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The perceived effectiveness of the National Plumbing Competency Test in Taiwan, Republic of China

Chang-Yen Tsai
Iowa State University

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The perceived effectiveness of the National Plumbing Competency Test in Taiwan, Republic of China

Tsai, Chang-Yen, Ph.D.
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the National Plumbing Competency Test
in Taiwan, Republic of China

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CHAPTER I. INTRODUCTION

Background

The social justification for licensure rests on the premise that there are certain occupations requiring regulation in order to protect the public from possible harm at the hands of incompetent unethical practitioners. Licensure is defined "as a process by which an agency of the government grants permission to an individual to engage in a given occupation after ensuring that the applicant has attained the minimal degree of competency required to ensure that the public health, safety, and welfare will be reasonably well protected" (U.S. Department of Health, Education & Welfare, 1977, p. 4). Licensing requires that applicants meet specified standards of training and experience and that they demonstrate competence by passing examinations.

The "Occupational Competency Test and Certificate Issuing Regulation in Taiwan" was initiated in 1972 and the first occupational competency test was held in the following year. Since then the scope of occupational competency tests has been extended to 98 trades up to present, such as plumbing, industrial wiring, and refrigerating and air conditioning. As indicated in Article 34 of the "Vocational Training Act" the certificate grade A will correspond to junior college graduates and the certificate grade B will correspond to
vocational high school graduates in the employment market. Based on the Act, the occupational competency test program will be further developed, and some other necessary measures will be taken such as: (1) improving occupational competency test methodology; (2) auditing occupational competency test norms; (3) expanding occupational competency test trades; (4) preparing more occupational competency test projects for stocking; (5) establishing a national occupational competency certificate system (Employment and Vocational Training Administration, 1987, p. 18). Most communities required plumbers to be licensed, and the researcher has worked as a judge of plumbing competency test for several years. Therefore, in this study the occupational area of plumbing will be examined.

Employment and Vocational Training Administration in Taiwan has made a concerted effort to establish an occupational license system. However, general entrepreneurs and the general public still do not recognize it. The major reasons are (1) people who are deeply rooted in old practices respect the traditional educational diploma, (2) the authority of national occupational competency testing has not been established, and (3) the industrialists hesitate to get involved.

The National Occupational Competency Test (NOCT) plays a critical role in determining who gets licensed. However,
examinations developed and utilized have not always been satisfactory. For example, (1) examination reliability and validity are often not well established, (2) rapid changes in job description, knowledge, and skills required in certain occupational areas lead to deficiency in a test's validity.

The NOCT include both written and performance skill tests. The written tests and guidelines for their administration are prepared by the Employment and Vocational Training Administration in Taiwan. The object is not only to test academic knowledge, but also to determine whether the applicant has the correct know-how and judgement to perform the work. With the rapid development of new machinery methods and materials, many occupations require an increasing amount of technical information. The NOCT and guidelines for their administration are prepared by the Employment and Vocational Training Administration, too. However, the tests are executed by local public occupational training centers or vocational technical high schools. Even though there are negotiation meetings beforehand, executive differences still prevail among judges and executive units.

In judging the usefulness of any test, prime consideration must be given to its validity - the correctness of the inferences that may be drawn from any individual's score. Validity refers to the meaningfulness and appropriateness of the interpretations to be made from test
scores (Gronlund and Linn, 1990, p. 48). A test must measure not only what it is intended to measure, but also it must be valid for the purpose it is to serve. The occupational competency tests are intended to measure the proficiency level of an individual relative to the proficiency standards determined in the occupation (Panitz et al., 1971).

Establishing the validity of licensure examinations typically includes three steps. First of all, conduct a role delineation or job analysis of professional practice. Secondly, develop test specifications based on the studies of practice. Finally, verify independently that the items and/or forms of the examination to assure they reflect the test specifications in a representative and fair manner consistent with the philosophy of examination (Smith and Hambleton, 1990, p. 7). Occupational competency tests are intended to measure outcomes relative to the proficiency standards demanded in the occupation. Klein (1979) also indicated that in order to construct valid performance tests, the test specialists need to obtain a timely occupational analysis from which the critical competencies and tasks can be determined. Once these critical competencies have been uncovered, they should be ranked in order of the frequency in which they occur as well as their relative importance in the job. In this way, a hierarchical list of critical competencies may be identified. Essentially, these key competencies set one role apart from
another by identifying the elements that give the occupation its uniqueness.

Next to validity, reliability is the most important quality to seek in evaluation results. Reliability refers to consistency of a test score from one measurement to another (Gronlund and Linn, 1990, p. 77). Despite all efforts to eliminate subjective judgements of examiners in evaluating the performance of a candidate, certain job factors cannot be appraised in any other way except by personal judgement. Experience has shown that training examiners with proper focus on the items to be evaluated and effective use of rating scale can produce agreement among different examinees. A high factor of reliability among examinees evaluating performance test has been found when these conditions are met. In addition to standardizing a test and obtaining measures of reliability and validity, it is important to provide data about the test to the users. There is also a need to have a reasonable sample of key concepts and practices on the "comprehensiveness of tests".

The identification of critical competencies that reflect the needs of the job are strongly tied to occupational competency. Hicks (1985) investigated perceived competencies as viewed by Student Occupational Competency Achievement Tests (SOCAT), workers, teachers, and supervisors. He indicated that industrialists in Industrial Electronics seemed to agree
moderately but few industrialists in Industrial Electricity considered the tasks necessary for the entry level workers. A relationship with both teachers and industry should be developed by competency-based test developers to ensure that the material being provided is useful and mutually acceptable. An important finding of the survey was that although there are stringent rules in the development of SOCAT tests, there can be an inconsistency in the results. A well organized system of development does not guarantee the usefulness of a test. Follow-up and fine tuning by educators and industry personnel are necessary to ensure that the competency test does what it is intended to perform.

In the United States, The National Occupational Competency Testing Institute (NOCTI) was organized in 1973. NOCTI provides high-quality occupational competency examinations on a national level that does serve as a reference for improving the NOCT in Taiwan. NOCTI has available competency tests including 69 occupational areas, such as plumbing, industrial electricity, etc. In regarding to the NOCT, little related research has been done in Taiwan. Kang et al. (1990) reported that (1) sixty-five percent of employers agreed that NOCT actually identified the particular occupational technical level; (2) most employers indicated that licensed workers performed better than unlicensed; (3) ninety percent of employers perceived that licensure
maintained occupational standards and ensured the product quality; and (4) fifty-eight percent of candidates indicated occupational written test met the needs of the actual job of the entry level worker. The content of the NOCT does meet the needs of enterprise to some extent, however, efforts directed at improvement needs to be placed on (1) revising and updating competency test, (2) involving representatives of enterprise in constructing test guideline, test items and grading, and (3) increasing the reliability and validity of the each test. The authors suggested the need to further test developers examine the critical competencies from an employer and worker perceptive. The effectiveness of NOCT not only can be judged by evaluating the program, but also can be reflected by the perception of NOCT among incumbent workers, supervisors, and vocational educators.

Understanding the current situation of NOCT in Taiwan can provide valuable suggestions to improve the situation.

Statement of the Problem

The problem of this study was to assess the effectiveness of the National Plumbing Competency Test (NPCT) in Taiwan.

Purpose of the Study

This study assessed the effectiveness of NPCT in Taiwan.
A survey was conducted to assess the perceptions of incumbent workers, supervisors, and vocational educators regarding the current effectiveness of such testing in theory and practical aspects.

Questions of the Study

This study attempted to answer the following questions:

1. Are there perceived differences in the assigned percentages of the critical competency factors as outlined by the NPCT Committee among the selected vocational educators, incumbent workers and supervisors of plumbers within the selected trade of plumbing?

2. Are there differences in perceptions regarding NPCT among the incumbent workers, supervisors and plumbing educators?

3. Are there differences in perception regarding the quality of NPCT among the incumbent workers, supervisors and vocational educators?

4. Are there differences in perception regarding the administration of NPCT among the incumbent workers, supervisors, and vocational educators?

5. Are there differences in perception regarding test scoring and interpretation of NPCT among the incumbent workers, supervisors, and vocational educators?

6. Are there differences in perception regarding
plumbing licensure among the incumbent workers, supervisors, and vocational educators?

7. Does the age of the respondents affect the perception toward NPCT?

8. Does the educational level of the respondents affect the perception toward NPCT?

9. Does the professional training experience of the respondents affect the perception toward NPCT?

Assumptions of the Study

The assumptions for this study were:

1. Groups representing the plumbing incumbent workers and supervisors in Taipei, Taiwan, R.O.C., and group representing the plumbing vocational educators in Taiwan who are willing to participate in this study.

2. The respondents are knowledgeable about the questions and will reply honestly.

3. The methods of data collection and statistical analysis used are appropriate for this study.

Delimitations of Investigation

The delimitations of this study were:

1. This study investigated only plumbing incumbent workers and supervisors of plumbing in Taipei.

2. Only the plumbing incumbent workers and supervisors
of plumbing who have attended plumbing competency test were eligible to participate in this study.

3. This study investigated only NPCT grade C in Taiwan.

Procedures of the Study

The procedures of this study were:

1. Identify the research problem.
2. Review the related literature on the occupational competency test.
3. Write a proposal and discuss it with the graduate advisor, the graduate committee, and the graduate students of the Industrial Education and Technology Department at Iowa State University.
4. Identify the population and sample for this study.
5. Construct test hypotheses.
6. Identify and label dependent and independent variables.
7. List all the sample subjects.
8. Select, develop, and modify an instrument for the study.
9. Present the proposal to the Graduate Committee members.
10. Translate the questionnaire into Chinese.
11. Perform a pilot study with a sample of plumbers in Taipei.
12. Discuss the pilot study with the committee members and revise the instrument based on their recommendations and the pilot study results.
13. Submit the proposal and instrument to Human Subjects Review Committee for approval.

14. Mail the questionnaires to the selected sample participants.

15. Follow-up with additional questionnaires and letters in case of inadequate or non-returns in the initial mailing.

16. Collect data from the questionnaires, codes and analyze the data.

17. Write the final report, summary, conclusion, and make recommendations based on the findings.

Definition of Terms

The following terms were utilized throughout the study:

**Competencies:** The knowledge, skills and abilities or capabilities that a person achieves, which become part of his or her being to the extent he or she can satisfactorily perform particular cognitive, affective, and psychomotor behaviors (McAshan, 1979, p. 45).

**Occupational Competency Test:** Requires an individual to perform job-like tasks required of a craftsman or skilled technician within an occupation according to industrial standards, speed, accuracy, procedures, etc. The test is administered under well-controlled conditions to measure the individual's job proficiency through his/her ability to perform actual or job-like tasks. A well-defined goal is
essential. The goal is the result the examinee is trying to achieve as he performs in a test situation. The goal should be the same for everyone and examinees must try to achieve the same results.

**Incumbent Worker:** An incumbent worker is a person who participates in an occupational survey of workers in business and industry and holds a specific job at the particular time of the survey.
CHAPTER II. LITERATURE REVIEW

Introduction

An occupational competency test requires an individual to perform job-like tasks required of a craftsman or skilled technician within an occupation according to industrial standards of speed, accuracy, procedures, etc. A well-defined goal is essential. The test is administered under well-controlled conditions to measure the individual's job proficiency through his/her ability to perform actual or job-like tasks.

For effective performance in any occupation, an individual acquires manipulative skills and certain "know-how" or trade information. With the rapid development of new machinery, methods and materials, many occupations require an increasing amount of technical information. While skills are ever changing, they do so mostly towards greater intricacy and the application of more information.

This review of the literature is organized into four sections: (a) development of occupational competency assessment, (b) test development, (c) studies related to occupational competency test, and (d) summary.

Development of Occupational Competency Assessment

The earliest record of a system of occupational
competency assessment dates back to 2200 B.C. During that period, the emperor of China decreed that all civil service officials would be examined every three years to determine their fitness for continuing employment. Following three of these evaluations, the employee was either promoted or dismissed (Wentling & Lawson, 1975). During the period of the Han Dynasty (206 B.C. - 220 A.D.), a battery of written civil service examinations was employed to assess competence in such areas as civil law, military affairs, agriculture, revenue, and geography (Wiggins, 1973).

The history of occupational competency assessment is a long one. However, for the purpose of this review it was decided to limit the discussion to competency test development in the United States and Taiwan. Development of occupational competency assessment in the United States was reviewed because these examinations have existed since 1800s and have a great impact on Taiwan's experience.

Development of occupational competency test in United States

Army occupational competency assessment The first formal occupational assessment procedures appear to have been established in the early 1800's. This system was introduced by the military. Just prior to the War of 1812, the Army had introduced a method of classifying personnel based upon their civilian occupations. During World War I, an overall trade
test was developed by the United States Army to more efficiently classify personnel for the many army occupations (Panitz, Adolf & Olivo, 1971). During the depression years, millions of unemployed persons needed occupational information. Efforts were made by the United States Employment Service to classify people according to certain skill levels in 150 trade areas.

World War II prompted the need for a better evaluation instrument besides the oral trade test. These tests fulfilled a need for mass screening of people wanting to enter one of the military trades, and were inadequate in measuring competencies. The employment service continued to use this question approach for the identification of training needs and job placement during the late forties; however, this practice ended in 1947 with the development of other measures, such as the General Aptitude Test Battery.

The Vocational Education Acts of 1963 and 1968 brought about the re-establishment of comprehensive high schools that stress vocational education. This re-emphasis on vocational education coincided with the needs of the nation for skilled craftsmen. In 1966, representatives attended a seminar to study the feasibility of providing trade competency examinations on a national basis at Rutgers University.

NOCTI The National Occupational Competency Testing Institute (NOCTI), an outgrowth of the National Occupational
Competency Testing Project, was formed as a non-profit organization in 1973. NOCTI was created in an effort to provide a uniform national occupational competency testing program to serve vocational education on a permanent basis. NOCTI is recognized as the national leader in occupational competency testing. The administration of the national group examinations began in the spring of 1974. Whitener (1990) indicates that it has become obvious to many that one of the ways to ensure a more productive work force is to graduate, hire, or promote based on a standardized demonstration of competency. As a result, occupational competency examinations are increasingly being used to assess and assure the competency of education or training program graduates and/or current or potential employees. Subsequently, the use of NOCTI student, teacher and industry testing services has vastly expanded.

NOCTI examinations are used for the following objectives:
1. Establishing evidence of occupational competency;
2. Admitting students to trade and industrial-technical teacher education programs;
3. Meeting state requirements for certification;
4. Determining advance standing in undergraduate or graduate programs of study; and
5. Diagnosing weak or deficient areas which the candidates need to correct (Whitener, 1981).
NOCTI examination includes two parts: a written test that measures knowledge of the field and a performance test that measures skills in performing tasks typical of the occupation. Candidates must take both parts. Within each occupational area, the process for administering the NOCTI written examination is identical. Candidates are allowed a standard time limit of three hours to complete the examination. Each examination is administered according to the guidelines set forth in the NOCTI Written Test Manual. Instructions to the performance examiner, which accompany each performance examination, specify equipment, tools, supplies, and materials required to administer the NOCTI examination. Although the physical facilities and brand names of tools and equipment may differ from one performance examination site to another, the tools and equipment remain consistent (Whitener, 1981).

Performance examiners are selected from known occupational competent vocational teachers, trade persons, and the individuals who have completed a NOCTI examination. Prior to administering a performance examination, the examiners are instructed as to the proper examination procedures and techniques. Directions to the performance examiner are included with each performance examination. These directions categorically instruct the examiners in all aspects of administration of the examination. Examiner training, coupled
with specific directions to the performance examiner, minimize examiner influence and error.

NOCTI provides high-quality occupational competency examination on a national level. Instrument internal reliability and content validity are established (Whitener, 1981). Committees of known occupationally competent trade persons and vocational teachers from each occupation were responsible for determining the test content. Each examination according to Panitz and Olivo (1971) was constructed in a similar manner which included:

Job analysis: Refers to the process of identifying knowledge and skills considered necessary for a person to perform at a journeyman level in each field. This work was done with universities, secondary schools and post secondary institution personnel at various locations throughout the United States.

Peer reviews: Panels of experts with prior occupational experience, together with personnel resources in test development in each field, were organized to conduct job and task analyses and to make recommendations for test item construction.

Test item writers: Selected industrial educators were asked to prepare test items and performance indicators of relative levels of importance and frequency of use. These preliminary test materials were then finalized and approved by
a "peer review committee". Careful attention to each of these steps provided the necessary assurance that the examinations would be content valid.

All examinations were field tested on journeymen and modifications in each test were made based on scores and input from each journeyman. After the modifications were completed, the instruments were again subjected to field tests to further improve validity, reliability, and internal consistency. The national scope of the project helped to set norms and establish standards to be used by each state in making its determinations (Olivo, 1980; Klein & Pfeiffer, 1980).

**SOCAT**

SOCAT stands for Student Occupational Competency Achievement Tests; NOCTI is a national pioneer in this field. With a decade of experience in teacher occupational competency testing, NOCTI recognized the need for the evaluation of vocational students, and in 1979, initiated a national program in cooperation with seven states to develop student occupational competency achievement tests. SOCAT was designed to establish levels of occupational competency, based on industrial task analysis needed for job placement. Competencies, indicated by test results, also have teaching effectiveness implications (Schwendau, 1989).

In an effort to meet national needs, NOCTI's goal was to develop SOCATs in a broad range of occupational areas. Over sixty SOCATs are now available for national use. SOCATs were
designed for the purpose of providing a standard, objective measure of secondary or post secondary student achievement in various vocational fields.

SOCATs are developed by outstanding vocational educators from across the nation with the cooperation of experienced personnel from the areas of agriculture, business, industry, health, and vocational home economics. These selected individuals from the world of work, judge the tests as to their fairness, comprehensiveness, and current demands of the occupation. The tests are then field tested in secondary and postsecondary schools throughout the country, and the examiners are invited to critique the tests for possible areas of improvement. Appropriate changes are then made if necessary (Norton, Fitch, & Harrington, 1988).

The SOCAT consists of two parts - written and performance. The written test, which has a multiple-choice format, covers factual knowledge, technical information, understanding of principles, and problem-solving abilities related to the occupation. The performance test, which is administered in a laboratory, school shop, or clinical setting, consists of work assignments designed to sample the manipulative skills required in an occupation. Thus, SOCATs enable students to demonstrate that they possess the knowledge and skills that competent entry crafts persons employ in their daily work.
Separate scores for the written and the performance examinations are reported along with subscores for each test. These scores can be used diagnostically to determine specific student, class, or school strengths and weaknesses. Students receive printouts which indicate their standing in relation to their class, school, state, and nation. Teachers also receive detailed printouts depicting their student and class scores with mean scores for the class, the school, the state, and the nation. Criterion reporting is also provided along with a certificate appropriate for inclusion with resume materials.

**Occupational licensing examination** The beginning of occupational licensing in the United State was initiated prior to 1800, with the enactment of state laws controlling who would practice in the profession of law and medicine. Nearly 1000 occupations are regulated by some or all of the 50 states, 643 occupations require registration, 65 occupations are certified in at least one of the 50 states, and 490 occupations are licensed (Young, 1987). Some occupations may be licensed in some states but only registered or certified in others.

Anyone seeking licensing is usually required to pass an examination to demonstrate that the candidate has the minimum knowledge, skill, and ability to practice at entry level. Licensing examinations should be designed to identify those who possess the knowledge, skills and abilities to perform
critical tasks in a manner that will adequately protect the public welfare. The test is concerned with minimum knowledge and skills, not with higher-level skills and knowledge. It is able to differentiate between those who are likely to do harm to the public and those who are not.

Through a licensing examination the state licensing boards determine the fitness of candidates to practice. Most of the states rely on national testing programs. Many states (specially those with strong central agencies) have established test consultation units staffed with examination specialists. These specialists are responsible for conducting job analyses, preparing test specifications, conducting training programs for item writers, reviewing and editing items, performing item analyses, and documenting the content validity of tests (Fortune, 1985).

**Development of occupational competency test in Taiwan**

The "National Occupational Competency Test and Certificate Issuing Regulation" was enacted in September, 1972 in Taiwan, and the first NOCT for refrigerating and air conditioning was held in the following year. Since then the scope of the NOCT has been extended to 98 trades and over 320,000 licenses have been issued up to the present. Within the issued licenses, 71% were grade C, 28% were grade B, and only 1% were grade A. Eighteen trades licenses have been
issued to more than 3,000 persons for each trade area which represent 87% of the total issued licenses. (Employment and Vocational Training Administration, 1991). As indicated in Article 34 of the "Vocational Training Act", the certificate grade A will correspond to junior college graduates, and the certificate grade B will correspond to vocational high school graduates in the employment market. The incentive provided by this regulation will induce more youths to participate in the technical competency testing.

Based on the Act, the NOCT program was further developed, and other necessary measures were taken such as:

1. Promoting the NOCT by:
   a. formulating and revising the NOCT standards;
   b. preparing reference manuals and question booklets for the NOCT;
   c. conducting seminars for proctors of the NOCT and on evaluation of practical courses;
   d. conducting the NOCT and awarding certificates to successful candidates;
   e. sponsoring seminars on the NOCT operations;
   f. evaluating agencies authorized to conduct the NOCT; and
   g. subsidizing training-related machinery and equipment.

2. Establishing the NOCT system promotes:
a. formulating laws and regulations governing
the NOCT; and

b. promoting the operations of the NOCT Committee.

3. Coordinating the establishment of occupational
certification systems allows for:

a. formulating reward guidelines for promotion of the
NOCT and establishment of an industrial
occupational certificate system to honor the
sponsoring units which have assisted the
certification system; and

b. coordinating central objective business supervisory
agencies to revise or establish laws to hire
certain ratio of certificated employees as
required.

The NOCT in Taiwan includes two parts: a written test
that assesses knowledge of the field and a performance test
that assesses skills in performing typical tasks of the
occupation. The written test is composed of one hundred
objective test items, containing 50 multiple choice and 50
true/false questions. A Table of Specifications is developed
to determine the contents and assigned emphasis to each. The
quality of the test items, item difficulty, and distribution
are considered. The content of grade C performance test is
published one month before the occupational competency test.
In addition to the test items, the directions for the test,
list of facilities, equipment, and materials which are used in test work places, time schedules, proctor guidelines, performance test assessment forms, and interpretation of judgement are all well-prepared before the examination.

Test Development

Written test

Written tests are effective instruments to appraise certain aspects of occupational competence. The content of a written test should include the following areas of occupational competence (Panitz & Olive, 1971; Vocational Technical Education Consortium of States, 1988):

1. Factual knowledge and technological information of the occupation.
2. Knowledge and understanding of the machines, tools, instruments, and apparatus of the occupation.
3. The properties and characteristics of materials and the parts, or systems, which are problem solved, that is diagnosed, processed and replaced.
4. The necessary calculations required for setting up, adjusting, testing and operating the machinery, apparatus, test equipment used in the occupation.
5. The reading and interpreting of specifications, technical drawings, wiring and circuit diagrams, and other graphic representations.
6. The interpretation of scientific principles as they apply to the design and/or operation of machines, apparatus, instruments and the processing of materials component parts and accessories.

7. Judgements and procedures involved in planning the work of the occupation, selection of materials and/or the replacement of component parts.

8. Classification of materials, component parts and specific tools, instruments and supplies.

9. General knowledge and work habits of the occupation, as well as specific requirements relating to occupational safety and hygiene, government regulations, and other conditions surrounding the occupation.

Planning written tests

Procedures for determining occupational competencies to be measured (Hsiao, 1992; Panitz & Olivo, 1971):

1. Establish the purposes and rationale behind the development of the occupational competency test.

2. Chart the overall project.

3. Select qualified personnel to serve as a test advisory and development committee.

4. Identify jobs by title and specifications that are typical of the occupational area, and give the range
of competencies required for the whole occupational area.

5. Group the job titles which require similar skills, technical knowledge, and other occupational responsibilities and duties into job clusters on different levels.

6. Determine the levels for which the occupational competency test is to be developed.

7. Make job analyses of jobs in the cluster in terms of:
   a. manipulative skills
   b. trade theory and judgements
   c. trade communication
   d. computational skills
   e. applied principles of sciences
   f. technological knowledge needed
   g. industrial safety, health and hygiene practices
   h. other information essential to the occupation

**Job description and test specifications**

1. Prepare job descriptions which should define job skills and accompanying trade theory for the performance part of the test.

2. Establish the scope of the test in terms of level and range of skills and information to be evaluated.

3. Determine the nature and format of test items that
should be prepared for the written part of the test.

4. Set up a table of specifications to roughly establish the component parts of the occupational competency test for each main subdivision. The number of proposed test items to consider should be noted.

**Test items, test construction and evaluation**

1. Establish procedures for data processing relating to test construction, administration, scoring, recording, analysis and evaluation.

2. Assess the test structure and the number of test items needed to achieve the test objective.

3. Prepare a pool of test items with answers.

4. Evaluate each test item and revise as needed.

5. Arrange test items in proper sequence within the occupational competency test.

6. Prepare a Handbook with answer sheets for the examiners.

7. Review the test in committee for structure, time, relevance, etc., utilizing the services of a test and measurement specialist.

