An application of the Analytic Hierarchy Process (AHP) for a competence analysis of technology managers from the manufacturing industry in Taiwan

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ABSTRACT: The purpose of this study was to explore the competences of technology managers from the manufacturing industry. The first-stage questionnaire, based on a literature review, was administered to five top-level and middle-level managers from the manufacturing industry in Taiwan. A hierarchy of the competences of technology managers from the manufacturing industry was then established. Based on this result, a second-stage questionnaire was developed as an investigation tool with 12 top-level and middle-level managers from the manufacturing industry. Finally, the Analytic Hierarchy Process (AHP) analysis was utilised and the relative importance of every hierarchy item was obtained. The findings presented in this article could provide the major basis of education and training for technology managers from the manufacturing industry.

INTRODUCTION

The effective management of technology is the key to economic growth and competitiveness. As such, it is important that managers think more carefully about how they should set about managing technologies relevant to their firms [1]. In Taiwan, the manufacturing industry, which plays the role of leading changes in the industrial structure, helps to drive the promotion of technology innovation activities. Hence, manufacturing firms should engage in early planning to train relative competences for technology management.

The Analytic Hierarchy Process (AHP) is a method for formulating and analysing decisions. For enterprises, identifying what the required competences are, ie the training for technology managers, is just as important as other decisions. The AHP can also be utilised to rank the importance of various alternatives. In this study, the application of the AHP technique helps identifying what competences a technology manager needs and their relative importance.

REVIEW OF THE COMPETENCES OF TECHNOLOGY MANAGERS

Technology management is a practice that entails the classification, selection, adoption and exploitation of technologies needed to maintain an organisation's current and future survival [2]. Figure 1 sets out the proposed framework with its constituent sub-processes of identification, selection, acquisition, exploitation and protection [3].

According to previous studies concerning the education and development of technology managers, the authors sorted competences based on technology management sub-process needs for technology managers [4-9]. Besides various sub-processes, the authors added a sixth practice, whole course controlling, for technology management.

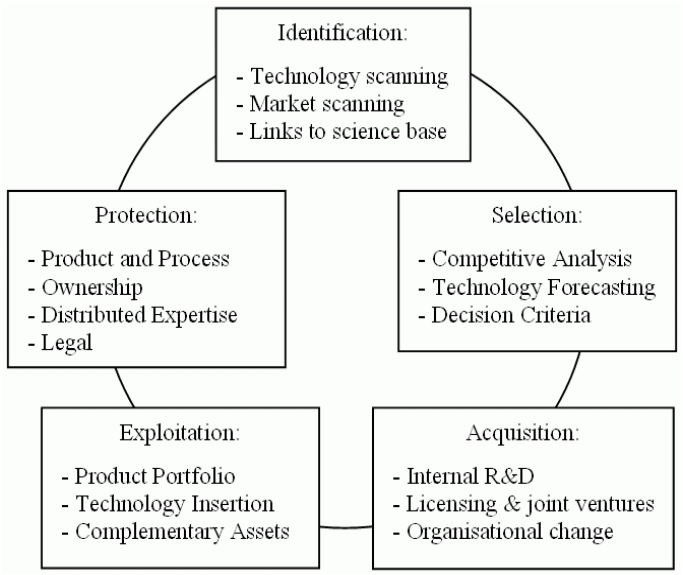

Figure 1: The technology management process framework.

The competences comprised in each process are listed as follows.

- *Identification*: Understanding technology constructs and identifying technology;
- *Selection*: Technology forecasting, technology assessing, formulating technology strategy criteria, and technology selection;
- *Acquisition*: Introducing new technology and facilitating technological R&D;
- *Exploitation*: Grasping customer needs, mastering labour and resources, applying financial constructs and applying marketing;
- *Protection*: Knowing laws related to technology and applying intellectual property rights;

- *Whole course controlling*: Understanding the external environment, making strategic decisions, interpersonal communication, teamworking, problem solving, integration and planning, and empowerment and commitment.

In this study, the authors applied the results of a literature review in order to generate a hierarchy framework of competences for technology managers.

METHOD

The major research method utilised was survey, and the AHP technique was adopted for analysis. The AHP is a method for breaking down a complex and unstructured situation into its component parts, then arranging those parts (or variables) into a hierarchical order. This method is based on the assignment of numerical values for subjective judgements on the relative importance of each variable, then synthesising the judgements to determine which variables have the highest priority [10].

Prior to developing the first-stage questionnaire, called *A hierarchy questionnaire of competences for technology managers*, a literature review helped to bring about a better understanding of the six technology management practices and 21 competences. A hierarchy of the competences of technology managers in the manufacturing industry was established by the survey results. The integrated result was to revise the competence of *technology assessing* as *assessing the feasibility of technology*. Also, the competence of *interpersonal communication* was revised as *communication and negotiation*. Based on these results, the second-stage questionnaire, called *An AHP-designed questionnaire of competences for technology managers*, was developed. Finally, the research results were acquired using the AHP technique.

