A Strategy of Product Sustainable Design and Development Based on Universal Design Handtools Product as Example

Hong-Yi Chen*, Jui-Che Tu**, Jou-Ping Wang ***

** Graduate School of Design, National Yunlin University of Science and Technology/Douliou, herrischen@gmail.com*
*** Graduate School of Design, National Yunlin University of Science and Technology/Douliou, tujc@yuntech.edu.tw*
**** Graduate School of Design, National Yunlin University of Science and Technology/Douliou, wangjp10@gmail.com*

In modern society, “sustainable design” has become the ideal of many enterprises to develop new products. Due to vigorous development of industrialization, ecological environment is polluted and damaged. The effect on life quality of the future generations of human beings is unpredictable. Thus, the concept “green product consumption” rises. In product design and development, firms not only encounter the resistance of domestic environmental groups and restriction of regulations, but also are regulated by international trade sanction and environmental laws. Concept and principle of universal design are based on precise thoughts and attitude. There is no unnecessary design and it will not waste tangible and intangible resources. It benefits ecological environment around the world and human beings’ life quality. It matches the core value of sustainable design. Thus, this study introduces universal design in strategic research of design and development of sustainable products and uses hand tools in daily lives as examples. By Analytic Network Process, this study recognizes ranking of weights of universal design application in product sustainable design development and product life cycle framework as criterion for research on development strategy of product sustainable design. By Modified Delphi Method, the researcher analyzes criteria of universal design application in sustainable design development of hand tool products and establishes evaluation criteria and checking list of product sustainable design development in order to accomplish the goal. Finally, the researcher integrates and establishes strategic application model of universal design introduction in product sustainable design development. By product sustainable design development, it improves the effect of different phases of product life cycle on environment, assists with and guarantees the accomplishment of sustainable products and functions as the criteria for firms to develop products to create economic mechanism with more profits and less risk.

Key words: Sustainable design, Universal design, Analytic Network Process, Modified Delphi Method, hand tools

1. Motives and Purposes

In past economic development, although Taiwan created the miracle of economic growth, under the vigorous industrialization, ecological environment was polluted and damaged. The effect on future generations is unpredictable. Thus, in modern society, “sustainable design” has become the ideal of many enterprises to develop new products. Concept and principle of universal design are based on careful thoughts and attitude. It will not

create unnecessary design and waste too many tangible and intangible resources. It benefits global ecological environment, enhances human beings' life quality and matches the core value of sustainable design. If concept of universal design can be applied to product sustainable design development, it will lead to convenience and comfort for human beings' lives, increase efficacy of resources and energy and avoid the production of waste (Yu, H.Y., 2005).

Thus, this study aims to construct a system framework which integrates overall life cycle environment of product with product sustainable design development by universal design introduced in product sustainable design development. In order to enhance sustainable value of product use, it not only improves consumers' product use (product functions), but also satisfies consumers' expected value. Thus, by introducing universal design in product sustainable design development, products will be improved and will not harm environment and human bodies, as shown in Figure 1.

