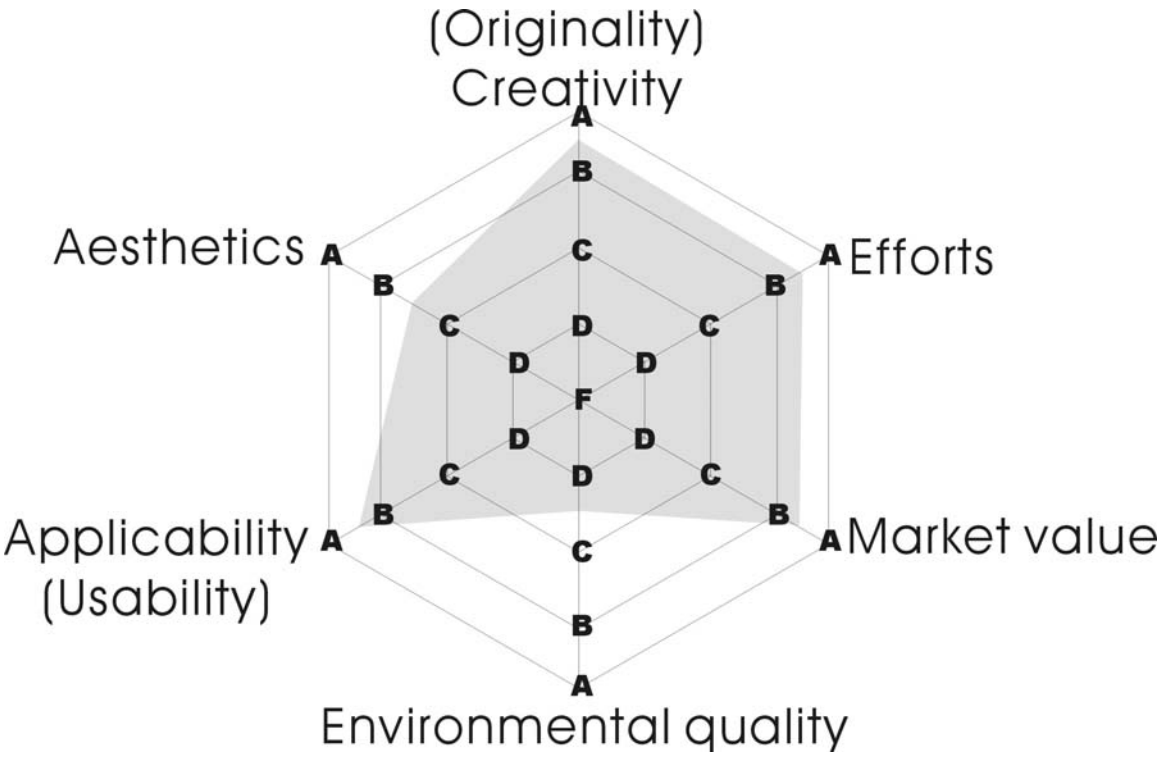

Figure 5.3 - An Example of the “Spider Web” Assessment Method

Note: the grey area shows a hypothetical score for a student’s work for a hypothetical course or project.

Different design projects might have different emphasis. Thus the criteria in the polygon and the weight of different criterion should be altered in response to individual courses and universities. Ideally, students are expected to excel in all criteria. Arguably, this method is more rational and meaningful in design education than the A-F or percentage assessment methods. Nonetheless, the final scores of the course might still have to follow the conventional methods so that the administrators can evaluate the programs.

For the evaluation of the framework itself, these criteria should be considered:

- Feedback from the students and educators
- Feedback from the employers of the graduates
- Job placement rate and feedback from the graduates

5.8. Policy intervention

5.8.1. Problems and Solutions

The researcher must demonstrate how the proposed new educational framework will improve the Chinese Industrial Design Education system. In Chapter One, four major problems of the Chinese educational system were introduced (as shown in Table 5.9). The proposed educational framework provides solutions to all these problems.

Table 5.9 - Problems and Solution

Problems	Solutions
The general structure of the educational system in China, mainly the standard test evaluation method, hinders the development of art and design education. K-12 education does not prepare for a design career.	The proposed framework uses an innovative evaluation method to evaluate students' works in Industrial Design. It encourages creativity development, critical thinking, and systems thinking.
Quantity is favored over quality in the current Chinese higher education.	The proposed framework carefully examines the discipline requirements of Industrial Design education to provide quality education.
Chinese Industrial Design education has little instruction related to the social and science subjects.	The proposed framework is built upon literature review and interview analysis. It has a clear structure and rationale for the selection of content.
Social and cultural structures in Mainland China provide insufficient support to design professions.	The proposed framework introduces discussions of social and cultural issues in the context of sustainability. It stresses on the "social contract" of education.

5.8.2. Strength and Weakness

The proposed educational framework has the potential to improve the current educational system for Industrial Design to include sustainability. However, results from the study of the current system presented in Chapter Four suggest some weaknesses that might cause “resistance” and prevent it from being adopted (Table 5.10).

Table 5.10 - Strength and Weakness

Strength	Weakness
Well-balanced courses that cover every aspect of Industrial Design	Might be considered as adding workload to students and educators
Introduces the constructivist pedagogical approach that is considered more suitable for design education	Might be in conflict with the traditional hierarchical and teacher-centered pedagogy in China
Provides a tool set for teaching and learning sustainable design	Might require a sharp learning curve for educators in preparing for new courses
Has a vision for the future needs	Long term benefits appear slowly while the short term workload increases

5.8.3. Reform on the Administrative Level

As discussed in Chapter Four, there are three strategies for policy intervention in the Industrial Design educational system in China: governmental policy, external pressure, and internal pressure. This framework creates the internal pressure to influence government decisions. The two main participants of an educational system, students and educators, will demand change in the system.

The reform of an educational system cannot be achieved by departmental efforts alone. The administrative structure of higher education has to allow change. Ideally universities should allow for a relatively flexible curriculum. This is the case especially in sustainable design education where students might need to take courses in several departments other than only in the Industrial Design department.

Typically, major changes to administrative structure take time. In Mainland

China, the actual educational practices could be quite different from the policy and official statement released by the universities and the National Education Bureau. The National Education Bureau only offers a set of general guidelines (see Appendix A) for discipline development which does not interfere with the actual curriculum, thus allowing for flexibility. The framework proposed in this dissertation covers all the requirements of the general guidelines, therefore its intervention will not contradict these guidelines. In fact, the framework complements the guidelines by providing a detailed curriculum proposal. Industrial Design departments can conveniently adopt this framework for their current curriculum without dramatic changes because this framework mainly builds on prevalent Industrial Design curriculum but with new focus on sustainable design and innovative pedagogical approaches.

5.9. Conclusion

The educational framework proposed in this chapter provides a general outline for an Industrial Design education system that is dedicated to sustainable design. The framework answers two key questions for sustainable design education: what should be taught, and how should educator teach these subjects? The philosophy, goals and objectives, content of courses, timeline of courses in a four-year college program of Industrial Design, pedagogical approaches, and evaluation methods are discussed. The proposed framework aims to assist educators who intend to reform their curriculum for sustainability how to organize their courses while giving them full freedom for their own creativity in educational practices.

Chapter Six: Critical Review by Interviews

This chapter discusses the procedures for the follow-up interviews with Chinese respondents which were used to obtain critical review opinions for the proposed educational framework. Their feedback was analyzed and adjustments to the framework were then made accordingly.

6.1. Sample Selection for the Follow-up Interviews

6.1.1. Selection Criteria

The selection criteria include these two requirements:

- The interviewees should have teaching experience in Industrial Design or are currently teaching in Industrial Design related areas in China.
- The interviewees should either have taught sustainable Industrial Design courses or anticipate teaching sustainable design in the near future. Thus, they are able to evaluate the proposed framework embedded with sustainability content.

The use of these criteria ensures that the interviewees who were selected have contemplated sustainable design education issues and are familiar with the design education issues presented in this dissertation. As such, it is likely that they are looking for improvement for design education or innovation in teaching sustainable design.

6.1.2 Selected respondents

Interview invitations were sent to the educators[49] who fulfill the selection criteria above (approximately ten), four of whom responded. The interviewees represent a

[49] Most of these educators have participated in the previous interview but this is not a criteria for selection.

cross section of the faculty members teaching or planning to teach sustainable design courses (as shown in Table 6.1). Their teaching experiences range from two years to ten years.

Table 6.1 - Selected Respondents and Their Qualifications

Name	Location	Qualifications
Participant A (teaching and practicing Industrial Design for over ten years)	Hong Kong	A has ample experience teaching and promoting sustainable product design both in higher education and also in the training of educators.
Participant B (teaching and practicing Industrial Design for eight years)	Beijing	As the director of an Industrial Design department, B is responsible for planning the design curriculum. He is able to evaluate the framework from the departmental perspective.
Participant C (teaching Industrial Design for six years)	Beijing	C is familiar with the research topic. She wrote and published a paper titled “Green Design and Product Development” in 2001.
Participant D (teaching Industrial Design for two years, practicing for more than five years)	Guangzhou	D is a junior faculty member. She is interested in sustainable design issues. She obtained her Master’s degree in the UK where she was exposed to sustainable design concepts.

6.2. Interview questions

Table 6.2 - Interview Questions and Their Purposes

Purpose	**Questions**
To examine if the educational framework has any fundamental conflict with the current system	**Main Question:** *Does this educational framework have any philosophical conflict with the philosophical foundation of your program?* Sub-questions: Is there a specific philosophy guiding your program and how would you describe it? What do you think of the structure of the framework?
To understand the goals and objectives of different universities and how the goal and objectives of the proposed educational framework can be incorporated	**Main Question:** *Are there any incentives to consider "achieving sustainability by design" as a goal in the curriculum development in your program?* Sub-questions: What are the goal and objectives of your program? Do the goals and objectives of this educational framework conflict with those of your program?
To evaluate the content of the educational framework	**Main Question:** *In the context of current professional requirements, what do you think of the content/course selection and timeline of the courses?* Sub-questions: What do you think of the four domains of knowledge? After reading the content of each course, do you think they cover most of, if not all, of the important issues in sustainable design and Industrial Design? Do you think the course load and timeline are reasonable?
To evaluate the applicability of the framework	**Main Question:** *What do you think of the usefulness and applicability of this educational framework engaged with sustainability in Mainland China?* Sub-questions: Does this framework have any relevance to the courses you are teaching or have taught? Does it inform your curriculum or courses in any way? What possible difficulties do you perceive in the implementation of this framework?

Table 6.2 continues on the next page.

Table 6.2 continued.

To obtain the suggestions for improvements	**Main Question:** *What would you like to suggest to improve this framework or research?* Sub-questions: Does this research present a realistic understanding of the current Industrial Design educational system in China? Are the methods used in this research convincing? What content of the framework would you like to add or delete?

The data from these interviews help evaluate the framework in terms of major concepts and course content. The opinions of respondents also reflect the particular needs of different types of universities.

6.3. Interview Process

The follow-up interviews followed the same protocol as the initial interviews except that the respondents were invited to participate in the research by instant messenger software, email or phone. The purpose of this research was explained in the invitation. The researcher sent them a condensed version of the dissertation (mainly Chapter Five and Chapter Two) with a nonexclusive list of questions. The respondents have one to two months to respond.

6.4. Feedback

6.4.1 The Philosophy of the Proposed Educational Framework

Participant D states that sustainable design is still only a small part of the existing curriculum due to the pragmatic philosophy of the current system. Participant A states that it may be difficult to identify Ecological Literacy as foundational learning or as a future Industrial Design education philosophy. The change from reactive to proactive might be the most difficult transition for the current educational system due to its centralized structure. The demands for change from

the educators and students, the most sensitive participants of the educational system, take a long time to reach the governing agencies, thus this system reacts slowly to changes.

6.4.2 The Goals of the Proposed Educational Framework

Participant A and B both agree that the intent of the proposed framework is good. Participant D points out that there is already considerable interest in sustainable design in the Chinese Industrial Design community. Hence, she believes this framework will be welcomed.

Though he believes that sustainable design education is important, participant B does not see the immediate market needs for industrial designers with sustainable design knowledge and skills. He believes that industry has a clear view of what the market needs and design education should always keep a close relation with business and strive to provide relevant training. Thus, he suggests engaging the educational framework with more of the industry's current requirements. He states that his department studies the needs of business and market before it prepares curriculum. He also provides a tip about how his department integrates industry's needs: he brings current design objectives and projects in Industrial Design from companies or in-house Industrial Design teams directly into the classroom. His response indicates that Chinese educators hold the view that the short-term objective of education is to provide students useful skills for immediate employment. To convince the administration of education, this framework needs to first address why the industry needs industrial designers with sustainable design skills.

6.4.3 The Course Content

Participant A thinks the proposed framework covers many topics of sustainable design. But he is concerned about three issues:

- Perhaps it is "too much" to learn within a four years program.

- The knowledge of sustainable design is broad, a part of it relates to a scientific dimension of design while others are more socially driven. The limited resources in design education can hardly cover all these subjects.

- The proposed framework for sustainability incorporates inadequate social studies.

Participant A suggests considering the use of more elective courses as a way to resolve the “broad” versus “specific” issues in sustainable design. In addition, since more basic concepts of Ecology could be promoted and taught at the levels of primary and secondary education, the framework should arrange focus on exploring specific sustainability concepts as they apply to design practice.

Participant D states that her department is trying to integrate more cultural and social issues into design courses. This shows that Chinese educators already see the need for expanding the scope of design curriculum and are experimenting.

Participant B requests that more sustainable design practice examples from international companies to be incorporated into the framework, perhaps in the form of case studies.

6.4.4 The Timeline

Participant A and B both think the timeline sounds logical. They think that the internship program is an important component in design education. They suggest reallocating the internship program to the third year because their departments both provide only three year education and moreover, the internship program is an important instrument to evaluate the educational efforts. Their departments monitor the feedback from the collaborators of the internship programs closely.

Participant D is worried that the proposed framework has too many courses and the theory of sustainability is introduced too early into the curriculum. She points

out that especially in the first year of college, students are required to take many courses by the governing agency. In her school, students do not start designing until the second year. As discussed in Chapter One, the educational system in Mainland China is rather linear and the standard test in K-12 education does not support the cultivation of artistic skills. Many students have limited artistic skills when they enter the Industrial Design program. Students have to focus on technical and basic communication skills in the first year, such as drafting and drawing. Participant D suggests beginning teaching sustainability concepts and theory at the post-graduate level. Graduate students are more acceptable to theories and when they become educators, they will be able to pass on the knowledge to undergraduates.

Participant C mentions that some universities in large cities are experimenting with "platform course" in the freshmen year: these are foundation courses that students from arts and design (at times architecture) majors attend together. These courses might be good opportunities to infuse concepts of sustainability into the curriculum and build the ecology literacy foundation for all majors.

6.4.5 The Applicability of the Framework

Participant A and B both think the proposed framework is an interesting proposal and would like to see a pilot run to evaluate it. Participant A thinks that as a re-engineered Industrial Design education model, it is not appropriate to implement only part of the framework. Many design schools have implemented at least some sustainable design education already. He suggests conducting more surveys about the effectiveness of those programs before implementing the proposed framework. It might be difficult to overlay the entire proposed framework on top of an existing educational framework.

Participant C states that sustainable design is gaining more and more attention in China. Industrial Design programs that are eager to distinguish themselves from other programs will consider adopting this framework because the concept is

considered “trendy” or “cutting-edge”. Participant C also points out that the differences in students’ backgrounds might be a main obstacle for the implementation of the framework. Without sufficient support of environmental education from K-12 education, students might simply ignore the sustainability issues in their design.

6.4.6 The Pedagogical Approaches

Participant B suggests when designing curriculum, educators should try to achieve three simple goals. The curriculum should first help students know what the subject is about (in this case, the subject is sustainable design); second, raise their interests in the subject; third, encourage their own creativity. Pedagogical approaches are then developed accordingly.

Participant D points out that due to many social constraints such as low income, Chinese educators are not as creative as their Western counterparts. In other words, they do not want to spend too much time to refine their courses or prepare for new pedagogical approaches. Nevertheless, they are interested in using well-established theories in teaching new subjects.

6.4.7 The Contribution to the Body of Knowledge

The respondents believe this framework clearly addresses several current problems in Chinese Industrial Design education. They agree that it integrates and introduces sustainable design theory and international practices that will help Chinese Industrial Design education relate sustainable design to current design and education practices. The dissertation presents a new direction for Chinese Industrial Design education that has not been developed in previous research. This framework presents a workable model for sustainable design education in the context of the existing Chinese educational practices. Thus it improves the overall Industrial Design educational system.

6.4.8 Suggestions for Further Research

Participant A and B both think that the proposed framework is well thought out. A test run will greatly improve this conceptual framework. Participant A also suggests conducting in-depth case studies of schools that have a reputation of having good Eco-design and/or sustainable design programs as comparison models for the newly proposed framework.

