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The Construction of an Instructional Quality System for Industrial Technology Education*

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In this article, the authors present the first-year results of a three-year project. The main purpose of the project was to develop a baccalaureate curriculum for industrial technology students at the college level. In order to achieve this objective, during the first year period, a study was conducted utilising document analysis, interviews, panel discussion and the Delphi technique. The following conclusions were reached. The baccalaureate curriculum for preparing industrial technology competences included 13 dimensions with 43 items. The instructional strategy for the industrial technology competence curriculum should include four stages, namely: the *preparation stage*, *teaching stage*, *end-of-teaching stage* and the subsequent *assessment stage*. The industrial technology competence curriculum should adopt multiple, qualitative and quantitative assessment strategies. The instructional quality system for the industrial technology competence curriculum should include four stages, such as *analysis*, etc. After finishing the first year of research, a curriculum based on the mentioned competences will be developed and this curriculum will be conducted as an experimental process to ascertain the final effect on industrial technology students.

INTRODUCTION

Research Background and Purpose

With the rapid development of information technology (IT), economic capital no longer emphasises substantial hardware, but has instead shifted its focus to invisible software, such as knowledge, techniques, brands, etc. It is envisaged that the combination of industry and knowledge will result in limitless benefits. In order to maintain and increase global economic growth, it is necessary to facilitate the application of knowledge information with an eye to speeding up the development of new industries, protecting mainstream products, and keeping the R&D, marketing and financial management of traditional industries [1][2].

Without doubt, regarding the development of the global economy, knowledge is set to play an important role in which the level of competition in industries will turn to competition between knowledge and technology. Professional knowledge workers will comprise the future industry workforce.

However, it has been shown from relevant research that the type of labour and competences developed by the college educational system do not meet the needs of industries, as provided by training programmes of the vocational training system [2]. This demonstrates that, with the development of the knowledge economy, industries need more workers who have higher education qualifications, more professional knowledge plus more competences combined with a theory background, as well as practical technological abilities. Therefore, the adjustment and modification of a baccalaureate curriculum for industrial technology is considered necessary [3][4].

Total Quality Management and Education

The pursuit of *excellent quality* and a *customer first* focus is the most essential recognition among

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contemporary entrepreneurs. A recent important issue has been the application of Total Quality Management (TQM) to the educational field [5-7]. From the perspective of TQM, the education system should be viewed as a whole first, including the conceptions and techniques involved in TQM and the instructional system, with the linkages related to the whole education system later concentrated on in order to assure the quality of education [6][7].

Hence, the common focus on the development of TQM and an instructional system for the industrial technology curriculum is to emphasise a systems approach, that is, to take the whole instructional system process into consideration. Therefore, in this study, through the analysis of curriculum content, the objectives of the subjects, the connotation of materials and the evaluation of teaching and assessment, the instruction quality system for preparing fundamental industrial technology competences were constructed.

The purposes of this study are as follows:

- To identify the core competences of industrial technology education;
- To propose the course framework for an industrial technology curriculum;
- To propose an instructional and evaluation strategy for the development of an industrial technology curriculum.

RESEARCH DESIGN AND IMPLEMENTATION

Research Design

On the whole, the study is based upon the concepts of quality management, instructional system design and authentic assessment. The research framework is shown in Figure 1, while the instructional system design concept is given in Figure 2.

In the first stage, the customer-oriented concept was applied, with the customers of the curriculum identified as employers and graduates. These two