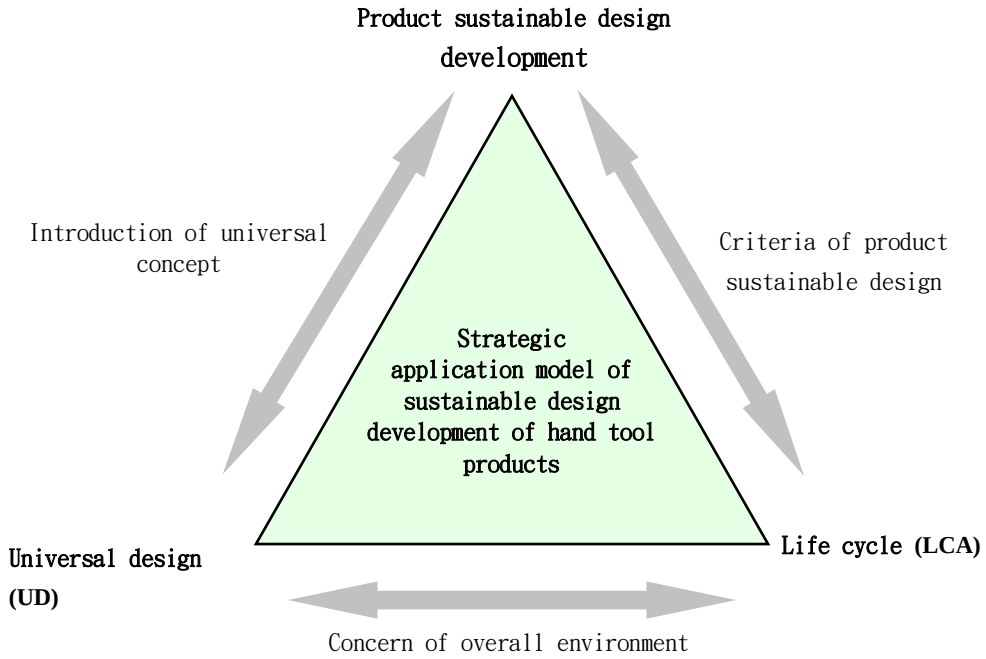


Figure 1. Relationship among universal design, life cycle and product sustainable design development

Universal design is not only the international design trend, but also the designers' social responsibility. In terms of design or marketing, universal design must be based on consumers and users. This study aims to establish optimal product sustainable design development model by universal design. Thus, in order to accomplish the above research goals. This study establishes the following specific purposes, as shown below:

1. To recognize ranking of weights of indicative universal design application in product sustainable design development and product life cycle framework.
2. To analyze the criteria of universal design application in hand tool product sustainable design development and establish evaluation criteria and checking list of product sustainable design development.
3. To analyze, develop and construct strategic application model of universal design introduction in product sustainable design development.

2. Literature Review

Currently, environmental issues are important for different circles. In extremely changeable 21st century, corporate operation emphasizes sustainable operation and development. Products on improvement of environmental problems will be new thought of strategic operation. Therefore, in operation, firms should concern about the responsibility of environmental protection and guide the innovation of environmental techniques by proper environmental standards in order to more effectively use resources, lower cost and increase product value. They can acquire the opportunity in future severe environmental trend. Introduction of universal design in product sustainable design development is a kind of trend and goal. By introduction of universal design, product sustainable design development becomes the product development framework model to protect the earth. It will be the important step to establish sustainable industry.

In this study, literature review will be based on universal design, product sustainable design development and case study of hand tools, as shown in Figure 2. It will function as the academic base of future studies and criterion of application.