6.5. Revisions to the Framework

The follow-up interviews suggest that the Chinese educators will be persuaded to adopt this framework if it is presented in the following ways:

- This framework will be most easily accepted if it is presented in the form of a textbook.
- The theory section of the framework (Chapter Five) is condensed; Chapter Two and Appendix H become the main part of the presentation.
- More pictorial materials should be included in the future presentation/publication of this dissertation as a textbook to educators to provide visual evidence.
- More sustainable design practice cases should be introduced.
- Practices of sustainable design education in other countries should be introduced.

6.6. Conclusion

The overall response of the proposed educational framework is positive. The respondents think this research is relevant to Chinese Industrial Design education and is important. They agree that the framework covers sufficient topics and contents in

Industrial Design engaged with sustainability.

Their main concerns are:

- How does the researcher or interested educators persuade the administrators of the educational system, educators, and students to adopt this framework?
- What extra resources does it take to implement this framework?
- How well will this framework integrate with the existing educational system?

They would like to see a test run of the framework, ideally in a newly established Industrial Design department to maximize its effectiveness.

According to the feedback from the follow-up interviews, the timeline of courses is revised as Figure 6.1. General attributes are infused into the course by constructivist pedagogical approaches. The suggested internship program is moved into the third year of the curriculum. In Appendix H, social issues are emphasized in Ecological Literacy (introduction) course.

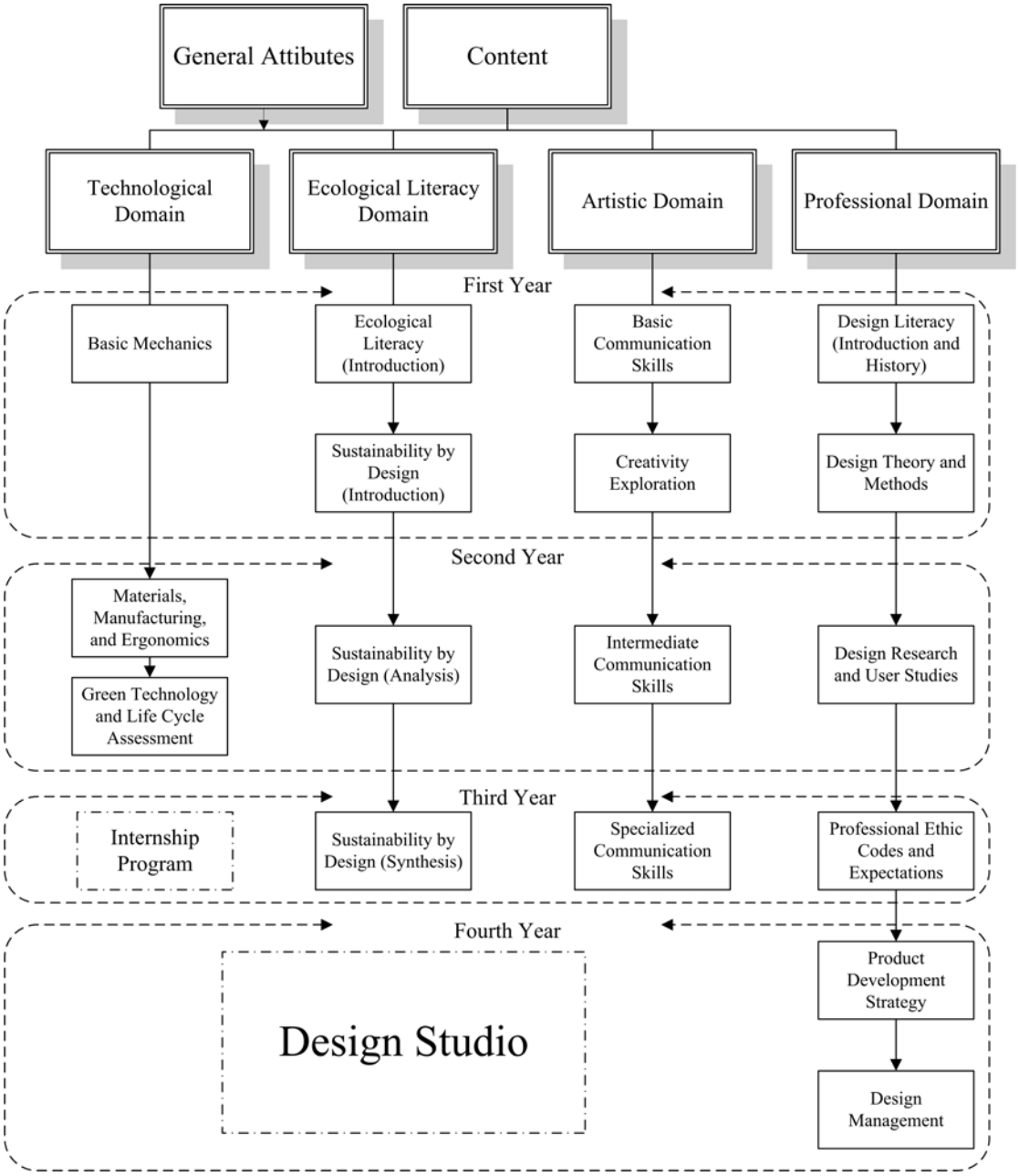

Figure 6.1 – Revised Timeline

Then the timeline and the main framework are combined as Figure 6.2. The "constraints and barriers of the current system" (as identified in Chapter Four) is shown as an element of the framework. The basic modules of courses are connected with the framework to support its superstructure. Design studio remains as a format of courses that can be used for other courses. The general attributes such as systems thinking, critical thinking, and communication skills are infused into the pedagogical approach to influence both teachers and students.

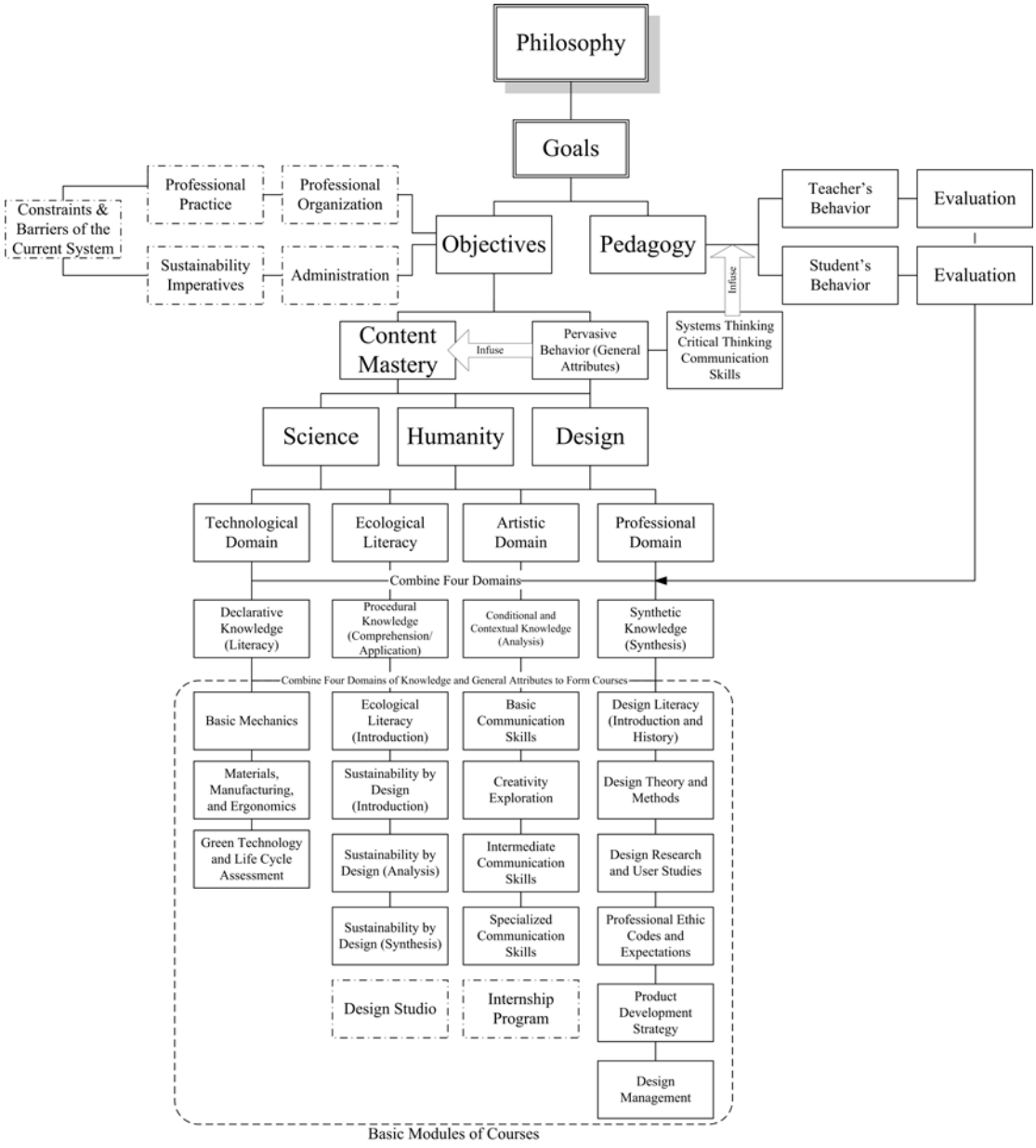

Figure 6.2 – Revised Framework

Chapter Seven: Conclusion

7.1. Answers to the Research Questions

As discussed in Chapter One, the main research question of this study is:

Can a framework be developed to reform Industrial Design education in China to comprehensively include issues of sustainability?

The sub-questions include: what efforts have been made in design education to promote engagement with issues of sustainability? What is the status of Industrial Design education in Mainland China? How would other countries' experience and practice help when reforming the Chinese design education system? When is the proper time to integrate sustainability concepts into product design education in a four-year higher education institute? What are the pedagogical methods suitable for sustainable design education? What are the barriers and constraints that must be overcome?

Chapter One states that China is developing its economy at the cost of its environment. Using sustainable design principles, Industrial Design can greatly reduce the negative environmental impacts of products thus contribute to a sustainable future. Industrial Design education at the higher education level should engage sustainability.

The researcher's observation and literature review indicate that the Industrial Design education in China is facing four major problems:

- The general structure of the educational system in China, mainly the standard test evaluation method, hinders the development of art and design education. The current K-12 education does not prepare students for a design career.

- Quantity is favored over quality in the current Chinese higher education

system.

- Chinese Industrial Design education has little instruction related to social and science subjects.

- Social and cultural structures in Mainland China provide insufficient support to design professions.

Other countries' practices on Industrial Design education are helpful to China but the status quo of the current Chinese educational system needs to be understood to provide a pragmatic and systematic solution for the reform of the Industrial Design educational system in China. Interviews of educators, students, and practitioners of the Chinese Industrial Design community were conducted in this study. One can conclude from the interview data that Industrial Design education in Mainland China has engaged sustainability concepts inadequately despite the fact that most educators have recognized the social and environmental responsibility of industrial designers. The interviews conclude that Chinese Industrial Design education is growing rapidly but it needs a comprehensive and pragmatic framework to help it overlay concepts of sustainability with the existing Industrial Design curriculum.

The interviews indicate these constraints and barriers for engaging sustainability in the current Industrial Design educational system (Table 7.1)

Table 7.1 - Barriers and Constraints

Categories	Barriers and Constraints
Social/Cultural	● Standardized tests in K-12 education ● Lack of appreciation for design as a profession ● Little social pressure or concern for the environmental impacts of design
Institutional/Administrative	● Evolved out of arts/craft tradition with little science content ● Centralized curriculum decision-making ● Slow to change curriculum ● Limited educational resources ● Limited scope
Faculty	● Lack of knowledge concerning sustainability ● Lack of training ● Too few faculty ● Lack of incentives ● Lack of references
Students	● Low quality of students ● Lack of motivation ● High school to college shock

Based on the interview data and the literature review, an educational framework is built to make suggestions to the philosophy, goals, structure, content, and pedagogical approaches of the Industrial Design curriculum in China. The study also concludes that a constructivist pedagogical approach should be most suitable for Industrial Design education. The sustainability concepts should be embedded in the curriculum as the foundation. The suggestion of the timeline of the courses was provided. The framework was then evaluated by four Chinese educators who are interested in sustainability issues.

7.2. Contribution to the Body of Knowledge

Aimed to apply Industrial Design in helping to build a more sustainable China, this dissertation builds on both literature and the reality of Chinese higher education in Industrial Design revealed by interviews of the Chinese Industrial Design community. The preliminary interviews gather thick and rich descriptions of the current educational system and its constraints and barriers for teaching sustainability.

These issues have not been examined in the past.

The interview data and literature review indicate that the Industrial Design education in Mainland China needs reform to integrate concepts of sustainability into a new educational framework. Using a systematic approach, the dissertation examines the characteristics and expectations of the Industrial Design education for a sustainably developing society. Based on literature review and interviews of the Chinese community, this dissertation presents an educational framework for this purpose shown as in Figure 7.1.

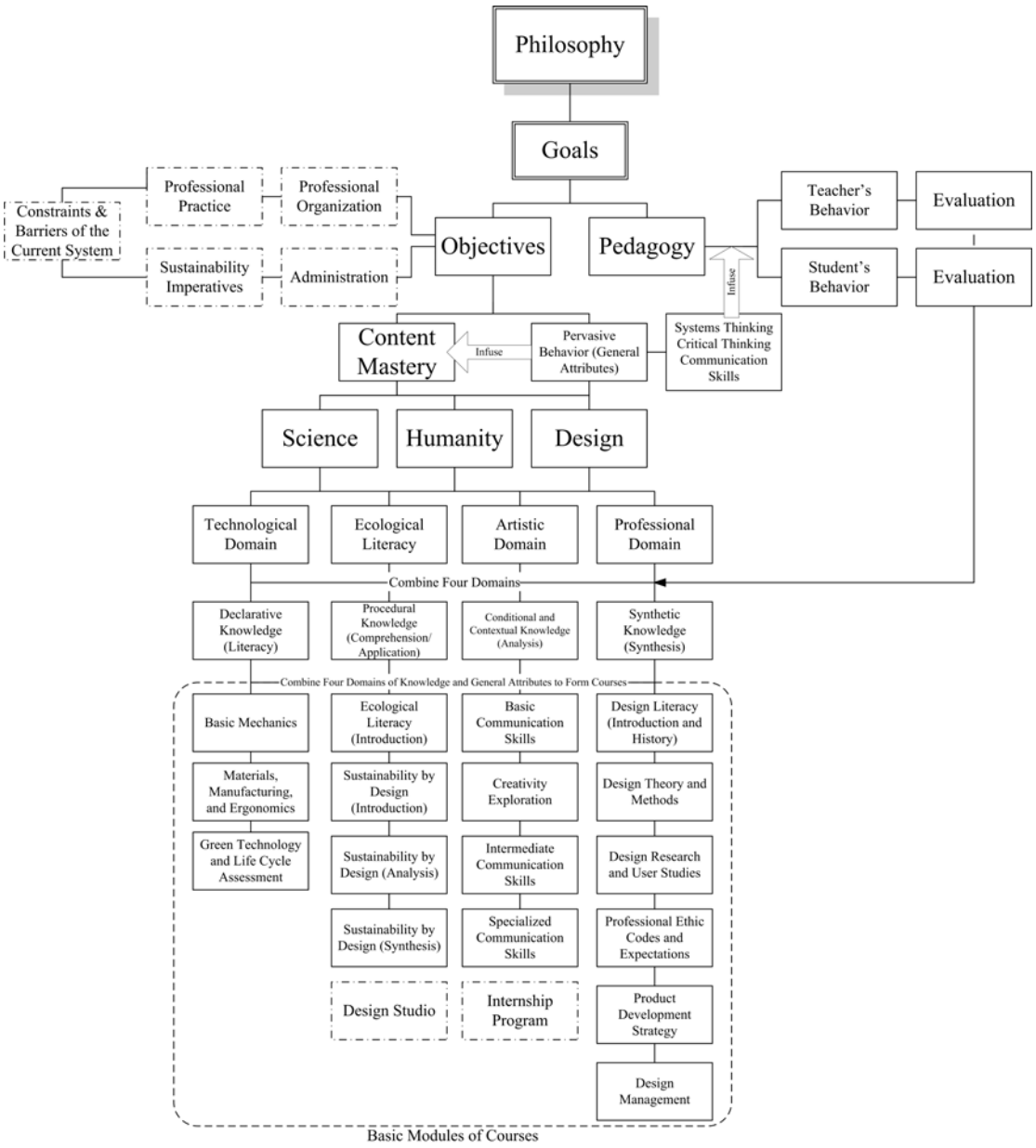

Figure 7.1 – The Overall Structure of the Proposed Framework

The proposed educational framework adopts Constructivism as the founding philosophy. The goals of the framework include the following:

- To provide instruction of curriculum building for Industrial Design educators in Mainland China according to the present and future needs of the profession.

- To provide a set of tools to teach sustainable design in Industrial Design education in a manner capable of generating justifiable responses to design

problems.