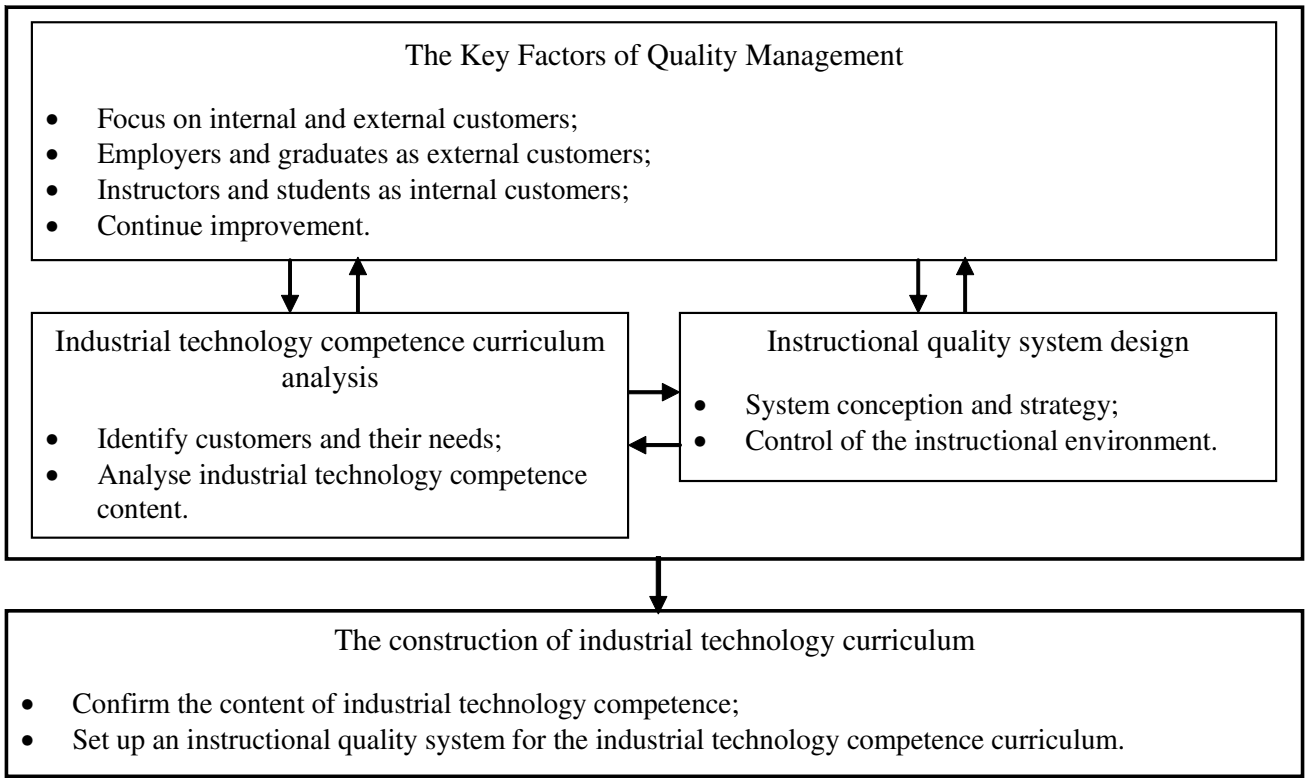

Figure 1: The research framework.

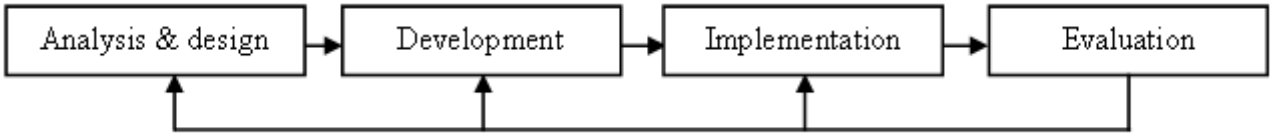

Figure 2: The instructional system design.

groups from the formal curriculum were invited to provide their opinions regarding the competences of the industrial technologist. Based on their opinions, a Delphi technique was also applied to the external customers.

After finishing the collection of this information, internal customer focus concepts and instructional system design ideas will be conducted. Experienced instructors will be invited to develop a curriculum prototype and some courses will be developed in more detail. In the final stage, the internal customers, ie students, will be involved in an experiment to examine the effect of the instructional system.

Research Procedure

During the first year of research, the following techniques and procedures were conducted.

Document Analysis

In order to achieve the purposes mentioned above, literature was first collected in order to establish the foundation in the theory of baccalaureate curricula in industrial technology. This included the current situation and developing tendencies, connotations of curricula, the construction of instructional systems, the development of curricula and the evaluation of fundamental industrial technology competences.