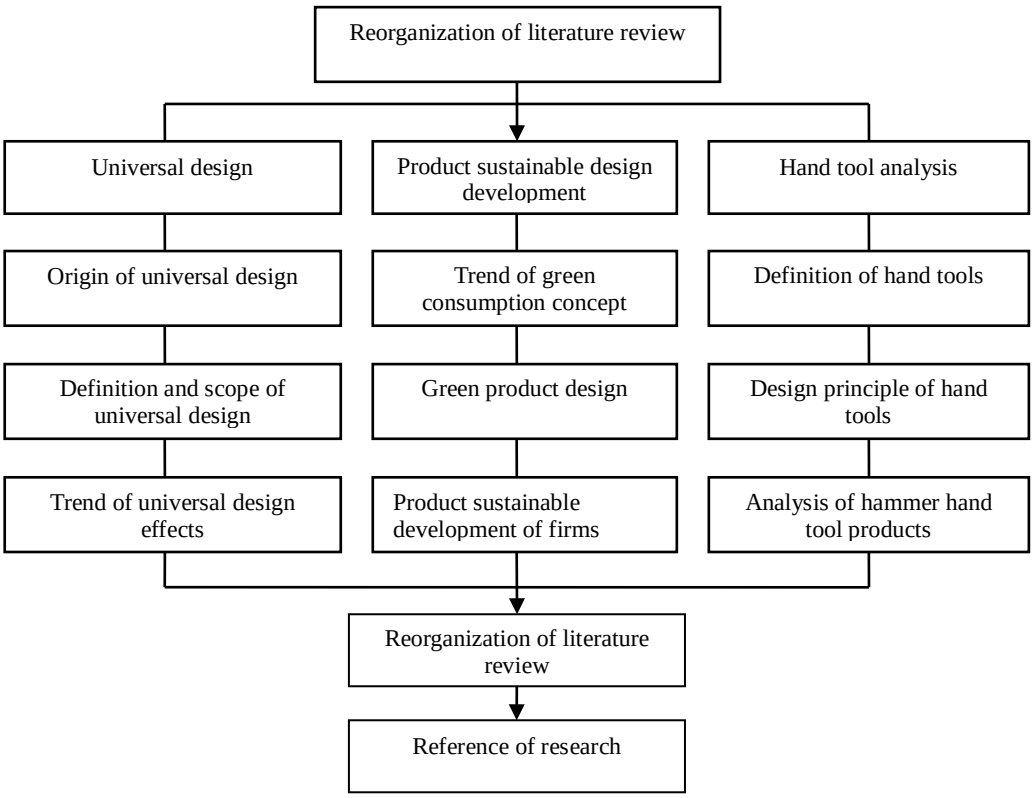


Figure 2. Frame work of literature review

3. Research method and framework

According to research purposes, the researcher develops the following phases and analysis, as shown in Figure 3.