- To foster systems thinking, critical thinking, and ecological understanding among Chinese industrial designers.

- To encourage discussions about educational reform and professional ethics in the Chinese Industrial Design community.

Using the industry's requirements for designers, the requirements summarized by the professional organizations, the requirements from the Chinese administration, and the sustainability imperatives for design education as references and boundary, and based on the literature, the framework suggests that the Industrial Design education needs a systematic reform. The content of the curriculum contains three cultures and four domains of knowledge. Also based on the hierarchy of learning process, the framework suggests that the knowledge involved in the Industrial Design education can be categorized as four types of knowledge, each of which should be taken into consideration when planning the timeline of the courses so as to cultivate all levels of skills. The framework insists on building an ecological literacy as a part of the foundation of Industrial Design education that is apparently absent in the current higher educational system for Industrial Designers in China.

The framework also suggests using constructivist and critical pedagogy and that the classroom setting should be mainly student-centered in the senior years to cultivate critical thinking. In the classroom, problem-based and project-based learning should be the main pedagogical approaches.

7.3. **Evaluation of the Research and Continuance**

The follow-up interviews presented the proposed framework to four Chinese educators for evaluation. The interviewees agreed that this research is timely and important. Their concerns about the framework concentrated on the barriers of implementation:

- How does the researcher or interested educators persuade the administrators of the educational system, educators, and students to adopt this framework?
- What extra resources does it take to implement this framework?
- How well will this framework integrate with the existing educational system?

Apparently, Chinese educators are concerned more about the application of the framework than its structure or content.

For the continuance of the research, an ethnography[50] study will greatly improve this study because it will examine the rooted cultural elements behind the design phenomenon to reveal other cultural benefits and barriers in promoting sustainable design in Chinese society.

7.4. Limitations of the Research

7.4.1. Applicability

This dissertation will be most useful for Industrial Design educators and educational decision makers in Mainland China when considering a timely and important reform of Industrial Design educational system. And it also helps educators in other countries when facing the same issue. It can also be referenced by other disciplines in the design field and other countries seeking to develop a sustainable design education curriculum especially in developing countries.

The research results might not be applied to every ethnic group or every region in Mainland China. To untrained eyes, Mainland China seems to have a mono culture while in fact, Chinese culture has distinct regional differences. This is reflected in the Chinese market and hence the requirements for Industrial Designers.

[50] *Ethnography* literally means writing about the way of life, or culture, of social groups. It involves the researchers inserting themselves into the natural setting of the social group being studied and participating in and observing their daily activities. The purpose of such research is to describe the culture and life style of the group of people being studied in a way that is as faithful as possible to the way they see it themselves and to the social contexts in which their behavior occurs (McNeill & Chapman, 2005).

The proposed framework is designed to have the flexibility to be adjusted according to local needs because the content of the courses cover many local design issues. The dissertation deliberately only suggests key issues for each course so the educators have the liberty to increase the capacities of the courses to best suit their needs (See Appendix H for course suggestions).

7.4.2. Scope

Sustainability has rich context. This research only focuses on the parts that influence the Industrial Design process. Other design disciplines, such as architecture, might have different educational goals than those of this framework, even on sustainability related courses. This is due to the differences of disciplines. In addition, because the practice and research of sustainable design and the discipline of Industrial Design are all developing rapidly, the content of this framework might need constant updates to better reflect the needs of the discipline.

7.4.3. Reference

Chinese design and design education have distinct cultural characteristics. Western pedagogy and educational practices might not be completely applicable to China. Since there is little literature on sustainable design education written by Chinese researchers, this dissertation uses mostly Western literature and practices of sustainable design to build the framework. Even after careful adjustment in this framework, these references might still be distance from the reality in Mainland China. For instance, the textbooks suggested in the Appendix H are mostly in English. This requires the educators conducting these courses to be fluent in English. Before a textbook on sustainable design education in Chinese is published, Chinese educators should consider using shorter articles and local publications for their courses if they cannot obtain the Chinese version of other textbooks.

7.4.4. Implementation

The purpose of this dissertation is to start a discussion of sustainable design education in Chinese design community and persuade educators to employ part of or the entire framework and gradually evaluate its effectiveness. At this moment, the researcher is not in a position to implement this framework in any Chinese university to validate it. The researcher's responsibility is to provide research results based on literature review, observation, and interview data for decision making. However, the researcher is currently not involved in the decision making process for Chinese higher education or affiliated with any Chinese university. Thus, it is impossible to validate this framework by implementation before the dissertation is submitted. Furthermore, an educational system takes a relatively long period of time to show its influence on the students and the profession. And this influence is difficult to measure quantitatively.

7.5. Final Remarks

As a comprehensive and practical guide, this framework will be helpful for many educators who are eager to change the educational landscape for sustainability. The researcher is working with Chinese Industrial Design educators who are interested in implementing the framework to publish part of this study in Chinese as a handbook style textbook.

7.6. Acknowledgement

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Appendix A: Qualifications for Undergraduate Industrial Design Education from the National Instructive Committee of Industrial Design Education (China)

Instituted by the National Instructive Committee of Industrial Design Education (China) in Sep.26th, 2001

1. Principles

1.1. This document is instituted according to the Qualifications for Undergraduate Disciplines in Higher Education Institutions and the Plan for Industrial Design Undergraduate Education issued by the Ministry of Education of PRC.

1.2. The qualifications include three parts: faculty and facility, educational resource, and curriculum.

1.3. This document is a general guideline for Industrial Design departments.

2. Terms

2.1. Faculty and Facility

2.1.1. According to the guidelines by the Ministry of Education, the ideal number for every class in Industrial Design department should be around 25 students. The ratio between teachers and students should be 1:8.

2.1.2. There should be adequate faculty members who can assume at least 80% of the teaching duty of the core courses. Adjunct faculty number cannot exceed 20% of the faculty.

2.1.3. Core faculty should have training professionally or have ample practicing experience.

2.1.4. Every class should have at least 2 faculty members for core courses. At least 30% of the faculty members should be associate professors or above.

2.1.5. There should be at least 10 faculty members, among whom at least one professor, two associate professors.

2.1.6. The department should have research capacity and facility.

2.1.7. The college should have relevant disciplines such as arts and mechanics to support Industrial Design.

2.1.8. The department should have full time management personnel.

2.2. Educational Resource

2.2.1. Classrooms

The department must have studio, multimedia, art studio, and model making classrooms and workshops.

2.2.2. Library resource

- Have more than 3,000 books relevant to design
- Have more than 50 Chinese and 15 foreign magazines relevant to design.
- Have relevant slides and videos.

2.2.3. Workshops

The department must have computer labs, photography and model making workshops.

2.3. Curriculum

2.3.1. The department must comply with the basic requirements for undergraduate education issued by the Ministry of Education and have workable curriculum, course plans, teaching archives, and teaching management.

2.3.2. Core courses should at least include:

- Design conspectus
- Ergonomics
- Design History
- Computer Aided Product Design
- Design foundation
- Product design and theory
- Industrial Design engineering basics
- Design expression
- Hands-on projects

3. Evaluation

The committee will evaluate every Industrial Design department on occasion.

Appendix B: A Survey of Current Industrial Design Curricula

Industrial design established itself as a discipline in the Bauhaus. Almost every design department and school in the world has adopted the Bauhaus model to build its curriculum. Though it is impossible to include curriculum in every school to illustrate the knowledge-building sequence in this exam, here is a list of curricula of randomly selected Industrial (Product) Design departments:

Table B.1. Survey of Curricula

Central Saint Martin College of Art and Design, London	
Year 1 Exploration and Self-Development:	Students' growing technical and creative skills are put into context by developing an understanding of how people react to everyday objects and their environment and through visits to manufacturers and design studios.
Year 2 Integration and Realization:	Here emphasis is placed on a range of product design issues, which encourage the students to realize a series of design outcomes. Visiting speakers are invited to relate their professional experience, giving the students insights into the product design industry. Towards the end of the year there is period of reflection which allows the students to review their future aspirations and to determine how they would best use the remainder of the course. This is achieved by developing a Personal Career Plan. The intention is that from this point forward the students will take more responsibility for initiating, directing, and managing your own learning. The year culminates in a self-initiated project.
Year 3 Self-Directed and Professional Practice:	This comprises three projects which bring together the core skills, knowledge, and understandings the students have developed in the previous two years of the program. The course team look to identify a series of mentors from industry relevant to the design activities the students are undertaking in their Self-Initiated projects. These mentors provide students with an objective viewpoint and impart their specialist knowledge and understanding of the subject area. This is particularly useful if the students are working in a new or emerging area. The students will also be asked to complete a Context and Rationale Paper to support their Self-Initiated Project, and will produce a theoretical analysis supported by Cultural Studies which may be associated with it. The summer term provides the opportunity to experience professional practice with Client Projects that embrace a range of different activities from corporate design strategies through to mainstream product design.

Table B.1. continued

Art Center of Design, Pasadena, CA	
First Year (Foundation Terms)	● Development of form ● Design 1 ● Model Construction ● Visual communication ● Perspective ● English composition ● Product design 1 ● Transportation design 1 ● Digital Design ● Introduction to modernism
Second Year (Transition Terms)	● Product design 2 ● Model Construction ● Visual communication ● 3D object modeling ● History of Industrial design ● Art of Research ● Transportation design 2 ● Environmental Design ● ID graphics ● Solid modeling ● Theory of structure
Third Year (Advanced Terms)	● Adv. Product design ● ID graphics ● Design management ● Visual communication ● Designer math ● Human factors
Fourth Year (Advanced Terms)	● Adv. Product design ● ID research ● Design management ● Portfolio ● Materials & methods ● Electives

Table B.1. continues on the next page.

Table B.1. continued.

Auburn University, College of Architecture, Design, and Construction, Alabama	
First Year	• Introduction to design • History • English • Math • Science core • Fine arts core • Free elective
Second Year	• 2-D Industrial Design principles • Rendering • Computer • Science core • 3-D Industrial Design principles • Anthropology • Industrial Design history • Social science core
Third Year	● Exhibition/package ● Methods ● Photography for ID ● Philosophy core ● Product design ● Materials ● Advanced computer ● Social science core
Fourth Year	● Adv. Product design ● Professional portfolio ● World literature ● Thesis ● Professional practice

Table B.1. continues on the next page.

Table B.1. continued.

Rhode Island School of Design, Department of Industrial Design	
First Year	Foundation Studies: • Foundation Drawing • Two-Dimensional Design • Three-Dimensional Design • English Composition + Literature • Art + Architectural History • Topics in Art History
Second Year	• Metal I • Wood I • Design Principles • Presentation I • Wood II or Metal II • History of Industrial Design • Liberal Arts
Third year	• Advanced Design Studio • Manufacturing Techniques • Presentation II or CAD • Non-Major Electives • Liberal Arts
Fourth year	• Advanced Design Studio • Non-Major Electives • Liberal Arts
Fifth year	• Industrial Design Studio • ID Graduate Studio • Degree Project • Legal and Business Practice • Major Elective • Liberal Arts

Table B.1. continues on the next page.

Table B.1. continued.

Takushoku University, School of Engineering, Japan	
First Year	• Introduction to Industrial Design • Design basics • Mechanical drawing • Psychology in design • Design sketch • Environmental design drawing
Second Year	• Design history • Design representation • Color theory • Ergonomics • Visual design • Sociology • Form and perception • Product strategy
Third Year	• Design and society • Materials • Design analysis • Japanese design • Cooperation identity • Cultural elements in design • Visual arts
Fourth Year	• Semeiology • Senior Projects
University of Technology Sydney, The Faculty of Design, Architecture and Building, Australia	
First Year	• Aesthetics in Industrial Design • Understanding Three-dimensional Form • Industrial Design Communications • Researching Design History • Problem Solving in Industrial Design • Industrial Design Digital Communication • Informing Industrial Design • Researching Design Processes

Table B.1. continues on the next page.

Table B.1. continued.

Second Year	• Computer-aided Industrial Design • Structure, Form and Material in Industrial Design • Ergonomics and Industrial Design • Material Manipulation • Sustainability and Design • Electives Select one subject from the following: • Design Futures: Creative Technologies • Design Futures: Sustainable Lifestyles • Design Arguments: Making Theories • Design Differences: Intercultural Asia • Theories of Change • Design Arguments: Critical Judgments • Design Differences: Other Identities • Interdisciplinary Project
Third Year	• Industrial Design Directions • Product Technology • Ecodesign Practice • Industrial Design Theory • Industrial Design Professional Communication Select one subject from the above list.
Fourth Year	• Industrial Design Project 700A • Industrial Design Professional Practice • Research Dissertation ID • Major Project ID Select one subject from the above list.
Carleton University, School of Industrial Design, Canada	
First Year	• Introduction to Economics • Introductory Psychology • Elementary Calculus • Elementary Algebra • Physics • Introduction to Industrial Design • Industrial Design Analysis • Projects I (studio)

Table B.1. continues on the next page.

Table B.1. continued.

Second Year	• Perception • Mass Production Technology • Computer Applications • Form and Color • Projects II (studio) • Ergonomics • Electives
Third Year	• Marketing • Projects III (studio) • Contextual Nature of Products • Industrial Design & the User • Professional Practice • Electives
Fourth Year	• Seminar • Major & Minor Projects IV (studio) • Internship • Electives
Tongji University, Architecture and Design School, Shanghai, PRC[1]	
First Year	• Design Basics • Art • Descriptive geometry • Introduction to design
Second Year	• Design mechanics • Product design theory • Ergonomics • Materials and technology
Third Year	• Architecture theory • Interior design theory • Structure in decoration design
Fourth Year	• Visual communication theory • Design history • Environmental design theory • Engineering theory • Value engineering
Fifth Year	• Automobile design • Webpage design • CAD • Thesis and senior projects

Table B.1. continued.

[1] Tongji University requires their Industrial Design students to take two years of courses with architecture students.

Tsinghua University (Combined with former Central Academy of Art and Design of PRC)	
First Year	• Color design basics • Perspective and design sketch • Graphic design • Mechanical drawing
Second Year	• Form design basics • 3D design expression • Engineering basics • Industrial Design theory • Design thinking • Manufacture basics • Product design basics • Modeling and rendering
Third Year	• Practice in manufacturing techniques • Design methods and procedure • Advance modeling and rendering • Ergonomics • Survey methods in design • Product refinement • Creative product design • Multimedia visual communication • Professional skills in design
Fourth Year	• Creative product design (studio) • Product color study • Systems design • Product planning and strategy • Senior project
WuHan University of Technology, PRC	
First Year	• Design sketch • Material and technology • Structure sketching • Art theory
Second Year	• Color design • Form basics • Product surface treatment • Rendering • Product forms • Mechanical drawing • Industrial Design theory

Table B.1. continues on the next page.

Table B.1. continued.

Third Year	• Modeling • Practice in manufacturing techniques • Multimedia visual communication • Design procedure and manufacturing • Ergonomics • Product design studio • Product planning • Design management
Fourth Year	• Product color design • Senior projects
Beijing Institute of Arts and Design, Beijing, PRC	
Common Requirements Module	• Introduction to design • Chinese composition • Art appreciation • Computer basics
Technical Skills Module	• Form design • Natural forms analysis • Color in design • Visual communication • Design sketch • Computer aided design • Modeling • Rapid prototyping and manufacturing technology
Creativity Module	• 3D object design • Ergonomics and interaction design • Engineering basics • Life study • Materials
Design Skills Module	• Design basics • Commercial design • Design project • Senior projects
Electives	• Legislations and professional code • Photography • Furniture design • Interior design • Multimedia design • Exhibition design

Table B.1. continues on the next page.

Table B.1. continued.

The Hong Kong Polytechnic University, School of Design, Hong Kong, PRC	
Compulsory Courses	• Introduction to design: Designing for people • Visualization skills: visualization and model making • Visualization skills: digital visualization: rendering & modeling • Design studio: design to be made • Design studio: design for leisure • Design studio: Chinese design • Design studio: design for Asian homes • Design studio: interaction design • Design studio: personal technologies • Professional practice • Independent study • Final projects
Electives	• Soft goods • Houseware • Fashion accessories • Public facility and street furniture design • Toy design • Interactive spaces / Interactive play • Asian/Europe/USA study trip • Personal transport • Product identity and product branding • Sustainable product design

Note:

- This list does not include all required nonmajor courses.
- The information was derived from departmental websites and course information packages. Actual courses might vary. The actual contents of courses under the same title might vary in different schools.

Appendix C: Information of the Universities Where the Research Was Conducted

Interviews were conducted in 4 universities. The profiles of these universities are summarized as below in an alphabetical order by their locations.

- **The University of Science and Technology Beijing**

University Basics: as one of the largest and most prestigious universities in China, this university is ranked as No.22 in the ranking of Chinese universities by online surveys done by www.netbig.com[2] in 2005. It receives large amount of financial support from the government each year (exceeds ten million dollars per year), a common practice in prestigious universities in Mainland China.