8. Determine a representative sample group for pilot testing the examination.

9. Field test, evaluate and refine (Panitz & Olivo, 1971)
A performance test for occupational proficiency generally involves a work sample test which requires the examinee to demonstrate his/her acquired skill by doing an actual segment of work using tools, materials, machines and equipment characteristic of the occupation for which the test is designed. The performance test samples an individual's ability to perform jobs and tasks that are judged to be critical and important within a given occupation. They may take the form of real work or a simulation of work. Regardless of what form they may take, they should be as realistic as possible. Performance tests provide a way to assess psychomotor skills as well as to provide for an alternative way of examining a person's problem-solving ability.

A good performance proficiency test (1) involves the measurement of critical skills of the occupation which distinguish the competent craftsperson from a less competent individual, and (2) includes selected manipulative processes which avoid extended repetition. Well-designed performance tests must include (Panitz & Olive, 1971; Wolansky, 1985):

1. The actual operation of machines, instruments, apparatus, and tools as utilized in a job situation.

2. Step-by-step procedures in designing, forming, shaping, turning, cutting materials into a finished
product, or diagnosing and assembling units and components.


4. The planning and actual replacement of defective parts or components.

5. The adjusting, maintaining, and utilizing of instruments of various kinds in carrying on the work of the occupation.

Planning performance tests

The following steps lead to the design of an effective performance test (Klein, 1979; Norton, Fitch & Harrington, 1988; Morris, Fitz-Gibbon & Lindhein, 1987):

1. Identify the field and level of jobs within each field.

2. Determine competency through occupational and task analysis.

3. Organize competencies by levels and categorize competencies by job level.

4. Analyze competencies per job level to identify critical competencies.

5. Identify jobs or tasks by which the critical competencies of individuals may be judged, and develop a blueprint for the test.
6. Identify weighted criteria for each job or task along with preparation of rating scales and scoring procedures.

7. Develop test items and standardize testing procedures. The materials, tools and equipment should be reduced to the smallest practical quantity and should be capable of standardization so that the same test may be given under uniform conditions. The performance should involve as little repetition of identical procedures as possible.

8. Pilot test the instrument. A preliminary tryout of performance tests should always be made using experts as typical examinees to detect possible problems or difficulties. In order to verify that the test items are an appropriate measure of the skill being measured, they must be tried out using a sample.

9. Analyze the data and revise tests as needed.

The criteria for assessing skill proficiency should include both process and product measures and a rating scale used by an evaluator to observe the subject. Performance of an individual taking such an examination might include such criteria as:

The criteria of process evaluation include: (1) handling of layout tools, (2) planning of layout procedure, and (3) layout process. The criteria of product evaluation include:
(1) accuracy, (2) precision, and (3) time. All of the measurements should possess certain characteristics.

**Characteristics of high quality tests**

High quality tests have the following characteristics (Norton, Fitch, Harrington, 1988; Shieh, 1985; Payne, 1992):

**Validity**

Validity refers to the appropriateness of interpretations made from test scores and other evaluation results, with regard to a particular use (Gronlund & Linn, 1990; APA, 1985). Good tests measure what they are intended to measure. Content-related, criterion-related, and constructed-related evidence are most useful in practical educational settings.

Content-related evidence is the extent to which a set of test tasks provides a relevant and representative sample of the domain of tasks about which interpretations of test scores are made. Content validation typically takes place during test development. It is primary used to prepare detailed test specifications and construct a test that meet these specifications. Shimberg (1981) recommended that the assessment of the validity of certification tests be done via a content validation strategy.

Whenever test scores are to be used to predict future performance or to estimate current performance on some valued measure other than the test itself, criterion-related evidence
are of concern. Horgan (1979) maintained that use of a criterion-related validity paradigm is appropriate since certification can have an impact on one's career. Criterion related validation is the process of determining the extent to which test performance is related to some other valued measure of performance (criterion). They are typically reported by means of a correlation coefficient called a validity coefficient.

Construct-related evidence is determined whenever interpretation of test performance is made in terms of some psychological trait or quality. Construct validation is the process of determining the extent to which test performance can be interpreted in terms of one or more constructs. Construct validation typically includes both content-related and criterion-related evidence plus other types of information. The procedure is one of clarifying what is being measured and what factors influence the test scores so that test performance can be interpreted most meaningfully (Payne, 1992).

Numerous factors tend to influence the validity of test interpretation. Some of these influences can be found in the test instrument itself, some in the relation of teaching to testing, the administration and scoring of the test, the atypical responses of examinees to the test situation, and others in the nature of the group tested and in the
composition of the criterion measures used (Gronlund & Linn, 1990).

The ways to write valid and technically accurate test items are as follows (Vocational Technical Education Consortium of States, 1988):

1. Each test item should be related to a critical "know" or "do" skill in the task analysis.
2. The test item should measure the students' knowledge of or their ability to safely perform a specific task.
3. Test items should be technically accurate.
4. Test items should not be designed to measure "trivia".
5. A sufficient number of test items should be written to adequately measure the students' knowledge of and their ability to perform the task.
6. Each test item should be constructed so that there is one, and only one, interpretation of the item.

Reliability

Reliability is the extent to which a test is accountable or the consistency in measuring whatever it measures (Payne, 1992). The chief methods of estimating reliability are test-retest, equivalent-forms, split-half, and Kuder-Richardson method. To estimate reliability by means of the test-retest method, the same test is administered twice to the same group with any time interval between tests. The resulting test scores are correlated, and this correlation coefficient provides a measure of stability.
Estimating reliability by means of the equivalent-forms method uses two different but equivalent forms of the test. The two forms of the test are administered to the same group of pupils in close succession and the resulting test scores are correlated. This correlation coefficient provides a measure of equivalence. The equivalent-forms method is sometimes used with a time interval between the administration of the two forms of the test. Under these test-retest conditions, the resulting reliability coefficient provides a measure of stability and equivalence.

Reliability also can be estimated from a single administration of a single form of a test. The test is administered to a group of examinees in the usual manner and then is divided in half for scoring purposes. This produces two scores for each examinee, and when correlated, this provides a measure of internal consistency.

Another method of estimating the reliability of test scores from a single administration of a single form of a test is by means of formulas which were developed by Kuder and Richardson. These formulas provide a measure of internal consistency (Grondlund & Linn, 1990).

Reliability estimates may vary in accordance with the length of the test, the spread of scores in the group tested, the difficulty of the test, the objectivity of the scoring, and the method of estimating reliability. These factors
should be taken into account when appraising reliability information for a particular test.

Criterion-referenced tests assess ability in terms of predetermined criteria, which in turn are based on realistic occupational behaviors. The purpose of criterion-referenced test is to: (1) measure specific behavioral objectives that represent actual performance requirements at predetermined cut-off score, (2) estimate an individual's proficiency level with the highest degree of accuracy, and (3) determine if that level exceeds a given minimum (Cantor & Hobson, 1986). Criterion-referenced tests that have a high degree of congruence to specific occupational objectives also have a high degree of content validity and provide for a more realistic and defensible criterion-referenced test (Cantor & Walker, 1987).

Appropriateness Tests should use appropriate evaluation methods for the types of objectives to be measured. Written multiple-choice items can provide an effective measure of occupational knowledge. Performance tests generally provide the best measure of occupational job skills.

Currency As occupational practices change so must the evaluation instrument. Task lists and tests must be reviewed on a regular basis and updated as necessary to ensure that they reflect current competencies and performance standards for the occupation.
Objectivity  For a test question to be considered objective, experts must agree on the "right" or "best" answer.

Fairness  The test should be constructed and administered in a manner that allows examinees an equal chance to demonstrate their knowledge or skill.

Balance  Balance in a test is the degree to which the proportion of items testing particular outcomes corresponds to the "ideal" test. The framework of the test is outlined by a Table of Specification.

Cut-off score

The cut-off criterion depends on many factors. It may be related to the supply and demand for a given occupation. In situations where there is a large demand and a small supply, a more liberal criterion might be used; and the reverse might be considered under appropriate conditions. If a high degree of skill is required to demonstrate competency, then the cut-off should reflect the critical level of competence regardless of market conditions (Spirer, 1978).

Shimberg (1981) observed that there are various decisions to be made regarding the cutoff(s). The first is whether there will be subcategory cutoffs for a single passing criterion. With subcategory cutoffs applicants are required to pass a criterion on each subpart before being licensed or certified. Another decision is whether to use absolute or
relative passing scores. Some professions set cutoffs so that a score of 20 means fail; this is an example of a relative cut-off score. One problem often cited when relative scores are used is that the composition of the group generally determines who fails and who succeeds. Absolute standards, such as getting 75% of the questions correct, are used most often. Shimberg (1981) supports this approach because the purpose of certification and licensing is to determine if an applicant is qualified or not to fill a certain number of positions.

Performance-standard/cut-off scores are generally believed to be essential for criterion-referenced measurement. There are no completely generalized rules to guide the setting of cut-off scores for criterion-referenced tests, nor is there one method that is superior under all conditions. All attempts to define competent worker mastery will ultimately depend on subjective judgement at some stage in the application of assessment methods.

The principles of pre-determined cut-off scores are as followings:

1. A test's cut-off score must be fair; fair to the candidates taking the examination and to the people they will serve in the occupation.

2. The process determining a pre-set cut-off score must be objective and open. The professional judges
involved in establishing pre-set cut-off scores should be representative.

3. A cut-off score should be revised if necessary. An appropriate cutting point reflects the competency status of the candidate in relation to his/her ability to practice (Pottinger, 1980; Wu, 1986). The typical methods for establishing cut-off scores for certification examination are (Pottinger, 1980):

1. asking professionals to estimate the number of questions they would expect a minimally competent individual to answer correctly;

2. having them estimate the number of applicants out of a sample of 100 who would be minimally competent;

3. having them judge the difficulty of individual test questions for minimally competent persons; or

4. asking them to construct a hypothetical group of persons, each of whom would have the minimum amount of knowledge to assure the public that only competent individuals are certified.

Nedelsky's (1954) method of choosing passing scores is being used by many licensing and certification boards. Leo Nedelsky developed a method for determining absolute grading standards for multiple choice tests. This method required a group of judges to examine each test question and eliminate those responses which the lowest D-student should be able to
reject as incorrect. The correct answer probabilities remaining were used in computing an expected test score for the hypothetical test taker. The passing scores were chosen to give the "F-D student" some specified probability of passing the test. Typically, the expected score of this hypothetical person (as determined from the judgments of the individual questions) is chosen as the passing score (Livingston, 1982).

Test related materials

In addition to obtaining measures of reliability and validity, it is important to provide data about the test to the users. This information may help the user make decisions about the appropriateness and adequacy of the examination as well as for providing directions for test administration, scoring, and interpreting the results. A manual should be designed to convey pertinent information to users of the test.

Directions for administration scoring a performance test should be clear so that the examination can be similarly conducted in all settings. One problem in preparing examinations is that the laboratories or shops where tests are conducted are different. Under strict standardization processes, it would be generally held that candidates taking the examination should be required to perform the test on the same piece of equipment. Although manufacturers tend to
produce machines of comparable design, tests, out of necessity, will be conducted using different makes of the same tool. Therefore, in the instructions to the evaluator, a notice should be given that equipment having similar specifications to the suggested standard may be substituted. In situations where candidates may be unfamiliar with a specific piece of equipment, they should be given an opportunity, prior to the examination, to become familiar with the controls of the equipment.

Studies Related to Occupational Competency Examinations

Hicks (1985) examined perceived differences in the relevances of critical competencies as outlined by the SOCAT test committees on the selected trades of industrial electronics and industrial electricity by educators, incumbent workers and supervisors of these selected trades. Data were collected from 120 Ohio and Kentucky T&I teachers, workers and supervisors in industrial electronics and industrial electricity.

Supervisors and workers in industrial electricity were in agreement as to the perceived importance of tasks as listed by SOCAT. This group rated selected tasks as essential 93 percent of the time. There was very little agreement between teachers of industrial electronics and supervisors with only
28 percent in mutual agreement on certain tasks. Teachers from both fields were in mutual agreement on the essentiality of the tasks for an entry level worker. All tasks were checked as essential by a minimum of 71 percent of the teachers. Industrialists in industrial electronics seemed to moderately agree but few in industrial electricity considered the tasks necessary for the entry level worker.

There were very high correlation coefficients between teachers, supervisors and workers in industrial electronics concerning agreement on critical competencies, with moderate agreement with the SOCAT test committee. Groups in Industrial Electricity were of similar agreement with each other concerning competencies but had very little agreement with each other concerning competencies and very little agreement with SOCAT. A negative correlation of -0.80 appeared between teachers and the SOCAT test committee concerning the critical competencies.

The identification of critical competencies that reflect the needs of the job are strongly tied to occupational competency. A relationship with both teachers and industry should be developed by competency-based test developers to insure that the material being provided is useful and mutually acceptable. Hick indicated an important finding of the survey which was that although there are stringent rules in the development of SOCAT tests, there can be an inconsistency in
the results. A well organized system of development does not
guarantee the usefulness of a test or curriculum. Follow up
and fine tuning with educators and industry is necessary to
ensure that tests measure what they are intended to measure.

Based on the results, Hick suggested: (1) there should
be more involvement by teachers in the identification of
critical competencies. This would benefit curriculum
development and make training more meaningful to both teachers
and future workers; and (2) during curriculum development,
utilize as many relevant sources of knowledge as possible with
constant updating with industry.

Whitener (1981) investigated the relationship between
occupational competence, as measured by NOCTI examination
scores, and occupational experience, teaching experience, and
educational level. The four selected occupations were auto
mechanics, carpentry, machine trades, and quantity foods,
which represent the largest categories in the number of
candidates that were in the NOCTI database. The sample
consisted of 1,556 candidates of which 685 were in auto
mechanics, 431 in carpentry, 336 in machine trades, and 104 in
quantity foods. The investigator indicated it was apparent
that occupational competency was related in different degrees
to occupational experience, teaching experience, and
educational level. There was evidence that these
relationships vary from occupation to occupation. Therefore,
implementing the same minimum requirements for all trades and
for industrial teacher selection and certification, as many
states are doing would not promote the utmost competence in
each occupational area.

For some occupations, there was little or no relationship
between occupational competence and occupational experience,
teaching experience, educational level, and their aggregate.
This suggested that these variables should not be used as
criteria for teacher selection and certification. In these
and other occupations, the use of NOCTI occupational
competency examinations should be considered as a more
reliable means of assessing occupational competence.
Accordingly, minimum requirements for the selection and
certification of trade and industrial teachers may have to
differ for each occupation if they are to reflect the utmost
in occupational competence.

Sharpton (1985) surveyed the relationship between NOCTI
occupational examination scores and teaching effectiveness as
rated by school administrators and Trade and Industrial state
supervisors as to instructional productivity, proficiency and
quality. Thirty-five candidates completed the examination and
worked in the teaching profession, seven Trade and Industrial
program supervisors, and thirty-five administrators were asked
to complete a survey questionnaire which rated the candidates' teaching effectiveness.
There were no significant relationships between the NOCTI written examination scores and the ratings of the supervisors and/or administrators. The researcher concluded that this examination is not a predictor of teacher effectiveness in the classroom. The findings would appear to correlate with McMahon's (1982) descriptions that the NOCTI examination was a test to measure a teacher's trade competencies and not a predictor of teacher effectiveness. Sharpton recommended that the NOCTI examination not be used as the only criterion for teacher employability or predictor of classroom success. Consideration should be given to administering the NOCTI examination in association with other examinations to determine employability of prospective teachers.

Walter (1984) studied which background characteristics of successful occupational competency assessment candidates are related to successful teaching. The sample consisted of 344 candidates who successfully completed occupational competency assessment during the period of 1975 through 1980. There were significant relationships between successful teaching and the variate age and residence location at the time of assessment. There were significant relationships between amount of teaching experience and the variate age, residence location, and year of assessment. There were significant relationships between amount of teaching experience for those classified as successful teachers and the variate age, part-time work
experience, and the year of occupational competency assessment.

Kang et al. (1990) investigated the current condition and problems of NOCT in Taiwan. Data were collected from 192 employees, 178 NOCT test candidates, and 188 subjects who had never participated in the NOCT. The subjects were selected from different occupations which included mechanics, electricity engineering, architecture, chemical engineering, and services. The major findings of the survey were:

1. Sixty-five percent of the employers agreed that the NOCT actually identified the particular occupational technical level.

2. Fifty-eight percent of the candidates indicated that the NOCT written tests meet the needs of actual job of the entry level worker.

3. Fifty-six percent of the candidates indicated that the NOCT performance tests meet the needs of the actual job of entry level workers.

4. The processes of competency tests being too complex (26%), lack of test guidance (19%), and lack of objectivity of judges (10%) were the weak areas of NOCT as perceived by some candidates.

5. Forty-seven percent of the subjects who have never participated in the NOCT indicated that the licensed workers performed better than the unlicensed. The
others indicated no difference between licensed and unlicensed workers.

6. Seventy-four percent of employers indicated that licensed workers performed better than unlicensed workers.

7. Licensure maintained occupational standards and ensurance of the product quality as perceived by ninety-one percent of employers.

8. The enterprise indicated that the major reasons for which the occupational licensure cannot be recognized by the public were (1) the NOCT did not meet the needs of enterprise (28.8%); (2) the public did not have an accurate perception (21.2%); (3) the government did not boost the licensure thoroughly (18.5%); and (4) lack of adequate law to enforce the licensure system (15.8%).

9. The candidates indicated that major reasons for which the occupational licensure could not be recognized by the public were (1) the government did not boost the licensure thoroughly (21.5%), (2) lack of adequate law to execute licensure system (20.7%), (3) the NOCT competency tests did not meet the needs of enterprise (17%), (4) the public did not have an accurate perception (16.3%).

Based on the findings, the investigators suggested that:
(1) the test development and scoring of the NOCT should involve a representative of enterprise; (2) the NOCT should be revised or rearranged from time to time to update and meet societal needs; (3) the validity and reliability of the NOCT should be improved; (4) the practice of the NOCT need to be reconsidered and improved; (5) using criterion referenced evaluation, reconsideration of the guidelines of the test and administering the test according to the guidelines should be considered; and (6) publish the test items, and increase the objectivity and fairness of the test. For further studies, the investigators recommended that they consider using the critical competency criteria from the perception of enterprise to receive their recognition.

Employment and Vocational Training Administration (1991) investigated the effectiveness and perception of NOCT in Taiwan. Data were collected from 111 subjects from enterprise. The major findings were:

1. Fifty-nine percent of the subjects in enterprise have hired licensed employees, the rest have not hired licensed employees.

2. Most (87%) subjects from enterprise were willing to encourage employees to take NOCT.

3. Forty-six percent of the subjects assessed the effectiveness of the NOCT as good; 46% assessed it as average; and 7.4% assessed it as "very bad".
4. The subjects judged the merits of licensed workers as being high quality of professional technique and good performance. The weaknesses of licensed workers were higher salary requests and higher mobility.

5. Thirty-five percent of the subjects from enterprise were willing to provide a higher salary for licensed employees. The rest of the subjects indicated that the salaries of employees depended upon their performance because (1) even though the workers passed the NOCT, they still needed on-job-training; (2) the items of the NOCT do not meet the needs of enterprise; (3) licensed workers did not perform better than unlicensed. The results indicated that the effectiveness of NOCT has not been confirmed by enterprise.

6. Eight percent of the subjects from enterprise recognized the scheme of the NOCT, the rest did not.

7. Half of the subjects did not quite understand NOCT.

8. Forty-nine percent of the subjects recognized that a public safety related business agency had to hire a specific ratio of licensed workers according to the Occupational Training Law. However, more than half of the subjects did not recognize the law.

Based on the findings the investigators suggested that the Employment and Vocational Training Administration needs to
(1) disseminate the conception and functions of NOCT to the enterprise, and (2) improve the NOCT test items, processes and methods. Then, enterprise will recognize the importance of licensure, and confirm the effectiveness of NOCT.

Summary

The review of related literature has shown evidence of a the long history of interest in the measurement of occupational competency in military, industry, and vocational education instruction in the United States. The National Occupational Competency Testing Institute (NOCTI) provides high quality occupational competency examinations at the national level which serve as a reference for improving NOCT in Taiwan. In addition, the development of an NOCT in Taiwan was reviewed to understand the background.

NOCT plays a critical role in determining who gets licensed. The assessment includes both written and performance tests. The objective is not only to test academic knowledge, but also to determine whether the applicant has the correct know-how and judgment to perform the work. The basic steps in developing written or performance tests are: (1) determine occupational competencies to be measured, (2) state a job description and test specifications, (3) write the test items, (4) review and edit the items, (5) field test the items, and (6) obtain reliability and validity data. In
judging the usefulness of the occupational competency test, prime consideration should be given to validity and reliability. Another critical factor is the cut-off point. Appropriate cut-off point reflects the competency status of the candidate in relation to his/her ability to practice.

More specifically, the review of literature has indicated (1) the perceived differences in the relevances of critical competencies as outlined by the NOCT test committees for the selected trades by educators, incumbent workers and supervisors of these selected trades, and (2) the relationship between the NOCT, candidate characteristics and successful job performance. Limited related research has been done in Taiwan. It is most appropriate for this study to follow the recommendation of Kang et al. (1990) and to further examine the critical competency criteria of NOCT from the employees and workers perspectives also to understand the perception of employees and workers toward NOCT.
CHAPTER III. METHODOLOGY

In this chapter, the methods and procedures used in the study are discussed in five sections: (1) description of population and sample, (2) instrumentation, (3) data collection, (4) hypotheses formulation and statistical methods, and (5) data analysis.

Description of Population and Sample

The target population included all plumbing incumbent workers and plumbing supervisors in Taipei, and plumbing educators in Taiwan. A name list of all plumbing companies was provided by the Plumbing Association in Taiwan. There were 808 plumbing companies in Taipei. A random sampling technique was used to select the sample of incumbent workers and supervisors. One hundred and sixty companies were randomly selected which was 20% of the population. Once the companies were selected, one supervisor and one incumbent worker of these companies were invited randomly to respond.

All plumbing vocational educators in Taiwan were invited to participate in the study. Those educators came from 4 industrial technical high schools and 5 vocational training centers. There were 35 vocational educators teaching plumbing in Taiwan.
Instrumentation

The questionnaire method of data collection was used for this study. The survey questionnaire was structured into three parts (Appendix A) - Part I, critical competencies judgement; Part II, perception assessment of the NOCT; Part III, demographic information.

Critical competencies judgement

Part I, includes NPCT critical competencies presently included as a part of the tests for plumbing. The critical competencies were developed by the NPCT Development Committee. The intention of this study was to compare the judgment of critical competencies and their weight as reflected in the entry level job in the plumbing occupation by plumbing incumbent workers, plumbing supervisors, and plumbing vocational educators. By having a large group of vocational educators, incumbent workers and supervisors evaluate the necessity and importance of each competency, and assign percentages to the various competencies as outlined by the NPCT Committee, so the perceptions of the various groups could be analyzed.

First, the subjects judged the necessity of each competency by answering yes or no. Once the competency was assessed as to necessary and the level of importance was evaluated, a continuum of five possible responses were used to
indicate the degree of importance, with 1 indicating no importance, 5 indicating very important.

**Perception assessment of NOCT**

Part II, the perception assessment was developed to ask individuals to rate how they felt about NPCT. The perception assessment contained 26 statements across four areas which were (1) quality of NPCT, (2) administration of NPCT, (3) test scoring and interpretation of NPCT, and (4) plumbing licensure. A continuum of five possible responses were used to indicate the degree of agreement. Rating scales for each item included: strongly disagree (SD = 1) to strongly agree (SA = 5).

**Personal information**

Part III addressed common personal information questions for incumbent workers, supervisors and vocational educators. These were age, highest education level, working experience, licensed/unlicensed, training experience, and when a plumbing license was obtained.

For plumbing supervisors, questions about current job positions, number of plumbers in their companies, and percentages of licensed employees were asked.

For vocational educators, questions about plumbing teaching experience and current job positions were also asked.
The questionnaire was submitted for a validation process by a panel of experts who were comprised of five members of the investigator's graduate committee and three plumbing/vocational education experts in Taiwan. The final draft of the instrument was translated into Chinese and used as a pilot test with a sample of 5 plumbing incumbent workers and 5 plumbing supervisors. Results of the pilot-test were used to examine and revise the questionnaire. The revised instrument was approved by the Human Subject Review Committee of Iowa State University on February 11, 1992 (see Appendix B). The Chinese version of the questionnaire is included in Appendix C. Based on the recommendations of this panel, the instrument was revised before a final draft was produced.

Data Collection

The questionnaire was mailed to each subject selected in the sample. A cover letter introducing the purpose of the study and assuring confidentiality of the data was enclosed (see Appendix D) for each subject. The participants were asked to complete the questionnaire within one week and to return it using the stamped, self-addressed envelope provided.