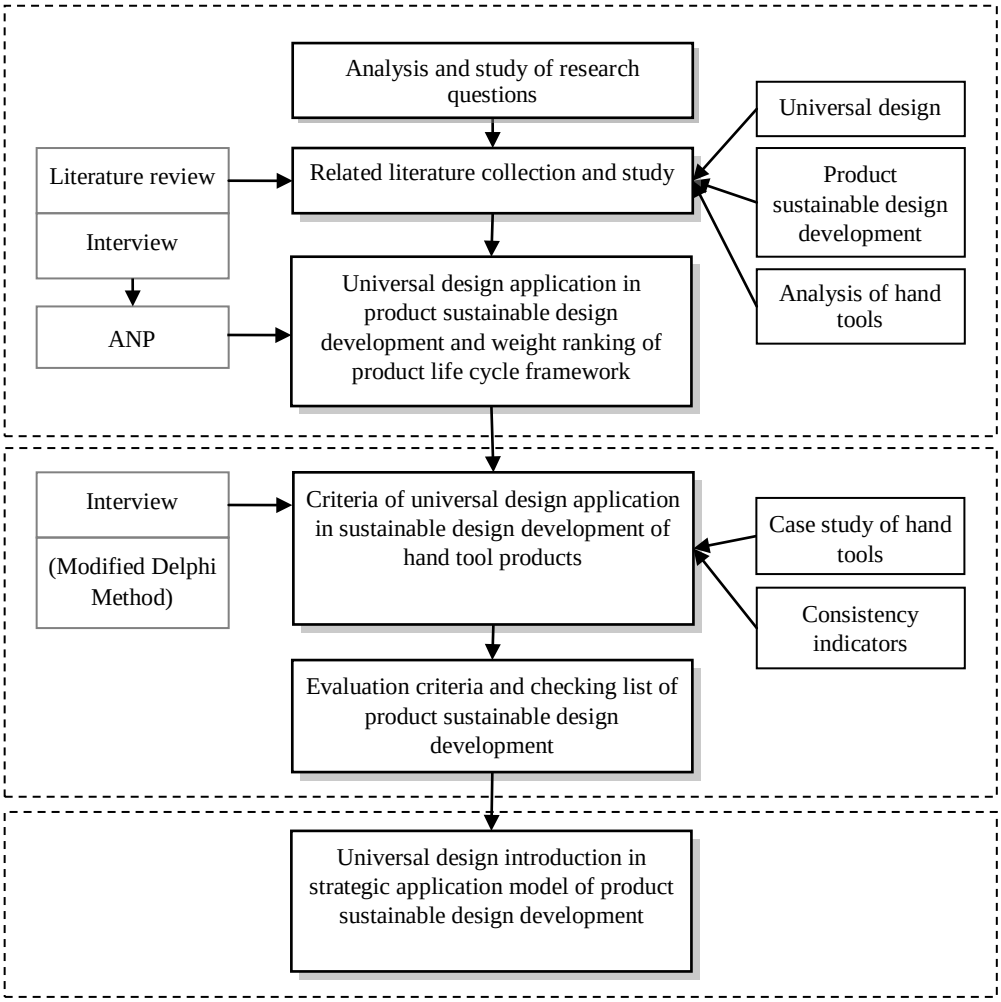


Figure 3. Research framework

3.1 Subjects of interview

In order to acquire reliable, effective and in-depth data, the researcher reviews literatures on hand tool products; besides, the subjects are domestic enterprises in hand tool industry. This study focuses on the enterprises with generally positive evaluation. The subjects include LUCKY-BRAND INDUSTRIAL CO. LTD., Dirotech Corp. and Topeak, Inc.

3.2 Research tools

As to use of research tools, first, by Analytic Network Process (ANP), the researcher acquires weight ranking of universal design and product life cycle framework in hand tool industry. By Modified Delphi Method and semi-structural questionnaire, this study applies universal design in criterion of sustainable design development of hand tool products. Questionnaire content is based on research purposes, sustainable design and universal design.

4. Analytical result of researc

4.1 Outcome of questionnaire survey of weights

Universal design includes 7 principles and 3 supplementary articles which are complicated. However, there is certain degree of correlation between 7 principles and 3 supplementary articles. Decision-making criteria (clusters), elements, nodes and links of Analytic Network Process can clearly show the dependence or feedback of elements. Therefore, by Analytic Network Process, this study analyzes and explores weight ranking of indicative universal design application in product sustainable design development and product life cycle framework. Thus, the weight analysis of the following three dimensions is conducted.

1. Pair comparison of universal design principles in “dependent relationship”.
2. Pair comparison of universal design principle and product life cycle framework.
3. Pair comparison of product life cycle framework in “dependent relationship”.

Figure 4 is bar chart of weight ranking of criteria. When the figures of ranking are higher, it means it is more important. The highest weight is consumer use and the lowest weight is packaging design. Thus, it should be the priority for improvement in universal design application in product sustainable design development.

