Analytic Hierarchy Process for Design Selection of Laminated Bamboo Chair

V. Laemlaksakul, S. Bangsarantrip

Abstract—**This paper demonstrates the laminated bamboo chair design selection, the applicability of Analytic Hierachy Process (AHP) in solving such a problem. AHP is a multi-criteria decision making (MCDM) approach, which is based on the pair-wise comparison of elements of a given set with respect to multiple criteria. Even though there are applications of the AHP to furniture design selection, using the Expert Choice software. We report our findings and our insights, together with the results of a sensitivity analysis.**

Key-Words—**analytic hierarchy process (AHP), multi-criteria decision making (MCDM), laminated bamboo chair, expert choice**

I. Introduction

Product innovation is a key factor of enterprise innovation, and creative design is the core of product innovation. The application of new materials is mainly dependent on the properties of the specific materials. In furniture, engineered wood products, bamboo can easily be production.

Bamboos possess several types of advantages including rapid growth rate, low cost and offering friendly environment. The plants are botanically considered as a special group in grass family which can be planted easily into any kind of land. They are also excellent for rejuvenating degraded areas and typically could grow much faster than other common trees as their daily growth rate is merely 80–300 mm^2.

The Analytic Hierarchy Process (AHP) developed by Saaty [1], has been studied extensively and used in almost all the applications related with multiple criteria decision making (MCDM) in the last 20 years. It is concerned with a model that reflects the decision problem's major components (such as decision criteria) and their inter-connections (such as comparisons with each other). It functions via breaking the problem into several sub-categories and blending the results throughout the world, the process relies on focusing on the goal of the problem and having adequate knowledge in each of and solutions of those sub-categories in a very systematic manner. Used in numerous applications of decision making the categories. It operates as a complete model, signifying the relations of importance, dominance, and preference among the aspects of the problem.

Many AHP applications in real-world decision-making have been reported [2-8]. The AHP was adopted in education, engineering, government, industry, management, manufacturing, personal, political, social, and sports [9]. The wide applicability is due to its simplicity, ease of use, and great flexibility. It can be integrated with other techniques, for instance, mathematical programming in order to consider not only both qualitative and quantitative factors, but also some real-world resource limitations.

In this paper describe a study which provides guidance in selection of the "best" laminated bamboo furniture through the AHP.

Manuscript received December 30, 2007. This research was a part of a research project titled "Design of laminated bamboo furniture by using ergonomics method" supported by King Mongkut's University of Technology North Bangkok, Thailand (the fiscal year 2007) under code: 5003110525033.

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II. Methodology

A. Criteria

AHP can pair-wise compare a set of attributes and distinguish in general the more important factors from the less important factors [10-11]. The pair-wise comparison judgments were made with respect to the attributes of one level of hierarchy given the attribute of the next higher level of hierarchy (from the main criteria to the sub-criteria). AHP is also able to solicit consistent subjective expert judgment via the consistency test. The stage AHP set out by Saaty [1].

For designing the paired comparison matrices, the decision hierarchies were formed (Fig. 1). The hierarchies reaffirmed the results of the general survey and depicted the attributes for selecting chairs. The top level was the selection goal, and following this was the building systems of laminated bamboo chair. The third and fourth level comprised the selection criteria and sub-criteria expanding from the building systems. In this study, identified seven criteria for which building the comparison matrices. Seven of these criteria are derived, which are function, material, construction, process, economy, aesthetic and ergonomics. The seventh criterion selected namely the ergonomics. The researcher has found out that "ergonomics" was the most important feature by author in using furniture.

B. Scale ranging

The relative importance of the criteria and sub-criteria were rated by the nine-point scale proposed by Saaty [1], as shown in Table 1, which indicated that the level of relative importance from equal, moderate, strong, very strong, to extreme level by 1, 3, 5, 7, and 9, respectively. The intermediate values between two adjacent arguments are represented by 2, 4, 6, and 8.

C. Sub-Ergonomics

The sub-criteria for sub-ergonomics evaluation are followed by the 6 fundamentals of seating as; lumbar support, backrest angle seat height, width/depth, armrest and seat angle.

The prototypes of laminated bamboo chair were designed based on the design criteria.

Table 1
The AHP pairwise comparison scale [1]

Given values (1-9)	Explanation
1 Equal	Both alternatives have equal importance.
3 Moderate	One of the alternatives is slightly more important than the other.
5 Strong	One of the alternatives is judged as strongly more important than the other by experts.
7 Very Strong	One of the alternatives is judged as very strongly important compared to the other.
9 Extreme Importance	One alternative is strictly superior to the other one.
2, 4, 6, 8 Intermediate values	Used for compromised judgments when necessary.