Each questionnaire was coded to verify individual respondents and to assist the researcher in the necessary follow-up process. Two weeks after the initial mailing, a follow-up letter (see Appendix E) with an additional
questionnaire and a stamped, self-addressed return envelope was distributed to each subject who had not returned the initial mailing by February 26, 1992.

By March 4, 1992, 117 (73%) questionnaires were returned from incumbent workers out of 160 possible, 113 (71%) questionnaires from supervisors out of 160 possible returns, and 30 (86%) questionnaires from vocational educators out of 35 possible returns, were received. Each returned questionnaire was carefully examined. If 10% or more of the total questions were not completed, then the questionnaire was considered invalid and removed from analysis. Finally, the actual number of questionnaires considered for data analysis included responses from 112 (70%) incumbent workers, 110 (69%) supervisors, and 30 (86%) vocational educators.

Hypotheses Formulation and Statistical Methods

Hypothesis 1

There is no difference between the perceived relevance of critical competencies for plumbing assigned by NPCT Committee, and the incumbent workers, supervisors and vocational educators.

Hypothesis 1.1a

H0: There is no difference between NPCT Committee and incumbent workers in terms of assigned percentage to the
importance of critical competencies related to reading the blueprint and drawing the manufacturer's schematic factor.

\[ H_0: \mu_1 = \mu_2 \]
\[ H_a: \mu_1 \neq \mu_2 \]

where \( \mu_1 \) = the mean score of Test Committee.
\( \mu_2 \) = the mean score of incumbent workers.

**Hypothesis 1.1b**

Ho: There is no difference between NPCT Committee and the incumbent workers in terms of the assigned percentage to the importance of the critical competencies related to the performance procedure factor.

\[ H_0: \mu_1 = \mu_2 \]
\[ H_a: \mu_1 \neq \mu_2 \]

where \( \mu_1 \) = the mean score of Test Committee.
\( \mu_2 \) = the mean score of incumbent workers.

**Hypothesis 1.1c**

Ho: There is no difference between NPCT Committee and the incumbent workers in terms of the assigned percentage to the importance of the critical competencies related to the accuracy of the performance factor.
\[ H_0: \mu_1 = \mu_2 \]
\[ H_a: \mu_1 \neq \mu_2 \]
where \( 1 \) = the mean score of Test Committee.
\[ 2 = \text{the mean score of incumbent workers.} \]

**Hypothesis 1.1d**

Ho: There is no difference between NPCT Committee and the incumbent workers in terms of the assigned percentage to the importance of the critical competencies related to the appearance of the product factor.

\[ H_0: \mu_1 = \mu_2 \]
\[ H_a: \mu_1 \neq \mu_2 \]
where \( 1 \) = the mean score of Test Committee.
\[ 2 = \text{the mean score of incumbent workers.} \]

**Hypothesis 1.1e**

Ho: There is no difference between NPCT Committee and the incumbent workers in terms of the assigned percentage to the importance of the critical competencies related to the hydrostatic test factor.

\[ H_0: \mu_1 = \mu_2 \]
\[ H_a: \mu_1 \neq \mu_2 \]
where \( \mu_1 \) = the mean score of Test Committee.
\[ \mu_2 \] = the mean score of incumbent workers.

**Hypothesis 1.2a**

**Ho:** There is no difference between the NPCT Committee and the supervisors in terms of the assigned percentage to the importance of the critical competencies related to reading the blueprint and drawing the manufacturer's schematics factor.

\[ H_o: \mu_1 = \mu_2 \]

\[ H_a: \mu_1 \neq \mu_2 \]

where \( \mu_1 \) = the mean score of Test Committee.
\[ \mu_2 \] = the mean score of supervisors.

**Hypothesis 1.2b**

**Ho:** There is no difference between NPCT Committee and the supervisors in terms of the assigned percentage to the importance of the critical competencies related to performance procedure factor.

\[ H_o: \mu_1 = \mu_2 \]

\[ H_a: \mu_1 \neq \mu_2 \]

where \( \mu_1 \) = the mean score of Test Committee.
\[ \mu_2 \] = the mean score of supervisors.
Hypothesis 1.2c

\( H_0: \mu_1 = \mu_2 \)

\( H_a: \mu_1 \neq \mu_2 \)

where \( 1 \) = the mean score of Test Committee.

\( 2 \) = the mean score of supervisors.

Hypothesis 1.2d

Ho: There is no difference between NPCT Committee and the supervisors in terms of the assigned percentage to the importance of the critical competencies related to the appearance of the product factor.

\( H_0: \mu_1 = \mu_2 \)

\( H_a: \mu_1 \neq \mu_2 \)

where \( 1 \) = the mean score of Test Committee.

\( 2 \) = the mean score of supervisors.

Hypothesis 1.2e

Ho: There is no difference between NPCT Committee and the supervisors in terms of the assigned percentage to the
importance of the critical competencies related to the hydrostatic test factor.

\( H_0: \mu_1 = \mu_2 \)

\( H_a: \mu_1 \neq \mu_2 \)

where \( l = \) the mean score of Test Committee.

\( 2 = \) the mean score of supervisors.

**Hypothesis 1.3a**

Ho: There is no difference between the NPCT Committee and the vocational educators in terms of the assigned percentage to the importance of the critical competencies related to reading the blueprint and drawing the manufacturer's schematics factor.

\( H_0: \mu_1 = \mu_2 \)

\( H_a: \mu_1 \neq \mu_2 \)

where \( l = \) the mean score of Test Committee.

\( 2 = \) the mean score of vocational educators.

**Hypothesis 1.3b**

Ho: There is no difference between NPCT Committee and the vocational educators in terms of the assigned percentage to the importance of the critical competencies related to the performance procedure factor.
Hypothesis 1.3c
Ho: There is no difference between NPCT Committee and the vocational educators in terms of the assigned percentage to the importance of the critical competencies related to the accuracy of the performance factor.

\[ H_0: \mu_1 = \mu_2 \]
\[ H_a: \mu_1 \neq \mu_2 \]

where 1 = the mean score of Test Committee.

2 = the mean score of vocational educators.

Hypothesis 1.3d
Ho: There is no difference between NPCT Committee and the vocational educators in terms of the assigned percentage to the importance of the critical competencies related to the appearance of the product factor.

\[ H_0: \mu_1 = \mu_2 \]
\[ H_a: \mu_1 \neq \mu_2 \]
where 1 = the mean score of Test Committee.

2 = the mean score of vocational educators.

**Hypothesis 1.3e**

Ho: There is no difference between NPCT Committee and the vocational educators in terms of the assigned percentage to the importance of the critical competencies related to the hydrostatic test factor.

\[ H_0: \mu_1 = \mu_2 \]

\[ H_a: \mu_1 \neq \mu_2 \]

where 1 = the mean score of Test Committee.

2 = the mean score of vocational educators.

**Hypothesis 2**

Ho: There was no difference of the perception score of NPCT among the incumbent workers, supervisors, and the vocational educators.

Ha: At least one of the groups is different from the others in the perception of the NPCT.

\[ H_0: \mu_1 = \mu_2 = \mu_3 \]

\[ H_a: \text{at least two } \mu \text{'s are different} \]
where 1 = incumbent workers, 2 = supervisors, and 
3 = vocational educators.

**Hypothesis 3**

There was no difference among the mean perception levels regarding (a) quality of NPCT, (b) administration of NPCT, (c) test scoring and interpretation of NPCT, (d) plumbing licensure.

**Hypothesis 3.1**

Ho: There is no difference among the mean perception levels on the quality of NPCT.

Ha: At least one of the groups is different from the others in terms of the perception of the quality of NPCT.

\[ H_0: \mu_1 = \mu_2 = \mu_3 \]

\[ H_a: \text{at least two } \mu \text{'s are different} \]

where 1 = incumbent workers, 2 = supervisors, and 3 = vocational educators.

**Hypothesis 3.2**

Ho: There is no difference among the mean perception levels on NPCT administration.
Ha: At least one of the groups is different from the others in terms of the perception of NPCT administration.

\[ H_0: \mu_1 = \mu_2 = \mu_3 \]

\[ H_a: \text{at least two } \mu \text{'s are different} \]

where 1 = incumbent workers, 2 = supervisors, and 3 = vocational educators.

Hypothesis 3.3
Ho: There is no difference among the mean perception levels on the test scoring and the interpretation of NPCT.

Ha: At least one of the groups is different from the others in terms of the perception of the test scoring and the interpretation of NPCT.

\[ H_0: \mu_1 = \mu_2 = \mu_3 \]

\[ H_a: \text{at least two } \mu \text{'s are different} \]

where 1 = incumbent workers, 2 = supervisors, and 3 = vocational educators.

Hypothesis 3.4
Ho: There is no difference among the mean perception levels on the plumbing licensure.
Ha: At least one of the groups is different from the others in terms of the perception of the plumbing licensure.

\[ H_0: \mu_1 = \mu_2 = \mu_3 \]
\[ H_a: \text{at least two } \mu \text{'s are different} \]
where 1 = incumbent workers, 2 = supervisors, and 3 = vocational educators.

**Hypothesis 4**

There was no difference among the mean perception levels in terms of NPCT regarding the selected demographic variables (a) age, (b) educational level, (c) professional training, (d) obtaining plumbing license years, and (e) plumbing working experience.

**Hypothesis 4.1**

\[ H_0: \text{There was no difference among the mean perception levels regarding the selected demographic variables age.} \]

Ha: At least one of the age group is different from the others in terms of the perception of NPCT.

\[ H_0: \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 \]
\[ H_a: \text{at least two } \mu \text{'s are different} \]
where 1 = 16-19 years old, 2 = 20-29 years old, 
3 = 30-39 years old, 4 = 40-49 years old, 
5 = above 50 years old.

**Hypothesis 4.2**

**H₀:** There was no difference among the mean perception levels regarding the selected demographic variables related to educational level.

**Hₐ:** At least one of the education group is different from the others in terms of the perception of NPCT.

\[ H₀: \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 \]

\[ Hₐ: \text{at least two } \mu \text{'s are different} \]

where 1 = Ph.D or master degree 
2 = bachelor's degree 
3 = senior high school diploma 
4 = junior high school diploma 
5 = elementary school diploma

**Hypothesis 4.3**

**H₀:** There was no difference among the mean perception levels regarding the selected demographic variables of professional training.
Ha: At least one of the age group is significantly different from the others in terms of the perception of NPCT.

\[ H_0: \mu_1 = \mu_2 = \mu_3 = \mu_4 \]
\[ H_a: \text{at least two } \mu \text{'s are different} \]
where 1 = plumbing education at technical high school
2 = plumbing vocational training
3 = plumber short-term intensive class
4 = on-the-job training

**Hypothesis 4.4**

Ho: There is no difference among the groups obtaining plumbing licenses 10 years ago, 6 to 10 years, or within the last 5 years in terms of perception of NPCT.

Ha: At least one of the groups was significantly different from the others in terms of its perception of NPCT.

\[ H_0: \mu_1 = \mu_2 = \mu_3 \]
\[ H_a: \text{at least two } \mu \text{'s are different} \]
where 1 = 10 years ago 2 = 6 to 10 years 3 = within the last 5 years
Hypothesis 4.5

Ho: There is no difference among the groups with different plumbing working experience in terms of the perception of NPCT.

Ha: At least one of the groups was significantly different from the others in terms of its perception of NPCT.

\[ H_0: \mu_1 = \mu_2 = \mu_3 = \mu_4 \]
\[ H_a: \text{at least two } \mu \text{'s are different} \]
where \( 1 = \text{less than 1 year} \quad 2 = \text{1 to 5 years} \)
\( 3 = \text{6 to 10 years} \quad 4 = \text{over 10 years} \)

Data Analysis

Totally, 252 usable questionnaires were coded and provided a data file for running statistical analyses by applying the statistical package of the social science revised version (SPSS-X) computer package.

The statistical methods selected for analyzing the data in this study were:

1. Mean scores: These were computed for all three groups in the study for all items related to each research question.

2. Frequency counts and percentages: These were used to summarize descriptive data.
3. One-way analysis of variance (ANOVA): The one-way ANOVA SPSS-X procedure was used to analyze one independent variable with two or more levels.

4. Duncan's multiple range test: A posthoc analysis using Duncan's multiple range test was carried out whenever significant differences beyond the assigned probability level of 0.05 were found for F-values among groups.

5. T-test: a t-test was used to test the difference between the means of two independent group of samples.

6. Spearman's rank correlation coefficient: This was used to test the correlation of rank order concerning perceived relevances of critical competencies by test groups.

7. Chi-Square: Chi-Square is a nonparametric test which yields information pertinent to deciding whether or not two group distributions differ significantly from each other. Chi-Square procedures were utilized to analyze the discrete category variables.

8. Reliability: Cronbach's alpha reliability coefficient of the instrument was calculated in this study. The reliability coefficient of a measure indicates its consistency. Cronbach's alpha, which essentially
calculates the average of all possible split-half reliability coefficient, is currently widely used (Bryman & Cramer, 1990).
CHAPTER IV. FINDINGS AND DISCUSSION

The purpose of this study was to determine the effectiveness of the NOCT in the plumbing trade in Taiwan. The assessments are based on 112 plumbing incumbent workers, 110 plumbing supervisors, and 30 plumbing vocational educators. This study was conducted in February, 1992. The findings for this study are presented and discussed under the following three sections (1) general characteristics of the sample, (2) general description of survey results, and (3) the findings for each hypothesis.

General Characteristics of the Sample

Demographic characteristics of plumbing incumbent workers, supervisors, and vocational educators are summarized in this section. These characteristics provide an overview of the nature of the sample as presented in Table 1.

Age

The plumbing incumbent workers were grouped into age ranges of 16-19 (4.5%), 20-29 (34.8%), 30-39 (28.6%), 40-49 (27.7%), and over 50 (4.5%). The plumbing supervisors were grouped into age ranges of 16-19 (1.8%), 20-29 (12.7%), 30-39 (34.5%), 40-49 (41.8%), and over 50 (9.1%). The plumbing vocational educators were grouped into age ranges of 30-39
Table 1. Frequency and percentage distribution of common demographic variables of incumbent workers, supervisors, and vocational educators

<table>
<thead>
<tr>
<th>Demographic Variables</th>
<th>Incumbent workers</th>
<th>Supervisors</th>
<th>Educators</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 to 19</td>
<td>5</td>
<td>4.5</td>
<td>2</td>
</tr>
<tr>
<td>20 to 29</td>
<td>39</td>
<td>34.8</td>
<td>14</td>
</tr>
<tr>
<td>30 to 39</td>
<td>32</td>
<td>28.6</td>
<td>38</td>
</tr>
<tr>
<td>40 to 49</td>
<td>31</td>
<td>27.7</td>
<td>46</td>
</tr>
<tr>
<td>over 50</td>
<td>5</td>
<td>4.5</td>
<td>10</td>
</tr>
<tr>
<td><strong>Highest Education Achieved</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ph.D or master degree</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Bachelor degree</td>
<td>10</td>
<td>9.1</td>
<td>32</td>
</tr>
<tr>
<td>Senior high school diploma</td>
<td>54</td>
<td>49.1</td>
<td>55</td>
</tr>
<tr>
<td>Junior high school diploma</td>
<td>31</td>
<td>28.2</td>
<td>14</td>
</tr>
<tr>
<td>Elementary school diploma</td>
<td>15</td>
<td>13.6</td>
<td>8</td>
</tr>
<tr>
<td><strong>Years of Industrial Experience</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>less 1 year</td>
<td>12</td>
<td>10.7</td>
<td>2</td>
</tr>
<tr>
<td>1 to 5 years</td>
<td>39</td>
<td>34.8</td>
<td>15</td>
</tr>
<tr>
<td>6 to 10 years</td>
<td>19</td>
<td>17.0</td>
<td>13</td>
</tr>
<tr>
<td>over 10 years</td>
<td>42</td>
<td>37.5</td>
<td>80</td>
</tr>
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Table 1. (Continued)

<table>
<thead>
<tr>
<th>Demographic Variables</th>
<th>Incumbent workers</th>
<th>Supervisors</th>
<th>Educators</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>Plumbing License Obtained</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before employed</td>
<td>33</td>
<td>30.3</td>
<td>27</td>
</tr>
<tr>
<td>After employed</td>
<td>72</td>
<td>66.0</td>
<td>80</td>
</tr>
<tr>
<td>Have not obtained</td>
<td>4</td>
<td>3.7</td>
<td>3</td>
</tr>
<tr>
<td>Year of License Obtained</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 years ago</td>
<td>35</td>
<td>31.5</td>
<td>69</td>
</tr>
<tr>
<td>6 to 10 years</td>
<td>19</td>
<td>17.1</td>
<td>19</td>
</tr>
<tr>
<td>Within 5 years</td>
<td>56</td>
<td>50.5</td>
<td>21</td>
</tr>
<tr>
<td>Attending Activity before Obtaining Plumbing License</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plumbing education at technical high school</td>
<td>28</td>
<td>25.7</td>
<td>21</td>
</tr>
<tr>
<td>Plumbing vocational training</td>
<td>15</td>
<td>13.8</td>
<td>12</td>
</tr>
<tr>
<td>Plumber short-term intensive class</td>
<td>26</td>
<td>23.9</td>
<td>37</td>
</tr>
<tr>
<td>On-the-job training</td>
<td>40</td>
<td>36.7</td>
<td>40</td>
</tr>
<tr>
<td>Current Job Position</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employer</td>
<td>67</td>
<td>60.9</td>
<td></td>
</tr>
<tr>
<td>Supervisor</td>
<td>25</td>
<td>22.7</td>
<td></td>
</tr>
<tr>
<td>Foreman</td>
<td>18</td>
<td>16.4</td>
<td></td>
</tr>
</tbody>
</table>
Table 1. (Continued)

<table>
<thead>
<tr>
<th>Demographic Variables</th>
<th>Incumbent workers</th>
<th>Supervisors</th>
<th>Educators</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td><strong>Current Job Position</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher</td>
<td>14</td>
<td>46.7</td>
<td>15</td>
</tr>
<tr>
<td>Trainer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Administrator</td>
<td>1</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td><strong>Years of plumbing teaching experience</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 1 year</td>
<td>1</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>1 to 5 years</td>
<td>3</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>6 to 10 years</td>
<td>9</td>
<td>30.0</td>
<td></td>
</tr>
<tr>
<td>over 10 years</td>
<td>17</td>
<td>56.7</td>
<td></td>
</tr>
<tr>
<td><strong>Number of plumbers in company</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 5</td>
<td>23</td>
<td>21.3</td>
<td></td>
</tr>
<tr>
<td>5 to 10</td>
<td>32</td>
<td>29.6</td>
<td></td>
</tr>
<tr>
<td>more than 10</td>
<td>53</td>
<td>49.1</td>
<td></td>
</tr>
<tr>
<td><strong>Percentage of employees in company are licensed</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below 10%</td>
<td>11</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>10 to 39%</td>
<td>39</td>
<td>35.5</td>
<td></td>
</tr>
<tr>
<td>40 to 69%</td>
<td>38</td>
<td>34.5</td>
<td></td>
</tr>
<tr>
<td>70 to 99%</td>
<td>18</td>
<td>16.4</td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td>4</td>
<td>3.6</td>
<td></td>
</tr>
</tbody>
</table>
(56.7%), 40-49 (36.7%), and over 50 (6.7%). There were no teachers under 29 years old.

Highest education achieved

Approximately forty-nine percent of the incumbent workers earned a senior high school diploma; a junior high school diploma, 28%; an elementary school diploma, 14%; and a bachelor's degree, 9%. Half of the plumbing supervisors earned a senior high school diploma; a bachelor's degree, 29%; a junior high school diploma, 13%; an elementary school diploma, 7%; and a doctoral or master's degree, 1%. A bachelor's degree was reported as the highest degree obtained by 89% of the plumbing vocational educators. Eleven percent of the plumbing vocational educators had a doctoral or master's degree.

Years of industrial working experience

In regards to years of industrial work experience, 37.5% incumbent workers had over 10 years of experience; 34.8% had 1-5 years; 17% had 6-10 years; and 10.7% had less than 1 year. Most supervisors (72.7%) had over 10 years of work experience; 13.6% had 1-5 years; 11.8% had 6-10 years; and 1.8% had less than one year. One third of the plumbing vocational educators had 1-5 years of experience; 23.3% had 6-10 years; 23.3% had over 10 years experience; and 20% had less than 1 year.
Plumbing license obtained

Two thirds of the incumbent workers obtained a plumbing license after employment; 30.3% obtained a license before employment; and 3.7% were unlicensed. Most supervisors (72.7%) also obtained a license after employment; 24.5% obtained a license before employment; and 2.7% were unlicensed. Fifty three percent of the educators were licensed; 16.7% of them obtained a license before employment; and 36.7% obtained a license after employment.

Year of license obtained

Half of the licensed incumbent workers obtained a license within 5 years; 32% obtained a license 10 years ago; 17% obtained a license within 6 to 10 years. Most of the licensed supervisors (63.3%) obtained a license 10 years ago; 19.3% obtained a license within 5 years; and 17.4% obtained it within 6 to 10 years. Forty-four percent of the licensed teachers obtained a license within 6 to 10 years; 31.2% obtained one within 5 years; and 25% obtained it 10 years ago.

Attending activity before obtaining plumbing license

It is important for both plumbing workers and educators to possess the necessary skills and knowledge to perform their occupation. Attending a training activity before obtaining a plumbing license, 36.7% incumbent workers have attended on-
the-job training; 25.7% attended plumbing education at a technical high school; 23.9% attended a plumber short-term intensive class; and 13.8% attended plumbing vocational training. Thirty six percent of the supervisors attended on-the-job training; 33.6% attended a plumber short-term intensive class; 19.1% attended plumbing education at technical high school; and 10.9% attended plumbing vocational training. Half of the educators attended plumbing vocational training; 31.3% attended on-the-job training; 12.5% attended plumbing education at technical high school; and 6.3% attended a plumber short-term intensive class.

**Current job position**

The current job position of most supervisors (60.9%) was the employer; 22.7% were supervisors; and 16.4% were foremen. Half of the educators were plumbing vocational trainers; 46.7% were plumbing vocational teachers; and 3.3% were administrators.

**Years of plumbing teaching**

Most plumbing vocational educators (56.7%) have more than 10 years of plumbing teaching experience; 30.0% have 6 to 10 years; 10.0% have 1 to 5 years; and 3.3% have less than 1 year.
Number of plumbers in company

In regard to the number of plumbers in a company, approximately half of the companies have more than 10 plumbers; 29.6% have 5 to 10 plumbers; and 21.3% have fewer than 5 plumbers.

Percentage of licensed employees in company

In regard to the percentage of employees in a company who are licensed, 35.5% of the companies have 10% to 39% licensed employees; 34.5% of the companies have 40 to 69% licensed employees; 16.4% of the companies have 70 to 99% licensed employees; 10% of the companies have less than 10% licensed employees; and only 3.6% of the companies have 100% the licensed employees.

General Description of Survey Results

Perceived critical competencies of the NPCT

The critical competency list of the questionnaire, Part I, was developed by NPCT Committee. The respondents were asked to judge the necessity of each critical competency. The perceived critical competencies of the NPCT are listed in Table 2. With the exception of three multiple choice type questions, the total number of critical competencies was 25. Seventy-one percent and above of the incumbent workers rated 22 of 25 critical competencies (88%) as necessary for an
Table 2. Perceived critical competencies of the NPCT

<table>
<thead>
<tr>
<th>% of Group Checking Competency</th>
<th>Number of items checked by</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Incumbent Workers</td>
</tr>
<tr>
<td>91-100%</td>
<td>4</td>
</tr>
<tr>
<td>81-90%</td>
<td>6</td>
</tr>
<tr>
<td>71-80%</td>
<td>12</td>
</tr>
<tr>
<td>61-70%</td>
<td>2</td>
</tr>
<tr>
<td>51-60%</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
</tr>
</tbody>
</table>

entry level worker in plumbing. The same percentage of supervisors rated 20 of 25 critical competencies (80%) as necessary for an entry level worker. The same percentage of vocational educators rated 17 of 25 critical competencies (68%) as necessary for an entry level worker. According to the findings an agreement between the Test Committee and three survey groups on perceived critical competencies of entry level workers was low.

Most critical competencies were judged as necessary by over 70% of the respondents. However, three of the twenty five critical competencies that were judged as necessary by fewer than 70% respondents included: (1) thread pipes were
assessed by the judge before joining, (2) cut ends of the pipes were assessed by the judge before joining, and (3) drawing a line or arc correctly by using a tool. Whether these three critical competencies should be included in NPCT needs to be reconsidered.

In addition to the 25 critical competencies mentioned above, three more critical competencies were included on the list of critical competencies by NPCT and were discussed as follows (Table 3):

The majority of respondents (58.3%) indicated that the radial pipe bend more/less than 5-10mm was a necessary competency for entry level workers; 0-4mm, 36.4%; 11-15mm, 4.5%; and above 16mm, 0.8%.

