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A Study of Competency Items for Engineering Draftsman: Gaining Knowledge and Skills for CAD Related Industries

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Abstract

During the whole manufacturing process, most draftsmen use CAD software to make engineering drawings. Yet, the training content in training organizations for draftsmen, which include Industrial Vocational High Schools, Junior Colleges and Vocational Training Centers etc., does not fit the industrial factories needs. The purpose of this study was to identify the essential competency items and their sequence. To achieve this purpose, both theoretical and empirical methods were used, such as document analysis, meetings of experts, and DACUM (Developing A Curriculum). The participants in this study included technicians, content specialists, and professors in the engineering drawing and design field. It was concluded that a total of 68 competency items could be grouped into 15 units. The 15 units are arranged in a sequence. The Geometry Drawing unit is first; it covers basic techniques. The second unit is orthographic Projection Drawing, which covers basic concepts. The CAD system is the third unit. When the learner has learned the basic techniques and basic concepts, he can learn the CAD system and then apply the CAD system skills to learn the other techniques and knowledge. Units 4 to 9 are working drawing units. Units 10 to 15 are professional drawing units. Currently, some of the draftsman in factories still use 2.5D CAD software, so the competency items include unit 10. In the future, when all of them use 3-D software, they can skip unit 10. The results of this study provide a basis not only for curriculum development for engineering drawing education and worker training, but also for improvement in engineering drawing education.

Key Words: competency item; engineering draftsman; engineering drawing; CAD software; DACUM; working drawing; professional drawing

I. Introduction

National development relies on the the high quality, large quantity human resources, as well as the maximization of human resources. The cultivation of human resources is a key factor in this maximization and is the purpose of engineering drawing education.

Graphic ability is acknowledged as one of the most important basic skills for engineers and technicians (Earle, 1991). From the viewpoint of industry, graphic ability plays an important and primary role (Kang & Tai, 1995).

During the whole manufacturing process, most draftsmen use CAD software to make their engineering drawings. Yet, the training content in training organizations for draftsmen, which include Industrial Vocational High Schools, Junior Colleges, Vocational Training Centers etc., does not fit the industrial factories needs.

Based on the above motivation, the purpose of this study was to identify the essential competency items for training engineering draftsman.

II. Methodology

In this study, the competency items of engineering draftsman were derived from a literature review, document analysis, interview, DACUM etc. The

process was as follows:

1. Review of Related Literature

First, occupational analysis, especially analysis of papers for engineering draftsman in Taiwan (Kang & Tai, 1996a,b; Kang & Tai, 1998), textbooks (French, Swenson, Helsel & Urbanick, 1992; Kang & Chu, 1996) and theories was carried out.

2. Planning of Competency Analysis Modules

The competency analysis modules were divided into four sections: planning, communication, controlling and paperwork. Watch section was arranged in five steps: analysis, designing, development, application, and adjustment.

3. Developing a Draft Checklist

The draft checklist of competency items was developed through literature review, document analysis, interviews etc. The competency items could be divided into following three groups: working drawing, exploded pictorial drawing and 3-D drawing with rendering.

4. Meeting of Experts (Expert Worker Input)

This was the first of two meetings of experts. The objective of the meeting was to discuss the suitability and completion of the competency items in the checklist, to share ideas about DACUM procedures and to explain the limitations in practicing DACUM.

5. Practicing DACUM

Of the various methods of occupational analysis, DACUM is one of the most effective and efficient strategies. The advantages of DACUM are: group interaction, energetic brainstorming, group synergy, group consensus, future orientation, comprehensive outcome, superior quality, and low a cost (Norton, 1997). Furthermore, DACUM is an innovative approach to occupational analysis that requires a well-qualified facilitator and a committee of expert workers.

The motivation for inviting the expert workers to a meeting was based on three logical premises: (1) Expert workers can describe and define their jobs more accurately than anyone else can. (2) Expert workers can also effectively define and precisely describe the tasks they perform in their jobs. (3) In order for tasks to be performed correctly, certain knowledge, skills, tools and behaviors must be employed. In addition to these three premises, the expert workers should come from the field of engineering drawing and design.

In this study, 15 expert workers were invited to participate in DACUM. At the meeting, DACUM was practiced and then the checklist was edited.

6. Meeting of Experts (Expert Group Review and Approval)

This was the second of two meeting. A different group of experts was invited to discuss the edited checklist. The participants included technicians, content specialists and professors; they all work in the engineering and design field. This panel of experts gave final approval to the checklist.

III. Findings and Conclusions

The study used document analysis, practiced DACUM and held meetings of experts.

Afterwards, opinions and suggestions made by experts and scholars were organized. 68 competency items, which are necessary for engineering draftsmen, were identified. These items have been grouped into 15 units or learning modules as shown in Table 1.

The 15 units are arranged in a sequence. The Geometry Drawing unit is first; it covers basic techniques. The second unit is Orthographic Projection Drawing, which covers basic concepts. The CAD system is the third unit. When the learner has learned the basic techniques and concepts, he can then learn CAD system and apply the CAD system skills to learn the other techniques and knowledge. Units 4 to 9 are working drawing units. Units 10 to 15 are professional drawing units. Among the professional drawing units, unit 10 and unit 12 are pictorial drawing units. Currently, some of the draftsman working in manufacturing companies still use 2.5D CAD software, so the competency items include unit 10. In the future, when all of them use 3-D software, they can skip unit 10 and study unit 12 only.