Department Basics: though its Industrial Design department has been established for only four years, it can already grant Master of Science degree. There are about 5 faculty members within the department. One of the teachers is currently working on her doctoral degree in Tsinghua University. Others all have Master's degrees. According to a former teacher in this department who is now residing in the United States, this university is among the most supported universities (both financially and politically) in Mainland China, thus it is much easier to establish a new department and improve its status within relatively short period of time compared to other universities.

Participants: a group interview of about 30 juniors was conducted in the time slot of a class.

- **Beijing College of Arts and Design**

University Basics: the school is the only professional art and design school at the higher education level in Beijing. Similar to many schools in Mainland China that mainly provide

[2] Ranking of universities is conducted by several different agencies by different methods in China every year. The Bureau of Education does not authenticate any of them. Because the information of university performance is not transparent to the public, any ranking might be based on limited information and rather rough. In this case, larger universities usually has the advantage since they have more funding and research projects.

professional training, it could only grant associate Bachelor's degree until two years ago when they were accredited to grant Bachelor's degree in design. The interviewees in this college represent a large proportion of Industrial Design students and teachers in China because there are a great number of small professional schools and private institutes offer Industrial Design courses. The school was established in the early 1950s. It has a long history of providing designers for local business.

Department Basics: Industrial Design department of this school is among the first Industrial Design departments to be established in the late 70s in China.

Participants: 4 interviews of undergraduate students and 5 interviews of teachers in Beijing Institute of Art and Design were conducted in this university.

- **Beijing Institute of Technology**

University Basics: this university is where I received my undergraduate education. It was established in the early 1950s and is among the largest comprehensive universities in China. It used to pertain to the military and still has close connection with Chinese national weapon manufacturers. Their Industrial Design department has worked on many military/government projects.

Department Basics: Industrial Design department of this school is among the first Industrial Design departments to be established in the late 70s in China.

Participants: Professor Nairen Zhang, the dean of the College of Design; Professor Hong Zhuang, the director of Environmental Design department.

- **Guang Dong University of Technology (Guang Dong Province)**

University Basics: this was the university that I worked for before I came to the United States. It has the largest undergraduates' body in Guang Dong province.

Department Basics: the Design School was founded in 2005, which consists of departments

of Industrial Design, Decoration Design, and Fashion Design. The former chair of the Industrial Design department, Professor Yang, became the dean of the School. There are currently 5 faculty members within the Industrial Design department. This School is working actively with the local business community and government. The department offers Bachelor of Science degrees.

Participants: Informal interviews were conducted.

- **Guangzhou Academy of Arts (Guang Dong Province)**

University Basics: this academy is known as the best design school in Southern China. The design college has departments of Industrial Design, Architecture and Environmental Design, Fashion Design, Design Arts, Graphic Design, Digital Arts, and Decoration Design.

Department Basics: the Industrial Design department of this academy, founded in the late 1970s, is among the first Industrial Design departments in China. The original Industrial Design department now has split into two departments: Industrial Design and Design & Arts, with the later one emphasizes more on design theories instead of specific design skills.

Participants: Professor Shu Feng, the director of Design & Arts department; one graduate student and one junior faculty member.

- **The Hong Kong Polytechnic University**

University Basics: known for its close connection with local business and global outlook, Hong Kong Polytechnic (PolyU) is the sole provider of design education at tertiary level in Hong Kong. It recently hired Professor Loraine Justice, who is the former director of the Industrial Design program in Georgia Tech, as the chair of their School of Design. After its inception in 1964, the School of Design has groomed thousands of graduates and many famous designers of various disciplines.[3]

[3] Information from Hong Kong Polytechnic website.

Department Basics: Industrial Design department has a faculty that consists of educators from all over the world and local educators with oversea experiences.

Participants: Professor Benny Leong, who was the coordinator of the workshop touring Mainland China titled "Sustainable Design" with Professor Ezio Manzini from Milan Polytechnic University and also the director of "Green Design" and "Sustainable Design" courses in Hong Kong Polytechnic.

- **Sichuan University (Sichuan Province)**

University Basics: this university is ranked as No.18 on the ranking of Mainland Chinese universities in 2005. It umbrellas several universities and colleges based in Chendu, the capital city of Sichuan province. To support this newly formed university, the government granted it new land to develop an entirely new campus.[4]

Department Basics: the university has a design school that includes Graphic Design, Digital Design, and Interior Design departments but no Industrial Design department. The faculty of the school is actively working towards building an Industrial Design department.

Participants: about fifty students and teachers attended the lecture.

[4] In recent reform of higher education, several gigantic comprehensive universities have been formed in a similar way of Sichuan University: merging several local colleges into a "new" university. A few large university such as Tsinghua University also merged with smaller and specialized colleges such as Central Academy of Arts and Design. Freshmen and sophomore year students are usually living on the new campus, while older students stay in the original campuses.

Appendix D: *ECOLOGY BY DESIGN* Syllabus by Professor Benny Leong

Phase II Discipline Specific Brief (Industrial Design)

Level 3, Year 2, BA(Hons) in Design 2004/05,
Duration: Week 4–8 (5 weeks)
Tutors: Benny Ding Leong, Roger Ball

Objectives

To explore product design in terms of ecological and sustainable design thinking
To broaden the student's conception of product design in terms manufacturing and eco-designing
To enrich the student's experience in hands on design practice
To address the practice of portfolio building

Project

You are required to develop and design an eco-friendly product from one of the 'Sustainable Solutions' that you or your peers had proposed in the phase I of this subject.
(Hereunder is a list of product ideas for you to select if you could not identify any product idea from the phase I Solutions at all:)

Food Preparation
- Health soup package
- Shopping bag/cart
- Lunchbox

Clothing care
- bathroom/ shower steamer for wrinkled clothing
- Ultrasonic stain pen
- out of season clothing storage

Work at Home
- digital presentation tool for distant meeting
- multi-purpose mini work surface/ desk
- paper shatter (designed to encourage reuse of paper)

Product should be developed and designed for service providers to rent and lease to the end users, or purchased by a group of end users (which formed a small community) to be shared.

Expected Outputs

1. research of manufacturing process and eco-materials
2. documentation of research analysis
3. design development sketches and drawings
4. final dummy of the selected design
5. exploded, assembling drawings and rendering of the final design
6. a well organised portfolio with all the outcomes specified above.

Schedule

Time		**seminars/ work studios / tutorials**
week 4	day 1 project briefing (product idea confirmation)	tutorial
	day 2- initial design	seminar 1+ tutorial: “concept of 3rs and DfDs”
week 5	day 1- design development	seminar 2+ work studio: interaction design
	day 2- design development & finalization	seminar 3+ tutorial: plastic parts design & ‘eco-materials’
week 6	day 1- design finalization + mock-ups making	work studio: drwg. presentation + portfolio building tutorial
	day 2- models / dummy making	
week 7	day 1- dummy making & presentation drawings	tutorial (optional)
week 7	day 2- dummy making & presentation preparation	
week 8	day 1- final critique / presentation	
	day 2- submission of portfolio	

Assessment Criteria

- Identification of the problem and research of manufacturing and eco-materials
- Evidence of design development (e.g. sketches, mockups, etc.)
- Demonstration of potential ecological benefit of the design
- Creativity & conceptual clarity of design
- Level of professional finish in final design
- Level of professionalism in design presentation & design folio
- Time management, motivation and class participation

Appendix E: Project Brief of course of Strategies for Sustainable Product Design by the School of Design, Hong Kong Polytechnic University

Project: **Green storage**

"Sunhing Design Award" sponsored by Sunhing Millennium Ltd.

Duration: 5 weeks

Tutor: Benny Ding Leong

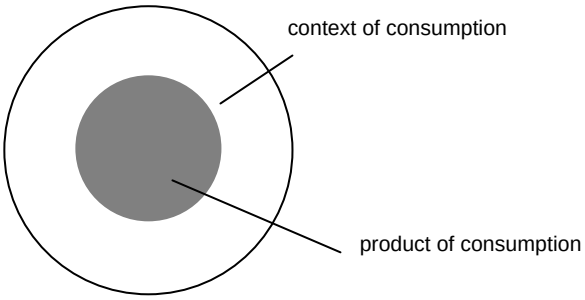
Guest tutors: Product Development team (Sunhing Millennium Ltd.)

Introduction

The practice of 'Design for Environmental'(DfE) in the field of industrial design has been evolving rapidly in the last 3 decades. From the end-of-pipe design approaches of 'Repair' and 'Refine' [(1)] to the strategic end of 'Redesign' and finally 'Rethink' [(2)] (the 4Rs), the development of DfE gradually engender the concept and practice of Sustainable Product Design quite recently. Unlike Ecodesign [(3)] Sustainable Product Design integrates social and ethical aspects of the product's life-cycle alongside environmental and economic consideration. In a word, Sustainable Product Design requires holistic design consideration from the outskirt of 'context of consumption' to the centre core of 'product of consumption' (see fig. 1 below).

In your 2nd year studies, you have learned the concept of ecological design and green design. And now for this project, you will be introduced to the concept of strategic thinking, the 3 dimensions ('social', 'cultural' & 'economic') of 'context of consumption' and the three DfD strategies ('Design for Disposal', 'Design for Disassembling' and 'Design for Durability') of 'product of consumption' on sustainable product design by means of a sponsored design competition.

Figure E.1 The scope of Sustainable Product Design



Notes:

- *'Repair' approach focus on existing / end-of-pipe product modification whilst 'Refine' approach emphasis the design of eco-efficient products.*

- *'Redesign' approach move towards the application of advance technologies and materials to produce that products that meet consumers' needs with greatly reduced environmental impact. When 'Rethink' is considered as a more radical approach that require new breakthroughs leading to alternative ways of living and the shift of consumption of physical 'products' to 'services'.*

- *'Ecodesign' (one of the very well developed design practice under the generic concept of DfE) "aims to integrate environmental considerations into product design and development. It involves life-cycle thinking, which overall goal is to minimize the consumption of natural resources and energy and the consequent impact on the environment.*

Objective

To introduce concept of Sustainable Product Design and its strategies

To reinforce knowledge of materials and manufacturing processes (with a particular focus on eco-design)

To provide opportunity for polishing design skills in a simulated industrial project

Project brief

You are requested to look into an existing ‘storage’ (e.g. CD/ DVD rack, wine rack, stationary rack, etc.) on the market and redesign it with the emphasis on the ‘economic’ aspect of ‘context of consumption’ and the exploration of one of the DfD strategies.

You are advised to employed the following design/ ecodesign method / tools which will be introduced within this subject:

- Eco-Indicator – a simplified product Life-Cycle Analysis (LCA) tool for designer
- Ecodesign strategic matrix – for the selection of ecodesign strategy
- Scenario building – for designs verification and consolidation

Assessment Elements

Assessment will be based on the following:

Project work (design work)	60%
Participation, and overall design presentation	25%
Group interaction and final presentation	15%

Schedule

Wk 1: day 1 Project briefing

Seminar 1: “the design, making and marketing of Sunhing” (by Elaine Chow)

Identification of existing product and target user

day 2 Seminar 2: “the concept of Strategy & the SD strategies” project tutorial

Wk 2: day 1 Seminar 3: “the concept of DfDs the introduction of Eco-indicator”

day 2 Seminar 4: “Introduction of eco-materials” project tutorial

Wk 3: day 1 Project tutorial

day 2 Project tutorial

Wk 4: day 1 Project tutorial

day 2 Optional tutorial

Wk 5: day 2 **Final presentation for the “Sunhing Design Award”**

Wk 6 **submission of project folder**

Submission of Works

You have to submit the following for final assessment:

1) A3 Folder which include:

   a) design sketches / drawings

   b) research findings (e.g. materials, assembling/ disassembling methods, manufacturing process)

   c) product design analysis (eco-design strategic matrix) and context design analysis

   d) technical drawings (e.g. G.A., exploded view, sectional views)

   e) digital color rendering - which help to visualize and illustrate necessary details of the final design

2) 3D mock-ups

Reference:

1) M. Charter and U. Tischner, *Sustainable Solutions: Developing Products and Services for the Future*, Greenleaf Publishing Ltd., UK., 2001.

2) H. Lewis & J. Gertsakis, *Design + Enviroment: a global guide to designing greener goods*, Greenleaf Publishing Ltd., UK., 2001.

3) W. McDonough & M. Braungart, *Cradle to Cradle: Remaking the Way We Make Things*, North Point Press, New York, 2002.

4) Leong, B.D. (2002) How can the concept of "System-Product Design" redirect contemporary ecodesign practice? International Conference on Eco-design New Delhi, India.

5) Leong, B.D. (2002a) *How will the Concept of 'Design for Sustainability' Revive Industrial Design Practice in China and the Rest of the World?* The 1st China-USA Joint International Conference on Design Education, Beijing, 2002

6) Leong, B.D. (2002b), *The investigation of Localization of DfS and its Implication to Industrial Design Education in China.* 2002 National Industrial Design Education Symposium, Changsha, Hunan, China 2002.

7) Leong B. D. (2001), *The Promotion of Design for Sustainability in China*, (paper unpublished) UNEP workshop on Sustainable Consumption for Asia Pacific, August, Kuala Lumpur, Malaysia, Aug. 2001.

8) Manzini, E., Leong, B. D. (2001), *Strategic Design and design for Sustainability. A general overview and some consideration in the Chinese context*, Tsinghua 2001 China International design Forum, Beijing, June 2001 (paper to be published)

www.dfschinanet.org - *Chinese Network on DFS*: DfS cases & examples both from research & design workshops

www.ecosite.co.uk - *Ecosite*: website for data, software, news and case studies on LCA

www.plasticsresource.com/recycling - *Plastic Resource*: website of the American Plastics Council, a directory of recyclers, products and general information.

www.http://grn.com - Global Recycling Network: for company directories, prices, publications and news.

Prepared by Benny Ding Leong 03.11.2003

Appendix F: Consent Form

VIRGINIA POLYTECHNIC AND STATE UNIVERSITY

Informed Consent for Participants

In Research Projects Involving Human Subjects

Title of Project: Recreating Product Design Education in China with Sustainability

Investigators: Tao Huang

Advisor: Dr. James Jones

I. Purpose of this Research

The purpose of this study is to construct a product design educational framework for China with sustainability. Researcher will interview educators, practitioners, and students in product design field from China and the United States for their perspectives of sustainable design in order to create a realistic framework. United States has begun to introduce sustainability issues into product design practice and education more than three decades ago. Educational practice in the States would be beneficial to China to help it begin to construct curricula engaged sustainability concepts.

II. Procedures

Each member of the research group will conduct a one-on-one interview with one participant. Each interview will last for one hour with each participant. The interviews will take place in an environment that is agreed upon and comfortable to both participant and researcher, and is guaranteed to protect the participant's privacy. Each interview will be tape-recorded, and transcribed by the research member who conducted the interview. Transcripts of interviews will be coded to identify emerging themes. Information collected from educators will be open to public. All information collected from all students and practitioners will be confidential.

III. Risks

Participants in interviews will be asked to describe their experiences in education or practice. These experiences will involve interactions with other human subjects, which sometimes might be described as being unpleasant. This could possibly cause feelings of discomfort if an unpleasant or a private experience is being described. Participants might also feel embarrassed or confused while encountering unfamiliar subjects emerged from the questions. Participants in class activities might feel stressed caused by new pedagogical approaches and time pressure of the activities. Researchers promise to take all possible measures to eliminate these minimal risks during the

course of the study. Researcher promises to provide adequate information of the subject of research. Participants will have full freedom to stop the interview or withdraw from the study at any point. Each participant will have full access to his/her case of the study as well as the opportunity to provide feedback to the research group.

IV. Benefits

Participants participating in this study will benefit from the opportunity of reflecting upon their personal experiences with sustainable design. They might evaluate their perspectives and knowledge with the subject. Educators might benefit from the findings of this study by utilizing them to modify their curricula. It is expected that this will increase the awareness and knowledge level of sustainable design for the participants. No promise or guarantees of benefits are offered from the researcher to any of the participants.

V. Confidentiality and Anonymity

Educators who participate in this study are public figures working in public arena. Thus, the educators will be identified unless the educator requests to remain anonymous. The information collected from all students and practitioners will be confidential. All interviews will be tape-recorded, and the tapes will be considered a primary data source. Tapes and transcriptions of interviews and journal entries will be stored in secure locations by the research group. Those materials that are confidential will only be accessible to the researcher and her advisors. Tapes and transcriptions will be destroyed when research involving these items is deemed complete by the researcher.

The researcher will be forced to break confidentiality if any abuse incidents are known or strongly suspected or if the participant is believed to be a threat to himself/herself or others.

VI. Compensation

The participants will receive no compensation for their participation in this study.

If members of the research group determine that the participant should seek counseling or medical treatment, a list of local services will be provided.

VII. Freedom to Withdraw

Participants will have full freedom to stop the interview or withdraw from the study at any point without penalty. Participants are free not to answer any interview questions that they choose.

There may be situations where the investigator may determine that a participant should not continue to be involved in the study.