Most respondents (53.2%) perceived that a measure error more/less than 5-10mm was a necessary competency for entry level workers; 0-4mm, 38.1%; 11-15mm, 4.8%; 16-20mm, 2.8%; and above 26mm, 1.2%.

Most respondents (55.6%) perceived that a P.V.C. pipe of single length or diameter 0-4mm was a necessary competency for entry level workers; 5-10mm, 36.8%; and 11-20mm, 7.6%.

Necessity of critical competencies as judged by incumbent workers, supervisors, and vocational educators

A detailed comparison of the necessity of critical competencies as judged by incumbent workers, supervisors, and
Table 3. Frequencies and percentages of critical competencies ratings by three groups

<table>
<thead>
<tr>
<th>Competency</th>
<th>Frequency</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial pipe bend more/less than</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0- 4mm</td>
<td>90</td>
<td>36.4%</td>
</tr>
<tr>
<td>5-10mm</td>
<td>144</td>
<td>58.3%</td>
</tr>
<tr>
<td>11-15mm</td>
<td>11</td>
<td>4.5%</td>
</tr>
<tr>
<td>above 16mm</td>
<td>2</td>
<td>0.8%</td>
</tr>
<tr>
<td>Measure error more or less than</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0- 4mm</td>
<td>96</td>
<td>38.1%</td>
</tr>
<tr>
<td>5-10mm</td>
<td>134</td>
<td>53.2%</td>
</tr>
<tr>
<td>11-15mm</td>
<td>12</td>
<td>4.8%</td>
</tr>
<tr>
<td>16-20mm</td>
<td>7</td>
<td>2.8%</td>
</tr>
<tr>
<td>21-25mm</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>over 26mm</td>
<td>3</td>
<td>1.2%</td>
</tr>
<tr>
<td>P.V.C. pipe single length or diameter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0- 4mm</td>
<td>139</td>
<td>55.6%</td>
</tr>
<tr>
<td>5-10mm</td>
<td>92</td>
<td>36.8%</td>
</tr>
<tr>
<td>11-20mm</td>
<td>19</td>
<td>7.6%</td>
</tr>
<tr>
<td>above 21mm</td>
<td>0</td>
<td>0.0%</td>
</tr>
</tbody>
</table>
vocational educators is presented on Table 4. The differences among the necessity of critical competencies judged by these three groups were tested by a Chi-Square. Only one competency was found that was independent among the ratings of incumbent workers, supervisors, and vocational educators. In total, 179 out of 252 respondents, or 71%, judged the competency of products followed the blueprint as necessary; 73 of 252, or 29%, judged it as not necessary. For those respondents who confirmed the necessity of this competency, 44.7% or 80 of 179 was found from the incumbent worker group; 40.2% or 72 of 179 was from the supervisors; and 15.1% or 27 of 179 was from vocational educators. With two degree of freedom, Chi-Square yielded a value of 6.92, p < 0.05. Therefore, it was concluded that the necessity of the competency of products followed by blueprint reading was independent of incumbent worker, supervisor, or vocational educator group.

Importance of critical competencies as judged by incumbent workers, supervisors, and vocational educators

A detailed comparison of importance of critical competencies as judged by incumbent workers, supervisors, and vocational educators is presented on Table 5. The difference among the importance of critical competencies judged by these three groups were tested by a one-way ANOVA test. Three competencies were found significantly different among the
Table 4. Chi-square table of necessity of critical competencies of NPCT by survey groups

<table>
<thead>
<tr>
<th>Observed Frequency (Expected Frequency)</th>
<th>Incumbent Workers</th>
<th>Supervisors</th>
<th>Educators</th>
<th>$\chi^2$</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading blueprint &amp; drawing manufacturer's schematics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draw line or arc correctly by using tool</td>
<td>Necessary</td>
<td>61 (60.04)</td>
<td>58 (59.4)</td>
<td>17 (16.2)</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>Not necessary</td>
<td>51 (51.6)</td>
<td>52 (50.6)</td>
<td>13 (13.8)</td>
<td></td>
</tr>
<tr>
<td>Manufacturer's schematics consistent with blueprint</td>
<td>Necessary</td>
<td>83 (82.2)</td>
<td>78 (80.8)</td>
<td>24 (22.0)</td>
<td>1.05</td>
</tr>
<tr>
<td></td>
<td>Not necessary</td>
<td>29 (29.8)</td>
<td>32 (29.2)</td>
<td>6 (8.0)</td>
<td></td>
</tr>
<tr>
<td>Complete manufacturer's schematics according to blueprint</td>
<td>Necessary</td>
<td>88 (87.6)</td>
<td>84 (86.0)</td>
<td>25 (23.5)</td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td>Not necessary</td>
<td>24 (24.4)</td>
<td>26 (24.0)</td>
<td>5 (6.5)</td>
<td></td>
</tr>
<tr>
<td>Observed Frequency (Expected Frequency)</td>
<td>Incumbent Workers</td>
<td>Supervisors</td>
<td>Educators</td>
<td>$\chi^2$</td>
<td>Prob.</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>------------------</td>
<td>-------------</td>
<td>-----------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td><strong>Process follow by drawing manufacturer's schematics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Necessary</td>
<td>87</td>
<td>87</td>
<td>23</td>
<td>0.11</td>
<td>0.9464</td>
</tr>
<tr>
<td></td>
<td>(87.6)</td>
<td>(86.0)</td>
<td>(23.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not necessary</td>
<td>25</td>
<td>23</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(24.4)</td>
<td>(24.0)</td>
<td>(6.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Performance procedure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thread pipes are assessed by the judge before joining</td>
<td>78</td>
<td>61</td>
<td>17</td>
<td>5.13</td>
<td>0.0768</td>
</tr>
<tr>
<td></td>
<td>(69.3)</td>
<td>(68.1)</td>
<td>(18.6)</td>
<td></td>
<td></td>
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<tr>
<td>Not necessary</td>
<td>34</td>
<td>49</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(42.7)</td>
<td>(41.9)</td>
<td>(11.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut ends of the pipes are assessed by the judge before joining</td>
<td>74</td>
<td>74</td>
<td>18</td>
<td>0.56</td>
<td>0.7565</td>
</tr>
<tr>
<td></td>
<td>(73.8)</td>
<td>(72.5)</td>
<td>(19.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not necessary</td>
<td>38</td>
<td>36</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(38.2)</td>
<td>(37.5)</td>
<td>(10.2)</td>
<td></td>
<td></td>
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</tbody>
</table>
Table 4. (continued)

<table>
<thead>
<tr>
<th>Observed Frequency (Expected Frequency)</th>
<th>Incumbent</th>
<th>Supervisors</th>
<th>Educators</th>
<th>$\chi^2$</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use facilities &amp; tools appropriately</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Necessary</td>
<td>102</td>
<td>99</td>
<td>24</td>
<td>3.14</td>
<td>0.2085</td>
</tr>
<tr>
<td>(100.0)</td>
<td>(98.2)</td>
<td>(26.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not necessary</td>
<td>10</td>
<td>11</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(12.0)</td>
<td>(11.8)</td>
<td>(3.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keep work areas clear of tools &amp; materials and do not borrow those from somebody else</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Necessary</td>
<td>79</td>
<td>79</td>
<td>19</td>
<td>0.82</td>
<td>0.6635</td>
</tr>
<tr>
<td>(78.7)</td>
<td>(77.3)</td>
<td>(21.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not necessary</td>
<td>33</td>
<td>31</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(33.3)</td>
<td>(32.7)</td>
<td>(8.9)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apply safety procedures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Necessary</td>
<td>107</td>
<td>105</td>
<td>30</td>
<td>1.41</td>
<td>0.4946</td>
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<tr>
<td>(107.6)</td>
<td>(105.6)</td>
<td>(28.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not necessary</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4.4)</td>
<td>(4.4)</td>
<td>(1.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4. (continued)

<table>
<thead>
<tr>
<th>Observed Frequency (Expected Frequency)</th>
<th>Incumbent Workers</th>
<th>Supervisors</th>
<th>Educators</th>
<th>$\chi^2$</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process cautiously without any accident</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Necessary</td>
<td>89</td>
<td>82</td>
<td>24</td>
<td>0.90</td>
<td>0.6374</td>
</tr>
<tr>
<td></td>
<td>(86.7)</td>
<td>(85.1)</td>
<td>(23.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not necessary</td>
<td>23</td>
<td>28</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(25.3)</td>
<td>(24.9)</td>
<td>(6.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy of performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut pipe squarely &amp; remove the cutting burrs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Necessary</td>
<td>92</td>
<td>94</td>
<td>23</td>
<td>1.38</td>
<td>0.5026</td>
</tr>
<tr>
<td></td>
<td>(92.9)</td>
<td>(91.2)</td>
<td>(24.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not necessary</td>
<td>20</td>
<td>16</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(19.1)</td>
<td>(18.8)</td>
<td>(5.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pipe threads have not been marred or broken over 5 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Necessary</td>
<td>93</td>
<td>85</td>
<td>25</td>
<td>1.34</td>
<td>0.5106</td>
</tr>
<tr>
<td></td>
<td>(90.2)</td>
<td>(88.6)</td>
<td>(24.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not necessary</td>
<td>19</td>
<td>25</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(21.8)</td>
<td>(21.4)</td>
<td>(5.8)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4. (continued)

<table>
<thead>
<tr>
<th>Observed Frequency (Expected Frequency)</th>
<th>Incumbent Workers</th>
<th>Supervisors</th>
<th>Educators</th>
<th>$\chi^2$</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insert join P.V.C. pipe beyond 1.5 O.D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Necessary</td>
<td>100 (97.3)</td>
<td>95 (95.6)</td>
<td>24 (26.1)</td>
<td>1.84</td>
<td>0.3979</td>
</tr>
<tr>
<td>Not necessary</td>
<td>12 (14.7)</td>
<td>15 (14.4)</td>
<td>6 (3.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solder block pipe less than 1/3 O.D.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Necessary</td>
<td>88 (84.9)</td>
<td>82 (83.4)</td>
<td>21 (22.7)</td>
<td>1.11</td>
<td>0.5731</td>
</tr>
<tr>
<td>Not necessary</td>
<td>24 (27.1)</td>
<td>28 (26.6)</td>
<td>9 (7.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipeline or fitting joint distort angle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>less than 3°</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Necessary</td>
<td>91 (87.1)</td>
<td>85 (85.6)</td>
<td>20 (23.3)</td>
<td>2.94</td>
<td>0.2299</td>
</tr>
<tr>
<td>Not necessary</td>
<td>21 (24.9)</td>
<td>25 (24.4)</td>
<td>10 (6.7)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4. (continued)

<table>
<thead>
<tr>
<th>Observed Frequency (Expected Frequency)</th>
<th>Incumbent</th>
<th>Supervisors</th>
<th>Educators</th>
<th>$\chi^2$</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make uniform and smooth pipe bend</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Necessary</td>
<td>86</td>
<td>90</td>
<td>22</td>
<td>1.39</td>
<td>0.4992</td>
</tr>
<tr>
<td></td>
<td>(88.0)</td>
<td>(86.4)</td>
<td>(23.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not necessary</td>
<td>26</td>
<td>20</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(24.0)</td>
<td>(23.6)</td>
<td>(6.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flatten pipe size by pressure less than 10 % O.D.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Necessary</td>
<td>85</td>
<td>80</td>
<td>19</td>
<td>1.90</td>
<td>0.3862</td>
</tr>
<tr>
<td></td>
<td>(81.8)</td>
<td>(80.3)</td>
<td>(21.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not necessary</td>
<td>27</td>
<td>30</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(30.2)</td>
<td>(29.7)</td>
<td>(8.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make uniform &amp; smooth solder joints</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Necessary</td>
<td>83</td>
<td>78</td>
<td>21</td>
<td>0.37</td>
<td>0.8325</td>
</tr>
<tr>
<td></td>
<td>(80.9)</td>
<td>(79.4)</td>
<td>(21.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not necessary</td>
<td>29</td>
<td>32</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(31.1)</td>
<td>(30.6)</td>
<td>(8.3)</td>
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</table>
Table 4. (continued)

<table>
<thead>
<tr>
<th>Process by following the blueprint</th>
<th>Incumbent Workers</th>
<th>Supervisors</th>
<th>Educators</th>
<th>$\chi^2$</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. fitting fit direction &amp; position correctly</td>
<td>103 (102.7)</td>
<td>98 (100.8)</td>
<td>30 (27.5)</td>
<td>3.70</td>
<td>0.1576</td>
</tr>
<tr>
<td>Necessary</td>
<td>103</td>
<td>98</td>
<td>30</td>
<td>3.70</td>
<td>0.1576</td>
</tr>
<tr>
<td>Not necessary</td>
<td>9 (9.3)</td>
<td>12 (9.2)</td>
<td>0 (2.5)</td>
<td>5.77</td>
<td>0.0559</td>
</tr>
<tr>
<td>b. process &amp; methods of joint following the blueprint</td>
<td>83 (84.9)</td>
<td>80 (83.4)</td>
<td>28 (22.7)</td>
<td>5.77</td>
<td>0.0559</td>
</tr>
<tr>
<td>Necessary</td>
<td>83</td>
<td>80</td>
<td>28</td>
<td>5.77</td>
<td>0.0559</td>
</tr>
<tr>
<td>Not necessary</td>
<td>29 (27.1)</td>
<td>30 (26.6)</td>
<td>2 (7.3)</td>
<td>6.92</td>
<td>0.0315*</td>
</tr>
<tr>
<td>c. products follow the blueprint</td>
<td>80 (79.6)</td>
<td>72 (78.1)</td>
<td>27 (21.3)</td>
<td>6.92</td>
<td>0.0315*</td>
</tr>
<tr>
<td>Necessary</td>
<td>80</td>
<td>72</td>
<td>27</td>
<td>6.92</td>
<td>0.0315*</td>
</tr>
<tr>
<td>Not necessary</td>
<td>32 (32.4)</td>
<td>38 (31.9)</td>
<td>3 (8.7)</td>
<td>9.13</td>
<td>0.0023*</td>
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</tbody>
</table>
Table 4. (continued)

<table>
<thead>
<tr>
<th>Observed Frequency (Expected Frequency)</th>
<th>Incumbent</th>
<th>Supervisors</th>
<th>Educators</th>
<th>$\chi^2$</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appearance of product</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The product is smooth and steady</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Necessary</td>
<td>90</td>
<td>83</td>
<td>25</td>
<td>1.25</td>
<td>0.5350</td>
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<tr>
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<td>(88.0)</td>
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<tr>
<td>Not necessary</td>
<td>22</td>
<td>27</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(24.0)</td>
<td>(23.6)</td>
<td>(6.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No injury track appear on the product</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>by careless work</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Necessary</td>
<td>83</td>
<td>73</td>
<td>23</td>
<td>2.14</td>
<td>0.3426</td>
</tr>
<tr>
<td></td>
<td>(79.6)</td>
<td>(78.1)</td>
<td>(21.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not necessary</td>
<td>29</td>
<td>37</td>
<td>7</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>(32.4)</td>
<td>(31.9)</td>
<td>(8.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remove excess fillet, burrs, oil spot &amp; solvent cement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Necessary</td>
<td>94</td>
<td>96</td>
<td>24</td>
<td>1.13</td>
<td>0.5688</td>
</tr>
<tr>
<td></td>
<td>(95.1)</td>
<td>(93.4)</td>
<td>(25.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not necessary</td>
<td>18</td>
<td>14</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(16.9)</td>
<td>(16.6)</td>
<td>(4.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrostatic test</td>
<td>Incumbent (Expected Frequency)</td>
<td>Supervisors</td>
<td>Educators</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------------</td>
<td>-------------</td>
<td>-----------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no leak under 7.5 kg/cm² hydrostatic test &amp; hold 3 minutes</td>
<td>Necessary 109 (110.7)</td>
<td>110 (108.7)</td>
<td>30 (29.6)</td>
<td>3.80 0.1499</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Not necessary 3 (1.3)</td>
<td>0 (1.3)</td>
<td>0 (0.4)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p<0.05
Table 5. Means and one-way ANOVA relating to the importance of critical competencies of NPCT among incumbent workers, supervisors, and vocational educators

<table>
<thead>
<tr>
<th>Factor</th>
<th>Incumbent Workers</th>
<th>Supervisors</th>
<th>Educators</th>
<th>F</th>
<th>Pr &gt; F</th>
<th>DUNCAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading blueprint &amp; drawing manufacturer's schematics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draw line or arc correctly by using tool</td>
<td>3.00</td>
<td>3.19</td>
<td>2.75</td>
<td>1.21</td>
<td>0.2993</td>
<td></td>
</tr>
<tr>
<td>Manufacturer's schematics consistent with blueprint</td>
<td>3.55</td>
<td>3.86</td>
<td>3.52</td>
<td>2.01</td>
<td>0.1363</td>
<td></td>
</tr>
<tr>
<td>Complete manufacturer's schematics according to blueprint</td>
<td>3.70</td>
<td>3.54</td>
<td>3.57</td>
<td>0.49</td>
<td>0.6143</td>
<td></td>
</tr>
<tr>
<td>Process follow by drawing manufacturer's schematics</td>
<td>3.88</td>
<td>3.99</td>
<td>3.27</td>
<td>4.37</td>
<td>0.0137*</td>
<td>1&gt;3, 2&gt;3</td>
</tr>
<tr>
<td>Performance procedure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thread pipes are assessed by the judge before joining</td>
<td>2.91</td>
<td>2.87</td>
<td>2.85</td>
<td>0.05</td>
<td>0.9544</td>
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</tr>
</tbody>
</table>
Table 5. (continued)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Incumbent Workers</th>
<th>Supervisors</th>
<th>Educators</th>
<th>F</th>
<th>Pr &gt; F</th>
<th>DUNCAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut ends of the pipes are assessed by the judge before joining</td>
<td>2.80</td>
<td>2.77</td>
<td>2.84</td>
<td>0.04</td>
<td>0.9628</td>
<td></td>
</tr>
<tr>
<td>Use facilities &amp; tools appropriately</td>
<td>3.66</td>
<td>3.97</td>
<td>3.62</td>
<td>2.34</td>
<td>0.0989</td>
<td></td>
</tr>
<tr>
<td>Keep work areas clear of tools &amp; materials and do not borrow those from somebody else</td>
<td>3.20</td>
<td>3.37</td>
<td>3.17</td>
<td>0.61</td>
<td>0.5426</td>
<td></td>
</tr>
<tr>
<td>Apply safety procedures</td>
<td>4.11</td>
<td>4.25</td>
<td>3.83</td>
<td>1.59</td>
<td>0.2069</td>
<td></td>
</tr>
<tr>
<td>Process cautiously without any accident</td>
<td>3.76</td>
<td>3.92</td>
<td>3.76</td>
<td>0.51</td>
<td>0.6016</td>
<td></td>
</tr>
<tr>
<td>Accuracy of performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut pipe squarely &amp; remove the cutting burrs</td>
<td>3.51</td>
<td>3.84</td>
<td>3.14</td>
<td>5.44</td>
<td>0.0049**</td>
<td>2&gt;1, 2&gt;3</td>
</tr>
<tr>
<td>Factor</td>
<td>Incumbent Workers</td>
<td>Supervisors</td>
<td>Educators</td>
<td>F</td>
<td>Pr &gt; F</td>
<td>DUNCAN</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>-------------------</td>
<td>-------------</td>
<td>-----------</td>
<td>-----</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>Pipe threads have not been marred or broken over 5 mm</td>
<td>3.67</td>
<td>3.66</td>
<td>3.43</td>
<td>0.60</td>
<td>0.5472</td>
<td></td>
</tr>
<tr>
<td>Insert join P.V.C. pipe beyond 1.5 O.D</td>
<td>3.80</td>
<td>3.91</td>
<td>3.83</td>
<td>0.23</td>
<td>0.7924</td>
<td></td>
</tr>
<tr>
<td>Solder block pipe less than 1/3 O.D.</td>
<td>3.48</td>
<td>3.70</td>
<td>3.77</td>
<td>1.28</td>
<td>0.2791</td>
<td></td>
</tr>
<tr>
<td>Pipeline or fitting joint distort angle less than 3°</td>
<td>3.43</td>
<td>3.61</td>
<td>3.52</td>
<td>0.68</td>
<td>0.5056</td>
<td></td>
</tr>
<tr>
<td>Make uniform and smooth pipe bend</td>
<td>3.57</td>
<td>3.59</td>
<td>3.74</td>
<td>0.32</td>
<td>0.7297</td>
<td></td>
</tr>
<tr>
<td>Flatten pipe size by pressure less than 10 % O.D.</td>
<td>3.47</td>
<td>3.65</td>
<td>3.70</td>
<td>1.11</td>
<td>0.3327</td>
<td></td>
</tr>
<tr>
<td>Make uniform &amp; smooth solder joints</td>
<td>3.41</td>
<td>3.69</td>
<td>3.29</td>
<td>2.76</td>
<td>0.0658</td>
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</tbody>
</table>
Table 5. (continued)

<table>
<thead>
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<th>Factor</th>
<th>Mean</th>
<th>Incumbent Workers</th>
<th>Supervisors</th>
<th>Educators</th>
<th>F</th>
<th>Pr &gt; F</th>
<th>DUNCAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process by following the blueprint</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. fitting fit direction &amp; position correctly</td>
<td>&amp;</td>
<td>4.07</td>
<td>4.11</td>
<td>4.08</td>
<td>0.03</td>
<td>0.9740</td>
<td></td>
</tr>
<tr>
<td>b. process &amp; methods of joint following the blueprint</td>
<td>&amp;</td>
<td>4.10</td>
<td>4.12</td>
<td>4.12</td>
<td>0.01</td>
<td>0.9894</td>
<td></td>
</tr>
<tr>
<td>c. products follow the blueprint</td>
<td>&amp;</td>
<td>4.07</td>
<td>4.04</td>
<td>4.14</td>
<td>0.11</td>
<td>0.8928</td>
<td></td>
</tr>
<tr>
<td>Appearance of product</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The product is smooth and steady</td>
<td></td>
<td>3.46</td>
<td>3.60</td>
<td>3.34</td>
<td>0.63</td>
<td>0.5329</td>
<td></td>
</tr>
<tr>
<td>No injury track appear on the product by careless work</td>
<td></td>
<td>3.30</td>
<td>3.31</td>
<td>2.96</td>
<td>1.30</td>
<td>0.2737</td>
<td></td>
</tr>
<tr>
<td>Remove excess fillet, burrs, oil spot &amp; solvent cement</td>
<td></td>
<td>3.59</td>
<td>3.79</td>
<td>3.18</td>
<td>3.46</td>
<td>0.0331*</td>
<td>2&gt;3</td>
</tr>
</tbody>
</table>
Table 5. (continued)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Incumbent Workers</th>
<th>Supervisors</th>
<th>Educators</th>
<th>F</th>
<th>Pr &gt; F</th>
<th>DUNCAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrostatic test</td>
<td>no leak under 7.5 kg/cm²</td>
<td>4.68</td>
<td>4.58</td>
<td>4.34</td>
<td>1.47</td>
<td>0.2325</td>
</tr>
<tr>
<td></td>
<td>hydrostatic test &amp; hold 3 minutes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Important rating scale: 5=very important, 4=important, 3=somewhat important, 2=little important, 1=not important.

*p<0.05

**p<0.01
incumbent workers, supervisors, and vocational educators. These competencies included (1) the processes followed when drawing the manufacturer's schematics, (2) cutting pipe squarely and removing the cutting burrs, and (3) removing excess fillet burrs, an oil spot and solvent cement. The competencies of (1) the processes followed when drawing of the manufacturer's schematics, (2) cutting the pipe squarely and removing the cutting burrs were judged to be of greater importance by incumbent workers and supervisors, than by vocational educators. The competency of removing excess fillet, burrs, an oil spot and solvent cement was judged to be of greater importance by the supervisors than by vocational educators. It seems in the actual workplace, people put more emphasis on the processes followed when drawing the manufacturer's schematics, accuracy of cutting the pipe, and the appearance of the product to meet the needs of the actual job performance. These competencies need to be reinforced in vocational education.

A comparison of incumbent workers, supervisors, and vocational educators perceptions of the importance of the critical competency found that no leak under a 7.5 kg/cm² hydrostatic test and holding 3 minutes was perceived as the most important competency by the overall mean scores greater than 4.60. Applying safety procedures was the competency that was rated as the second most important by the overall mean
score being greater than 4.14. The process of following the blueprint was the competency that rated as the third most important, by mean scores greater than 4.07, which included (1) correctly fitting direction and positioning, (2) processes and methods of the joint following the blueprint, and (3) products following the blueprint.