A document analysis was carried out so as to obtain the connotation of fundamental industrial technology competences.

Expert/Professional Interviews

Interviews were conducted in order to understand the current situation in industry, labour needs, as well as enterprise opinions on fundamental industrial technology competences. The interviews were audio-taped and carried out using a semi-structured questionnaire with senior managers from four companies.

Panel Discussion

In the middle of the study, a panel discussion with eight experts and professionals was conducted in order to integrate the different opinions from the literature review, document analysis and interviews. It was also used to ascertain the results using the Delphi technique.

Delphi Technique

The Delphi technique was utilised for the 22 experts and professionals in order to gain consensus regarding both the practical and theoretical systems of a baccalaureate curriculum that will facilitate the preparation fundamental industrial technology competences.

RESEARCH RESULTS AND DISCUSSION

A content analysis of baccalaureate industrial technology competences revealed the following:

- As for the content of baccalaureate industrial technology competences, according to the results based on the document analysis, the preparation of students' industrial technology competences should focus on:

  - The preparation of professional knowledge and technology;
  - Knowledge of common basic subjects.

  Hence, the content of industrial technology competences should include a professional competence field, as well as a common competence field;
- In the professional competence field, according to the results of expert/professional interviews (listed in Table 1), the most important competence is professional knowledge, the second is professional technology and the third is theory-based knowledge. In the common competence field, the most important competences are innovative R&D and relearning ability, as well as language ability;
- The results of the panel discussion revealed that the ability of innovative R&D and relearning should be divided into an innovative R&D ability and an active learning ability. The human relationship and communication ability should be divided into facilitating positive human relationships, and the ability to communicate and negotiate. Furthermore, the abilities of controlling the industrial environment, problem-solving, teamwork, knowledge sharing and emotion management should also be included in industrial technology competences;
- As for the results of the Delphi questionnaire, 22 experts and professionals reached a consensus on both practical and theoretical systems of a baccalaureate curriculum for preparing fundamental industrial technology competences. A curriculum to prepare industrial technology competences should include 13 dimensions with 43 items, which are listed in Table 2.

Table 1: The analysis of industrial technology competence content acquired from the expert/professional interviews.

Content Field	Competence Content	Visitor				Freq.
		A	B	C	D	
Professional competence field	Professional technology	14	4	1	4	23
	Professional knowledge	19	7	0	4	30
	Theory-based knowledge	8	7	0	4	19
	Practical experience	12	1	1	1	15
Common competence field	Information application	5	0	1	0	6
	Management	6	2	2	4	14
	Language	11	1	1	5	18
	Innovative R&D and relearning	13	0	1	5	19
	Humane and social capacities	3	0	1	1	4
	Social relationships and community	4	1	1	3	9
	Business ethics	8	0	2	0	10
	Career planning	1	0	0	0	1

Note: The coding of the items for *content field* and *competence content* is acquired from the document analysis.

Instructional Quality System Analysis of the Baccalaureate Industrial Technology Competence Curriculum

Through the document analysis, interviews, panel discussion and Delphi technique, the results of the instructional quality system analysis into baccalaureate industrial technology competences were obtained as follows:

- The instructional system of a fundamental industrial technology competence curriculum should involve the continuous process of analysis, design, development, implementation, evaluation and improvement, such as analysing customers' needs, designing and developing instructional strategies, evaluating teaching performance, etc;
- The composition of fundamental industrial technology competences should include cognitive, affective and psychomotor materials. The material content should focus entirely on continuity. Additionally, students' backgrounds should also be considered;
- The instructional strategy of the curriculum to facilitate fundamental industrial technology competence should include four stages, as follows:
  - At the stage of preparation, the learning objectives and learners' basic knowledge should be ascertained;
  - At the stage of teaching, learning motivation should be aroused and the learning objectives and content should be stated;
  - At the stage of the end of teaching, the key points of learning should be generated and the assignment should be pointed out;
  - At the stage of subsequent assessment, a suitable assessment method should be adopted.