The study concluded that the 68 essential competency items found are necessary knowledge and skills that engineering draftsman need to succeed in their field.

IV. Recommendations

The following suggestions are provided as reference for the people in engineering drawing and design or in other areas for further study on competency analysis.

Table 1. The Competency Items for Engineering Draftsmen

1. Geometry Drawing
   - Tools and Techniques of Drawing
   - Alphabet of Lines and Lettering
   - Geometric Figures and Constructions
   - Border Line and Title Block
2. Orthographic Projection Drawing
   - Orthographic Projection
   - Multi-view Drawing
   - Conventional Practices
   - Freehand Sketching
3. CAD System
   - Application of Computers in Drawing
   - Hardware and Software Requirements in CAD
   - Installation of the Peripherals in Computer Drawing
   - Creating Basic Geometry
   - Modifying Geometry
   - Special Functions
   - File Management
4. Sections
   - Sectional Views
   - Types of Sections
   - Conventional Practices
5. Auxiliary Views
   - Classification of Surfaces
   - Normal Views of Inclined Surfaces
   - Normal Views of Inclined Surfaces on Practical Objects
6. Dimensions, Notes and Precision
   - English/Metric Conversion
   - Dimensioning
   - Notes
   - Understanding Manufacturing Processes
   - Making Surface Finishing Marks
   - Specifying Tolerance and Fit
   - Specifying Geometric Tolerance
   - Specifying Surface Hardness Dimensions
   - Testing
7. Standard Machinery Part Drawing, Specifications and Using Tables
   - Threaded Parts and Fasteners
   - Key, Pins, Washers and Retaining Rings
   - Bearings, Pulleys, Chain Wheels and Cams
   - Springs
8. Working Sketches and Drawings
   - Exploded Parts and Assemblies
   - Measuring and dimensioning
   - Material Understainding, Distinguishing, Application and Representation
   - Treatment Decisions
   - A set of Drawings
   - Sketching Technique
   - Sketching Parts
   - Sketching Structures and Machines
9. Reading Working Drawings
   - Reading Detail Drawings
   - Reading Assembly Drawings
10. Exploded Isometric Projection Drawings
   - Making Isometric Projection Drawings
   - Making Exploded Isometric Projection Drawings
11. Development
   - Development of Prisms, Cylinders
   - Development of Pyramids, Cones
   - Development of Spheres
   - Development of Transition Pieces
   - Intersections and Development between Prisms
12. 3D Drawing
   - Constructing 3D Concepts
   - Making 3D Detail Drawings
   - Making 3D Assembly Drawings
   - Making Exploded Drawings
   - Rendering
13. Welding Drawing
   - Welding Symbols
   - Welding Symbols on Working Drawing
14. Pipe Drawing
   - Types of Pipes
   - Pipe Joint Drawings
   - Types of Valves and Valve Drawings
   - Pipe Systems in Orthographic Views
   - Pipe Systems in Pictorial Views
15. Diagrams of Hydraulic and Pneumatic Components
   - Understanding Hydraulic and Pneumatic Components
   - Drawing Hydraulic Symbols
   - Drawing Hydraulic Circuits
   - Drawing Pneumatic Symbols
   - Drawing Pneumatic Circuits

1. In constructing the occupational work contents for various technicians, in addition to document analysis and interview, it is recommended that DACUM be used.
2. For adjusting engineering drawing curriculum in vocational training centers and industrial vocational high schools, the results of this study can serve as reference in order to match students' present or future work requirements.
3. The results of this study can be used as a reference for selecting teachers for engineering drawing.
4. The results of this study can also be used as reference for creating the criteria in examination of the engineering drawing certification.

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機械製圖員能力項目之研究：在 CAD 相關產業界所需知識與技能之能力項目

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摘 要

由於產業界的電腦化，大多數工廠的機戒製圖員都使用電腦輔助製圖的軟體來繪工程圖。但目前培養機械製圖員的學校或訓練單位，其教授的內容均未能配合產業的需要。本研究利用文獻探討、專家學者座談以及 DACUM 等方法來確認目前機械製圖員所需之能力項目以及其學習之順序。

本研究共得 68 項能力項目，主將其歸納為 15 個單元或學習模組，這 15 個單元均依其學習順序排列。幾何作圖為第一單元，含蓋基本製圖技術。第二單元為正投影視圖，為機械製圖的基本觀念。而電腦輔助製圖系統為第三個單元，有了製圖的基本技術與觀念，便可學習電輔助製圖系統。接著，再利用電腦輔助製圖系統及基本技能來學習以後各單元的知識及技能。從單元四到單元九為一般平面工作圖所需的能力項目，單元十到單元十五則為專業製圖所需之能力項目。單元十與單元十二均屬立體製圖。因目前 2.5D 的 CAD 軟體仍在使用，所以必需具有單元十之能力項目，但將來產業界如均使用 3D CAD 軟體時，則只要學習單元十二而將單元十省略。本研究所得的結果，可提供學校及訓練單元發展製圖課程以及改進機械製圖教學之參考。