DATA COLLECTION

The first-stage questionnaires were sent to five top-level and middle-level managers from the manufacturing industry. The second-stage questionnaires were investigated with 12 top-level and middle-level managers from the manufacturing industry. For both stages, manufacturing firms were selected from the list of the 2001 top 1,000 manufacturing firms as published by *Common Wealth* – Taiwan's leading magazine. In both stages, all managers completed and returned the survey.

RESULTS

The main results of analysis, including the hierarchy of competences for technology managers and the relative importance of every hierarchical item, are shown as Figure 2. The generalised research results as detailed below.

The duty of technology managers in the manufacturing industry belonged to the top-level and middle-level managers; moreover, they placed approximately equal importance on duty. The importance of duty for technology management is shown in Table 1.

Table 1: The results of pair-wise comparisons for the importance of duty.

Technology Management Duty	Priority	Rank
Middle managers	0.549	2
Top managers	0.541	1

The most important practice of technology management for middle-level managers in the manufacturing industry was *exploitation*. The most important practice of technology management for top-level managers in the manufacturing industry was *whole course controlling*. The importance of practices of technology management for top-level and middle-level managers are listed in Tables 2 and 3.

Table 2: Ranked results of pair-wise comparisons for important practices of technology management for middle-level managers.

Practices of Technology Management	Priority	Weighted Priority	Rank
Identification	0.079	0.036	5
Selection	0.139	0.064	4
Acquisition	0.170	0.078	3
Exploitation	0.294	0.135	1
Protection	0.071	0.033	6
Whole course controlling	0.247	0.113	2

Table 3: Ranked results of pair-wise comparisons for important practices of technology management for top-level managers.

Practices of Technology Management	Priority	Weighted Priority	Rank
Identification	0.092	0.050	5
Selection	0.197	0.106	2
Acquisition	0.188	0.102	3
Exploitation	0.184	0.099	4
Protection	0.066	0.036	6
Whole course controlling	0.273	0.148	1

The practices of technology management in the manufacturing industry covered six sections, including *whole course controlling*, with the composite weights shown in Table 4.

Table 4: The results of composite weights for important practices of technology managers.

Practices of Technology Management	Composite Priority	Rank
Identification	0.086	5
Selection	0.170	4
Acquisition	0.180	3
Exploitation	0.235	2
Protection	0.068	6
Whole course controlling	0.261	1

The competence of *identifying technology* was the most important in the practice of *identification*. The importance of *identification* competences are listed in Table 5.

Table 5: Ranked results of pair-wise comparisons for the importance of *identification* competences.

Competences of the Practice of *Identification*	Priority	Weighted Priority	Rank
Understanding technology constructs	0.476	0.041	2
Identifying technology	0.524	0.045	1

The competence of *assessing the feasibility of technology* was the most important in the practice of *selection*. The importance of competences regarding *selection* are shown in Table 6.