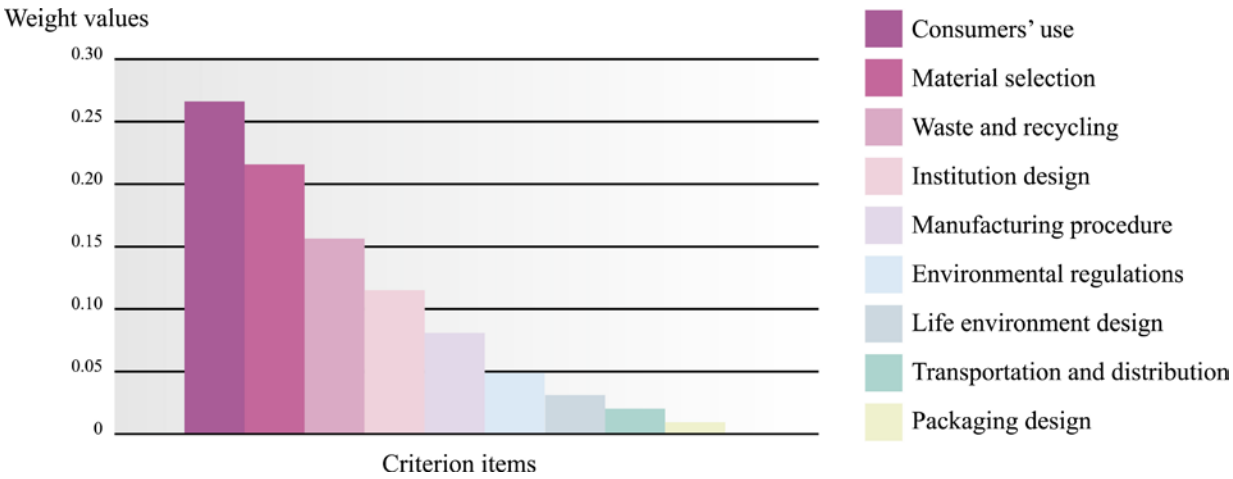


Figure 4. Universal design application in product sustainable design development and weight ranking of product life cycle framework

4.2 Development principle of sustainable design of hand tool products

From perspective of design, different kinds of hand tools have different design criteria, according to functions. Therefore, in this study, regarding sustainable design criteria, the researcher treats hand tools as subjects. By introduction of green design and universal design, it increases value added of products and leads to sustainable operation of hand tool industry.

Questionnaires of Modified Delphi Method are distributed to three enterprises interviewed: supervisors of design department and basic designers of LUCKY-BRAND INDUSTRIAL CO. LTD., Topeak, Inc. and Dirotech Corp. There are 8 valid questionnaires and it matches the sampling standard of Delphi questionnaire. The researcher then compiles statistics of related data after the return of questionnaires. Questionnaire is based on

product life cycle and expert interview and the purpose is to validate the items of criteria. Table 1 is statistical result of questionnaire.

Table 1. Statistical result of universal design introduction in hand tool questionnaire

Material selection				
Design criteria of green product	Agree	Percentage	Disagree	Percentage
1. Suitable product use	8	100%	0	0%
2. Avoidance of use of toxic and hazard components.	8	100%	0	0%
3.Decomposed by organisms.	3	38%	5	62%
4. Simple, avoidance of compound materials.	5	63%	3	37%
5. Recycled materials.	7	88%	1	12%
6. Avoidance of material use.	8	100%	0	0%
7. Correct matching and use of materials.	8	100%	0	0%
8.Pay attention to characteristics and use of materials.	8	100%	0	0%
9. Use of compatible materials	5	63%	3	37%
10. Reduction of chemical treatment	6	75%	2	25%

The researcher conducts questionnaire survey and analysis on items of other concepts of product life cycle in order to find the criteria generalized by academic study matching actual product development in industrial circle. Thus, the following research result can benefit the industrial circle.

4.3 Evaluation criteria and checking list of tool product sustainable design development

Checking list of green design is used for environmental analysis of green product development. The researcher thoroughly recognizes the environmental problems in different phases of product life cycle in order to propose more effective improvement of green product design. Items of checking list of UD introduction in product sustainable design development are based on the outcomes of questionnaire analysis and conclusion. After carefully checking the questionnaire items, the checking items are reorganized. The purpose is for green test according to green design criteria in hand tool industry with sustainable design development. By precise test process, it guarantees ideal sustainable design development and production of green hand tool products. It is the key point and purposes of the test in this study. Table 2 is green design criteria of evaluation elements.

Table 2 Checking list of universal design introduction in sustainable design development of hand tool products

Strategy of universal design introduced in product sustainable design development	Life cycle	Evaluation items	Scoring			
			Good	Acceptable	Should be improved	Remark
	Material selection	Suitable product use				
		Avoidance of use of toxic and hazard components				
		Reduction of material use				
		Correct matching and use of materials.				
		Pay attention to characteristics and use of materials				
		Recycled materials				
		Reduction of chemical treatment				
		Simple, avoidance of compound materials.				
		Use of compatible materials				
		Decomposed by organisms.				