VIII. Approval of Research

This research project has been approved, as required, by the Institutional Review Board for Research Involving Human Subjects at Virginia Polytechnic and State University.

IRB Approval Date: 4-28-2005
IRB Approval Expiration Date: 4-28-2006

IX. Subject's Responsibilities

I voluntarily agree to participate in this study. I have the following responsibilities:
1. To participate in a one-hour one-on-one interview.
2. Provide feedback to the research group as needed.

X. Subject Permission

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:
_____Date _____
Subject Signature

Should I have any questions about this research or its conduct, I may contact:

- Investigator(s) Telephone/E-mail:

Tao Huang taohuang@vt.edu 1- (540)-232-2253

- Advisor Telephone/E-mail:

Dr. James Jones jajone10@vt.edu 1- (540)-231-7647

Departmental Reviewer/ Department Head Telephone/e-mail:

_____

Chair, IRB Telephone/e-mail:

_David M. Moore moored@vt.edu 1-540-231-4991

Subjects must be given a complete copy (or duplicate original) of the signed Informed Consent.

Appendix G: Invitation Letters for Participation

Dear XXX,

I will like to invite you to participate in our study titled: “Recreating Industrial Design Education in Mainland China for Sustainability”.

Sustainable design is referred to as a series of design philosophy and methods with the purpose of reducing or even eliminating environmentally destructive impacts of products. The need for teaching and training of the new generation of designers about sustainable design is clear and pressing. Design professions are fast growing in China. However, design education is still, on the whole, dominated by the western modernist design education theories which were developed by Bauhaus since 1920. To achieve the goal of sustainable development, we have to pay special attentions to Chinese product design education because Chinese industries have to satisfy the enormous internal needs of China while export billions of products oversea every year.

The purpose of this study is to construct a product design educational framework for Mainland China for sustainability. Researcher will interview educators, practitioners, and students in Industrial Design field from China for their perspectives of sustainable design in order to create a realistic framework.

For the interviews, researcher will identify a sample of approximately twenty full-time Chinese educators who are teaching in Industrial Design. A sample of no more than fifty students and practitioners will be chosen as well. Samples will be selected in different cities and different types of universities to represent a diverse population. The study will address the following research questions:

1.What efforts have been made in design education to improve sustainable design education?

2.How do educators properly integrate sustainability concepts into product design education in a four-year higher education institute?

3.What are the pedagogical methods suitable for sustainable product design education?

Participants in interviews will be asked to describe their experiences in education or practice. These experiences will involve interactions with other human subjects, which sometimes might be described as being unpleasant. This could possibly cause feelings of discomfort if an unpleasant or a private experience is being described. Participants might also feel embarrassed or confused while encountering unfamiliar subjects emerged from the questions. Participants in class activities might feel stressed caused by new pedagogical approaches and time pressure of the activities. Researchers promise to take all possible measures to eliminate these minimal risks during the course of the study. Researcher promises to provide adequate information of the subject of research. Participants will have full freedom to stop the interview or withdraw from the study at any point. Each participant will have full access to his/her case of the study as well as the opportunity to provide feedback to the research group.

Participants participating in this study will benefit from the opportunity of reflecting upon their personal experiences with sustainable design. They might evaluate their perspectives and knowledge with the subject. Educators might benefit from the findings of this study by utilizing them to modify their curricula. It is expected that this will increase the awareness and knowledge level of sustainable design for the participants. No promise or guarantees of benefits are offered

from the researcher to any of the participants.

Thank you for your interest in participating in this research. Please feel free to contact me or Dr. James Jones (email: jajone10@vt.edu) for any questions. I am looking forward to your reply.

Regards

Tao Huang
PhD Candidate
Environmental, Design and Planning
College of Architecture and Urban Planning
Virginia Tech

Appendix H: Suggestions for Contents of Courses in Detail

H.1. Ecological Literacy Domain

H.1.1. Ecological Literacy (Introduction)

Course Objectives:

- To establish a more informed view of ecology and environment. Based on their backgrounds, students have different levels of understanding of ecological issues. Industrial Design departments in Mainland China are scattered through different provinces and schools, though mainly around large cities. Hence, they might have various experiences in dealing with environmental issues. Having this diversity on mind, it is important to address them their views in the course.
- To identify ecological issues that are relevant to design at the beginning of undergraduate studies.
- To build a holistic worldview / to familiarize students with systems thinking
- To provide a global and local picture of environmental issues.

Contents of the course:

An introductory course to familiarize students with basic sustainable design ideas, this course provides an overview of ecology issues.

i. Local culture and the environment / The environmental issues around us

This module of the course is a great opportunity for students to get to know and learn from each other. Even for students grew up in the same geographical region, they might encounter various environmental issues and have different ideas about their local culture. The study of local issues aims to help students relate themselves to sustainability at a smaller scale. It also creates a relaxing environment for the start of students' educational journey in college because discussion of local and familiar issues may be less intimidating. Moreover, students would not have the impression that this course is just another propaganda scheme.

ii. The environmental problems our human society is facing and sustainability

This module of the course talks about the environmental issues at a global scale.

- The summary of energy consumption in the world;

First, educator introduces energy types:

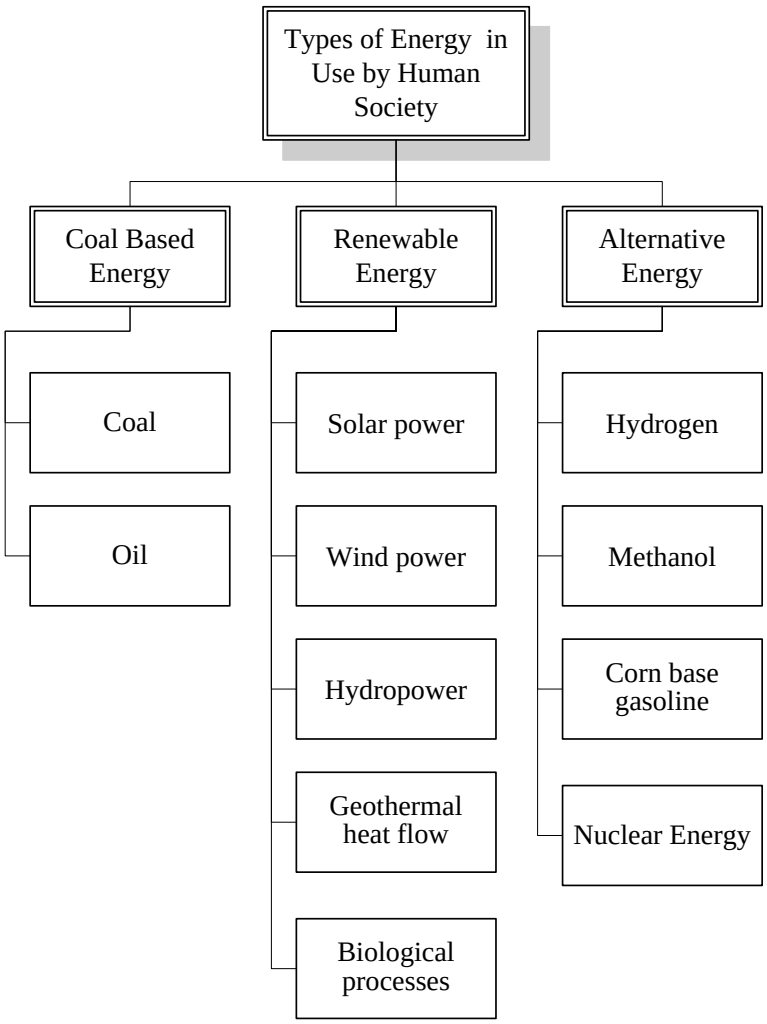


Figure H.1 - Types of Energy in Use by Human Society

Second, educator embarks a discussion to map the energy consumption of the world. The correlation between natural resources and local industries will also be discussed.

- The interconnection of culture, economy, and design in environmental problems;
- The concept and connotation of sustainability;
- The concept and connotation of sustainable development.

iii. Relevancy to design

The problem of sustainability is fundamentally a design problem. In this module, teachers

show cases of how changes in design can help mitigate or avoid environmental problems, and demonstrates why designers, especially Industrial Designers should care about environmental impacts their work has.

Sample 1: Solar Decathlon Project

Solar Decathlon is a biannual competition among universities and colleges around the world to design, build, and operate the most attractive and energy-sufficient solar-powered home. The US Department of Energy, American Institute of Architecture, American Society of Heating, Refrigerating and Air-conditioning Engineers, and other institutions and companies sponsor the Solar Decathlon. The participants of this competition are students and faculty ranging from department of engineering, architecture, Industrial Design, and interior design. Studying this competition is a great opportunity for students to learn what they can achieve in sustainable design. Choosing this competition as the first sample for sustainable design is a strategic move to demonstrate to the students that sustainable design is not beyond their reach.[5] This sample also demonstrates the recognition by governmental agencies and business for the enormous potential of design in building a sustainable future.

Sample 2: Climatex® Lifecycle Upholstery Fabric

In his book *Cradle-to-Cradle* (McDonough & Braungart, 2002), William McDonough uses a chapter to describe his team's search for biodegradable and compostable fabrics to make carpets and furniture. In this project, he and his colleagues tested thousands of chemicals used in the manufacturing process of fabric. They achieved the elasticity, absorbency, and stretch of fabric required for furniture design by integrating natural fiber. They selected sixteen dyes out of 1,600 that are environmental friendly and will not harm the workers during production. This case demonstrates that designers and chemists, as well as other professionals, can work together to use vigorous scientific methods to reduce harm from products. It is also a case that has a complete process, from commission, research and experiments, negotiation with the client, methods, and

[5] Solar Decathlon is unknown to most Chinese designers and architects. In the future publication of this dissertation in China, the researcher will use her experience in participating the Solar Decathlon preliminary competition in Virginia Tech to illustrate the process of the competition. Also, she will introduce the two houses designed by Virginia Tech team for the competition as case study. In this version of the dissertation, such information is omitted because it is easy to find information about Solar Decathlon on Virginia Tech website and the US Department of Energy's website.

disposal of the waste. This case clearly demonstrates how sustainable design can help with building industry's cooperate image and gaining business growth.

iv. The green philosophy

Green philosophy is referred to as a series of philosophical ideas of the relations between human beings and the natural environment. Philosophy courses are mandatory for undergraduates in Mainland China, but the focus of these courses is on politics and socialism with Chinese characteristics. Students can hardly learn any other philosophical point of views in those courses, even the traditional Chinese philosophies can only be discussed in elective courses. Thus, alternative philosophical ideas are offered in this course. Green philosophy concerns the fundamental worldviews. Considering that students might be confused when their old paradigm is challenged by new philosophical ideas, this section should be planned in the first year of undergraduate study. Philosophical ideas could be discussed in this section are summarized in Table H.1.

Table H.1 - Green Philosophy Simplified Summary

Philosophy	**Definition**	**Key Features**
Naturalism in Chinese Traditional philosophy	Taoist naturalism	The integration of Confucian ethics and Taoist Naturalism in the modern society.
Natural Capitalism (1999)	Natural Capitalism is a new business model that takes natural resources and the ecological systems as natural capital. It is considered as part of the "Green Philosophy" in this course because Chinese students do not have opportunity to discuss "capitalist ideas" in other occasions.	Four key strategies for an "industrial revolution" that could save the economy and planet from the economic, social and ecological costs of an exorbitant industrial system. These are: • Radical resource productivity – a 90% reduction in energy and material intensity; • Biomimicry – redesigning industrial systems on biological lines to eliminate waste and toxicity • Service and flow economy – life cycle product stewardship focused on meeting customer needs rather than the acquisition of goods; • Investing in natural capital – restoring the health of natural systems so the biosphere can continue to produce ecosystem services and natural resources.
Environmentalism (General Greens)	A theory that is the advocation of preservation, restoration, or improvement of the natural environment, such as the control of pollution. It is a movement to protect the quality and continuity of life through conservation of natural resources, prevention of pollution, and control of land use.	This movement identifies industrial growth and ill-advised government policies as major causes of environmental destruction, and seeks social change through greater ecological understanding and more sustainable practices.
Extreme environmentalism	A series of radical theories which pursue environmental protection in drastic ways. It opposes most technologies, progresses, and economic development.	As a part of the general environmentalist movement, this movement tends to take more radical actions, e.g., violence and political demonstrations.

v. Systems thinking for Industrial Designers

Using discussion of systems theory in Chapter Two, this module discusses the concept of hard system and soft system, the systems thinking principles and its implementation in the design system, the elements involved in design system, etc.

For each course module, a few questions and projects are suggested (Table H.2.).

Table H.2 - Suggestions of questions and projects for Ecological Literacy (Introduction) Course

Content Modules	**Questions**	**Projects**
Local culture and the environment and the environmental issues around us	• What are the distinct characteristics of your local culture? • What major industry is there in your town? • What are the local social and environmental issues that concern you if any?	• Investigations of local strategies of environment management. • Discussions and presentations of local cultures.
The environmental problems our human society is facing and sustainability	What is the most recent event about our environment that you have heard? What do you think of that event? If it presents a problem, how do you suggest to solve it?	• Investigations of global environmental problems. Students can organize in teams and research on different countries. • Discussions and presentations of local cultures.
Relevancy to design	Can you tell us any successful stories of reversing the environmental damages in your area by design and in the world? (This can be assigned as a case study)	

Pedagogical Approaches:

i. Lectures of basic concepts.

Chinese students usually have some difficulties adjusting to college lives and study methods in the first year. Lecture remains a conventional but effective pedagogical approach, especially when providing introduction to a discipline. However, there should be modification to this approach to change it into “Interactive Lecturing”. The lectures should be planned in a way that encourages students’ self-authorship. Discussions should be greatly encouraged.

ii. Case study

Case study is an important pedagogical approach in this educational framework and it should be done mostly by the students themselves. The students can share their reports of case study in class using many creative forms of presentation. It brings the reality into the classrooms.

iii. Field trips

Educators should arrange field trips to local environmental educational facilities. For example, an educational facility in the suburb of Guangzhou named "The Green Field Environmental Education Center" was found in early 1990s by Guangzhou Research Institute of Environmental Protection and several nongovernmental environmental organizations from Hong Kong. It has established organic farms and laboratories to demonstrate new technologies for the protection of the environment. The center provides environmental education to all levels of educational institutions and agencies. Educational centers like this one are established in many large cities in Mainland China such as Beijing, Shanghai, and Chendu.

iv. Role play

In case study, students can identify the stakeholders in their cases and present different concerns of them.

Recommended Textbooks and Reading Materials:

Orr, D. W. (1992). *Ecological literacy : education and the transition to a postmodern world.* Albany: State University of New York Press.
McDonough, W., & Braungart, M. (2002). *Cradle to cradle : remaking the way we make things* (1st ed.). New York: North Point Press.

H.1.2. Sustainability by Design (Introduction)

Course Objectives:

As students' knowledge of design grows through their first year of design education, they are ready for theoretical knowledge. If the first year course is about *what and why*, this course is about *how*. This course connects sustainable design issues with students' first year knowledge of design to provide them theory and methods that they can utilize in their design practices. The scope of study is much smaller than the first course and more focused on design issues. Through projects and case study, students start to combine the design skills and their knowledge and intuition about environmental issues. Besides the key topics suggested below, educators can take full liberty to expand the topics they believe most needed for the local Industrial Design profession.

Contents:

i. Comparison of conventional and ecological design

Sim van der Ryn and Stuart Cowan (Van der Ryn & Cowan, 1995) lay out the differences of conventional and ecological design in their book *Ecological Design* as Table H.3. below:

Table H.3- The differences of conventional and ecological design

Issue	**Conventional Design**	**Ecological Design**
Energy use	Design relying on fossil fuels or nuclear power.	Design using renewable energy sources.
Materials use	High volume of materials is used, sometimes resulting pollutions.	Restorative materials cycles in which for one process becomes food for the next.
Pollution	Copious and endemic	Minimized
Toxic substances	Common	Minimized
Ecological accounting	Limited to compliance with mandatory requirements such as environmental impact reports.	Built in accounting for ecological impacts over the entire life cycle of the project.
Ecology and economics	Perceived as in opposition; short-run view	Perceived as compatible; long-run view
Design criteria	Economics, custom, and convenience	Human and ecosystem health, ecological economics
Sensitivity to ecological context	Little regard to local culture or environment	Responds to bio-region
Biological, cultural, and economic diversity	Tends to build a homogeneous global culture	Respects and nurtures traditional knowledge place and local materials and technologies; Maintain biodiversity
Knowledge base	Narrow disciplinary focus	Comprehensive
Spatial scales	Work at one scale at a time	Integrates design across multiple scales
Systems	Divides systems into parts	Works with whole systems
Role of nature	Exploits and controls over nature	Includes nature as a partner
Underlying metaphors	Machine, product, part	Cell, organism, ecosystem
Level of participation	Limits community involvement in critical design decisions	Everyone is a designer.