Three competencies that had a mean score less than or equal to 3.0 included (1) the thread pipes which were assessed by the judge before joining, (2) the cut ends of the pipes which were assessed by the judge before joining, and (3) drawing a line or arc correctly by using a tool were judged to be of least importance. The respondents probably thought that as long as examinees were able to process accurately, it seemed unimportant to be assessed by the judges before joining. Two competencies that had a mean score less than 3.5 and were thus considered of less importance, were (1) keeping work areas clear of tools and materials, and not borrowing those from somebody else, and (2) no injury track appearing on the product due to careless work. Besides those competencies that have been mentioned, the other competencies had a mean score between 3.5 and 4.0, which indicated that these competencies were considered to be important.
Relevance of critical competency factors as viewed by NPCT Committee, incumbent workers, supervisors, and vocational educators

The respondents assigned percentages (the total not to exceed 100%) to the importance of the critical competency factors in an entry level position. These percentages were compared with those specified by NPCT Committee. The relationships among the perceived relevances of critical competency factors for plumbing assigned by NPCT Committee, incumbent workers, supervisors, and vocational educators was examined by applying the Spearman's Rank Correlation Coefficient. Rank order of the five factors based on mean percentages of 4 groups was as follows (see Table 6).

Spearman's Rank Correlation Coefficient provides a measure of correlation between ranks of survey groups and the Test Committee. The Spearman's rank correlation coefficient between incumbent workers and NPCT Committee is 0.60 (Table 7).

The Spearman's rank correlation coefficient between the supervisors and NPCT Committee is 0.80. The correlation coefficient between the vocational educators and NPCT Committee is 0.80. There are high Spearman's rank correlation coefficients among survey groups concerning the agreement on critical competency factors, with a moderate agreement between the incumbent workers and NPCT Committee.
Table 6. Rank order of five factors by Test Committee, incumbent workers, supervisors, and vocational educators

<table>
<thead>
<tr>
<th>Order</th>
<th>Test Committee</th>
<th>Incumbent Worker</th>
<th>Supervisors</th>
<th>Vocational Educators</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(5)*</td>
<td>(3)</td>
<td>(3)</td>
<td>(3)</td>
</tr>
<tr>
<td>2</td>
<td>(3)</td>
<td>(5)</td>
<td>(5)</td>
<td>(5)</td>
</tr>
<tr>
<td>3</td>
<td>(2)</td>
<td>(4)</td>
<td>(2)</td>
<td>(2)</td>
</tr>
<tr>
<td>4</td>
<td>(1)</td>
<td>(2)</td>
<td>(4)</td>
<td>(4)</td>
</tr>
<tr>
<td>5</td>
<td>(4)</td>
<td>(1)</td>
<td>(1)</td>
<td>(1)</td>
</tr>
</tbody>
</table>

*Critical competency factors: (1) reading blueprint & drawing manufacturer's schematic, (2) performance procedure, (3) accuracy of performance, (4) appearance of product, and (5) hydrostatic test

Table 7. Spearman's rank correlation coefficient between survey group and Test Committee

<table>
<thead>
<tr>
<th></th>
<th>Test Committee</th>
<th>Incumbent Worker</th>
<th>Supervisors</th>
<th>Vocational Educators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Committee</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incumbent Workers</td>
<td>0.60</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supervisors</td>
<td>0.80</td>
<td>0.90</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Vocational Educators</td>
<td>0.80</td>
<td>0.90</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>
The Spearman's rank correlation coefficient between the incumbent workers and the vocational educators is 0.90. The correlation coefficient between the supervisors and the vocational educators is 1.00. The correlation coefficient between the supervisors and the incumbent workers is 0.90. There are very high Spearman's rank correlation coefficients among incumbent workers, supervisors, and vocational educators in plumbing concerning the agreement on critical competency factors in an entry level position.

Perception of NPCT

Quality of NPCT

Ten items relating to the quality of NPCT factor were included in the questionnaire, and respondents were asked to rate to what extent they agreed with the statements.

1. Sixty-six percent of the respondents agreed that the contents of the NPCT Written Test met the needs of the actual job of the entry level worker, but 20% of the respondents disagreed (Table 8).

   The agreed percentage in this study is greater than the finding of Kang (1990) who reported that 58% of the candidates agreed that the contents of the NPCT Written Test met the needs of actual job performance (mean = 3.66).

2. Sixty-five percent of the respondents perceived that the contents of the NPCT Performance Test met the needs of the
Table 8. Frequencies and percentages of each item on perception of NPCT ratings by three groups

<table>
<thead>
<tr>
<th>Item</th>
<th>SD\textsuperscript{a}</th>
<th>D</th>
<th>N</th>
<th>A</th>
<th>SA</th>
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<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
<td>N</td>
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<td>Quality of NPCT</td>
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<td>1</td>
<td>3</td>
<td>1.2</td>
<td>48</td>
<td>19.0</td>
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<td>2</td>
<td>4</td>
<td>1.6</td>
<td>33</td>
<td>13.1</td>
<td>51</td>
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<td>2.4</td>
<td>58</td>
<td>23.0</td>
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<td>4</td>
<td>1</td>
<td>0.4</td>
<td>16</td>
<td>6.4</td>
<td>61</td>
</tr>
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<td>5</td>
<td>0</td>
<td>0.0</td>
<td>14</td>
<td>5.6</td>
<td>83</td>
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<tr>
<td>6</td>
<td>4</td>
<td>1.6</td>
<td>36</td>
<td>14.3</td>
<td>78</td>
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<td>7</td>
<td>2</td>
<td>0.8</td>
<td>25</td>
<td>9.9</td>
<td>78</td>
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<tr>
<td>8</td>
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<td>2.8</td>
<td>21</td>
<td>8.3</td>
<td>64</td>
</tr>
<tr>
<td>9</td>
<td>7</td>
<td>2.8</td>
<td>45</td>
<td>17.9</td>
<td>79</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>1.2</td>
<td>32</td>
<td>12.7</td>
<td>51</td>
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<tr>
<td>Administration of NPCT</td>
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<td></td>
<td></td>
</tr>
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<td>1</td>
<td>3</td>
<td>1.2</td>
<td>49</td>
<td>19.4</td>
<td>71</td>
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<td>1.2</td>
<td>38</td>
<td>15.1</td>
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<td>3</td>
<td>8</td>
<td>3.2</td>
<td>49</td>
<td>19.4</td>
<td>78</td>
</tr>
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<td>2</td>
<td>0.8</td>
<td>16</td>
<td>6.3</td>
<td>53</td>
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<tr>
<td>Test scoring and interpretation of NPCT</td>
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<td>1</td>
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<td>3.6</td>
<td>36</td>
<td>14.3</td>
<td>101</td>
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<td>1.6</td>
<td>36</td>
<td>14.3</td>
<td>66</td>
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<td>2</td>
<td>0.8</td>
<td>9</td>
<td>3.6</td>
<td>81</td>
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<td>0.8</td>
<td>17</td>
<td>6.7</td>
<td>79</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>2.8</td>
<td>33</td>
<td>13.1</td>
<td>66</td>
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<tr>
<td>Plumbing licensure</td>
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<td>5.2</td>
<td>36</td>
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<td>76</td>
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<td>2</td>
<td>8</td>
<td>3.2</td>
<td>17</td>
<td>6.8</td>
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<td>9</td>
<td>3.6</td>
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<td>14.7</td>
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<td>1.2</td>
<td>17</td>
<td>6.8</td>
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<tr>
<td>5</td>
<td>0</td>
<td>0.0</td>
<td>15</td>
<td>6.0</td>
<td>38</td>
</tr>
</tbody>
</table>

\textsuperscript{a}SD = strongly disagree; D = disagree; N = neutral; A = agree; SA = strongly agree.
actual job performance in terms of the essential skills, but 15% did not (mean = 3.78).

3. Forty-nine percent of the respondents agreed that NPCT did actually identify the particular occupational technical level, but 25% of the respondents disagreed (mean = 3.29). The agreed percentage in this study is lower than the finding of Kang (1990) who indicated that 65% of the employers agreed that NOCT actually identified the particular occupational technical level.

4. Sixty-nine percent of the respondents agreed that the directions for taking test clearly indicated to the examinees how to respond to the test items, but 7% disagreed (mean = 3.77).

5. Sixty-two percent of the respondents indicated that the test items were clearly expressed, but 6% disagreed (mean = 3.65).

6. Fifty-three percent of the respondents indicated that the length of the NPCT Written Test was appropriate, but 16% of the respondents disagreed (mean = 3.42).

7. Fifty-eight percent of the respondents agreed that the proper arrangement of the test items, with the easiest items first was evident, but 11% disagreed (mean = 3.58).

8. Sixty-four percent of the respondents agreed that sufficient time was provided for the majority of the examinees to complete the NPCT (mean = 3.68).
9. Forty-eight percent of the respondents indicated that the difficulty of each test item was consistent with the learning outcome it was designed to measure, however 20% of the respondents disagreed (mean = 3.76).

10. Sixty-six percent of the respondents agreed that each test item had only one accurate or best answer, but 14% disagreed (mean = 3.72).

**Administration of NPCT**

1. Fifty-one percent of the respondents agreed that adequate work places were provided for the examinees in the NPCT Performance Test that were experienced in the work place, but 21% of the respondents disagreed (mean = 3.43).

2. Fifty-five percent of the respondents perceived that a safe and similar work places were provided at different areas in the NPCT, but 16.3% of the respondents did not (mean = 3.52).

3. Forty-six percent of the respondents agreed that appropriate facilities and instruments were provided for each examinee in NPCT, but 23% of the respondents disagreed (mean = 3.30).

4. Sixty-six percent of the respondents indicated that the materials which were used in NPCT were consistent with the specifications of the actual job performance, but 13% disagreed (mean = 3.71).

5. Seventy-five percent of the respondents perceived that
the proctors followed the test directions strictly and adhered to the exact time schedule, and only 4% of the respondents did not (mean = 3.97).

6. Seventy-two percent of the respondents indicated that the judges did not interfere in the examinees' performance test, but 7% respondents disagreed (mean = 3.91).

Test scoring and interpretation of NPCT

1. Forty-two percent of the respondents agreed that the criteria could reliably predict those who had actual competency, but 18% of the respondents disagreed (mean = 3.31).

2. Fifty-eight percent of the respondents agreed that the minimum cutting point of 60 points was reasonable for NPCT criteria, but 16% disagreed (mean = 3.54).

3. Sixty-three percent of the respondents perceived that the judges treated each examinee fairly, but 4% of the respondents did not (mean = 3.76).

4. Sixty-one percent of the respondents indicated that the overall process of NPCT was adequate, accurate and fair, but 8% disagreed (mean = 3.71). The satisfaction level in this study is higher than the finding of the Employment and Vocational Training Administration (1991) which indicated that 46% of the subjects assessed the effectiveness of NOCT as "good" or "very good".

5. Fifty-eight percent of the respondents agreed that the
results of NPCT could also be used to evaluate the effectiveness of the plumbing instruction or training, but 16% of the respondents disagreed (mean = 3.55).

**Plumbing licensure**

1. Fifty percent of the respondents perceived that the plumbing employers who employed or promoted the workers depended on the license as one source of reliable information, 20% of the respondents did not (mean = 3.42). The result coincides with the findings of the Employment and Vocational Training Administration (1991) which indicated 59% of the subjects in enterprise had hired licensed employees.

2. Sixty-three percent of the respondents indicated that the plumbing licensure ensured the public health, safety, and welfare, and maintained occupational standards, but 10% of the respondents disagreed (mean = 3.74). The agreed percentage in this study is lower than that of the findings of Kang (1990) which indicated 91% of the employers perceived that the licensure maintained occupational standards and insurance of the product quality.

3. Forty-nine percent of the respondents perceived that the licensed plumbers were expected to perform better than the unlicensed, but 18% of the respondents did not (mean = 3.37). The agreed percentage in this study is similar to the findings of Kang (1990) who reported that 47% of the subjects who had never attended the occupational competency tests perceived
that licensed workers performed better than the unlicensed, and 74% of the employees also agreed with this statement.

4. Sixty-seven percent of the respondents indicated that experienced workers had a higher ratio to obtain the plumbing license than nonexperienced, but 8% of the respondents disagreed (mean = 3.75).

5. Seventy-nine percent of the respondents perceived that professionally trained workers had a higher ratio to obtain the plumbing license than untrained workers, but 6% of the respondents did not (mean = 4.0) perceive this to be so.

Individual item regarding the perception of NPCT as judged by incumbent workers, supervisors, and vocational educators

A detailed comparison of the incumbent workers, supervisors, and vocational educators perceptions of NPCT is presented on Table 9. The differences among perceptions of NPCT rated by these three groups were tested by a one-way ANOVA. Moreover, Duncan's multiple-range tests were used to compare, pairwise, the results when the overall ANOVA test was significant.

Within the quality of NPCT factors, the content of the NPCT written test does meet the needs of the actual job of entry level worker and was perceived more positively by vocational educators than by the incumbent workers and supervisors. The items that were perceived more positively by
Table 9. Means and one-way ANOVA relating to each item regarding the perception of NPCT among incumbent workers, supervisors, and educators

<table>
<thead>
<tr>
<th>Factor</th>
<th>Incumbent Workers</th>
<th>Supervisors</th>
<th>Educators</th>
<th>F</th>
<th>Pr &gt; F</th>
<th>DUNCAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of NPCT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The contents of plumbing competency written test meet the needs of actual job of entry level worker</td>
<td>3.54</td>
<td>3.62</td>
<td>4.23</td>
<td>5.34</td>
<td>0.0054**</td>
<td>3&gt;1, 3&gt;2</td>
</tr>
<tr>
<td>The contents of plumbing competency performance test meet the needs of actual job performance in terms of essential skills</td>
<td>3.71</td>
<td>3.75</td>
<td>4.13</td>
<td>1.93</td>
<td>0.1467</td>
<td></td>
</tr>
<tr>
<td>The plumbing competency test does actually identify the particular occupational technical level</td>
<td>3.19</td>
<td>3.30</td>
<td>3.63</td>
<td>2.46</td>
<td>0.0876</td>
<td></td>
</tr>
<tr>
<td>Directions of test clearly indicate to examinees how to respond to the test items</td>
<td>3.74</td>
<td>3.70</td>
<td>4.07</td>
<td>2.55</td>
<td>0.0800</td>
<td></td>
</tr>
<tr>
<td>The test items are clearly expressed.</td>
<td>3.63</td>
<td>3.58</td>
<td>3.93</td>
<td>2.90</td>
<td>0.0571</td>
<td></td>
</tr>
</tbody>
</table>
Table 9. (continued)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Incumbent Workers</th>
<th>Supervisors</th>
<th>Educators</th>
<th>F</th>
<th>Pr &gt; F</th>
<th>DUNCAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>The length of plumbing competency written test is appropriate</td>
<td>3.47</td>
<td>3.28</td>
<td>3.73</td>
<td>3.75</td>
<td>0.0249*</td>
<td>3&gt;2</td>
</tr>
<tr>
<td>Proper arrangement of test items, with the easiest items first is</td>
<td>3.63</td>
<td>3.43</td>
<td>3.90</td>
<td>4.32</td>
<td>0.0143*</td>
<td>3&gt;2</td>
</tr>
<tr>
<td>evident</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sufficient time is provided for the majority of examinees to complete</td>
<td>3.70</td>
<td>3.55</td>
<td>4.07</td>
<td>3.46</td>
<td>0.0329*</td>
<td>3&gt;2</td>
</tr>
<tr>
<td>the test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The difficulty of each test item is consistent with the learning</td>
<td>3.28</td>
<td>3.28</td>
<td>3.73</td>
<td>3.00</td>
<td>0.0518</td>
<td></td>
</tr>
<tr>
<td>outcome it is designed to measure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Each test item has only one accurate or best answer</td>
<td>3.61</td>
<td>3.74</td>
<td>4.10</td>
<td>3.07</td>
<td>0.0482*</td>
<td>3&gt;1</td>
</tr>
</tbody>
</table>
Table 9. (continued)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Incumbent</th>
<th>Supervisors</th>
<th>Educators</th>
<th>F</th>
<th>Pr &gt; F</th>
<th>DUNCAN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Workers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Administration of NPCT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adequate work places are provided for examinees in the plumbing competency performance test that are experienced in the work place</td>
<td>3.33</td>
<td>3.39</td>
<td>3.90</td>
<td>4.17</td>
<td>0.0165*</td>
<td>3&gt;1, 3&gt;2</td>
</tr>
<tr>
<td>Safe and similar work places are provided at different areas in plumbing competency performance test</td>
<td>3.47</td>
<td>3.52</td>
<td>3.73</td>
<td>0.87</td>
<td>0.4190</td>
<td>3&gt;2</td>
</tr>
<tr>
<td>Appropriate facilities and instruments are provided for each examinee in the NPCT</td>
<td>3.31</td>
<td>3.21</td>
<td>3.57</td>
<td>1.58</td>
<td>0.2089</td>
<td>3&gt;2</td>
</tr>
<tr>
<td>The materials which are used in competency test are consistent with the specification of actual job performance</td>
<td>3.68</td>
<td>3.62</td>
<td>4.20</td>
<td>4.81</td>
<td>0.0089**</td>
<td>3&gt;1, 3&gt;2</td>
</tr>
</tbody>
</table>
Table 9. (continued)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Incumbent Workers</th>
<th>Supervisors</th>
<th>Educators</th>
<th>F</th>
<th>Pr &gt; F</th>
<th>DUNCAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>The proctors follow the test directions strictly and stick to the exact time schedule</td>
<td>3.97</td>
<td>3.87</td>
<td>4.33</td>
<td>3.71</td>
<td>0.0259*</td>
<td>3&gt;1, 3&gt;2</td>
</tr>
<tr>
<td>The judges do not interfere in examinees' work during the performance test</td>
<td>3.82</td>
<td>3.92</td>
<td>4.23</td>
<td>2.53</td>
<td>0.0819</td>
<td></td>
</tr>
<tr>
<td>Test scoring &amp; interpretation of NPCT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The criteria can reliably predict those who have actual competency</td>
<td>3.36</td>
<td>3.13</td>
<td>3.80</td>
<td>6.27</td>
<td>0.0022**</td>
<td>3&gt;1, 3&gt;2</td>
</tr>
<tr>
<td>The minimum cutting point of 60 points is reasonable for plumbing competency test criteria</td>
<td>3.56</td>
<td>3.44</td>
<td>3.87</td>
<td>2.46</td>
<td>0.0871</td>
<td></td>
</tr>
<tr>
<td>The judges treat each examinee fairly</td>
<td>3.72</td>
<td>3.72</td>
<td>4.10</td>
<td>2.91</td>
<td>0.0562</td>
<td></td>
</tr>
</tbody>
</table>
Table 9. (continued)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Incumbent Workers</th>
<th>Supervisors</th>
<th>Educators</th>
<th>F</th>
<th>Pr &gt; F</th>
<th>DUNCAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>The overall process of NPCT is adequate, accurate and fair</td>
<td>3.61</td>
<td>3.67</td>
<td>4.27</td>
<td>7.32</td>
<td>0.0008***</td>
<td>3&gt;1, 3&gt;2</td>
</tr>
<tr>
<td>The results of NPCT can also be used to evaluate the effectiveness</td>
<td>3.54</td>
<td>3.46</td>
<td>3.90</td>
<td>2.28</td>
<td>0.1046</td>
<td></td>
</tr>
<tr>
<td>of plumbing instruction or training</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plumbing licensure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plumbing employers who employ or promote the workers depend on the</td>
<td>3.45</td>
<td>3.14</td>
<td>4.37</td>
<td>17.13</td>
<td>0.0000***</td>
<td>1&gt;2, 3&gt;1, 3&gt;2</td>
</tr>
<tr>
<td>license as one source of reliable information</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The plumbing licensure ensures the public health; safety; and</td>
<td>3.76</td>
<td>3.56</td>
<td>4.33</td>
<td>7.68</td>
<td>0.0006***</td>
<td>3&gt;1, 3&gt;2</td>
</tr>
<tr>
<td>welfare, and maintains occupational standards</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 9. (continued)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Incumbent Workers</th>
<th>Supervisors</th>
<th>Educators</th>
<th>F</th>
<th>Pr &gt; F</th>
<th>DUNCAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>The licensed plumbers</td>
<td>3.32</td>
<td>3.19</td>
<td>4.20</td>
<td>14.28</td>
<td>0.0000***</td>
<td>3&gt;1, 3&gt;2</td>
</tr>
<tr>
<td>are expected to perform better than the unlicensed Experienced workers have a higher ratio to obtain plumbing license than nonexperienced</td>
<td>3.68</td>
<td>3.73</td>
<td>4.07</td>
<td>2.56</td>
<td>0.0795</td>
<td></td>
</tr>
<tr>
<td>Professional trained</td>
<td>3.80</td>
<td>4.04</td>
<td>4.60</td>
<td>12.59</td>
<td>0.0000***</td>
<td>2&gt;1, 3&gt;1</td>
</tr>
<tr>
<td>workers have higher ratio to obtain plumbing license than untrained</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3&gt;2</td>
</tr>
</tbody>
</table>

*Perception rating scale: 5=strongly agree, 4=agree, 3=neutral, 2=disagree, 1=strongly disagree.

*p<0.05
**p<0.01
***p<0.001
vocational educators than supervisors included: (1) the length of the NPCT written test was appropriate, (2) proper arrangement of test items, with the easiest item listed first was evident, and (3) sufficient time was provided for the majority of the examinees to complete the test. Each test item had only one accurate or best answer and was perceived more positively by vocational educators than by the incumbent workers. Within the administration of NPCT factor, the items that were perceived more positively by vocational educators than by the incumbent workers and supervisors were (1) adequate work places are provided for the examinees in the plumbing competency performance that are frequently experienced in the work place; (2) the materials which were used in the NPCT are consistent with the specifications of the actual job performance; and (3) the proctors follow the test directions strictly and adhere to the exact time schedule.

Within the test scoring and interpretation of NPCT factor, vocational educators had more positive perceptions toward the statements of (1) the criteria can reliably predict those who have actual competency, and that (2) the overall process of NPCT being adequate, accurate and fair by the incumbent workers and supervisors.

Within the plumbing licensure factor, four of the five items that were perceived more positively by vocational educators than by the incumbent workers and supervisors
included (1) plumbing employers who employed or promoted the workers depended upon the license as one source of reliable information; (2) the plumbing licensure ensures the public health, safety, and welfare, and maintains occupational standards; (3) the licensure plumbers are expected to perform better than the unlicensed; and (4) professionally trained workers have a higher ratio to obtain a plumbing license than the untrained workers. Moreover, the perception of the professional trained worker having a higher ratio to obtain a plumbing license than the untrained was perceived more positively by supervisors than by the incumbent workers. Incumbent workers had more positive perceptions toward the plumbing employers who employed or promoted the workers depending upon the license as one source of reliable information than that of the supervisors.

Reliability of instrument

The reliability of each factor regarding the necessity of the critical competency, importance of the critical competency, perception of NPCT, and the overall items were tested. The overall reliability of the necessity of the critical competency was 0.9139 and the four factors ranged from 0.7750 to 0.8800. The overall reliability of the importance of the critical competency was 0.8996 and the four factors ranged from 0.5612
to 0.8732. Table 10 displays this information in detail. The overall reliability of the perception of NPCT was 0.9391 and the four factors ranged from 0.7411 to 0.8753 (Table 11). Hence, the factor scores would be expected to be relatively consistent for each respondent at different time periods.

Findings for Each Hypothesis

Hypothesis 1.1a

H0: There is no difference between NPCT Committee and the incumbent workers in terms of the assigned percentage to the importance of the critical competencies related to reading the blueprint and drawing the manufacturer’s schematics factor.

Hypothesis 1.1a through 1.3e were tested by means of a t-test. Table 12 indicates the results of the t-test for two groups. This null hypothesis was rejected. The t value, 4.93, was significantly different at 0.001 level. The percentage of the importance of the critical competencies related to reading the blueprint and drawing the manufacturer’s schematics factor assigned by the incumbent workers was higher than that assigned by the NPCT Test Committee.
### Table 10. Reliability of critical competencies of NPCT

<table>
<thead>
<tr>
<th>Factor</th>
<th>Reliability Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Necessity of critical competency</strong></td>
<td></td>
</tr>
<tr>
<td>Reading blueprint &amp; drawing manufacturer's schematics</td>
<td>0.8505</td>
</tr>
<tr>
<td>Performance procedure</td>
<td>0.8388</td>
</tr>
<tr>
<td>Accuracy of performance</td>
<td>0.8800</td>
</tr>
<tr>
<td>Appearance of product</td>
<td>0.7750</td>
</tr>
<tr>
<td>Overall</td>
<td>0.9139</td>
</tr>
<tr>
<td><strong>Importance of critical competency</strong></td>
<td></td>
</tr>
<tr>
<td>Reading blueprint &amp; drawing manufacturer's schematics</td>
<td>0.5612</td>
</tr>
<tr>
<td>Performance procedure</td>
<td>0.7856</td>
</tr>
<tr>
<td>Accuracy of performance</td>
<td>0.8732</td>
</tr>
<tr>
<td>Appearance of product</td>
<td>0.7374</td>
</tr>
<tr>
<td>Overall</td>
<td>0.8996</td>
</tr>
</tbody>
</table>

### Table 11. Reliability of perception of NPCT

<table>
<thead>
<tr>
<th>Factor</th>
<th>Reliability coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of NPCT</td>
<td>0.8614</td>
</tr>
<tr>
<td>Administration of NPCT</td>
<td>0.8753</td>
</tr>
<tr>
<td>Test scoring &amp; interpretation of NPCT</td>
<td>0.7411</td>
</tr>
<tr>
<td>Plumbing licensure</td>
<td>0.7981</td>
</tr>
<tr>
<td>overall</td>
<td>0.9391</td>
</tr>
</tbody>
</table>
Table 12. Mean, standard deviation, and t-test relating to the critical competencies judged by NPCT Committee and incumbent workers

<table>
<thead>
<tr>
<th>Factor</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>T-Value</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Committee</td>
<td>Incumbent Workers</td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>Reading blueprint &amp; drawing manufacturer's schematics</td>
<td>7.50</td>
<td>9.84</td>
<td>2.34</td>
<td>5.02</td>
</tr>
<tr>
<td>Performance procedure</td>
<td>12.50</td>
<td>10.93</td>
<td>-1.57</td>
<td>6.05</td>
</tr>
<tr>
<td>Accuracy of performance</td>
<td>25.00</td>
<td>36.78</td>
<td>11.78</td>
<td>9.98</td>
</tr>
<tr>
<td>Appearance of product</td>
<td>5.00</td>
<td>11.96</td>
<td>6.96</td>
<td>5.40</td>
</tr>
<tr>
<td>Hydrostatic test</td>
<td>50.00</td>
<td>30.68</td>
<td>-19.32</td>
<td>13.15</td>
</tr>
</tbody>
</table>

**p<0.01
***p<0.001
Hypothesis 1.1b

Ho: There is no difference between NPCT Committee and the incumbent workers in terms of the assigned percentage to the importance of the critical competencies related to the performance procedure factor.