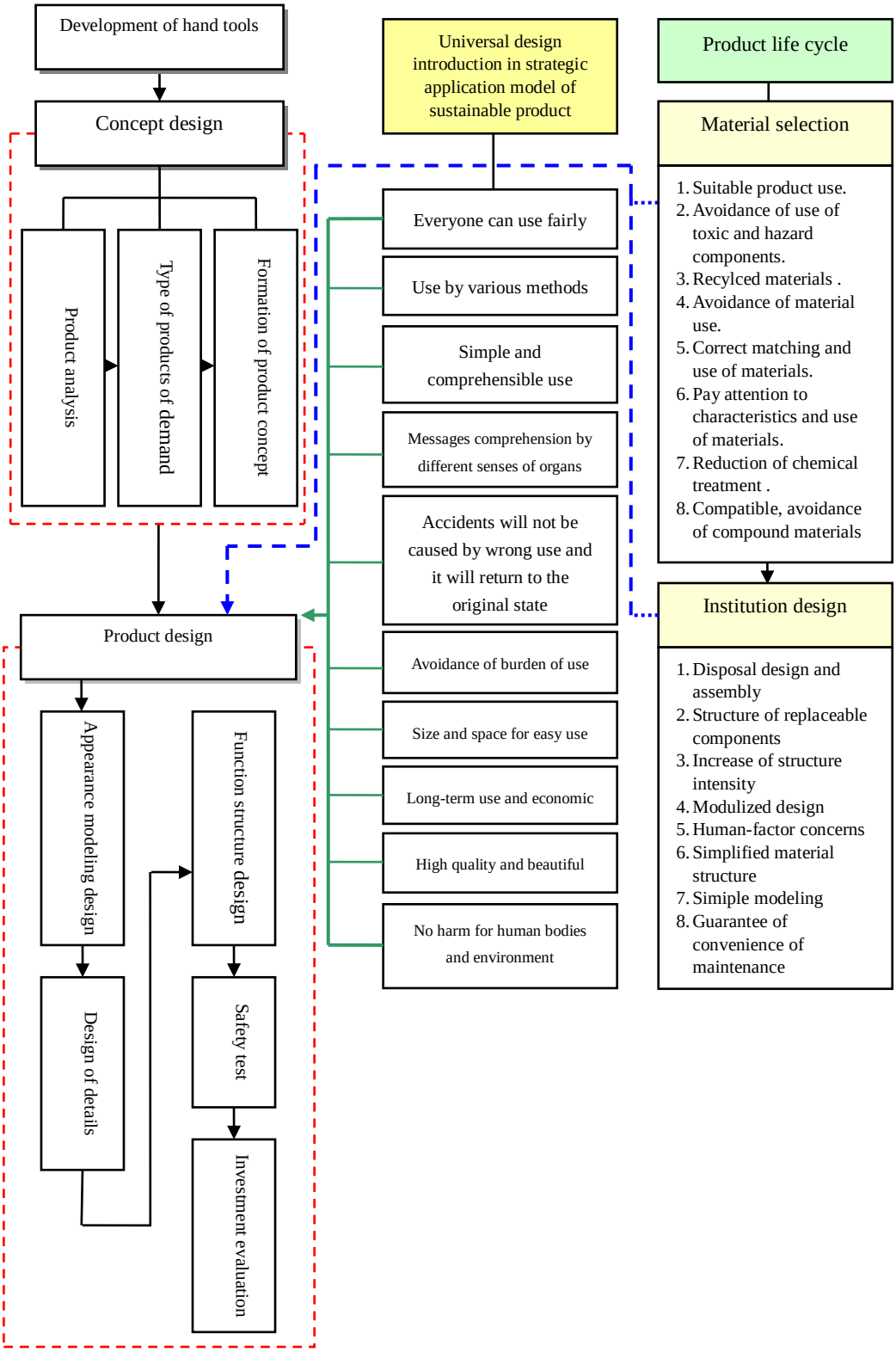
	Institution design	Disposal design and assembly.				
		Structure of replaceable components				
		Increase of structure intensity				
		Modulized design				
		Human-factor concerns.				
		Simplified material structure				
		Simple modeling				
		Guarantee of convenience of maintenance				
	Manufacturing procedure	Reduction of wasted materials				
		Development of manufacturing technology with more energy resources				
		Saving of material manufacturing				
		Adoption of natural energy				
		Reduction of pollutant emission and noise				
		Use of extra energy				
	Packaging design	Little amount and simple measure				
		Enhancement of intensity by structure design				
		Intoxic, decomposable and recyclable packaging materials				
		Reduction of use of foamed plastic				
		.Use of natural resources or paper materials				
		Simple material selection				
		Combined design of product and packaging.				
	Transportation and distribution	Reduction of pollution in transportation				
		The most environmental transportation				
	Consumers use	Increase of use efficiency and satisfaction				
		Simplified function and easy operation				
	Waste and recycling	Encouragement of recycling.				
		Proper treatment of waste.				
		Construction of complete recycling system				
	Life environment design	Concern of overall outdoor landscape design and community planning				
		Offering of beautiful and suitable planning design for urban lives				
	Environmental regulations	Following environmental regulations and standards of different countries.				
		Certification of environmental marks				
Total scoring of design and development effectiveness						