- The design theories responding to sustainability
- 3R principles: *Reduce, Reuse,* and *Recycle*
- Deep Design and Responsible Design: explore the alternative mental model for developments and call for design practices that are responsible for the preservation of the world’s biological and cultural wealth.

- Green Design, Design for Environment (DFE), and Eco-Design, etc.: various design theories responding sustainability developed from 1970 to 1990.
- *Cradle-to-Cradle*: industrial model developed by William McDonough and Michael Braungart.
- Radical design theories

People used to call Victor Papanek “radical” when he first published his book but now we realized he was right. This module provides an opportunity for the class to depart from existing design theories and brainstorm radical design solutions for the environmental problems.

ii. Life cycle thinking of products and services

Industrial Designers sometimes overlook the possible harmful effects while their products are providing services or being made. Thus this module analyzes every step of a possible life cycle of a product, from design stage to manufacturing stage, marketing stage to the functional stage, till the disposure stage. When designing a service or a series of products, it is more difficult to analyze the life cycle and requires longer research period. Class should cross-reference with the materials, manufacturing process, the green technology, and life cycle assessment courses to understand the aspects of life cycles, which include:

- Energy consumption

What kind of energy the product (service) uses? Is there any local and economical energy source? How much energy it takes to disassemble and discard this product (service)?

- Material application

The class will learn about local indigenous materials, natural and renewable materials, recycled and salvaged materials, low or nontoxic materials, non-ozone-depleting materials, etc, in addition to the materials they have learned about in other courses.

- Packaging and Transportation

Over-packaging has been a major environmental problem in China because packaging signifies the “face” value of products, which means Chinese usually consider packaging equally important as the quality of the product. This cultural demand probably will not disappear if ever,

but Industrial Designers can use recyclable materials in packaging to reduce the environmental impacts it causes.

- Chemical contents in manufacturing process

This part of the course may be more difficult for students in arts and design colleges, since normally these students do not take chemistry in their high schools in Mainland China. Educators should use cases to discuss general problems such as hazardous working environment and solid, liquid, and air pollutions caused by chemicals, etc, and tailor this part according to the chemistry knowledge level of their students. The purpose of this module is to remind students of the possible harm manufacturing process could cause to the environment and workers. Industrial Designers have to work with chemists and industrial system managers to control these processes.

- Suppliers for sustainable design

Educators should arrange field trips to local suppliers of environmental friendly materials. The class could also become familiar with products variety and cost.

iii. Sustainable product design process

This process is developed based on common design process, with the emphasis on design research and feedback analysis. While the typical design process is iterative and nonlinear, here are several steps designers usually follow:

- Define issue (problems) and design tasks
- Design research
- Idea generation and selection
- Working out realistic solutions
- Final assessment of drafts
- Realization and marketing
- Review after product's market introduction

iv. Performance indicators and demands on a product

To change the prevalent perception of that environmental friendly products are less attractive

or more expensive, therefore less competitive than traditionally designed products, products designed with sustainable design guidelines have to be examined using the same vigorous standards. The common standards for a good designed product are:

- Functionality and Usability

Can the product (service) do what it claims to do? Is it comfortable to use? These are simple but effective questions to determine the functionality and usability of a product. Students should cross-reference with the ergonomics and kinesics courses offered in the same semester.

- Quality

A product using expensive materials does not necessarily mean that this product has high quality. Quality is greatly affected by how much thoughts have been put into the design of a product (service) and how it is put together.

- Desirability

Who wants this product (service) and why? How could this product (service) create new market? These are major issues in market research for Industrial Designers.

- Durability

Nowadays products tend to have less durability than twenty years ago because the trends change much quickly and the markets are more diverse. However, Industrial Design should not promote low durability through design because that will encourage unnecessary waste of materials and energy. If the products (services) have to be discarded after relatively short term of use, designers must reduce the efforts for recycling and reuse for the end users and recycling industry.

v. Price/Performance relation

Understanding the relation between price and performance is crucial in sustainable design because designers and clients often assume practicing sustainable design would cost more money than conventional design. This module is the first step in understanding the complicated relations among society, economics, and design. Using systems thinking, the *Price* and *Performance* in the module refer to not only the market price, resources and labor price, product performance and function, but also the long term environmental cost and cost reduction made

possible by using sustainable design. These costs cannot be captured by economics easily but environmental laws have clear regulations about fines on pollutions and product malfunctions. This module requires the class to discuss potential long term effects of design.

vi. Environmental policies and legislations relating to sustainable development

There are few Industrial Design departments in Mainland China offering courses on policy and legislations. Students usually gain their knowledge about general legal issues from elective courses offered by other departments. These courses do not cover many legal issues relevant to design practice. This module discusses environmental policies and legislations relating to sustainable development that are strong incentives for business to adopt sustainable design. Thus, understanding these will greatly help the negotiation between designers and their clients. The legal issues include copyrights and environmental requirements for manufacturing process.

Pedagogical Approaches: lectures of basic concepts; case study; field trips and Seminar discussions

Educators should constantly encourage discussions in the classroom. However, in Chinese classroom, it is impossible to allow enough time for every student to express his or her opinions due to the large number of students. The researcher suggests randomly selecting about one third of the students after each class to discuss class topics: every student will have to prepare and pay attention because anyone might be called on. Students are still encouraged to speak up during the class but the seminar is mandatory and eventually will include every student.

Table H.4 - Suggestions of Questions and Projects for Sustainability by Design (Introduction)

Course

Content Modules	**Questions**	**Projects**
Comparison of conventional and ecological design	• How would you relate the green philosophies and systems thinking discussed in the first semester to this comparison?	• Role play or debate about the pros and cons of conventional and ecological design (students are free to choose sides) • Product case study
The design theories responding to sustainability	• What are the strengths and weaknesses of these theories?	• Theories comparison and debate
Life cycle thinking of products and services	• What part of the life cycle is the most difficult for you as an Industrial Designer?	• Product case study • Design Project: solve a social issue/problem using both products and services design.
Sustainable product design process	• How would you evaluate your own design process? • Do you think innovation is a flash of ingenuity or a planned process?	• Product case study
Product performance indicators and demands	• How do designers navigate through all these demands and still come up with innovative solutions?	• Product case study • Discussion: local standards and global demands; globalization and its effects on local economy; etc.
Price performance relation	• Does sustainable design really cost more than conventional design?	• Product case study • Discussion
Legislations	There are a lot of difficulties in enforcing laws locally in Mainland China, what is your suggestion as an Industrial Designer?	Students are assigned to research on local and international legislations that regulate the environmental performance of business and design.

Recommended Textbooks and Reading Materials:

Wann, David. *Deep Design: pathways to a livable future*. Washington, D.C.: Island Press, 1996. 216 pp.

H.1.3 Sustainability by Design (Analysis)

Course Objectives:

- To enhance their analysis and critical thinking ability and encourage them to think more independently. In junior year, students are capable of analyzing more complicated issues after the introductory courses.

- To arm the students with facts of the merits of sustainable design in order to build the arguments for sustainable design.

Contents:

In this intermediate course, students learn to critique and analyze sustainable design practices. This course concerns mainly the interaction of the industry and Industrial Design because these two are connected closely together.

i. "Green Business" and Sustainable Design

- Environmental values of design profession

First a question needs to be asked, what values can design profession provide to business? This issue is much talked about in business world and the value of design profession has been greatly appreciated. The environmental values of design profession lie in its vision and its potential to influence business decisions towards sustainability. A small change of materials based on Industrial Designer's decisions could enhance products' environmental performances and save energy expenses for both consumers and business, let alone the increasingly prominent benefit of green marketing for building a socially responsible image for business.

- Stakeholder issues

Stakeholder means the person or organization who holds an interest in the matter. As private business and government business often intermingle in Mainland China, at times it is

difficult to identify all the stakeholders in the project. Industrial Designers should understand the typical trade-offs as shown in Table H.5. They should have the knowledge of stakeholders because they usually need to work with many departments of a company, besides the engineering team. Inevitably, they will need to negotiate with the marketing team and other executives.

Table H.5 - Typical Trade-offs (adopted from OKALA)

Choices >	**Consequence**
Using recycled materials >	Lower tolerances & specifications
Increasing energy efficiency >	Higher electronic design costs
Extending product life >	New product sales reduction
Design for disassembly >	Higher production costs
Biodegradability >	Shorter life, lower strength
Local production >	Fewer choices / less selection
Leasing instead of owning >	Increased transport impacts
Dematerialization >	Fragility / shorter life
Aggressive green marketing >	Potential perception of inferior quality

- Profit from sustainable design (can be combined with green marketing module in Product Development Strategy course)

The social and economical profits from sustainable design can be enormous. A large number of corporation, especially those which traditionally cause pollutions or consume huge amount of coal-based energy, e.g. automobile industry and oil industry, started to invest more and more money into research for alternative energy resource to change their public image, also to protect their business from competition for energy in the near future.

ii. International evaluation tools for sustainable design

How could design be evaluated to determine if they match sustainable design principles? What makes a product or service green? Alex Wilson (Wilson, 2000) from BuildingGreen, Inc. summarizes his company's standards for their GreenSpec directory of green building products.

- Products Made with Salvaged, Recycled, or Agricultural Waste Content

Salvaged products; Products with post-consumer recycled content; Products with pre-consumer recycled content; Products made with agricultural waste material.

- Products That Conserve Natural Resources

Products that reduce material use; Products with exceptional durability or low maintenance requirements; Certified wood products; Rapidly renewable products

- Products That Avoid Toxic or Other Emissions

Natural or minimally processed products; Alternatives to ozone-depleting substances; Alternatives to hazardous products; Products that reduce or eliminate pesticide treatments; Products that reduce stormwater pollution; Products that reduce impacts from construction or demolition activities; Products that reduce pollution or waste from operations

- Products That Save Energy or Water

Building components that reduce heating and cooling loads; Equipment that conserves energy and manages loads; Renewable energy and fuel cell equipment; Fixtures and equipment that conserve water

- Products That Contribute to a Safe, Healthy Built Environment

Products that do not release significant pollutants into the building; Products that block the introduction, development, or spread of indoor contaminants; Products that remove indoor pollutants; Products that warn occupants of health hazards in the building; Products that improve light quality; Products that help noise control; Products that enhance community well-being

Many countries have also developed evaluation tools for building construction and architectural design. For example, in the United Kingdom, a company called Building Research Establishment developed Envest 2, a software that evaluates whole life cost for low environmental

impact building design. LEED (Leadership in Energy and Environmental Design) is a green building rating system developed by the U.S. Green Building council that benchmark design, construction, and operation of buildings. It measures buildings' environmental performances in five areas: sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality. BEES 3.0 (Building for Environmental and Economic Sustainability) is a software developed by the National Institute of Standards and Technology (affiliated with the U.S. Department of Commerce). It measures the environmental performance of building products by using the life cycle assessment approach specified in ISO 14000 standards. Though there are few tools tailored for Industrial Design, Industrial Designers could make reference to those tools.

Pedagogical Approaches: discussions**;** case study**;** team work on projects.

Recommended Textbooks and Reading Materials:

Wann, David. *Deep Design: pathways to a livable future*. Washington, D.C.: Island Press, 1996. 216 pp.

H.1.4. Sustainability by Design (Synthesis)

Course Objectives:

In this final course, which might be combined with design studio courses, students are invited to discuss the design issues they are interested in and work on design projects. This course gives self authorship to students to synthesize their previous knowledge in design practices and discuss how sustainable design may fit or alter current practice and structure. It prepares students for their future design practices while restating social responsibilities issues. This course builds heavily on design projects.

Contents:

- Design as a political issue: explore the social responsibilities of an industrial designer; discuss the economic benefits for clients and the strategy of negotiation; discuss relevant governmental regulations and their leverage on business; discuss the trade-offs of economic development and environmental protection; discuss the market strategy of promoting environmentally sound products and services.
- Social issues and Product Design

After three years of study, students are ready to examine the social issues relevant to Industrial Design. Here is a short list of potential topics:

- Design for luxury versus design for the mass
- Global design market versus local design market
- Design for fast consumption (quick turnover) versus design for durability
- Design's impacts on popular culture
- Design for public projects (for example, to address design needs of an aging society)
- Design and social marketing

This is also an opportunity for both the students and educators to understand and observe the educational results from the first three years.

- Design projects

This course, combined with studio course, offers students the opportunity to practice sustainable design principles in hands-on design projects.

Pedagogical Approaches: seminar discussions; self-reflection and self-evaluation**;** peer evaluation**;** presentation and exhibitions

Recommended Textbooks and Reading Materials:

Contemporary journal articles

H.2. Artistic Domain

H.2.1. Basic Communication Skills

Course Objectives:

- To foster basic artistic skills required by the Industrial Design profession
- To lay solid groundwork for creativity and design

This course follows Bauhaus's categorizes of basic skills: graphic design (two-dimension) basics, three-dimension design, and color design. These skills are all basic communication skills and should be taught continuously for at least two semesters to ensure the continuity of design theories and practices. Design studio course offered in the same period should require students to practice these skills in design projects.

Contents:

- Aesthetic Principles and Elements

Aesthetic principles could be drastically different due to cultural differences. In this first module of the course, the class should discuss their different perceptions of beauty, what is aesthetically appealing to them and why, etc. Educators should introduce common aesthetic principles such as: rhythm, contradiction, balance, harmony, emphasis, etc.

- Graphic design basics

This module introduces graphic elements in two-dimensional mediums, starts with points, lines, surface, and their relationships.

- Color theory

This module introduces basic color theory, including what color is, how we experience it, light and color, the wheel of colors, the relationships among different colors, commercial color productions, etc.

- Typography

This module has to be taught quite differently in Mainland China than in its western counterparts because calligraphy is a major part of art in Chinese culture. Hence, Chinese students have to learn additional cultural and aesthetic implication of typography.

- 3D forms basics

This module studies three-dimensional forms and shapes using models and computer software.

- Drafting and Sketching

The importance of drafting skill has not diminished upon the introduction of computer-aided design. Since most students have a certain level of drafting skill before they enter the department, this course emphasizes on drafting industrial products, joints, and the relationships between the users and the products.

- Model making

Model making is a crucial skill for Industrial Designers. They have to learn to use three dimensional objects to present their creative ideas since the beginning of their study. However, this skill needs to be cultivated gradually, as students learn the attributes of modeling materials and become familiar with the techniques of using them. This module introduces the common materials and tools used in product model making.

Pedagogical Approaches: lectures; art studio practices; projects; workshops

H.2.2 Creativity Exploration

Course Objectives: creativity is a mental process involving the generation of new ideas or concepts, or new associations between existing ideas or concepts (wikipedia). For a great deal of Chinese students, it is necessary to help them explore their creativity before they start sophisticated product design practices because the lack of such creativity fostering in K-12 education. This course consists of numerous hands-on design projects to explore students' creativity.

Contents:

- Creative behaviors and thinking
- Art (artifacts) appreciation: painting, architecture, ceramics, music, movies, plays, etc.
- Creative thinking methods and techniques.
- There are countless methods that have been developed for creative thinking. The class should use small creativity projects to experience some of these methods.
- Creative expressions: sculpture, freehand drawing and painting, and other art forms.
- Problem solving methods and process.

Problem solving is not a "flash of genius" in many cases. As figure 2.2 suggests, it is a nonlinear process, it usually includes these procedures: information gathering –brain storming - analysis - visible thinking – solution forming and selection- communication (visually and verbally). The difference between problem solving and creative thinking lies in that problem solving is a more scientific and legible process. It relies on problem solvers' analytical skill and research ability.

Pedagogical Approaches: project-oriented and issue-oriented learning; field trips.

Table H.6. Suggestions of Questions and Projects for Creativity Explore Course

Content Modules	**Questions**	**Projects**
Creative behaviors and thinking	• What are the differences between art and design if there is any? • Where can we find inspirations? What is plagiarism?	• Local and traditional artistic activities survey
Problem solving methods and process	• How do you solve problems?	Practice different methods for the same set of problems
Creative expressions	• How do you feel most comfortable expressing yourself?	Art project using certain themes, i.e. local culture impressions.

H.2.3 Intermediate Communication Skills

Course Objectives: graphic communication is only a part of multiple communication skills. Students will encounter more and more occasions that they will need to orally and professionally present their works and ideas. In this intermediate course, students learn advance communication skills in CAD, oral presentation, and professional presenting. This course can be segmented into two or three modules to be presented in two to three semesters in junior and senior years.

Contents:

- Computer Aided Design: 2D graphic design programs
- Computer Aided Design: 3D graphic design programs
- Computer Aided Design: rapid modeling
- Oral presentation skills

Part of a designer's responsibilities is to persuade his or her clients to accept his or her ideas. Thus, oral and graphic presentation skills are equally important to designers. In this module of the class, students learn about the techniques of public speaking and practice them in groups. The class should discuss the topics below:

- The audience of speech
- The goal of speech
- The timeframe and the frame of speech
- The issues to avoid in public speaking
- The appropriate dress code for public speaking

Pedagogical Approaches: lectures**;** computer labs**;** student presentations; case study

H.2.4. Specialized Communication Skills

Course Objectives: To accommodate the job market in China, students have the liberty to choose particular skills they intend to specialize in at this stage of their study. These courses are elective courses offered in multiple design and art departments according to the teaching capacity of the university.