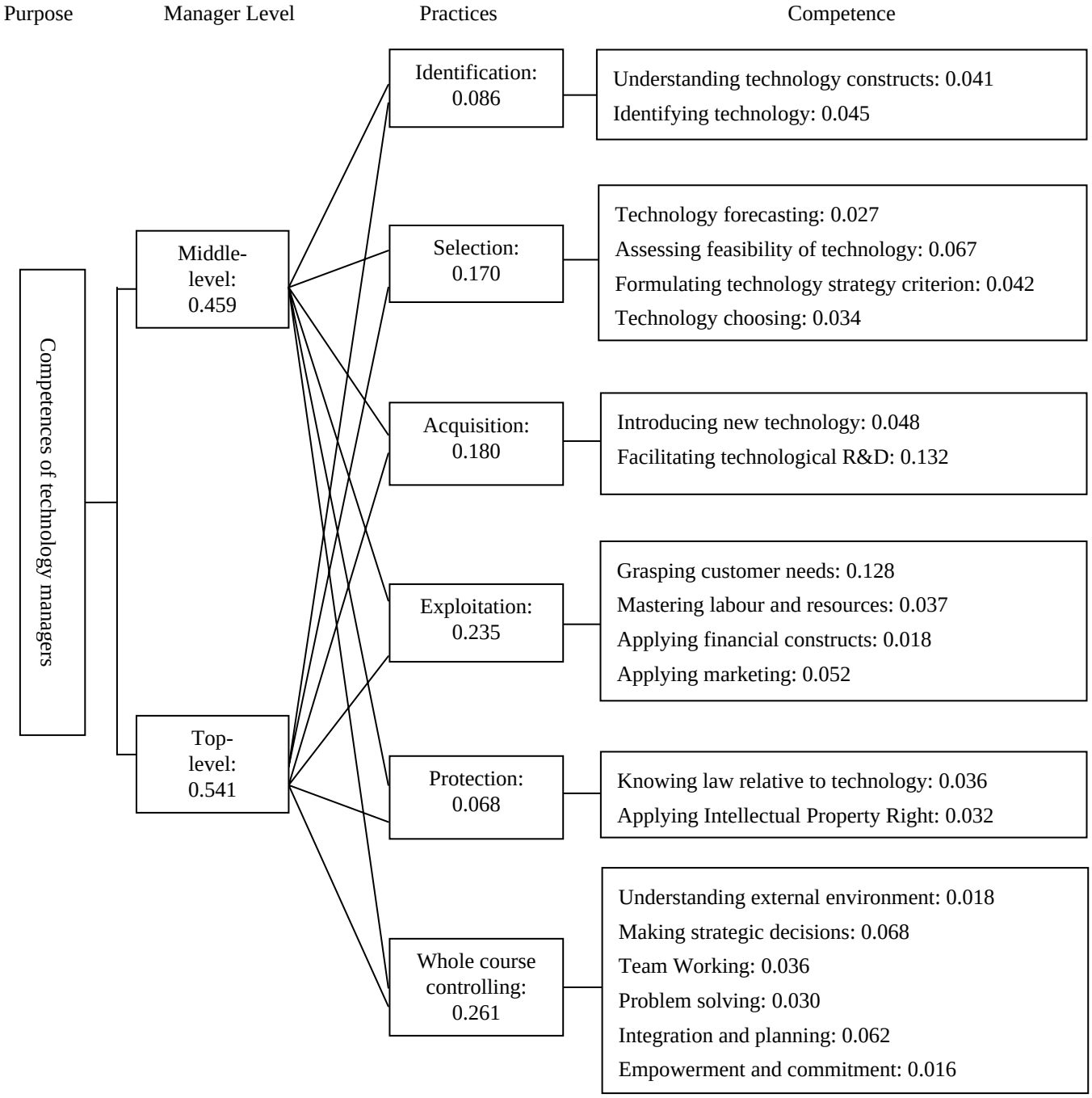

Figure 2: The hierarchy structure and relative weights of competences of technology managers in the manufacturing industry.

Table 6: Ranked results of pair-wise comparisons for the importance of competences in the practice of *selection*.

Competences of Practice of *Selection*	Priority	Weighted Priority	Rank
Technology forecasting	0.161	0.027	4
Assessing the feasibility of technology	0.392	0.067	1
Formulating technology strategy criteria	0.249	0.042	2
Technology selection	0.198	0.034	3

The competence of *facilitating technological R&D* was deemed the most important in the practice of *acquisition*. The importance of competences for *acquisition* practices are listed in Table 7.

The competence of *grasping customer needs* was considered to be the most important in the practice of *exploitation*. The importance of competences for *exploitation* practices are listed in Table 8.

Table 7: Ranked results of pair-wise comparisons for the importance of competences in the practice of *acquisition*.

Competences of Practice of *Acquisition*	Priority	Weighted Priority	Rank
Introducing new technology	0.266	0.048	2
Facilitating technological R&D	0.734	0.132	1

Table 8: Ranked results of pair-wise comparisons for the importance of competences in the practice of *exploitation*.

Competences of Practice of *Exploitation*	Priority	Weighted Priority	Rank
Grasping customer needs	0.543	0.128	1
Mastering labour and resources	0.156	0.037	3
Applying financial constructs	0.079	0.018	4
Applying marketing	0.222	0.052	2

The competence of *knowing laws relative to technology* was found to be the most important in the practice of *protection*. The importance of competences for *protection* practices are shown in Table 9.

Table 9: Ranked results of pair-wise comparisons for the importance of competences in the practice of *protection*.

Competences of Practice of *Protection*	Priority	Weighted Priority	Rank
Knowing laws relative to technology	0.527	0.036	1
Applying intellectual property rights	0.473	0.032	2

The competence of *making strategic decisions* was the identified as being the most important in the practice of *whole course controlling*. The importance of competences for practices in *whole course controlling* are shown in Table 10.

Table 10: Ranked results of pair-wise comparisons for the importance of competences in the practice of *whole course controlling*.

Competences of Practice of *Whole Course Controlling*	Priority	Weighted Priority	Rank
Understanding the external environment	0.067	0.018	6
Making strategic decisions	0.260	0.068	1
Communication and negotiation	0.120	0.031	4
Teamworking	0.136	0.036	3
Problem solving	0.116	0.030	5
Integration and planning	0.238	0.062	2
Empowerment and commitment	0.063	0.016	7

Among all the competences, the most important was found to be *facilitating technological R&D*. The importance of all competences are listed in Table 11.

CONCLUSION

In Taiwan, there is still no explicit function of office for technology management. Nevertheless, the immediate need for technology management with industry change is positive. From the AHP-designed survey, an analysis of the competences for technology managers was undertaken with the relative importance of each competence identified. This could provide the major basis and arrangement of education and training for the practice of technology management for the manufacturing industry.

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Table 11: The importance of competences needed for technology managers.

Rank	Competences
1	Facilitating technological R&D
2	Grasping customer needs
3	Making strategic decisions
4	Assessing feasibility of technology
5	Integration and planning
6	Applying marketing
7	Introducing new technology
8	Identifying technology
9	Formulating technology strategy criterion
10	Understanding technology constructs
11	Mastering labour and resources
12	Knowing law relative to technology
13	Team Working
14	Technology choosing
15	Communication and negotiation
16	Applying Intellectual Property Right
17	Problem solving
18	Technology forecasting
19	Applying financial constructs
20	Understanding external environment
21	Empowerment and commitment