According to the results reported in Table 12, this null hypothesis was rejected. The t value, -2.75, was significantly different at 0.01 level. Assigned percentages to the performance procedure factor assessed by the Test Committee was different from that assessed by the incumbent workers. The percentage of the performance procedure assigned by the incumbent workers was less than that assigned by the Test Committee.

Hypothesis 1.1c

Ho: There is no difference between NPCT Committee and the incumbent workers in terms of the assigned percentage to the importance of the critical competencies related to the accuracy of the performance factor.

According to the results reported in Table 12, this null hypothesis was rejected. The t value, 12.49, was significantly different at 0.001 level. The percentage of the importance of the critical competencies related to the
accuracy of the performance factor assigned by the incumbent workers was higher than that assigned by the Test Committee.

Hypothesis 1.1d

Ho: There is no difference between NPCT Committee and the incumbent workers in terms of the assigned percentage to the importance of the critical competencies related to the appearance of the product factor.

According to the results reported in Table 12, this null hypothesis was rejected. The t value, 13.64, was significantly different at the 0.001 level. The assigned percentage to the importance of the critical competencies related to the appearance of the product factor assigned by the incumbent workers was higher than that assigned by the Test Committee.

Hypothesis 1.1e

Ho: There is no difference between NPCT Committee and the incumbent workers in terms of the assigned percentage to the importance of the critical competencies related to the hydrostatic test factor.

According to the results reported in Table 12, this null hypothesis was rejected. The t value, -15.55, was significantly different at 0.001 level. The assigned
percentage to the importance of the critical competencies related to the hydrostatic test factor assessed by the Test Committee was different from that assessed by the incumbent workers. The percentage of the hydrostatic test assigned by the incumbent workers was less than that assigned by the Test Committee.

Hypothesis 1.2a

Ho: There is no difference between NPCT Committee and the supervisors in terms of the assigned percentage to the importance of the critical competencies related to reading the blueprint and drawing the manufacturer's schematics factor.

Table 13 indicates the results of the t-test for two groups. This null hypothesis was rejected. The t value, 4.59, was significantly different at 0.001 level. The percentage of the importance of the critical competencies related to reading the blueprint and drawing the manufacturer's schematics factor assigned by the supervisors was higher than that assigned by the Test Committee.

Hypothesis 1.2b

Ho: There is no difference between NPCT Committee and the supervisors in terms of the assigned percentage to the
Table 13. Mean, standard deviation, and t-test relating to the critical competencies judged by NPCT Committee and supervisors

<table>
<thead>
<tr>
<th>Factor</th>
<th>Mean Committee</th>
<th>Mean Supervisors</th>
<th>Difference Mean</th>
<th>Difference S.D.</th>
<th>t-Value</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading blueprint &amp; drawing manufacturer's schematics</td>
<td>7.50</td>
<td>9.68</td>
<td>2.18</td>
<td>4.99</td>
<td>4.59</td>
<td>0.0000***</td>
</tr>
<tr>
<td>Performance procedure</td>
<td>12.50</td>
<td>12.55</td>
<td>0.05</td>
<td>6.24</td>
<td>0.08</td>
<td>0.9390</td>
</tr>
<tr>
<td>Accuracy of performance</td>
<td>25.00</td>
<td>34.32</td>
<td>9.32</td>
<td>10.55</td>
<td>9.27</td>
<td>0.0000***</td>
</tr>
<tr>
<td>Appearance of product</td>
<td>5.00</td>
<td>11.73</td>
<td>6.73</td>
<td>5.64</td>
<td>12.50</td>
<td>0.0000***</td>
</tr>
<tr>
<td>Hydrostatic test</td>
<td>50.00</td>
<td>32.09</td>
<td>-17.91</td>
<td>12.82</td>
<td>-14.65</td>
<td>0.0000***</td>
</tr>
</tbody>
</table>

***p<0.001
importance of the critical competencies related to performance procedure factor.

According to the results reported in Table 13, this null hypothesis was retained. The t value, 0.08, was not significantly different at 0.05 level. In other words, no significant difference existed between the Test Committee and the supervisors regarding the importance of performance procedure ratings.

Hypothesis 1.2c
Ho: There is no difference between NPCT Committee and the supervisors in terms of the assigned percentage to the importance of the critical competencies related to the accuracy of the performance factor.

According to the results reported in Table 13, this null hypothesis was rejected. The t value, 9.27, was significantly different at 0.001 level. The percentage of the importance of the critical competencies related to the accuracy of the performance factor assigned by the supervisor was higher than that assigned by the Test Committee.

Hypothesis 1.2d
Ho: There is no difference between NPCT Committee and the
supervisors in terms of the assigned percentage to the importance of the critical competencies related to the appearance of the product factor.

According to the results reported in Table 13, this null hypothesis was rejected. The t value, 12.50, was significantly different at 0.001 level. The percentage of the importance of the critical competencies related to the appearance of the product factor assigned by the supervisors was higher than that assigned by the Test Committee.

**Hypothesis 1.2e**

Ho: There is no difference between NPCT Committee and the supervisors in terms of the assigned percentage to the importance of the critical competencies related to the hydrostatic test factor.

According to the results reported in Table 13, this null hypothesis was rejected. The t value, -14.65, was significantly different at 0.001 level. The assigned percentage to the importance of the critical competencies related to the hydrostatic test factor assessed by test committee was different from that assessed by the supervisors. The percentage of the hydrostatic test assigned by the supervisors was less than that assigned by the Test Committee.
Hypothesis 1.3a

Ho: There is no difference between NPCT Committee and the vocational educators in terms of the assigned percentage to the importance of the critical competencies related to reading the blueprint and drawing the manufacturer's schematics factor.

Table 14 indicates the results of the t-test for two groups. This null hypothesis was rejected. The t value, 3.62, was significantly different at 0.01 level. The percentage of the importance of the critical competencies related to reading the blueprint and drawing the manufacturer's schematics factor assigned by the vocational educators was higher than that assigned by the Test Committee.

Hypothesis 1.3b

Ho: There is no difference between NPCT Committee and the vocational educators in terms of the assigned percentage to the importance of the critical competencies related to the performance procedure factor.

According to the results reported in Table 14, this null hypothesis was retained. The t value, 0.17, was not significantly different at 0.05 level. No significant difference existed between the assessment by the vocational
Table 14. Mean, standard deviation, and t-test relating to the critical competencies judged by NPCT Committee and vocational educators

<table>
<thead>
<tr>
<th>Factor</th>
<th>Mean Committee</th>
<th>Mean Educators</th>
<th>T-Value</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading blueprint &amp; drawing manufacturer's schematics</td>
<td>7.50</td>
<td>9.63</td>
<td>2.13</td>
<td>3.62</td>
</tr>
<tr>
<td>Performance procedure</td>
<td>12.50</td>
<td>12.67</td>
<td>0.17</td>
<td>0.17</td>
</tr>
<tr>
<td>Accuracy of performance</td>
<td>25.00</td>
<td>35.07</td>
<td>10.07</td>
<td>5.81</td>
</tr>
<tr>
<td>Appearance of product</td>
<td>5.00</td>
<td>11.97</td>
<td>6.97</td>
<td>9.51</td>
</tr>
<tr>
<td>Hydrostatic test</td>
<td>50.00</td>
<td>30.33</td>
<td>-19.67</td>
<td>-9.67</td>
</tr>
</tbody>
</table>

**P<0.01
***P<0.001
educators and the Test Committee regarding the critical competencies related to the performance procedure.

**Hypothesis 1.3c**

Ho: There is no difference between NPCT Committee and the vocational educators in terms of the assigned percentage to the importance of the critical competencies related to the accuracy of the performance factor.

According to the results reported in Table 14, this null hypothesis was rejected. The t value, 5.81, was significantly different at 0.001 level. The percentage of the importance of the critical competencies related to the accuracy of the performance factor perceived by the vocational educators was higher than that perceived by the Test Committees.

**Hypothesis 1.3d**

Ho: There is no difference between NPCT Committee and the vocational educators in terms of the assigned percentage to the importance of the critical competencies related to the appearance of the product factor.

According to the results reported in Table 14, this null hypothesis was rejected. The t value, 9.51, was significantly different at 0.001 level. The percentage of the importance of
the critical competencies related to the appearance of the product factor assigned by the vocational educators was higher than that assigned by the Test Committee.

Hypothesis 1.3e

Ho: There is no difference between NPCT Committee and the vocational educators in terms of the assigned percentage to the importance of the critical competencies related to the hydrostatic test factor.

According to the results reported in Table 14, this null hypothesis was rejected. The t value, -9.67, was significantly different at 0.001 level. The assigned percentage to the importance of the critical competencies related to the hydrostatic test factor perceived by the Test Committee was significantly different from that perceived by the vocational educators. The percentage of the hydrostatic test assigned by the vocational educators was less than that assigned by the Test Committee.

Hypothesis 2

Ho: There was no difference of the perception score among the incumbent workers, supervisors, and the vocational educators.
Ha: At least one of the groups is different from the others in the perception of NPCT.

Hypothesis 2 through 4 were tested by means of a one-way ANOVA. Moreover, Duncan's multiple-range tests were used to compare, pairwise, mean values within predictor variables when the overall ANOVA test was significant.

Table 15 presents the results of the analysis of the variance of the three groups in terms of the perception of NPCT. This null hypothesis was rejected.

The F value, with 2 and 244 degrees of freedom, was 11.99, which is significant at 0.001 level. In other words, at least one of the groups was significantly different from the others in terms of the perception of NPCT. By using the Duncan's test to examine the means, differences were found between the vocational educators and the other groups. The mean perception score by the groups was significantly higher for the vocational educators than for the supervisors and the incumbent workers, indicating the educators have a more positive perception toward NPCT than the other groups.

**Hypothesis 3.1**

Ho: There is no difference among the mean perception levels on the quality of NPCT.
Table 15. Means and one-way ANOVA relating to the perception of NPCT among incumbent workers, supervisors, and vocational educators

<table>
<thead>
<tr>
<th>Factor</th>
<th>Mean^a</th>
<th>Incumbent Workers (1)</th>
<th>Supervisors (2)</th>
<th>Educators (3)</th>
<th>F</th>
<th>Pr &gt; F</th>
<th>DUNCAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of NPCT</td>
<td>3.55</td>
<td>3.52</td>
<td>3.95</td>
<td>6.76</td>
<td>0.0014**</td>
<td>3&gt;1,3&gt;2</td>
<td></td>
</tr>
<tr>
<td>Administration of NPCT</td>
<td>3.60</td>
<td>3.59</td>
<td>4.00</td>
<td>4.93</td>
<td>0.0079**</td>
<td>3&gt;1,3&gt;2</td>
<td></td>
</tr>
<tr>
<td>Test scoring &amp; interpretation of NPCT</td>
<td>3.56</td>
<td>3.48</td>
<td>3.99</td>
<td>9.07</td>
<td>0.0002***</td>
<td>3&gt;1,3&gt;2</td>
<td></td>
</tr>
<tr>
<td>Plumbing licensure</td>
<td>3.60</td>
<td>3.53</td>
<td>4.31</td>
<td>19.39</td>
<td>0.0000***</td>
<td>3&gt;1,3&gt;2</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>3.57</td>
<td>3.53</td>
<td>4.04</td>
<td>11.99</td>
<td>0.0000***</td>
<td>3&gt;1,3&gt;2</td>
<td></td>
</tr>
</tbody>
</table>

^Perception rating scale: 5=strongly agree, 4=agree, 3=neutral, 2=disagree, 1=strongly disagree.

**p<0.01
***p<0.001
Ha: At least one of the groups is different from the others in terms of the perception of the quality of NPCT.

According to the results reported in Table 15, the null hypothesis was rejected. The F value, with 2 and 248 degrees of freedom, was 6.76, was significant at 0.01 level. In other words, at least one of the groups was significantly different from the others in terms of the perception of the quality of NPCT. Moreover, the results of Duncan's test indicated differences were found among the vocational educators and the other groups. The mean score of the perception by the groups was significantly higher for the vocational educators than for the supervisors and the incumbent workers, indicating the vocational educators have a more positive perception toward the quality of NPCT than the supervisors and the incumbent workers.

Hypothesis 3.2
Ho: There is no difference among the mean perception levels on NPCT administration

Ha: At least one of the groups is different from the others in terms of the perception of NPCT administration.

According to the results reported in Table 15, the null
hypothesis was rejected. The F value, with 2 and 248 degrees of freedom, was 4.93, was significant at 0.01 level. In other words, at least one of the groups was significantly different from the others in terms of the perception of NPCT administration. Moreover, the results of Duncan's test indicated differences were found among the vocational educators and the other groups. The mean score of the perception by the groups was significantly higher for the vocational educators than for the supervisors and the incumbent workers, indicating the vocational educators have a more positive perception toward NPCT administration than the supervisors and the incumbent workers.

Hypothesis 3.3

Ho: There is no difference among the mean perception levels on the test scoring and the interpretation of NPCT.

Ha: At least one of the groups is different from the others in terms of the perception of the test scoring and the interpretation of NPCT.

According to the results reported in Table 15, the null hypothesis was rejected. The F value, with 2 and 247 degrees of freedom, was 9.07, was significant at 0.001 level. In other words, at least one of the groups was significantly
different from the others in terms of the perception of the test scoring and the interpretation of NPCT. Moreover, the results of Duncan's test indicated differences were found among the vocational educators and the other groups. The mean score of the perception by the groups was significantly higher for the vocational educators than for the supervisors and the incumbent workers, indicating the vocational educators have a more positive perception toward the test scoring and the interpretation of NPCT than the supervisors and the incumbent workers.

Hypothesis 3.4

H₀: There is no difference among the mean perception levels on the plumbing licensure.

Hₐ: At least one of the groups is different from the others in terms of the perception of the plumbing licensure.

According to the results reported in Table 15, the null hypothesis was rejected. The F value, with 2 and 248 degrees of freedom, was 19.39, was significant at the 0.001 level. In other words, at least one of the groups was significantly different from the others in terms of the perception of the plumbing licensure. Moreover, the results of the Duncan's test indicated differences were found among the vocational
educators and the other groups. The mean score of the perception by the groups was significantly higher for the vocational educators than for the supervisors and the incumbent workers, indicating the vocational educators have a more positive perception toward the plumbing licensure than the supervisors and the incumbent workers.

Hypothesis 4.1

Ho: There was no difference among the mean perception levels regarding the selected demographic variables age.

Ha: At least one of the age group is different from the others in terms of the perception of NPCT.

Table 16 presents the results of an analysis of the variance of the different age groups in terms of their perceptions of NPCT. As can be seen from the results reported in Table 16, this null hypothesis was retained. The F value, with 4 and 242 degrees of freedom, was 0.39, which was not significant at the 0.05 level. No difference exist among the different age groups on the perception of NPCT.

Hypothesis 4.2

Ho: There was no difference among the mean perception levels regarding educational level.
<table>
<thead>
<tr>
<th>Factor</th>
<th>Mean*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16-19</td>
</tr>
<tr>
<td>Quality of NPCT</td>
<td>3.51</td>
</tr>
<tr>
<td>Administration of NPCT</td>
<td>3.81</td>
</tr>
<tr>
<td>Test scoring &amp; interpretation of NPCT</td>
<td>3.60</td>
</tr>
<tr>
<td>Plumbing licensure</td>
<td>3.57</td>
</tr>
<tr>
<td>Overall</td>
<td>3.61</td>
</tr>
</tbody>
</table>

*Perception rating scale: 5=strongly agree, 4=agree, 3=neutral, 2=disagree, 1=strongly disagree.
Ha: At least one of the education groups is different from the others in terms of the perception of NPCT.

Table 17 presents the results of an analysis of the variance of the different education level groups in terms of their perceptions of NPCT. According to the results of analysis in this Table, null hypothesis 4.2 was rejected. The F value, with 5 and 240 degrees of freedom, was 4.04, which was significant at the 0.01 level. At least one of the groups was significantly different from the others in terms of the perception of NPCT. Moreover, the results of Duncan's test indicated significant differences were found between the group means of the respondents with a college diploma and those with a bachelor's degree, a senior high school diploma or an elementary school diploma. A difference also was found between the group means of the respondents with a junior high school diploma and those with a senior high or an elementary school diploma. The group with a college diploma had the most positive perception toward NPCT.

Regarding the factors of the perception of NPCT, the results of Duncan's test indicated significant differences were also found among different education level groups in terms of the perception of the quality of NPCT, test scoring and interpretation of NPCT, and plumbing licensure. The group with a college diploma also had the most positive perception
Table 17. Means and one-way ANOVA relating to the perception of NPCT among groups of different educational levels

<table>
<thead>
<tr>
<th>Factor</th>
<th>Meana</th>
<th>Groupb</th>
<th>F</th>
<th>Pr &gt; F</th>
<th>DUNCAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of NPCT</td>
<td>3.63</td>
<td>3.52</td>
<td>4.02</td>
<td>3.54</td>
<td>3.80</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Administration of NPCT</td>
<td>3.71</td>
<td>3.70</td>
<td>4.00</td>
<td>3.54</td>
<td>3.75</td>
</tr>
<tr>
<td>Test scoring &amp; interpretation of NPCT</td>
<td>3.55</td>
<td>3.53</td>
<td>4.15</td>
<td>3.51</td>
<td>3.73</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plumbing licensure</td>
<td>4.05</td>
<td>3.74</td>
<td>4.25</td>
<td>3.53</td>
<td>3.80</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>3.71</td>
<td>3.60</td>
<td>4.08</td>
<td>3.52</td>
<td>3.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

aPerception rating scale: 5=strongly agree, 4=agree, 3=neutral, 2=disagree, 1=strongly disagree.

bGroup: 1=Ph.D or master degree, 2=bachelor degree, 3=college diploma, 4=senior high school diploma, 5=junior high school diploma, 6=elementary school diploma.

**p<0.01
***p<0.001
toward the quality of NPCT, test scoring and interpretation of
NPCT and the plumbing licensure.

**Hypothesis 4.3**

**Ho:** There was no difference among the mean perception levels
regarding the selected demographic variables of
professional training.

**Ha:** At least one of the groups is significantly different
from the others in terms of the perception of NPCT.

Table 18 presents the results of an analysis of the
variance of the different training experience groups in terms
of their perceptions of NPCT. As can be seen from Table 18,
this null hypothesis was retained. The F value, with 3 and
227 degrees of freedom, was 1.80, which was not significant at
the 0.05 level. No significant differences exist among the
different training experience groups in terms of the
perception of NPCT.

**Hypothesis 4.4**

**Ho:** There is no difference among the groups obtaining a
plumbing license 10 years ago, 6 to 10 years, or within
the last 5 years in terms of the perception of NPCT.
Table 18. Means and one-way ANOVA relating to the perception of NPCT among subjects with different training experience

<table>
<thead>
<tr>
<th>Factor</th>
<th>Meana</th>
<th>Groupb</th>
<th>F</th>
<th>Pr &gt; F</th>
<th>DUNCAN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td></td>
</tr>
<tr>
<td>Quality of NPCT</td>
<td>3.45</td>
<td>3.57</td>
<td>3.74</td>
<td>3.54</td>
<td>2.56</td>
</tr>
<tr>
<td>Administration of NPCT</td>
<td>3.43</td>
<td>3.59</td>
<td>3.68</td>
<td>3.72</td>
<td>2.23</td>
</tr>
<tr>
<td>Test scoring &amp; interpretation of NPCT test</td>
<td>3.42</td>
<td>3.52</td>
<td>3.69</td>
<td>3.56</td>
<td>2.14</td>
</tr>
<tr>
<td>Plumbing licensure</td>
<td>3.57</td>
<td>3.83</td>
<td>3.66</td>
<td>3.58</td>
<td>1.47</td>
</tr>
<tr>
<td>Overall</td>
<td>3.46</td>
<td>3.62</td>
<td>3.69</td>
<td>3.59</td>
<td>1.80</td>
</tr>
</tbody>
</table>

aPerception rating scale: 5=strongly agree, 4=agree, 3=neutral, 2=disagree, 1=strongly disagree.

bGroup: 1=plumbing education at technical high school, 2=plumbing vocational training, 3=plumber short-term intensive class, 4=on-the-job-training.
Ha: At least one of the groups was significantly different from the others in terms of its perception of NPCT.

Table 19 presents the results of an analysis of the variance of three groups in terms of the perception of NPCT. According to the analysis results reported in the following Table, null hypothesis 4.4 was retained. The F value, with 2 and 227 degrees of freedom, was 1.40, which was not significant at 0.05 level. No significant differences existed among groups from different time periods in obtaining a license, indicating the perception of NPCT was consistent for different time periods. However, a significant difference was found among the three groups in terms of one factor within the perception of NPCT, plumbing licensure. The groups obtaining a license 6-10 years ago have a more positive perception toward the plumbing licensure than the other groups.

Hypothesis 4.5
Ho: There is no difference among the groups with different plumbing work experience in terms of the perception of NPCT.

Ha: At least one of the groups was significantly different from the others in terms of its perception of NPCT.
Table 19. Means and one-way ANOVA relating to the perception of NPCT among subjects with different year of obtaining license

<table>
<thead>
<tr>
<th>Factor</th>
<th>Mean*</th>
<th>Group</th>
<th>F</th>
<th>Pr &gt; F</th>
<th>DUNCAN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of NPCT</td>
<td>3.52</td>
<td>3.62</td>
<td>3.61</td>
<td>0.77</td>
<td>0.4463</td>
</tr>
<tr>
<td>Administration of NPCT</td>
<td>3.53</td>
<td>3.63</td>
<td>3.71</td>
<td>1.61</td>
<td>0.2015</td>
</tr>
<tr>
<td>Test scoring &amp; interpretation of NPCT</td>
<td>3.48</td>
<td>3.58</td>
<td>3.63</td>
<td>1.64</td>
<td>0.1968</td>
</tr>
<tr>
<td>Plumbing licensure</td>
<td>3.55</td>
<td>3.90</td>
<td>3.59</td>
<td>4.74</td>
<td>0.0096** 2&gt;1,2&gt;3</td>
</tr>
<tr>
<td>Overall</td>
<td>3.52</td>
<td>3.67</td>
<td>3.63</td>
<td>1.40</td>
<td>0.2486</td>
</tr>
</tbody>
</table>

*Perception rating scale: 5=strongly agree, 4=agree, 3=neutral, 2=disagree, 1=strongly disagree.

bGroup: 1=10 years ago, 2=6-10 years ago, 3=within the last 5 years.

**p<0.01
Table 20 presents the results of an analysis of the variance of the three groups in terms of the in perception of NPCT with varying years of experience. According to the results reported in this Table, null hypothesis 4.5 was rejected. The F value, with 3 and 343 degrees of freedom, was 3.84, which was significant at the 0.05 level. At least one of the groups was significantly different from the others in terms of its perception of NPCT in relation to years of work experience. The results of Duncan's test indicated that the group with less one year work experience had more positive perception toward NPCT than the group with above 10 years of work experience. The group with 1 to 5 years of work experience also had more positive perception toward NPCT than the group with above 10 years of work experience.