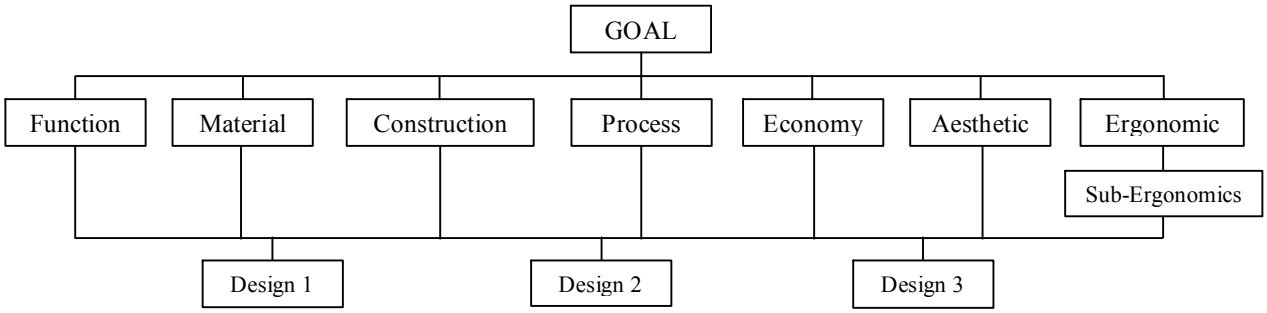

Fig. 1. The decision hierarchy for selecting laminated bamboo chairs

Design 1 Design 2 Design 3

Fig. 2. The selected designs for laminated bamboo chair

D. Data Collection

A questionnaire was designed for data collection, and the format was synthesized with reference to AHP matrix. Since the assignment of the weight requires logical and analytical thinking, only the relevant experts or professionals providing penetrating insights were highly valuable to an empirical inquiry. In order to select the suitable respondents, a question on the preceding (general) survey asked the respondents if they were experienced in furniture design and development. A total of 7 experienced respondents in the general survey replied and expressed their interest in conducting the AHP questionnaire.

E. Analysis

To analyses the survey findings, the judgment matrices were pair-wise compared and computed via the use of commercial software packages (ExpertChoice™). The local priority weights of all main criteria and sub-criteria were first calculated, and then combined with all successive hierarchical levels in each matrix to obtain a global priority vector.

III. Results

In our study, 7 returned questionnaires were received for the AHP survey. By evaluating the consistency level of the collected questionnaires, questionnaires appeared to have acceptable consistency (Table 2) and would enter into analysis. This AHP survey further confirms the significance of all crucial selection criteria by the experts who have a high level of experience in furniture industry. Findings relating to relative importance of selection criteria and sub-criteria are summarized below: From Table 2, the total weight for furniture design 1 is highest relating to 5 fundamentals of seating. Normally, one of the most concerned factors for chair design is ergonomics and the purpose of chair design is to comfort users when sitting. By this reason, if ergonomics criteria are best concerned, furniture design 1 would be the most appropriate for this analysis.

However, if an ergonomics criterion is solely considered, it lacks of reasonable for applications because there are some important criteria omitted such as function, material, construction, aesthetic, process and economy. The Figure 3 shows that furniture design 1 is accorded to all criteria except aesthetic and economy. Furniture design 2 is the best appropriate for aesthetic and furniture design 3 is the best appropriate for economy. From Table 3 and Figure 4, Design 1 was most appropriate followed by all sub-criteria. It is concluded that furniture design 1 is the best choice for further analysis.

After selecting the appropriate furniture design by AHP, the consistency ratio for main criteria and sub-criteria were calculated as shown in Table 4 and 5 respectively. It is clearly that all consistency ratios are less than 0.1 (or 10%). It can be said that the furniture design selecting by AHP is significantly reasonable.

Table 2
Weight for main criteria analysis.

Design No.	Function 0.248	Material 0.024	Construction 0.417	Ergonomics 0.129	Process 0.030	Economy 0.055	Aesthetic 0.096	Total
1	0.203	0.014	0.290	0.053	0.020	0.007	0.013	0.600
2	0.023	0.002	0.031	0.037	0.008	0.005	0.074	0.180
3	0.023	0.009	0.096	0.039	0.002	0.042	0.008	0.219

Table 3
Ergonomics weight for sub-criteria analysis.

Design No.	Lumbar Support 0.011	Backrest Angle 0.016	Seat Height 0.047	Width/Depth 0.023	Armrest 0.023	Seat Angle 0.011	Total
1	0.003	0.007	0.016	0.017	0.008	0.004	0.053
2	0.001	0.007	0.016	0.002	0.008	0.004	0.037
3	0.008	0.002	0.016	0.003	0.008	0.004	0.039

Table 4
Inconsistency ratio for main criteria.

	Main Criteria							
	Goal	Function	Material	Construction	Ergonomics	Process	Economy	Aesthetic
Inconsistency Ratio	0.05	0.00	0.05	0.07	0.04	0.02	0.10	0.05

Table 5
Inconsistency ratio for sub-criteria

	Sub- Criteria					
	Lumbar Support	Backrest Angle	Seat Height	Width/Depth	Armrest	Seat Angle
Inconsistency Ratio	0.09	0.00	0.00	0.02	0.00	0.00