  The result of the assessment would be further analysed to contemplate the teaching problems in order to improve teaching and assessment strategies;
- The assessment strategies of a fundamental industrial technology competence curriculum should be based on these teaching objectives, the improvement of teaching quality, problem-solving abilities, adequate information and teaching strategies;
- The fundamental industrial technology competence curriculum should be able to develop students' professional knowledge, specialised technology, innovation, active learning, language, management, communication, facilitation of positive human relationships, etc.

Instructional Quality System Procedure of Baccalaureate Industrial Technology Competence Curriculum

Based upon the concept of TQM, the instruction procedure of a baccalaureate industrial technology competence curriculum should adopt the systemised steps detailed below.

Focus on Analysis

The instructional quality system of an industrial technology competence curriculum should initially

Table 2: The analysis of the core industrial technology competence acquired from the Delphi questionnaire.

Competence Item	Mean	SD	Rank	D
Professional Technology				
Tool/machine operating techniques	5.03	1.07	35	3.31**
Inspection instrument operating techniques	5.09	0.95	33	3.47**
Electromechanical integration	5.34	0.87	26	5.04**
Diagram reading	5.60	0.91	19	3.23**
Integrating and applying technology procedures	5.75	0.80	16	4.56**
Professional Knowledge				
Understanding the concept of occupational safety and health	5.21	1.02	30	3.95**
Understanding the working principles of equipment and instruments	5.46	0.75	24	7.86**
Understanding the product manufacture, processing methods and procedures	5.84	0.71	14	6.37**
Understanding business law (eg intellectual property rights)	4.66	0.99	40	5.29**
Theory-based knowledge				
Physics-related background theory	5.54	0.97	21	6.05**
Chemistry-related background theory	5.06	1.10	34	4.73**
Mathematics-related background theory	4.99	0.73	36	5.53**
Innovative Research and Development				
Product design	5.60	1.23	19	6.37**
Innovative improvements	6.13	0.86	6	6.60**
Information Application				
Computer-Aided Design (CAD)	5.49	1.01	23	4.70**
Word processing	4.96	0.78	37	3.68**
Management Knowledge				
Financial management	3.96	1.57	43	3.13**
Marketing	4.09	1.31	42	4.63**
Production management	5.16	1.10	32	4.76**
Quality management	5.54	0.66	21	7.80**
System management	4.93	1.02	38	5.85**
Knowledge management	5.27	0.74	28	3.12**
Leadership management	5.36	0.79	25	5.01**
Project planning	5.66	0.54	17	8.26**
Language				
Language skills (eg English, Japanese)	5.91	0.81	11	6.97**
Relearning				
Active learning	6.52	0.58	3	7.29**
Problem-solving	6.53	0.63	2	7.85**
Humane and Social Capacity				
Humane capacity (eg arts and aesthesis)	4.81	0.81	39	5.56**
World perspective	5.20	1.01	31	5.42**
Human Relationship				
Actively caring for others	5.62	0.56	18	5.21**
Teamwork skills	6.41	0.74	4	7.36**
Emotional control	6.08	0.60	7	4.36**
Communication				
Self-expression	5.91	0.52	12	4.76**
Communication and negotiation	6.23	0.86	5	8.06**
Project and written reports	5.78	0.42	15	9.19**
Capacity for Business Ethics				
Business ethics and morality	5.97	0.67	9	3.47**
Knowledge-sharing	5.86	0.47	13	5.32**
Good working attitude	6.56	0.57	1	7.82**
Working enthusiasm	6.06	0.67	8	3.95**
Career Planning				
Ability to predict national policies	4.29	1.44	41	4.36**
Ability to control the industrial environment	5.29	1.13	27	5.22**
Ability to set up and adjust career objectives	5.26	0.86	29	4.25**
Adapting to the environment	5.93	0.73	10	5.02**

identify customers, both internal and external, and further analyse customers' needs, teaching objectives, material content and learners' characteristics in order to control each factor thoroughly.

Emphasis on Design and Development

According to the analysis results, the instructional design and development should be developed, such as choosing or developing teaching aids, confirming material content, developing suitable instruction and assessment strategies, etc.

Exact Execution

Whether or not the instruction is executed exactly has significant consequences; therefore, suitable strategies should be adopted in order to attain the instructional objectives.