By construction of checking list of UD introduction in product sustainable design development design, the researcher examines green design effectiveness in sustainable design strategy. By suggestion, green evaluation and modification are practiced to fulfill corporate sustainable design and increase corporate competitiveness.

4.4 Strategic application model of universal design introduction in product sustainable design development

Figure 5 is hand tool product development and 9 dimensions of product life cycle: material selection, institution design, manufacturing procedure, packaging design, distribution and transportation, consumer use, waste and recycling, life environment design and environmental regulations. They are basic criteria of sustainable design development of hand tool products to fulfill sustainable design, establish strategic application model of

universal design introduction in sustainable design development of hand tool products to effectively accomplish the goal of green sustainable operation.



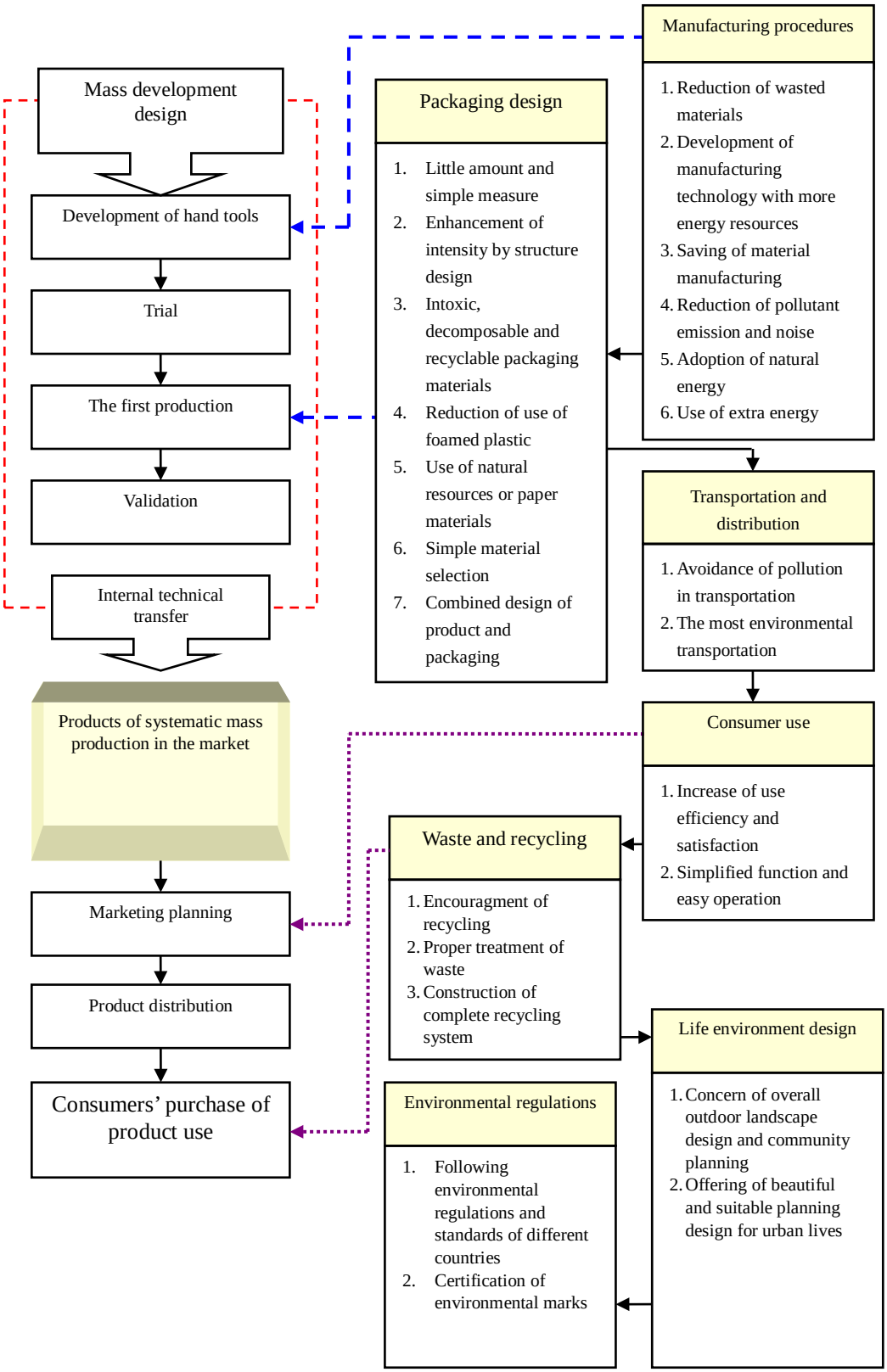


Figure 5. Introduction of universal design in strategic application model of product sustainable design development (Source: compiled by this study)

5. Conclusions

Hand tools have been necessary tools. Knocking, hitting or turning all rely on these tools. Thus, by the strategic application model, the researcher aims to assist with product development of hand tool industry. This study also intends to increase value added of products, trigger consumers' purchase intention and enhance marketing. Thus, hand tool industry in Taiwan will be the first around the world to create sustainable hand tool products.

According to research findings, conclusions are shown below:

1. By Super Decision, the researcher constructs ANP model of this study. According to figures analyzed in matrix, we can find the correlation among the weights and weight ranking of the items.

   By ANP model, the researcher obtains eigen vector and weighted super matrix and limiting super matrix. By the analytical result, designers can immediately control product life cycle dimensions of design of green sustainable products in different principles of universal design.
2. By Modified Delphi Method, the researcher recognizes criteria of universal design introduction in sustainable design development of hand tool products.

   When designers design hand tools, they can follow specific criteria and it will effectively accomplish sustainable products.
3. Checking list is established by evaluation criteria of sustainable design.

   This study effectively applies criteria of universal design introduction in sustainable design development of hand tool products in product design procedure. The checking list can guarantee the accomplishment of sustainable design.
4. The researcher introduces hand tool development to establish strategic application model of universal design introduction in product sustainable design development.

The above will be the criteria for firms to design hand tools. By the model, designers can recognize the proper green design criteria in product design.

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