Electives:

- Photography

This course should offer basic techniques and equipments of photography with the emphasis on product photo and lighting control.

- Human-computer interaction and interface

Recently HCI design has become a popular career path for Industrial Designers. Since it is an interdisciplinary subject that involves computer science, design, and many other fields of study and research and has great relevance with Industrial Design[6], this course might expand to a core course or interact with other courses such as ergonomics and user study.

- Web design and development

Web design and development are also the professions that many Industrial Design graduates will choose. Many Chinese Industrial Design departments offer this course. However, those courses usually only focuses on computer programs such as DreamWeaver or Flash, without touching on the computer programming part of web development. To prepare students with higher competency, it is suggested that at least one computer programming language should be the prerequisite for this course, preferably JAVA or HTML.

- Pottery

Students work as apprentices in labs or workshops with teacher. They can learn to work with raw materials and cultivate their creativity in this course. It is widely popular as an elective in many art schools.

[6] Undoubtedly, a major part of Industrial Designers' work deals with the interaction between man-made objects and humans. HCI course will help students understand certain aspects of user psychology and physical needs. However, it is difficult to find qualified teachers for HCI course since it is a relatively new subject.

- Carpentry

Like pottery, carpentry can be set up as a workshop course. Carpentry is important for students to understand the characteristics of wood, especially in model making.

- Illustration and rendering

Illustration and rendering is an advance course for students who intend to polish their drawing skills to add artistic touches to their product design renderings.

Pedagogical Approaches: lectures; field trips; case study; apprentice in workshops

H.3 Technical Training Domain

H.3.1 Mechanics (Introduction)

Course Objectives: to foster the ability of reading and drawing mechanical drawings for Industrial Design students, also their abilities to verbally and visually communicate with mechanical engineers. Since this course is well established in Mainland China and usually taught by teachers from mechanical engineering department, no detailed suggestions to this course will be made in this dissertation. However, this course involves large amount of homework and even quizzes. The researcher suggests selecting design projects from concurrent design courses to use in this course and eliminate exams. Because this joint effort ensures that students learn while simultaneously practice drawing skills for their own design projects. Final or midterm exams are not necessary because in their future practice, students could always refer to mechanical handbooks and computer-aided design can help them make these drawings. Thus, learning the basic mechanic and to read the mechanical drawings are the major objectives of this course.

Contents:

This is an introductory course to build solid skills and understanding of basic mechanics in product design.

i. Mechanics Basics

- Tooling of mechanical parts (devices and techniques)
- Common mechanical parts
- Industrial systems (facility, assembly lines, packaging, distribution and transportations, etc.)

ii. Drafting for product design

- Geometric construction
- Technical sketching
- Orthographic projection
- Pictorial drawing (isometric, oblique, perspective)
- Sections and conventions

- Dimensions and tolerances
- Dimensioning for production
- Fastening, joining, and standard parts
- Production drawings
- 3D geometry concepts
- 3D geometry applications
- Graphical presentation of data
- Design process and mechanical drafting

iii. Common manufacturing procedures

This module is an introduction to polymer, metal, and natural materials processing, which will be discussed in depth in the next course.

iv. Design for disassembly

According to Philips Corporate Design's Guidelines for Ecological Design published in 1996, "Design for disassembly" should follow these principles:

- Minimize the time required to separate the product into parts (this may include reducing the total number of parts).
- Design for easy repair, cleaning and enable easy replacement of parts when worn out or obsolete.
- Design for easy removal of hazardous components (batteries, circuit boards) prior to recycling or shredding.
- Avoid fixing dissimilar materials together so that they cannot be separated (for instance, no molded-in or glued-on metal parts in plastic).
- Design sub-assemblies so they are easily separated into fragments with different waste

treatments.

- Dried paint should not exceed 1% of the total weight of a plastic part.

- Label parts greater than 25 grams to identify their polymer type (for manual disassembly).

Pedagogical Approaches: lectures; apprentice in workshops

A few large Chinese universities have their own factories and workshops for students to work on hands-on projects. Students should spend at least two weeks during the course in these workshops to better understand mechanics.

H.3.2. Materials, Manufacturing, and Ergonomics

Course Objectives: this is the key course of the technical Domain of the framework. It aims to familiarize students with materials, manufacturing, and ergonomics commonly used in Industrial Design. It is also a well-established course in Mainland China.

Contents:

i. Materials and alternative materials

- Conventional materials: wood, glass, ceramics, carbon, rubbers, elastomers, metal, plastics.
- Impact factors of materials

The energy spent and environmental impacts in the extraction of materials; the transportation of raw materials; the processing of materials: pollutants emissions; energy usage; chemicals used during process; the disposal of materials

- Low-impact materials

Recyclable and reusable materials; naturally fast-growing materials (i.e. bamboo); materials requiring least processing procedures and energy

ii. Optimized manufacturing process: quality control and Total Quality Management

Quality control mindset is important for Industrial Designers because it ensures strict execution of design plans and strategies. According to the definition of International Organization for Standards (abbreviated as ISO), “Total Quality Management (TQM) is a management approach for an organization, centered on quality, based on the participation of all its members and aiming at long-term success through customer satisfaction, and benefits to all members of the organization and to society.”

iii. Minimalization of procedures and materials

According to the “dematerialization” principle, the fewer procedures and materials are used in the manufacturing process, the less energy is used and the fewer waste products will be produced by the manufacturing process. The class should discuss the minimalist movement in architecture and design for this module to understand the connection between style and

manufacturing process[7].

iv. Ergonomics: Human scales in a local perspective

Ergonomics has been a major study topic in Industrial Design research in Mainland China. Chinese educators usually use data from Japanese researchers in ergonomics course due to the ethnologically similarity between the two ethnic groups. The class should study the general considerations in ergonomics while being aware of the variety of people in both local and global perspectives. "Average people" is an overly-generalized term. Humans, like all the other organic creatures on Earth, are individually different. Industrial Designers should always consider "the extreme cases" and try to make our products or services usable to as many people as allowed by budget and resources.

Pedagogical Approaches: lectures; field trips; case study; apprentice in workshops

[7] Note that minimalism does not equal minimalization of materials or process, in many cases, minimalism requires intense energy and materials use.

Table H.7 - Questions and Project Suggestions for Materials, Manufacturing, and Ergonomics Course

Content Modules	**Questions**	**Projects**
Materials and alternative materials	• Where can designers find alternative or innovative materials? • What are the local providers of these materials?	• Role play or debate about the pros and cons of conventional and ecological design (students are free to choose sides) • Product case study
Optimized manufacturing process	• In manufacturing process, when and how can designers suggest for the adaptation of new technology?	Visiting factories
Ergonomics	• What is the relationship between the target users and ergonomics? • How should we accommodate the "extreme" human cases in our design?	Survey of a family's use of a certain common product to understand the different needs of people according to their age, sex, and preference.

Recommended Textbooks and Reading Materials:

Lesko, J. (1999). *Industrial Design Materials and Manufacturing*. New York: Wiley.

Yuan, B. X. (2005). *Ergonomics in Industrial Design*. Beijing: Beijing Institute of Technology Press.

Jiang, X. Y. (2003). *Materials for Industrial Design and Processing Techniques*. Beijing: Beijing Institute of Technology Press.

H.3.3 Green Technology and Life Cycle Assessment

Course Objectives: to explore alternative and innovative technology for sustainable design, to equip students with the latest technological development for sustainability.

Contents:

i. The definition of LCA

According to the U.S. Environmental Protection Agency, Life-cycle assessment (LCA) is a technique to assess the environmental aspects and potential impacts associated with a product, process, or service, by:

- compiling an inventory of relevant energy and material inputs and environmental releases;
- evaluating the potential environmental impacts associated with identified inputs and releases;
- interpreting the results to help you make a more informed decision.

ii. Procedures of LCA

The common procedures in LCA (as summarized by Arizona Public Service's Environmental Showcase Home) include:

- Identify raw materials and associated costs for harvesting that material for use.
- Identify all energy, materials, and chemicals used as input to the manufacturing process and the hazards associated with their use.
- Identify all materials and chemical generated in the manufacturing process and the hazards associated with their production.
- Identify disposal methods for waste products and impacts to air, water, and other environmental concerns.
- Identify the materials used in packaging the product for shipment.
- Identify the energy used in transporting this product to its final destination.

- Identify the resources used in the use of the product, such as energy consumption.
- Identify the methods of disposal for this product, whether it can be recycled or it has to go to the landfill.

The International Organization for Standardization issues ISO 14040:2006, which describes the principles and framework for LCA including: definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for use of value choices and optional elements. This is the standard document that Industrial Designers can refer to when they communicate with their clients.

iii. Innovative technology survey

In this module of course, the class mainly discusses innovative materials and technology that students present. The discussion does not limit to new technology associated with sustainability issues. The class should collect information on innovative technology and hold a small exhibition at the beginning of every class. The most interesting or controversial ones will be discussed in depth in the class.

iv. Environmental benchmarking and validation

In Sustainability by Design course, the assessment tools for sustainable design and products are discussed. Environmental benchmarking is a management and planning tool for government and organizations to improve their environmental performances. Its process includes (Agathe Bolli, 2001):

- Plan: analyze critical success; Select process for benchmarking; Develop performance measures for process to be benchmarked.
- Search: find benchmarking partners who perform this process best.
- Observe: collect information; understand and document the partner's process, both performance and practice.
- Analyze: identify the gap in performance; find the cause for the gaps.

- Adapt: choose “best practice”; adapt to the organization’s conditions; implement the changes.

Understanding this process gives Industrial Designers the tool to evaluate their clients’ organizations’ environmental performance in order to make insightful suggestions about clients’ products and services. Industrial Designers could also gain practical knowledge about how organizations operate and how to optimize the operation process through this module, which will benefit their studios’ operation in the future.

Pedagogical Approaches: lectures; field trips; discussions and meetings with manufacturers and practicing designers; case study

Table H.8 - Questions and Project Suggestions for Green Technology and Life Cycle Assessment Course

Content Modules	**Questions**	**Projects**
Different methods of LCA	• Where can designers find alternative or innovative materials? • What are the local providers of these materials?	• Role play or debate about the pros and cons of conventional and ecological design (students are free to choose sides) • Product case study
LCA process (guided by international ISO 14040 series standard)	• What are the interest rates and escalation rates in LCA? • How to evaluate the lost of materials and energy in LCA process?	Visiting factories
Innovative technology survey	• How to estimate the cost of new technology?	
Environmental benchmarking and validation	• How can designers gain feedback of their design to validate their design methods? • How to define the life expectancy of products?	

Recommended Textbooks And Reading Materials:

Birkland, J. (2002). *Design for Sustainability: a sourcebook of integrated, eco-logical solution*. London ; Sterling, VA: Earthscan Publications Ltd.

Charter, M., Tischner, U. (2001). *Sustainable Solution: Developing Products and Services for the Future*. UK: Greenleaf Publication Limited.

H.4. Professional Knowledge Domain

H.4.1 Design Literacy (Introduction and History)

Course Objectives: this course integrates the history of artifacts and design with basic facts of design professions to provide students an overall portrait of the Industrial Design profession and the foundation for professional discourse. This module could be offered as one credit courses (short term courses) occurring in every semester or as series of lectures to ensure the timeliness of the course materials. In addition, different educators could provide different perspectives of design in separate courses or lectures.

Contents:

i. The development of the profession of Industrial Design

- Artifacts

Educators should provide at least replicates of ancient artifacts in addition to pictures and documentary in the class. Multiple museum trips are necessary. Anthropology and history should be discussed in the class to build the connection of artifacts and the living conditions and needs of their creators. This module concludes with the discussion of "what is design?"

- Design and Craft

This module mainly discusses the "birth" of Industrial Design from the tradition of craft after the Industrial Revolution, how modern designers are different from traditional craftsmen, and the interaction of them in modern settings. This module answers the question: what is Industrial Design?

- Different eras/ism of design in history

This module proceeds to survey the recent 100 years of history of Industrial Design, the

various isms in design, and their impacts on the society. Because design theories usually have close connections with the Zeitgeist, the class should discuss the relevant social theories and movements for a better understanding of these isms. In the advanced course of design theories and methods, the class could revisit this subject and expand the discussions.

ii. Who is who: accomplished designers and their works

Industrial Designers usually work in teams and cannot claim all the credits for the success of products. Therefore, there are less famous individual Industrial Designers as architects. This model should be organized to answer this question: what do Industrial Designers do? It introduces important designers and design teams.

iii. Design and culture

This module could be fully developed into a course focuses on the discussion of the interactions between design and cultures because the span of the subject. The discussions should progress beyond the superficial survey of styles and focuses on the cultural elements behind styles. Students should understand not only the design styles of different regions, but also why and how they developed. Case study is the main pedagogical approach in this module.

- Scandinavian design
- German design
- British design
- Japanese design
- North American design
- Local design and globalization

Pedagogical Approaches: lectures and guest lectures; seminar discussions; case study; field

trips; student presentations

H.4.2. Design Theory and Methods

Course Objectives:

- To systematically introduce contemporary design theories (other than sustainable design theory) and the interactions of them;
- To cultivate creative thinking and build problem solving ability.

Contents:

i. Design theories

- What is design theory?

By definition, design theory is a set of statements or principles that guides design actions or judgments in design practice. Different from scientific theories, which explain a group of facts and phenomenon, design theories usually provide an ideological framework based on both scientific research and artistic opinions. The class should also discuss nomothetic (general rules) and idiographic (concerning specific products) knowledge.

- Contemporary design theories: modernism, post-modernism, neo-modernism, minimalism, etc.
- Theory infiltration/interaction

This module discusses the continuity in design theory development, how theories involve and depart from one another, and the social and cultural context of design theories. The purpose of this module is to offer a holistic view of design theories to minimize bias and false assumptions.

ii. Design methods

The topics of this module range from general methods to specific techniques of conducting design activities.

- Idea generation techniques

In this module, students discuss the idea generation techniques of brain-storming, storyboarding, visible thinking, design journals, and idea mining, etc.

- Semantics and deconstruction

Semantics refers to the study of meanings in visual presentation of products or services in Industrial Design. In other words, it studies the context and subtext of design by taking the object apart. Deconstruction represents the philosophical idea to analyze objects by challenging their axioms. Used as design methods in Industrial Design, semantics and deconstruction help designers to improve their understanding of products and services.

- Problem analysis

Arguably, problem analysis is the first step of innovation. To analyze a problem, one first has to identify the problem. Problems exist within systems and they can only be solved using systematic approach. There are numerous problem analysis tools the class can explore, for example, Dr. Kaoru Ishikawa, a Japanese quality control statistician, invented the fishbone diagram for problem analysis in business management. This diagram categorizes issues of a problem into these categories: the 4 M's: Methods, Machines, Materials, Manpower; The 4 P's: Place, Procedure, People, Policies; The 4 S's: Surroundings, Suppliers, Systems, Skills. The class should discuss the adaptations of different tools in design.

iii. Design process

Non-linear, lateral, and iterative process are co-existing in design process. Figure H.2 shows Bryan Lawson's simplified diagram of the design process. It shows that design consists of analysis, synthesis and evaluation linked in an iterative cycle (Lawson, 1997).

Pedagogical Approaches: lectures; field trips; case study

Recommended Textbook:

Lawson, B. (1997). *How Designers Think: the design process demystified* (Completely rev. 3rd ed.). Oxford; Boston: Architectural Press.

Gorman, C. (2005). The industrial design reader. New York: Allworth Press.

H.4.3. Design Research and User Study

Course Objectives: to utilize design research to braid theory and practice to make the design stronger (Laurel, 2003).

Research can help designers to explore design opportunities and challenges for any design projects (e.g., designing a chair):

- **Goals and Scope.** Learn about the content and context of the project: What is this object for? What do I want to achieve in this project? What are the performance requirements? So forth and so on.

- **Constraints.** Research on the public policies, safety requirement, sustainability requirements, project budget, schedule, project team, and technology infrastructure, etc.

- **User study.** Project-specific research to learn about the unique blend of users for the project: whom do I design this for? What is appealing to them? What is the most comfortable design for them? So forth and so on.

- **Manufacturing.** Research on the process of manufacturing, the materials, the transportation and purchasing of resources, etc.

- **Competitive Analysis.** Reviewing what everyone else is doing, borrowing from the best, learning from the failures. This is similar to the literature review in other disciplines.

- **Expertise and Experience.** What kind of expert you need to accomplish this project?

- **Usability Testing.** Iterative project-specific testing of prior designs and new prototypes.

- **Market Research.** Research on the future market proportion and profit of the object, the cost of the object, and the consumer behaviors, etc.