Significant differences were also found among the four groups in terms of the factors regarding the perception of NPCT, which included the quality of NPCT, NPCT administration, and test scoring and interpretation of NPCT. Overall, the respondents with less plumbing work experience had a more positive perception toward NPCT.
Table 20. Means and one-way ANOVA relating to the perception of NPCT among subjects with different year of plumbing working experience

<table>
<thead>
<tr>
<th>Factor</th>
<th>Mean*</th>
<th>Group(^b)</th>
<th>F</th>
<th>Pr &gt; F</th>
<th>DUNCAN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(1) (2) (3)</td>
<td>(4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of NPCT</td>
<td>3.86</td>
<td>3.66</td>
<td>3.62</td>
<td>3.50</td>
<td>2.70</td>
</tr>
<tr>
<td>Administration of NPCT</td>
<td>3.93</td>
<td>3.83</td>
<td>3.55</td>
<td>3.53</td>
<td>4.48</td>
</tr>
<tr>
<td>Test scoring &amp; interpretation of NPCT</td>
<td>3.93</td>
<td>3.68</td>
<td>3.58</td>
<td>3.47</td>
<td>4.54</td>
</tr>
<tr>
<td>Plumbing licensure</td>
<td>3.85</td>
<td>3.63</td>
<td>3.85</td>
<td>3.58</td>
<td>2.22</td>
</tr>
<tr>
<td>Overall</td>
<td>3.89</td>
<td>3.70</td>
<td>3.63</td>
<td>3.51</td>
<td>3.84</td>
</tr>
</tbody>
</table>

^Perception rating scale: 5=strongly agree, 4=agree, 3=neutral, 2=disagree, 1=strongly disagree.
^Group: 1=less than 1 year, 2=1-5 years, 3=6-10 years, 4=above 10 years.
*p<0.05
**p<0.01
CHAPTER V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The first four chapters of this study dealt with the introduction of the study, a review of the literature, methodology and procedures, analysis of the data, and findings and discussion. The purpose of this chapter is to summarize the preceding chapters, draw conclusions based on the findings, and present recommendations.

Summary

This study was designed to gather the perceptions of the plumbing incumbent workers, supervisors, and vocational educators regarding the current effectiveness of NPCT in theory and practical aspects, and make recommendations from an analysis results of the study for improvement of NPCT.

Restatement of the problem

The problem of this study was to assess the effectiveness of the occupational competency test for the plumbing trade in Taiwan.

The study especially set out to provide answers to the questions:

1. Are there perceived differences in the assigned percentages of the critical competency factors as outlined by NPCT Committee among the selected vocational educators,
incumbent workers and supervisors of plumbers within the selected trade of plumbing?

2. Are there differences in perceptions regarding NPCT among the incumbent workers, supervisors and plumbing educators?

3. Are there differences in perceptions regarding the quality of NPCT among the incumbent workers, supervisors and vocational educators?

4. Are there differences in perceptions regarding the administration of NPCT among the incumbent workers, supervisors, and vocational educators?

5. Are there differences in perceptions regarding test scoring and interpretation of NPCT among incumbent workers, supervisors, and vocational educators?

6. Are there differences in perceptions regarding plumbing licensure among incumbent workers, supervisors, and vocational educators?

7. Does the age of the respondents affect the perceptions toward NPCT?

8. Does the educational level of the respondents affect the perceptions toward NPCT?

9. Does the professional training experience of the respondents affect the perceptions toward NPCT?

The target population included all plumbing incumbent workers and supervisors in Taipei, and plumbing vocational educators in Taiwan. A random sampling technique was used to
select the sample of the plumbing incumbent workers and supervisors. One hundred and sixty companies were randomly selected, which was 20% of the population. Once the companies were selected, one supervisor and one incumbent worker of these companies were invited randomly to respond. All plumbing vocational educators in Taiwan were invited to participate in the study.

The questionnaire method of data collection was used for this study. The questionnaire was structured into three parts. Part I, NPCT critical competencies which were developed by NPCT Committee were included. The respondents were asked to judge the necessity and importance of each competency, and assign percentages to the various competency factors. Part II, the perception assessment, was developed to ask respondents to rate how they felt about NPCT. The perception assessment contained 26 statements across four areas which were (1) quality of NPCT, (2) administration of NPCT, (3) test scoring and interpretation of NPCT, and (4) plumbing licensure. Part III included personal information questions concerning age, highest educational achievement, working experience, licensed/unlicensed, training experience, when the plumbing license was obtained, etc.

Totally, 252 usable questionnaires were coded and analyzed, responses to the instrument were obtained from 112 plumbing incumbent workers, 110 supervisors, and 30 vocational
educators. The statistical methods chosen for analyzing the data were the t-test, Chi-Square analysis, Spearman's rank correlation coefficient, and one-way analysis of variance. There were twenty-five null hypotheses tested in this study. Statistical findings and conclusions for each hypothesis are presented in the next section.

The Cronbach's alpha reliability of the instrument was also tested to ensure that the measurement device was reliable, the overall reliability of the necessity of the critical competency was 0.9139; importance of the critical competency was 0.8996; and the perception of NPCT was 0.9391.

Based on the analyses of data and the findings presented in Chapter IV, general description of survey results, were summarized as follows:

Perceived critical competencies of NPCT

The respondents judged the necessity of critical competencies which were developed by NPCT Committee. Seventy-one percent and above of plumbing incumbent workers rated 22 of 25 competencies (88%) as necessary for an entry level worker in plumbing. The same percentage of supervisors rated 20 of 25 competencies (80%) as necessary and the same percentage of vocational educators rated 17 of 25 competencies (68%) as necessary for an entry level worker. An agreement between the Test Committee and three survey groups on
perceived competencies of entry level workers was low. Three out of all competencies that were judged as necessary by less than 70% of the respondents included (1) thread pipes that were assessed by the judge before joining, (2) cut ends of the pipes that were assessed by the judge before joining, and (3) drawing a line or an arc correctly by using a tool. Whether these three competencies should be included in NPCT needs to be reconsidered.

**Necessity of critical competencies as judged by incumbent workers, supervisors, and vocational educators**

The only competency that was found independent of the incumbent workers, supervisors, or vocational educators group was the product following the blueprint.

**Importance of critical competencies as judged by incumbent workers, supervisors, and vocational educators**

Three critical competencies were found significantly different among incumbent workers, supervisors, and vocational educators. These competencies included (1) processes followed by drawing the manufacturer's schematics, (2) cutting pipe squarely and removing the cutting burrs, and (3) removing the excess fillet burrs, oil spot and solvent cement. Vocational educators judged these three competencies of lesser importance than the supervisors and incumbent workers.
Three competencies that were judged of lesser importance were (1) thread pipes that were assessed by the judge before joining, (2) cut ends of the pipes that were assessed by the judge before joining, and (3) drawing a line or an arc correctly by using a tool.

Relevance of critical competency factors as viewed by NPCT Committee, incumbent workers, supervisors, and vocational educators

The respondents assigned percentages (the total not to exceed 100%) to the importance of the critical competency factors in an entry level position. These percentages were compared with those specified by NPCT Committee. Spearman's Rank Correlation Coefficient between Test Committee and incumbent workers, supervisors, and vocational educators were 0.60, 0.80, 0.80 respectively.

Perception of NPCT

Quality of NPCT More than sixty-five percent the respondents perceived that (1) the contents of the NPCT Written Test met the needs of the actual job of the entry level worker, (2) directions of the test clearly indicated to examinees how to respond to the test items, and (3) each test item had only one accurate or best answer. Sixty-one to sixty-five percent of the respondents indicated that (1) test
items were clearly expressed, (2) sufficient time was provided for the majority of examinees to complete the test, and (3) the contents of the NPCT Performance Test met the needs of the actual job performance in terms of essential skills. Fifty-one to sixty percent of the respondents agreed that (1) the length of the NPCT Written Test was appropriate, (2) proper arrangement of test items, with the easiest items first was evident. Less than fifty percent of the respondents perceived that (1) NPCT actually identify the particular occupational technical level, and (2) the difficulty of test item was consistent with the learning outcome it was designed to measure.

Administration of NPCT More than seventy percent of the respondents indicated that (1) the proctors followed the test directions strictly and adhered to the exact time schedule, and (2) the judges did not interfere in the examinees' performance test. Sixty-six percent of the respondents indicated that materials which were used in the NPCT were consistent with the specifications of the actual job performance. Fifty to fifty-five percent of the respondents perceived that (1) adequate work places were provided for the examinees in NPCT Performance Test, and (2) a safe and similar work place was provided at different areas in the NPCT Performance Test. Less than fifty percent of the respondents agreed that appropriate facilities and instruments were provided for each examinee in NPCT.
Test scoring and interpretation of NPCT

More than sixty percent of the respondents indicated that (1) the overall process of NPCT was adequate, accurate and fair, and (2) the judges treated each examinee fairly. Fifty-eight percent of the respondents perceived that (1) the minimum cutting point of 60 points was reasonable for NPCT criteria, and (2) NPCT could also be used to evaluate the effectiveness of plumbing instruction or training. Forty-two percent of the respondents agreed that the criteria could reliably predict those who had actual competency.

Plumbing licensure

Seventy-nine percent of the respondents perceived that professional trained workers had a higher ratio to obtain a plumbing license than untrained workers. Sixty percent and above of the respondents indicated that (1) the plumbing license ensured the public health, safety, and welfare, and maintained occupational standards; and (2) experienced workers had higher ratio to obtain the plumbing license than nonexperienced. Fifty percent of the respondents perceived that the plumbing employers who employed or promoted the workers depended on the license as one source of reliable information. Less than fifty percent of the respondents agreed that the licensed plumbers were expected to perform better than the unlicensed.

Comparison of the incumbent workers, supervisors, and vocational educators perceptions of NPCT, overall, vocational
educators perceived more positive attitudes towards the effectiveness of the test than supervisors and incumbent workers.

Conclusions

The major conclusions and statistical findings of this study, related to each hypothesis, are presented in this section.

Hypothesis 1.1a

This null hypothesis was rejected. The percentage of the importance of the critical competencies related to reading the blueprint and drawing the manufacturer's schematics factor assigned by the incumbent workers was higher than that assigned by the Test Committee.

Hypothesis 1.1b

This null hypothesis was rejected. Assigned percentages to the importance of the critical competencies related to the performance procedure factor assessed by the Test Committee was different from that assessed by the incumbent workers. The percentage of the performance procedure assigned by the incumbent workers was less than that assigned by the Test Committee.
Hypothesis 1.1c

This null hypothesis was rejected. The percentage of the importance of the critical competencies related to the accuracy of the performance factor assigned by the incumbent workers was higher than that assigned by the Test Committee.

Hypothesis 1.1d

This null hypothesis was rejected. The assigned percentage to the importance of the critical competencies related to the appearance of the product factor assigned by the incumbent workers was higher than that assigned by the Test Committee.

Hypothesis 1.1e

This null hypothesis was rejected. The assigned percentage to the importance of the critical competencies related to the hydrostatic test factor assessed by the Test Committee was different from that assessed by the incumbent workers. The percentage of the hydrostatic test assigned by the incumbent workers was less than that assigned by the Test Committee.

Hypothesis 1.2a

This null hypothesis was rejected. The percentage of the importance of the critical competencies related to reading the
blueprint and drawing the manufacturer's schematics factor assigned by the supervisors was higher than that assigned by the Test Committee.

**Hypothesis 1.2b**

This null hypothesis was retained. No significant difference existed between the assessment by the Test Committee and the supervisors.

**Hypothesis 1.2c**

This null hypothesis was rejected. The percentage of the importance of the critical competencies related to the accuracy of the performance factor assigned by the supervisor was higher than that assigned by the Test Committee.

**Hypothesis 1.2d**

This null hypothesis was rejected. The percentage of the importance of the critical competencies related to the appearance of the product factor assigned by the supervisors was higher than that assigned by the Test Committee.

**Hypothesis 1.2e**

This null hypothesis was rejected. The assigned percentage to the importance of the critical competencies
related to the hydrostatic test factor assessed by test committee was different from that assessed by the supervisors. The percentage of the hydrostatic test assigned by the supervisors was less than that assigned by the Test Committee.

**Hypothesis 1.3a**

This null hypothesis was rejected. The percentage of the importance of the critical competencies related to reading the blueprint and drawing the manufacturer's schematics factor assigned by the vocational educators was higher than that assigned by the Test Committee.

**Hypothesis 1.3b**

This null hypothesis was retained. No difference existed between the assessment by the vocational educators and the test committee.

**Hypothesis 1.3c**

This null hypothesis was rejected. The percentage of the importance of the critical competencies related to accuracy of the performance factor perceived by the vocational educators was higher than that perceived by the Test Committee.

**Hypothesis 1.3d**

This null hypothesis was rejected. The percentage of the
importance of the critical competencies related to the appearance of the product factor assigned by the vocational educators was higher than that assigned by the Test Committee.

Hypothesis 1.3e

This null hypothesis was rejected. The assigned percentage to the importance of the critical competencies related to the hydrostatic test factor assessed by the Test Committee was different from that assessed by the vocational educators. The percentage of the hydrostatic test assigned by the vocational educators was less than that assigned by the Test Committee.

Hypothesis 2

This null hypothesis was rejected. At least one of the groups was significantly different from the others in terms of the perception of NPCT. By using Duncan's test to examine the means, differences were found between the vocational educators and the other groups. The mean perception score by the groups was significantly higher for the vocational educators than for the supervisors and the incumbent workers, indicating the educators have a more positive perception toward NPCT than the other groups.
Hypothesis 3.1

This null hypothesis was rejected. At least one of the groups was significantly different from the others in terms of the perception of the quality of NPCT. Moreover, the results of Duncan's test indicated differences were found among the vocational educators and the other groups. The mean score of the perception by the groups was significantly higher for the vocational educators than for the supervisors and the incumbent workers, indicating the vocational educators have a more positive perception toward the quality of NPCT than the supervisors and the incumbent workers.

Hypothesis 3.2

The null hypothesis was rejected. At least one of the groups was significantly different from the others in terms of the perception of NPCT administration. Moreover, the results of Duncan's test indicated differences were found among the vocational educators and the other groups. The mean score of the perception by the groups was significantly higher for the vocational educators than for the supervisors and the incumbent workers, indicating the vocational educators have a more positive perception toward administration of NPCT than the supervisors and the incumbent workers.
Hypothesis 3.3

The null hypothesis was rejected. At least one of the groups was significantly different from the others in terms of the perception of the test scoring and the interpretation of NPCT. Moreover, the results of Duncan's test indicated differences were found among the vocational educators and the other groups. The mean score of the perception by the groups was significantly higher for the vocational educators than for the supervisors and the incumbent workers, indicating the vocational educators have a more positive perception toward the test scoring and the interpretation of NPCT than the supervisors and the incumbent workers.

Hypothesis 3.4

The null hypothesis was rejected. At least one of the groups was significantly different from the others in terms of the perception of the plumbing licensure. Moreover, the results of Duncan's test indicated differences were found among the vocational educators and the other groups. The mean score of the perception by the groups was significantly higher for the vocational educators than for the supervisors and the incumbent workers, indicating the vocational educators have a more positive perception toward the plumbing licensure than the supervisors and the incumbent workers.
Hypothesis 4.1
This null hypothesis was retained. No significant difference existed among the different age groups in terms of their perceptions of NPCT.

Hypothesis 4.2
This null hypothesis was rejected. At least one of the groups was significantly different from the others in terms of the perception of NPCT. Moreover, the results of Duncan's test indicated differences were found between the group means of the respondents with a college diploma and those with a bachelor's degree, a senior high school diploma or an elementary school diploma. A difference also was found between the group means of the respondents with a junior high school diploma and those with a senior high or an elementary school diploma. The group with a college diploma had the most positive perception toward NPCT.

Regarding the factors of the perception of NPCT, significant differences were also found among different education level groups in terms of the perception of the quality of NPCT, test scoring and interpretation of NPCT, and plumbing licensure. The group with a college diploma also had the most positive perception toward the quality of NPCT, test scoring and interpretation of NPCT and the plumbing licensure.
Hypothesis 4.3

This null hypothesis was retained. No significant difference existed among the different training experience groups in terms of the perception of NPCT.

Hypothesis 4.4

This null hypothesis was retained. No significant difference exists among groups with different years of obtaining a license, indicating the perception of NPCT was consistent at different time periods. Significant difference was found among the three groups in terms of one factor within the perception of NPCT, plumbing licensure. The group obtaining a license 6-10 years ago have a more positive perception toward plumbing licensure than the other groups.

Hypothesis 4.5

This null hypothesis was rejected. At least one of the groups was significantly different from the others in terms of its perception of NPCT. The results of Duncan's test indicated that the group with less one year work experience had more positive perception toward NPCT than the group with above 10 years of work experience. The group with 6 to 10 years of work experience also had more positive perception toward NPCT than the group with above 10 years of work experience.
Significant differences were also found among the four groups in terms of the factors within the perception of NPCT, which included the quality of NPCT, administration of NPCT, and test scoring and interpretation of NPCT. Overall, the respondents with less plumbing working experience had a more positive perception toward NPCT.

A summary of results of testing each hypothesis was tabulated in Table 21 and Table 22. These tables include t values, F values, probability of significance, and the results.

Table 21. Summary of the results of hypothesis for testing the differences between groups for assigned percentage to the importance of critical competency factors

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>t-test value</th>
<th>Prob.</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1a</td>
<td>4.93</td>
<td>0.0000***</td>
<td>Reject</td>
</tr>
<tr>
<td>1.1b</td>
<td>-2.75</td>
<td>0.0070**</td>
<td>Reject</td>
</tr>
<tr>
<td>1.1c</td>
<td>12.49</td>
<td>0.0000***</td>
<td>Reject</td>
</tr>
<tr>
<td>1.1d</td>
<td>13.64</td>
<td>0.0000***</td>
<td>Reject</td>
</tr>
<tr>
<td>1.1e</td>
<td>-15.55</td>
<td>0.0000***</td>
<td>Reject</td>
</tr>
<tr>
<td>1.2a</td>
<td>4.59</td>
<td>0.0000***</td>
<td>Reject</td>
</tr>
<tr>
<td>1.2b</td>
<td>0.08</td>
<td>0.9390</td>
<td>Retain</td>
</tr>
<tr>
<td>1.2c</td>
<td>9.27</td>
<td>0.0000***</td>
<td>Reject</td>
</tr>
<tr>
<td>1.2d</td>
<td>12.50</td>
<td>0.0000***</td>
<td>Reject</td>
</tr>
<tr>
<td>1.2e</td>
<td>-14.65</td>
<td>0.0000***</td>
<td>Reject</td>
</tr>
<tr>
<td>1.3a</td>
<td>3.62</td>
<td>0.0010**</td>
<td>Reject</td>
</tr>
<tr>
<td>1.3b</td>
<td>0.17</td>
<td>0.8670</td>
<td>Retain</td>
</tr>
<tr>
<td>1.3c</td>
<td>5.81</td>
<td>0.0000***</td>
<td>Reject</td>
</tr>
<tr>
<td>1.3d</td>
<td>9.51</td>
<td>0.0000***</td>
<td>Reject</td>
</tr>
<tr>
<td>1.3e</td>
<td>-9.67</td>
<td>0.0000***</td>
<td>Reject</td>
</tr>
</tbody>
</table>
Table 22. Summary of the results of hypothesis for testing the differences between groups for mean perception levels scores

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>F value</th>
<th>Prob.</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>11.99</td>
<td>0.0000***</td>
<td>Reject</td>
</tr>
<tr>
<td>3.1</td>
<td>6.76</td>
<td>0.0014**</td>
<td>Reject</td>
</tr>
<tr>
<td>3.2</td>
<td>4.93</td>
<td>0.0079**</td>
<td>Reject</td>
</tr>
<tr>
<td>3.3</td>
<td>9.07</td>
<td>0.0002***</td>
<td>Reject</td>
</tr>
<tr>
<td>3.4</td>
<td>19.39</td>
<td>0.0000***</td>
<td>Reject</td>
</tr>
<tr>
<td>4.1</td>
<td>0.39</td>
<td>0.8160</td>
<td>Retain</td>
</tr>
<tr>
<td>4.2</td>
<td>4.04</td>
<td>0.0015**</td>
<td>Reject</td>
</tr>
<tr>
<td>4.3</td>
<td>1.80</td>
<td>0.1477</td>
<td>Retain</td>
</tr>
<tr>
<td>4.4</td>
<td>1.40</td>
<td>0.2486</td>
<td>Retain</td>
</tr>
<tr>
<td>4.5</td>
<td>3.84</td>
<td>0.0102*</td>
<td>Reject</td>
</tr>
</tbody>
</table>

Recommendations

Recommendations for practice

1. Review the critical competencies for the entry level of the plumbing workers by doing a job analysis. The agreement between NPCT Committee and the three survey groups (incumbent workers, supervisors and vocational educators) on perceived critical competencies of entry level workers was low in this study.

The purpose of NOCT is to examine the knowledge and skill level of the entry worker at a particular trade. Therefore, the critical competencies developed by the Test Committee need to be consistent with the perception of the supervisors and incumbent workers. Job analysis can be used to identify the
knowledge and skills considered necessary for a person to perform at a journeyman level in each field. The results of job analysis can be used as the basis for test item construction.

2. Establish the Table Specification of NPCT based on updated job analysis.

3. Reconsider the score distribution of NPCT factors.

4. Continue to improve NPCT by:

(1) Increasing the number of the representatives from enterprise involved in test development and scoring.

(2) Revising or rearranging the task list and test items on a regular basis and update the tests to reflect current competencies and performance standards for the occupation to meet the societal needs.

(3) Analyze reliability and validity of the test items to improve the test and construct an efficient test item bank.

(4) Emphasize post-test conference to review and discuss past performance strengths and weaknesses of instrument as a basis for improving future test administration.

(5) Setting cut-off point based on recommendations from professional judges who should be representative. Cut-off score should be revised if necessary.
5. Identifying current updated critical competencies in order to improve NOCT, and also benefit the vocational instruction and make training more meaningful.

6. Emphasize licensure by means of

(1) continuing efforts to encourage workers to attend the relative NPCT by informing them of the conception, functions, and importance of the licensure. The percentage of licensed workers in companies was low in this study.

(2) Formulating and revising relative laws and regulations governing occupational competency test and licensure to achieve the ultimate goal of hiring licensed employees as required to ensure that the public health, safety, and welfare are reasonably well protected.

Recommendations for future research

1. Replication of this study in other cities in Taiwan. R.O.C. The findings could be further generalized to a larger population by expanding the existing study to other cities.

2. The assessment model used in this study can be adapted for use in other trades.

3. Replicate this study by focusing on the precise critical competencies of the entry level of plumbers.
REFERENCES


I wish to express my genuine appreciation to Dr. William Wolansky, my major professor, for providing exceptional guidance, continual encouragement, patience, and friendship during my doctoral program. I sincerely appreciate the unique contribution made by each of my program of study committee members: Dr. Arthur Akers, Dr. Larry Bradshaw, Dr. Donald Mckay, and Dr. Robert Strahan. I also wish to express my gratitude to:

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Hsin-Tien and Hsin-Ruey, my two children, for sharing in the joy and excitement of achievements and successes throughout the program as only preschoolers can.
APPENDIX A

INSTRUMENT
Instrument part I

Critical Competency For Plumbing Competency Performance Test

a. Read the critical competency statements and place a check mark "x" in the column labeled yes if it is performed by an entry level plumber.

b. Rate the importance of this critical competency to an entry level plumber at your company by using the number 1,2,3,4 or 5 in the column labeled Importance. Use the following scale:
   1. Not Important
   2. Little Important
   3. Somewhat Important
   4. Important
   5. Very Important

c. Assign a percentage to each group of critical competency an entry level plumber performs.

<table>
<thead>
<tr>
<th>Critical Competency</th>
<th>Check Yes(X)</th>
<th>Importance, rate 1-5</th>
<th>Percent of total job</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading blueprint &amp; drawing manufacturer's schematics.</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>1. Draw line or arc correctly by using tools------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Manufacturer's schematics consistent with blueprint------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Complete manufacturer's schematics according to blueprint-------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Process follow by drawing manufacturer's schematics------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance procedure.</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>5. Thread pipes are assessed by the judge before joining------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Cut ends of the pipes are assessed by the judge before joining--------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Use facilities &amp; tools appropriately-----------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Keep work areas clear of tools &amp; materials and do not borrow those from somebody else-----------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Apply safety procedures-----------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Process cautiously without any accident------------------------------------------</td>
<td></td>
<td></td>
<td>%</td>
</tr>
</tbody>
</table>
### Accuracy of performance.