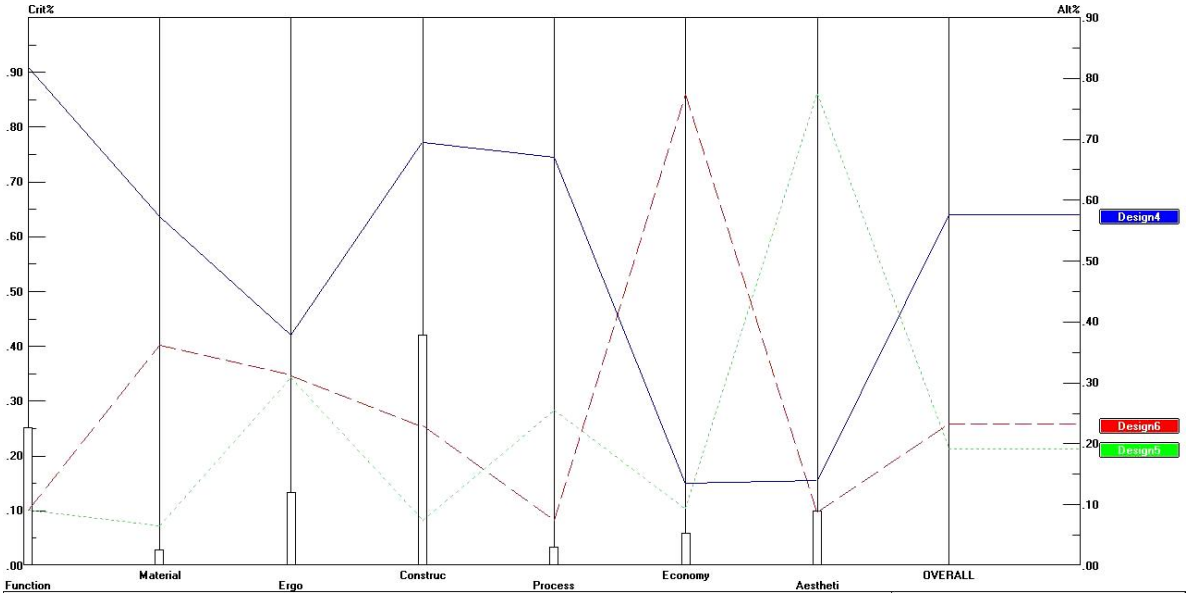

Fig. 3. Performance sensitivity graph for 7 criteria.

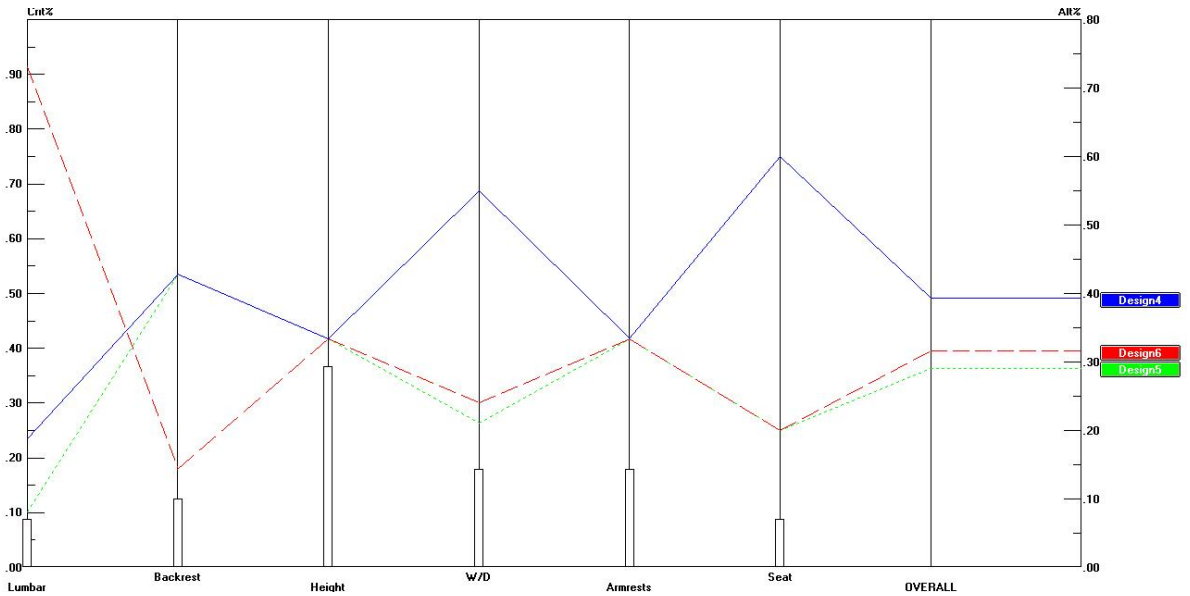

Fig. 4. Performance sensitivity graph for sub-criteria

IV. Conclusions

From this research, Analytic Hierarchy Process (AHP) was applied to select the appropriate laminated bamboo chair. Furniture design 1 was most appropriate followed by all criteria, especially ergonomics criterion. However, furniture design 1 needs to be improved in term of economy criterion.

This research was limited only dining chair. The developed AHP guideline can well apply for other styles of furniture design beyond laminated bamboo but concerning on ergonomics criterion.

Acknowledgment

Authors thank the College of Industrial Technology, King Mongkut's University of Technology North Bangkok, Thailand for supporting the experimental equipments to conduct this research.

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