This is only an inexhaustible list of how research can be implemented in the design process. Research should be a fact-based investigation. There are high validity and reliability requirements involved in research activity. Many designers might be creative by nature, but unlike biologists and chemists, they are not well trained to conduct *research*. Research requires skills that are not inherent in design education. While many designers solve problems in their practices, they generally do research in an intuitive way, a less self-conscious way, an idiographic way as opposed to a nomothetic way. What is needed in design education is to prepare students for the forms of research they will encounter in practice. This course should bring students to understand how to formulate substantive questions, identify analytical frameworks and developing methodologies to examine the questions. Educators have an important part to play as role models, demonstrating research activity through both traditional forms of research as well as in the form of peer reviewed theoretical works, built and unbuilt.

Course contents:

i. Literature review

ii. Survey design

iii. Qualitative research: interviewing skills for focus groups

iv. Quantitative research: using statistics to understand human behaviors

v. Reading and writing design research reports

vi. Human behavior study

- Human scale revisited (ergonomics)
- Categorizing users by age, sex, life style, and cultural background

vii. Micro-behavior and Macro-economics

Pedagogical Approaches: lectures; role play; case studies

Recommended Textbook:

Feng, X.T. (2005). *Research methods in sociology.* Beijing: China Remin University Press. (ISBN: 7300037135)

Flick, U. (2002). *An introduction to qualitative research* (2nd ed.). London; Thousand Oaks, Calif.: SAGE Publication

H.4.4. Professional Ethics Codes and Expectations

Course Objectives: to introduce common professional ethics codes mainly from business practice and the expectations for Industrial Designers compiled by International Council of Societies of Industrial Design.

In senior year, students need hands-on directions to prepare them for professional practices. Mainland China does not have professional license programs for Industrial Designers nor official professional ethic codes issued by professional organizations for Industrial Designers. There are few textbooks available for this course. Therefore, the class relies mainly on relevant articles, documentary films, and guest lectures.

Contents:

i. Professional ethic codes from local and international professional design organizations.

ii. Professional expectations

Designers are usually considered as “artistic” and not bound by the conventional professional behaviors of the business world. However, Industrial Designers work closely with other professionals that they need to understand what acceptable behaviors are and what are not. The class should discuss:

- Technical writing: including resume, executive brief, and other common written documents circulating in the business world.
- Work ethics: positive attitude, honesty, reliability, cooperation, team work, appropriate manners, etc.
- Professional dress codes
- The differences of professional behaviors in different cultural settings.

As the opportunities of international cooperation increase exponentially, Chinese designers have to familiarize themselves with the common perception of professional behaviors in the international community, especially how to manage the multicultural working environment.

iii. Portfolio building

In many Chinese universities, portfolio building is considered as a self-taught skill that students will gradually learn through the years. Portfolio could be an artistic expression but it is mainly a tool to advertise one's artistic or creative talents. There are many techniques and common sense that might be overlooked in building an effective portfolio. The class should discuss:

- Who are your audience?
- What should be included in your portfolio?
- What format is appropriate?
- Graphic design considerations
- Peer critiques of portfolios

iv. Design a career path

The module discusses different expectations and needs of different types of corporations, for instance, local factories and international corporations have quite different requirements for talents. In this module, students can experiment with various personalities and career planning examination methods, analyze their advantages and disadvantages in job finding, and design their career paths accordingly.

v. Job searching techniques

- Where to find a job?

While searching for jobs on the internet is not as popular as it is in the United States, Chinese students usually attend career affairs to look for jobs. This module introduces students to various resource and opportunities of job searching.

- How to interview for a job?

This module discusses interview techniques for job application, including the proper attire for interviews, questions that are likely to be asked, thorough study of the employer, preparation and rehearsals, etc. The class can divide into small groups: group members play the roles of interviewer or interviewee. Guests from industry or other departments would be invited to observe and give their feedbacks, or act as interviewers to recreate the tensions in interviews. These hands-on practices are important preparations for the young professionals.

Pedagogical Approaches:

- Role play and scenario reenactment

The class should play employer and employee roles in interview setting and review each other's resume and portfolio. The department should arrange exhibitions of portfolios to obtain feedbacks from wide audience. These reenactments can be video taped as teaching materials, or put on online forums for discussions.

- Case studies

Case study in this course emphasizes on interview questions

- Guest lectures and tutoring

The main purpose of inviting guests for this course is to simulate the interview situation where the interviewers and interviewees have not met each other before the interview in most cases. Guests should be authoritative figures of interview experiences, such as career planners and human resource specialists.

H.4.5. Product Development Strategy (Introduction to Business Activities)

Course Objectives: to understand product development strategy, one must first understand the business framework and marketing. There is no identical product development strategy for every company. A good designer should have good business sense to contribute to the business strategy. Understanding the basic concepts and operation of business management will greatly enhance designer's ability to identify problems and stake holders and use the systematic approach to provide design solutions. Since Chinese K-12 education usually largely ignores the teaching of common knowledge of business activities, this course is an introduction to business issues closely related to Industrial Design.

Contents:

i. Learning about business corporations

- What is a *company or corporation*?

This module discusses the legal definition and the rights and limitations of a corporation.

- What are the components of a corporation?

This module discusses the purpose and organization of a corporation, including the board, the stakeholders, the managers, and the usual position and power of Industrial Designers within a corporation other than a typical design firm.

- Contracts and copyrights

This module introduces how to negotiate for a typical design contract, the format of a contract, and the legal issues of copyright protection.

ii. Business models

- Traditional retail/wholesale business

- Traditional manufacturing business
- Service business
- Electronic business

iii. Corporate Identity Systems

Since most Industrial Designers in Mainland China would work on corporate identity design projects, this module introduces the design components of corporate identity systems. As the only design module in this course, this module provides the students the opportunity to use their business sense in this design project.

iv. Market and customers: Green marketing

Green marketing has broader meaning than promoting or advertising the environmental characteristics of products. As a subset of common marketing activities, green marketing was defined by Michael Jay Polonsky as "consisting of all activities designed to generate and facilitate any exchanges intended to satisfy human needs or wants, such that the satisfaction of these needs and wants occurs, with minimal detrimental impact on the natural environment." More and more corporations realize their responsibilities as environmentally conscious components of the society and their environmental improvements can be used as a marketing tool. This is the crucial common ground for clients and Industrial Designers who want to promote sustainable design. Industrial Designers must understand and explain the benefits of green marketing to their clients to persuade them to adopt sustainable development philosophy. Here are three cases of how international companies adopt sustainability as part of their business planning (adopted from OKALA).

Table H.9 – Case Study

Company Policy	Company Philosophy	Business Plan
NIKE Nike's corporate environmental policy that states that they will endeavor to: ● Integrate principles of sustainability into all of their business decisions ● Scrutinize their environmental impacts in their day to day operations and throughout every stage of the product lifecycle ● Design and develop product, materials and technologies according to the fundamental principles of sustainability	**CANON** Canon Corporation has created an environmental philosophy that places an emphasis on issues pertaining to social equity. Canon's environmental philosophy: • Our corporate philosophy is called *kyosei*, which means "living and working together for the common good." We seek coexistence and harmony in our pursuit for corporate growth and development to contribute towards the prosperity of the world and the happiness of mankind. • We aim to help realize a society of sustainable development by maximizing resources efficiency to contribute towards the prosperity of the world and the happiness of mankind. • Integrate environmental and economic goals in all corporate activities in line with the EQCD Policy, provide "green products" by improving resource efficiency through innovation, and also eliminate behaviors that threaten the health and safety of mankind and the environment.	**HERMAN MILLER** This final planning example from Herman Miller echoes what many global companies are now saying: "At Herman Miller, respecting the environment is more than good business practice—it is the right thing to do. We believe that continued economic growth and environmental protection are inextricably linked—that the quality of life depends on meeting human needs without destroying the environment on which all life depends. As business leaders we are committed to develop sustainable business practices that meet the needs of the present without compromising the welfare of future generations. Sustainability demands that we pay attention to the entire life cycle of our products. We will develop strategies that enable us to move toward sustainability while enhancing the value offered to customers. We will measure and monitor progress toward our environmental goal(s) as a key metric of our business success."

Pedagogical Approaches: lectures; field trips; case study; role play

H.4.6 Design management

Course Objectives: to provide more details about design in business activities and prepare skills for entrepreneurial adventure for the design students.

This course not only discusses how business manages design to build brand value and corporate innovation, but also how to manage design as a business. Opening design company or studio is a common practice for designers. Even as an in-house design team, designers still need to learn to manage the design process and outcome. This course is a highly comprehensive synthesis course that encompasses knowledge in business and design fields.

Contents:

i. Design and other components of business

- Industrial Designer's major responsibilities within a business
- Assessment, evaluation, and feedback of product design

Before the market release of any product, the manufacturers will rigorously test and refine the product. Industrial Designer should evaluate the design with other departments in the prototype phase. One might argue that the marketing is the best evaluation for the success of design, however, designers need more scientific evaluation and assessment methods. The class should focus on conducting market surveys and interviews and analyzing the results by quantitative research method in this module.

- Communicating effectively with other teams in a corporation

ii. Innovative Marketing

- Advertising campaigns

Since many Industrial Design graduates enter advertising business or work with

advertisement companies in Mainland China, this module discusses the basic elements in advertisement for products and service. The class studies various successful advertising campaigns, discusses their themes and strategies, analyzes the media involved and their influence, and discusses the subsequent design improvements. Interested students should be advised to take courses in advertising department if available.

- Integrated Marketing Communication

Integrated Marketing Communication (IMC) is a holistic approach of marketing in the digital economy. It integrates all the media channels and platforms. This module discusses the traditional marketing channels, such as print and television, and the uprising online marketing channel, such as search engine optimization and RSS[8].

iii. Small business management

This module discusses managing design as a business.

- Finding the product or service to sell
- Small business logistics
- Distribution
- Local business legislations
- Online business

Pedagogical Approaches: case studies; guest speakers lectures; lectures.

Recommended textbooks:

Huang, W. et al (2005). *Managing Design for Business Success: readings & case studies for design management*. Beijing: Beijing Institute of Technology Press.

[8] RSS is a family of web feed formats used to publish frequently updated pages, such as blogs or news feeds.

H.4.7. Design Studio (Synthesis)

Course Objectives: a project oriented course that integrates all the knowledge and skills of students, this course is an element that “sews” everything together in the curriculum. It can be combined with any synthesis course listed above. It should start as early as the first year of college because the early students learn to work in teams, the more they will learn from each other, the more competitive they will become, and the better they will learn to work as a team. In studio courses, the class works on multiple design projects, ideally two to three projects per semester, for design competitions and actual clients. It requires students to work as teams to plan for their own timelines, present works in the public either orally or graphically, analyze existing products and their strategies, practice their skills obtained in other courses.

Pedagogical Approaches: this course combines all constructive pedagogical approaches, while emphasizes the interactions between the educators and the students, as well as the interactions among students.

H.4.8 Internship Program (Practice and Synthesis)

This framework requires students to complete an internship program of three to six months in their senior years. Internship programs in Mainland China are usually not required for design majors but students usually get design contracts during their school years. This framework suggests for a more structured internship program that conducts a detailed evaluation survey among employers to evaluate both the design ability of students and the effectiveness of design education. This survey should also inquire the business philosophy, recent business objectives, and plans of the employing companies to study the interaction between industry and academia. The internship program can benefit not only students and their employers, but also design departments and future design education.

Appendix I: Glossary

If not otherwise noted, the definitions of terms listed in this glossary are derived from the *American Heritage Dictionary of the English Language*.

Table I.1 – Terms and Definitions

Term	**Definition**
Axiology	The study of the nature of values and value judgments.
Coding	Refers to the process of naming or labeling things, categories, and properties (Merriam, 1998)
Confucianism	The system of ethics, education, and statesmanship taught by Confucius and his disciples, stressing love for humanity, ancestor worship, reverence for parents, and harmony in thought and conduct.
Constructivism	Egon Guba and Yvonna Lincoln describe constructivist paradigm as a philosophy that assumes truth is a matter of the best-informed and most sophisticated construction on which there is consensus at a given time.
Consumerism	Webster's Dictionary defines "Consumerism" as "the promotion of the consumer's interests" and "the theory that an increasing consumption of goods is economically desirable".
Critical theory	A theoretical approach developed by the "Frankfurt School" of social thinkers, which stresses that all knowledge is historical and biased and thus claims to "objective" knowledge are illusory (Merriam-Webster Inc., 2007).
Deep ecology	Deep ecology is a recent branch of ecological philosophy (ecosophy) that considers humankind as an integral part of its environment.
Eco-feminism	Eco-feminism is a social and political movement which unites environmentalism and feminism, with some currents linking deep ecology and feminism (Adams, 1993).
Eco-socialism	Eco-socialism or Green socialism is an ideology fusing Green movement values with socialism. Eco-socialists believe that capitalism is inherently harmful to society and the environment due to waste, pollution, and overconsumption ().
Epistemology	The branch of philosophy that studies the nature of knowledge, its presuppositions and foundations, and its extent and validity.
Essentialism	A doctrine that certain traditional concepts, ideals, and skills are essential to society and should be taught methodically to all students, regardless of individual ability, need, etc.
Experimentalism	A doctrine or practice of relying on experimentation; empiricism.
Globalization	The tendency of investment funds and businesses to move beyond domestic and national markets to other markets around the globe, thereby increasing the interconnectedness of different markets.(investopedia.com, 2007)

Term	Definition
Interdisciplinary	Combining or involving two or more academic disciplines or fields of study
Mechanical (hard) system	A system whose behaviors can be successfully described and predicted in mechanical terms.
Methodology	A set of beliefs or assumptions, concepts, values, and practices that constitutes a way of viewing reality for the community that shares them, especially in an intellectual discipline.
Multidisciplinary	Of, relating to, or making use of several disciplines at once
Non-linear	Of or relating to a system of equations whose effects are not proportional to their causes.
Ontology	The branch of metaphysics that deals with the nature of being.
Paradigm	A research paradigm is a set of beliefs or assumptions, concepts, values, and practices that constitutes a way of viewing reality for the community that shares them, especially in an intellectual discipline.
Pedagogy	The art or profession of teaching.
Perennialism	From a perennialist perspective, the value of learning is unalterably tied to the subject matter. Learning is primarily a matter of immersion in a set of subjects believed to be endowed with the verities and virtues of Western civilization (Hlebowitsh, 2005).
Positivism	A doctrine contending that sense perceptions are the only admissible basis of human knowledge and precise thought.
Postmodernism	A philosophy seeks to de-center from the Western modernist tradition to expose and undermine the privileging of Western patriarchal culture with its representations of domination rooted in a Eurocentric conception of the world (Hlebowitsh, 2005).
Qualitative research method	One of the two major approaches to research methodology that involves an in-depth understanding of human behavior and the reasons that govern human behavior.
Quantitative research method	The systematic scientific investigation of quantitative properties and phenomena and their relationships
Reductionism	An attempt or tendency to explain a complex set of facts, entities, phenomena, or structures by another, simpler set
Renewable energy	Any naturally occurring, theoretically inexhaustible source of energy, as biomass, solar, wind, tidal, wave, and hydroelectric power, that is not derived from fossil or nuclear fuel.
Romantic Naturalism	Taking its philosophical learning from Rousseau, romantic naturalism puts forward the idea that children are best educated in a free and largely unhampered environment, with only minimal adult intervention (Hlebowitsh, 2005).

Table I.1 continues on the next page.

Table I.1 continued.

Term	Definition
Self-authorship	Marcia Baxter Magolda defines *self-authorship* as “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” (Baxter Magolda, 1999).
Social ecology	Social ecology is concerned with the relationships between human populations and their environments.
Social efficiency	A concept of curriculum that is management oriented, efficient driven, and highly prescriptive in its detail (Hlebowitsh, 2005).
Social reconstructionism	A philosophy dedicates to educating youth in socialist doctrine and the new social order it demanded (Hlebowitsh, 2005).
Social responsibility	Social responsibility is a doctrine that claims that an entity whether it is state, government, corporation, organization or individual has a responsibility to society. This responsibility can be "negative," in that it is a responsibility to refrain from acting, or it can be "positive," meaning a responsibility to act.
Soft system	Systems that have fuzzy boundaries that are not easily defined or predicted and are characterized by complex dynamic interaction and feedback.
Sustainable development	The Commission's report, *Our Common Future*, defines *Sustainable Development* as development that meets the needs of the current generation without compromising the ability of future generations to meet their needs.
System	An entity that maintains its existence and cuntions as a whole through the interaction of its parts (*O'Connor* & *McDermott*, 1997).
Taoism	A principal philosophy and system of religion of China based on the teachings of Lao-tzu in the sixth century B.C. and on subsequent revelations. It advocates preserving and restoring the Tao in the body and the cosmos.
Theoretical sampling	In grounded theory, the term "theoretical sampling" means the researcher examines individuals who can contribute to the evolving theory (Creswell, 1998)
Triangulation	A surveying technique in which a region is divided into a series of triangular elements based on a line of known length so that accurate measurements of distances and directions may be made by the application of trigonometry. In research, triangulation means

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