<table>
<thead>
<tr>
<th>11. Cut pipe squarely &amp; remove the cutting burrs</th>
<th>⬝</th>
<th>⬝</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. Pipe threads have not been marred or broken over 5 mm</td>
<td>⬝</td>
<td>⬝</td>
</tr>
<tr>
<td>13. Insert join P.V.C.P. beyond 1.5 O.D.</td>
<td>⬝</td>
<td>⬝</td>
</tr>
<tr>
<td>14. Solder block pipe less than 1/3 O.D.</td>
<td>⬝</td>
<td>⬝</td>
</tr>
<tr>
<td>15. Pipeline or fitting joint distort angle less than three degree</td>
<td>⬝</td>
<td>⬝</td>
</tr>
</tbody>
</table>

*16. Radial pipe bend more/less than*

| a. (0mm - 4mm) | ⬝ |
| b. (5mm - 10mm) | ⬝ |
| c. (11mm - 15mm) | ⬝ |
| d. (above 16 mm) | ⬝ |

17. Make uniform and smooth pipe bend

18. Flatten pipe size by pressure less than 10 % O.D.

19. Make uniform & smooth solder joints

20. fitting fit direction & position correctly

21. process & methods of joint following the blueprint

22. products follow the blueprint

*23. Measure error more/less than*

| a. (0mm - 4mm) | ⬝ |
| b. (5mm - 10mm) | ⬝ |
| c. (11mm - 15mm) | ⬝ |
| d. (16mm - 20mm) | ⬝ |
| e. (21mm - 25mm) | ⬝ |
| f. (above 26 mm) | ⬝ |

### Appearance of product.

24. The product is smooth and steady

25. No injury track appear on the product by careless work

26. Remove excess fillet, burrs, oil spot & solvent cement

*27. P.V.C. pipe singe length or diameter*

| a. (0mm - 4mm) | ⬝ |
| b. (5mm - 10mm) | ⬝ |
| c. (11mm - 20mm) | ⬝ |
| d. (above 21mm) | ⬝ |

### Hydrostatic test

28. no leak under 7.5 kg/cm hydrostatic test & hold 3 minutes

*These three competencies are presented as multiple choice type.*
Directions:

There are 26 statements in this section, please circle the appropriate number which expresses what you think each statement.

5. Strongly agree (S.A.)
4. Agree (A.)
3. Uncertain (U.)
2. Disagree (D.A.)
1. Strongly Disagree (S.D.)

Quality of NPCT

1. The contents of plumbing competency written test meet the needs of actual job of entry level worker............ 5 4 3 2 1
2. The contents of plumbing competency performance test meet the needs of actual job performance in terms of essential skills ......................... 5 4 3 2 1
3. The plumbing competency test does actually identify the particular occupational technical level ........ 5 4 3 2 1
4. Directions of test clearly indicate to examinees how to respond to the test items ......................... 5 4 3 2 1
5. The test items are clearly expressed. 5 4 3 2 1
6. The length of plumbing competency written test is appropriate .......... 5 4 3 2 1
7. Proper arrangement of test items, with the easiest items first is evident ......................... 5 4 3 2 1
8. Sufficient time is provided for the majority of examinees to complete the test .......................... 5 4 3 2 1

9. The difficulty of each test item is consistent with the learning outcome it is designed to measure .............. 5 4 3 2 1

10. Each test item has only one accurate or best answer ...................... 5 4 3 2 1

Administration of NPCT

11. Adequate work places are provided for examinees in the plumbing competency performance test that are experienced in the work place ...... 5 4 3 2 1

12. Safe and similar work places are provided at different areas in plumbing competency performance test 5 4 3 2 1

13. Appropriate facilities and instruments are provided for each examinee in the plumbing competency test .......................... 5 4 3 2 1

14. The materials which are used in competency test are consistent with the specification of actual job performance .......................... 5 4 3 2 1

15. The proctors follow the test directions strictly and stick to the exact time schedule ............. 5 4 3 2 1

16. The judges do not interfere in examinees' work during the performance test .................. 5 4 3 2 1

Test scoring & interpretation of NPCT

17. The criteria can reliably predict those who have actual competency ... 5 4 3 2 1
18. The minimum cutting point of 60 points is reasonable for plumbing competency test criteria .......... 5 4 3 2 1

19. The judges treat each examinee fairly .................................. 5 4 3 2 1

20. The overall process of plumbing competency test is adequate, accurate and fair ................. 5 4 3 2 1

21. The results of plumbing competency test can also be used to evaluate the effectiveness of plumbing instruction or training .......... 5 4 3 2 1

**Plumbing licensure**

22. Plumbing employers who employ or promote the workers depend on the license as one source of reliable information .......................... 5 4 3 2 1

23. The plumbing licensure ensures the public health; safety; and welfare, and maintains occupational standards 5 4 3 2 1

24. The licensed plumbers are expected to perform better than the unlicensed . 5 4 3 2 1

25. Experienced workers have a higher ratio to obtain plumbing license than nonexperienced ................. 5 4 3 2 1

26. Professional trained workers have higher ratio to obtain plumbing license than untrained .......... 5 4 3 2 1
Personal Information

Directions:

Please put the number in the blank that best describes you.

Supervisor

____ 1. Age: (1) 16-19  (2) 20-29  (3) 30-39  (4) 40-49  
(5) above 50 years old.

____ 2. The highest educational degree you have achieved:  
(1) Ph.D or master degree  
(2) bachelor degree  
(3) senior high school diploma  
(4) junior high school diploma  
(5) elementary school diploma 

____ 3. Current job position: (1) employer  (2) supervisor  
(3) foreman

____ 4. How long have you worked in the plumbing occupation?  
(1) less 1 year  (2) 1-5 years  (3) 6-10 years  
(4) above 10 years

____ 5. How many plumbers in your company or division?  
(1) less than 5 (2) 6-10 (3) more than 10.

____ 6. How many percentage of employees in your company are  
licensed? (1) below 10%  (2) 10-39%  (3) 40-69%  
(4) 70-99%  (5) 100%.

____ 7. You obtained the plumbing license: (1) before employed  
(2) after employed  (3) have not obtained.

____ 8. When did you obtain the plumbing license:  
(1) 10 years ago  (2) 6-10 years ago  
(3) within 5 years.

____ 9. Have you ever attend the following activities before  
obtaining plumbing license: (1) plumbing education at  
technical high school  (2) plumbing vocational  
training  (3) plumber short-term intensive class  
(4) on-the-job training
Incumbent worker

1. Age: (1) 16-19 (2) 20-29 (3) 30-39 (4) 40-49 (5) above 50 years old.

2. The highest educational degree you have achieved:
   (1) Ph.D or master degree
   (2) bachelor degree
   (3) senior high school diploma
   (4) junior high school diploma
   (5) elementary school diploma

3. How long have you worked in the plumbing occupation?
   (1) less 1 year (2) 1-5 years (3) 6-10 years (4) above 10 years

4. You obtained the plumbing license: (1) before employed (2) after employed (3) have not obtained

5. When did you obtain the plumbing license?
   (1) 10 years ago (2) 6-10 years ago (3) within the last 5 years.

6. Have you ever attend the following activities before obtaining a plumbing license? (1) plumbing education at technical high school (2) plumbing vocational training (3) plumber short-term intensive class
Vocational Educator

1. Age: (1) 16-19 (2) 20-29 (3) 30-39 (4) 40-49 (5) above 50 years old.

2. The highest educational degree you have achieved: (1) Ph.D or master degree (2) bachelor degree (3) college degree

3. Current job position: (1) teacher (2) trainer (3) administrator

4. How long have you been a plumbing teacher? (1) less 1 year (2) 1-5 years (3) 6-10 years (4) above 10 years

5. How much industrial experience have you had in the plumbing field? (1) less 1 year (2) 1-5 years (3) 6-10 years (4) above 10 years

6. You obtained the plumbing license: (1) before teaching (2) after teaching (3) have not obtained

7. When did you obtain the plumbing license? (1) 10 years ago (2) 6-10 years ago (3) within the last 5 years.

8. Have you ever attend the following activities before obtaining a plumbing license? (1) plumbing education at technical high school (2) plumbing vocational training (3) plumber short-term intensive class (4) on-the-job training
APPENDIX B

IOWA STATE UNIVERSITY COMMITTEE ON
THE USE OF HUMAN SUBJECTS IN RESEARCH APPROVAL
Checklist for Attachments and Time Schedule

The following are attached (please check):

12. X Letter or written statement to subjects indicating clearly:
   a) purpose of the research
   b) the use of any identifier codes (names, #s), how they will be used, and when they will be removed (see Item 17)
   c) an estimate of time needed for participation in the research and the place
   d) if applicable, location of the research activity
   e) how you will ensure confidentiality
   f) in a longitudinal study, note when and how you will contact subjects later
   g) participation is voluntary; nonparticipation will not affect evaluations of the subject

13. □ Consent form (if applicable)

14. □ Letter of approval for research from cooperating organizations or institutions (if applicable)

15. □ Data-gathering instruments

16. Anticipated dates for contact with subjects:
   First Contact                                    Last Contact
   Feb. 25, 1992                                      Mar. 30, 1992
   Month / Day / Year                                 Month / Day / Year

17. If applicable: anticipated date that identifiers will be removed from completed survey instruments and/or audio or visual tapes will be erased:
    Apr. 10, 1992
   Month / Day / Year

18. Signature of Departmental Executive Officer    Date    Department or Administrative Unit
    ___________________________  ________________  ____________________________

19. Decision of the University Human Subjects Review Committee:
    X Project Approved  _ Project Not Approved  _ No Action Required

   Patricia M. Keith  2/11/92
   Name of Committee Chairperson                    Date                  Signature of Committee Chairperson
APPENDIX C

CHINESE VERSION OF THE INSTRUMENT
第一部分

這部分是關於配合工丙級（木匠）技能檢定的術科評分項目，共有26題，每一題都附有三個部分：（一）您認為此分項細目是否必要。 （二）此分項細目的重要性。 （三）此評分項目應占總分的百分比。請先閱讀題目，並在「甲」、「乙」、「丙」三欄分別標記。

甲欄：若您認為此分項細目實屬必要，請在空格內打「×」。

乙欄：您認為此分項細目的重要性，請標出評定等級。

1. 不重要
2. 稍許重要
3. 有些重要
4. 重要
5. 非常重要

丙欄：請將該評分項目應占總分的百分比標寫在空格內（總合請勿超過100％）。

第一部分範例

<table>
<thead>
<tr>
<th>評分項目</th>
<th>甲</th>
<th>乙</th>
<th>丙</th>
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</thead>
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<tr>
<td>項目內容</td>
<td>此分項細目</td>
<td>此分項細目的重要性</td>
<td>此評分項目應占總分的百分比</td>
</tr>
<tr>
<td>1. 落樣圖標出尺寸...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. 計算管段長度...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>項目</td>
<td></td>
<td></td>
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<th>乙</th>
<th>丙</th>
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</thead>
<tbody>
<tr>
<td>項目內容</td>
<td>此分項細目</td>
<td>此分項細目的重要性</td>
<td>此評分項目應占總分的百分比</td>
</tr>
<tr>
<td>1. 創線規矩。</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2. 落樣與圖相符合。</td>
<td></td>
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</tr>
<tr>
<td>3. 按圖面完成落樣。</td>
<td></td>
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</tr>
<tr>
<td>4. 按規定落樣而後作業。</td>
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<td></td>
</tr>
<tr>
<td>評分項目</td>
<td>內容</td>
<td>此項細目實務必要</td>
<td>此項細目的重要性</td>
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<td>----------</td>
<td>------</td>
<td>------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>1</td>
<td>管口或孔口切削整齊，並清除毛邊。</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>螺紋連接處螺牙在5mm以下。</td>
<td></td>
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<tr>
<td>3</td>
<td>螺紋管接長度差達1.50以上。</td>
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<tr>
<td>4</td>
<td>检錨選項管內在1/3以下。</td>
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<td></td>
</tr>
<tr>
<td>5</td>
<td>管或管件標號與無偏差或歪斜</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>管管半徑差達（此題請勿勾選一項）</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>曲曲均勻且平整。</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>管徑偏在管外徑之10%內。</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>鍋造均勻、平整。</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>按圖施工</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>料件裝置方向及部位正確。</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>加工或接合方式符合。</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>外形與圖相符。</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>尺寸誤差（此題請勿勾選一項）</td>
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<td></td>
</tr>
<tr>
<td>a</td>
<td>±4mm以下。</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>±(5mm - 10mm)。</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>±(10mm - 15mm)。</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>±(15mm - 20mm)。</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e</td>
<td>±(20mm - 25mm)。</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f</td>
<td>±26mm以上。</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>水壓試驗7.5kg/cm² 持續3分鍾以上，無漏水現象。</td>
<td></td>
<td></td>
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</tbody>
</table>
第二部分

這部分共有26題，請依您對配管工丙級（水匠）技能檢定的看法，圈選出適當的答案。

| 第二部分範例： | 非常 | 中 | 同意 | 不同 | 非常
|----------------|------|----|------|------|------
| 1. 檢定報告手續簡便。 | 1 2 3 4 5 |     |      |      |      |
| 2. 檢定報告收費合理。 | 1 2 3 4 5 |     |      |      |      |
| 3. 考場所在位置交通方便。 | 1 2 3 4 5 |     |      |      |      |

A. 配管工丙級（水匠）技能檢定的品質

1. 學科內容符合實際工作中需要。--------------------------------------- 1 2 3 4 5
2. 術科內容符合實際工作中所需技能。--------------------------------------- 1 2 3 4 5
3. 檢定能實際測出本行業技術水準。--------------------------------------- 1 2 3 4 5
4. 檢定的「試題說明」及「圖例」清晰易懂。--------------------------------------- 1 2 3 4 5
5. 檢定的題目，其難易程度適當。--------------------------------------- 1 2 3 4 5
6. 學科的題數適當。--------------------------------------- 1 2 3 4 5
7. 學科考題安排適當，由易而難。--------------------------------------- 1 2 3 4 5
8. 試題時間充裕，大部分的考生可完成。--------------------------------------- 1 2 3 4 5
9. 試題難度與所要評量的學習成果一致。--------------------------------------- 1 2 3 4 5
10. 試題有公認的正確答案。--------------------------------------- 1 2 3 4 5

B. 配管工丙級（水匠）技能檢定的實施

11. 術科場地適合考生的技能表現。--------------------------------------- 1 2 3 4 5
12. 不同的檢定場地提供考生安全且相似的環境。--------------------------------------- 1 2 3 4 5
13. 考場所準備的設備、器具對每位考生都有相同的良好使用狀況。--------------------------------------- 1 2 3 4 5
14. 檢定時所使用的材料符合實際工作時所用材料的規格。--------------------------------------- 1 2 3 4 5
15. 試卷考前督導遵守考試規則與時間表。--------------------------------------- 1 2 3 4 5
16. 及時現場評審時不會妨礙考生的作業。--------------------------------------- 1 2 3 4 5

C. 評定成績與效標參照測驗之設計

17. 評分標準能可靠的評定出考生的實力。--------------------------------------- 1 2 3 4 5
18. 學術科成績六十分及格是合理的標準。--------------------------------------- 1 2 3 4 5
19. 成績公平的對待每一位考生。--------------------------------------- 1 2 3 4 5
20. 檢定的過程適當、精確且公平。--------------------------------------- 1 2 3 4 5
21. 檢定的結果可用來評價配管教學與訓練的成效。--------------------------------------- 1 2 3 4 5

D. 配管工丙級（水匠）證照

22. 自來水承裝業應主以配管工（水匠）證照作業用或昇選員工的可靠依據。--------------------------------------- 1 2 3 4 5
23. 配管工（水匠）證照可保障消費者健康、安全與福利，且

維持職業水準。--------------------------------------- 1 2 3 4 5
24. 持有配管工（水匠）證照的員工技能表現比未持有者較好。--------------------------------------- 1 2 3 4 5
25. 有實際工作經驗者考取配管工（水匠）證照的比率較高。--------------------------------------- 1 2 3 4 5
26. 受過專業教育或訓練者考取配管工（水匠）證照的比率較高。--------------------------------------- 1 2 3 4 5
配管教育者問卷

敬啟者：

建立配管工(水匠)職業證照制度是提升配管業整體技術水準，確保配管業服務品質及公共安全的重要途徑，亦是我國教育、訓練、及政府等有關部門所共同努力的目標。本研究旨在探討我國配管工(水匠)技能檢定實施之成效。由蔡長榮先生；美國愛荷華州立大學研究生，進行研究。故此，本問卷將於二月一日發送，您的意見經過統計分析之後，將列為本研究的重要參考依據。非常感謝您的鼎力協助，特此

敬啟

萬幸如意

行政院勞工委員會職業訓練局

美國愛荷華州立大學工業教育研究所

八十一年二月 日

個人資料

[填答說明]：請依您的實際狀況，填答下列問題。

1. 年齡：(1) 16-19歲 (2) 20-29歲 (3) 30-39歲 (4) 40-49歲 (5) 50歲以上。

2. 最高學歷：(1) 博士或碩士 (2) 學士 (3) 專科畢業。

3. 目前職務：(1) 教師 (2) 訓練師 (3) 行政主管。

4. 您擔任配管教師有多久？(1) 1年以內 (2) 1-5年 (3) 6-10年 (4) 10年以上。

5. 您在配管業界實際工作經驗？(1) 1年以下 (2) 1-5年 (3) 6-10年 (4) 10年以上。

6. 您取得配管工(水匠)證照是在(1) 任教前 (2) 任教後 (3) 未取得證照。

7. 您取得配管工(水匠)證照是在(1) 10年前 (2) 6-10年 (3) 5年内。

8. 您取得配管工(水匠)證照前曾參加過(1) 配管的職業訓練 (2) 水匠長期補習班 (3) 師徒傳授。
老闆、監工、或領班問卷

啟者：

透過營業績效及勞工福祉等多方面因素，我國自民國七十七年十一月起，配合建築及營業經濟發展，協助企業進行組織設計、職等劃分及制度設計。

設於本院之建築臺灣省土地銀行營業績效及勞工福祉調查計畫，原計畫期中，經由地方公務員考試院及有關單位聘請專家學者編撰，擬於民國七十七年十一月起，配合建築及營業經濟發展，協助企業進行組織設計、職等劃分及制度設計。

為確保調查之公平性，本計畫之調查需在企業組織內進行，並蒐集相關資料。故請貴企業提供相關資料，俾便於調查之進行。本計畫之結果將以匿名方式公布，並同意於調查前後將資料寄回本院。

敬請貴企業於民國七十七年十一月三十一日將相關資料寄回本院。

行政院勞工委員會營業績效調查

查詢資料

一、貴企業之營業年額、勞工人數及經營狀況。

二、貴企業之營業年額、勞工人數及經營狀況。

三、貴企業之營業年額、勞工人數及經營狀況。

四、貴企業之營業年額、勞工人數及經營狀況。

五、貴企業之營業年額、勞工人數及經營狀況。

六、貴企業之營業年額、勞工人數及經營狀況。

七、貴企業之營業年額、勞工人數及經營狀況。

八、貴企業之營業年額、勞工人數及經營狀況。

九、貴企業之營業年額、勞工人數及經營狀況。

十、貴企業之營業年額、勞工人數及經營狀況。

十一、貴企業之營業年額、勞工人數及經營狀況。

十二、貴企業之營業年額、勞工人數及經營狀況。

十三、貴企業之營業年額、勞工人數及經營狀況。

十四、貴企業之營業年額、勞工人數及經營狀況。

十五、貴企業之營業年額、勞工人數及經營狀況。

十六、貴企業之營業年額、勞工人數及經營狀況。

十七、貴企業之營業年額、勞工人數及經營狀況。

十八、貴企業之營業年額、勞工人數及經營狀況。

十九、貴企業之營業年額、勞工人數及經營狀況。

二十、貴企業之營業年額、勞工人數及經營狀況。

二十一、貴企業之營業年額、勞工人數及經營狀況。

二十二、貴企業之營業年額、勞工人數及經營狀況。

二十三、貴企業之營業年額、勞工人數及經營狀況。

二十四、貴企業之營業年額、勞工人數及經營狀況。

二十五、貴企業之營業年額、勞工人數及經營狀況。

二十六、貴企業之營業年額、勞工人數及經營狀況。

二十七、貴企業之營業年額、勞工人數及經營狀況。

二十八、貴企業之營業年額、勞工人數及經營狀況。

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三十三、貴企業之營業年額、勞工人數及經營狀況。

三十四、貴企業之營業年額、勞工人數及經營狀況。

三十五、貴企業之營業年額、勞工人數及經營狀況。

三十六、貴企業之營業年額、勞工人數及經營狀況。

三十七、貴企業之營業年額、勞工人數及經營狀況。

三十八、貴企業之營業年額、勞工人數及經營狀況。

三十九、貴企業之營業年額、勞工人數及經營狀況。

四十、貴企業之營業年額、勞工人數及經營狀況。

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五十、貴企業之營業年額、勞工人數及經營狀況。

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五十八、貴企業之營業年額、勞工人數及經營狀況。

五十九、貴企業之營業年額、勞工人數及經營狀況。

六十、貴企業之營業年額、勞工人數及經營狀況。

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六十九、貴企業之營業年額、勞工人數及經營狀況。

七十、貴企業之營業年額、勞工人數及經營狀況。

七十ー、貴企業之營業年額、勞工人數及經營狀況。

七十ニ、貴企業之營業年額、勞工人數及經營狀況。

七十参、貴企業之營業年額、勞工人數及經營狀況。

七十隨、貴企業之營業年額、勞工人數及經營狀況。

七十則、貴企業之營業年額、勞工人數及經營狀況。

七十即、貴企業之營業年額、勞工人數及經營狀況。

七十戊、貴企業之營業年額、勞工人數及經營狀況。

七十已、貴企業之營業年額、勞工人數及經營狀況。

七十庚、貴企業之營業年額、勞工人數及經營狀況。

七十辛、貴企業之營業年額、勞工人數及經營狀況。

七十壬、貴企業之營業年額、勞工人數及經營狀況。

七十癸、貴企業之營業年額、勞工人數及經營狀況。

七十子、貴企業之營業年額、勞工人數及經營狀況。

七十丑、貴企業之營業年額、勞工人數及經營狀況。

七十寅、貴企業之營業年額、勞工人數及經營狀況。

七十卯、貴企業之營業年額、勞工人數及經營狀況。

七十辰、貴企業之營業年額、勞工人數及經營狀況。

七十巳、貴企業之營業年額、勞工人數及經營狀況。

七十午、貴企業之營業年額、勞工人數及經營狀況。

七十未、貴企業之營業年額、勞工人數及經營狀況。

七十申、貴企業之營業年額、勞工人數及經營狀況。

七十酉、貴企業之營業年額、勞工人數及經營狀況。

七十戌、貴企業之營業年額、勞工人數及經營狀況。

七十亥、貴企業之營業年額、勞工人數及經營狀況。

三、貴企業之營業年額、勞工人數及經營狀況。
配管工（水匠）問卷

個人資料

【填答說明】: 請依您的實際狀況，填答下列問題。

_____1. 年齡：(1) 16-19 歲 (2) 20-29 歲 (3) 30-39 歲 (4) 40-49 歲
(5) 50 歲以上。

_____2. 最高學歷：(1) 大專畢業 (2) 高中 (職) 畢業 (3) 高中或 初職
畢業 (5) 小學畢業。

_____3. 您從事配管行業有多久？(1) 1 年以下 (2) 1-5 年 (3) 6-10 年
(4) 10 年以上。

_____4. 您取得配管工（水匠）證照是在 (1) 就業前 (2) 就業後 (3) 未取
得證照。

_____5. 您取得配管工（水匠）證照是在 (1) 10 年前 (2) 6-10 年 (3) 5
年內。

_____6. 您取得配管工（水匠）證照前曾參加過 (1) 配管的高工教育
(2) 配管的職業訓練 (3) 水匠短期補習班 (4) 師徒傳授。
APPENDIX D

COVER LETTER
incumbent worker

Dear plumbing supervisors,

educator

I am a graduate student in the Department of Industrial Education and Technology at Iowa State University. As a part of the degree requirements, I am conducting a study with the objective of investigating the perception of plumbing workers, supervisors, and educators in terms of national plumbing competency test as a basis for improving the test in Taiwan.

Your assistance is requested for this study and your participation is vital to its success. However, your participation is entirely voluntary. Any information you provide will be kept strictly confidential and all information will be released as summary statistics only. If a question seems too personal, you may choose not to answer it but all questions asked are critical to the success of this study. The code number on the questionnaire will be used for purpose of follow up only on unreturned questionnaires. After the original data have been collected, and before data analysis, the list of participants will be destroyed to preserve the anonymity of respondents.

Please take about twenty minutes to complete the questionnaires and return it by February 26, 1992. For your convenience, postage for returning this booklet is prepaid. We appreciate your prompt cooperation and professional contribution.

Sincerely,

Chang-Yen Tsai
Doctoral Student
Industrial Education and Technology

Dr. William D. Wolanksy
Professor of Industrial Education and technology, and Coordinator of International Education Program, College of Education
APPENDIX E

FOLLOW-UP LETTER
February 26, 1992

Vocational Educator
Dear Incumbent Worker : Supervisor

I realize that you have very busy schedules, especially at the beginning of the new year. Perhaps that is why I have not received your completed questionnaire for the study of the effectiveness of the plumbing competency test, which was mailed to you at two weeks ago. I am enclosing another copy of questionnaire for your response in case your questionnaire was not received.

Although your participation is totally voluntary, this study cannot be successfully concluded without your support and cooperation. If you have recently returned your questionnaire, please accept this note as a thank you for your contribution. If your have not done so, would you take a little of your time to complete and return it as early as possible.

Sincerely,

Chang-Yen Tsai
Doctoral candidate
Industrial Education & Technology