Correct Assessment

With the practical and multiple characteristics of industrial technology competence curriculum, the adoption of assessment methods should take the teaching strategies into consideration; hence, the multiple, qualitative and quantitative assessment strategies should be adopted so as to assess students' learning efficiencies.

CONCLUSIONS

Based on the above research objectives and data analysis, the following conclusions were obtained.

- The baccalaureate curriculum for preparing industrial technology competence includes 13 dimensions and 43 items;
- The teaching strategy of an industrial technology competence curriculum should include four stages, specifically: the preparation stage, teaching stage, end-of-teaching stage and the subsequent assessment stage;
- The industrial technology competence curriculum should adopt multiple, qualitative and quantitative assessment strategies;
- The instructional quality system of industrial technology competence curriculum should include four stages, including analysis, design/development, execution and assessment.

SUGGESTIONS

Based on the conclusions of this study, the following suggestions are proposed:

- The baccalaureate curriculum for preparing fundamental industrial technology competences should focus on developing students' practical abilities for future markets;
- The instruction and assessment should be based on the fundamental industrial technology competences curriculum;
- With the complexity of the industrial technology competences curriculum, multiple, qualitative and quantitative assessment strategies should be adopted to assess the efficiency of students' learning;
- The instructional quality system in this study may be taken as a reference point during the instruction of the industrial technology competences curriculum;
- The construction of other related curricula may be based on research procedures in this study;
- In this study, the fundamental industrial technology competences curriculum and instructional quality system model have been constructed. Future researchers should focus on adopting an experimental design to verify the feasibility of the above curriculum and quality system model in order to meet the needs of future markets.

REFERENCES

1. Wu, M.H. and Hwang, C.C., The exploration of knowledge innovation content in enterprises in the knowledge economic epoch. *Technological and Vocational Educ. J.*, 66, 6-9 (2001)(in Chinese).
2. Council for Economic Planning and Development, Plan for National Development in the New Century (2002)(in Chinese), http://www.cepd.gov.tw/eco-plan/index.htm
3. Yang, S.C., The favorite college students for enterprises. *Commonwealth Magazine*, 20, 130-137 (1998)(in Chinese).
4. Hsiao, H.C. and Chao, C.Y., *The Development of Technological and Vocational Education.* Changhua: National Changhua University of Education (1999)(in Chinese).
5. Hsu, Y.L. and Wang, K.M., The establishment of promoting a college education quality system – the application of ISO 9000 quality standards. *Proc. Conf. on Promoting College Instructional Quality*, Taipei, Taiwan (1995)(in Chinese).
6. Chao, C.Y., The application of total quality management in vocational education. *Proc. Inter. Conf. on Vocational Educ. and Training*, Taipei, Taiwan (1996).
7. Chao, C.Y., The construction and verification of instructional quality system in technological and vocational education. NSC90-2516-S-018-010 (2002)(in Chinese).

BIOGRAPHIES

Professor Chih-Yang Chao is the President of Lee-Ming Institute of Technology In Taishan, Taiwan, since August 2006. He began his teaching career in 1981 and has been an instructor, associate professor and full professor in the Department of Industrial Education at the National Changhua University of Education in Changhua, Taiwan. His major research interests include competence management, innovation management and quality management in the public and private sectors. He has published about 60 conference and journal papers in these areas.

Prof. Chao is an active member of the UICEE and received the UICEE Silver Badge of Honour for *…distinguished contributions to engineering education, outstanding achievements in the globalisation of engineering education through the activities of the Centre, and, in particular, for remarkable service to the UICEE* at the *3rd Global Congress on Engineering Education* held in Glasgow, Scotland, UK in mid-2002.

Principal Pao-Chin Yang is a PhD candidate of the National Changhua University of Education in Changhua, Taiwan. Her major is industrial education and technology. She has been a senior high school principal for 15 years. During her formal career, she has received an award for excellence of leadership as a high school principal in 2006. She is now working towards her dissertation regarding teacher evaluation at the high school level. She has published several conference and journal papers concerning teacher quality issues.