# The study of practical competence indicator analysis and establishment of an automatic measurement technology course

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ABSTRACT: The aim of this study was to establish practical competence indicators for an Automatic Measurement Technology Course (AMTC) of industry-oriented needs, and this development is expected to promote technical quality and student ability. Industrial supervisors, engineers and university scholars responded to a Delphi questionnaire, and the Kolmogorov-Smirnov One Sample Test was applied to obtain competence indicators for this course. The results confirmed the following: 1) Four items were revealed as the competence indicators for Virtual Instrument; 2) Eight items were revealed as the competence indicators for LabVIEW Programming Design; 3) Four items were revealed as the competence indicators for the Interface of Signal Transmission; 4) Four items were revealed as the competence indicators for Sensing and Measuring Devices; 5) Three items were revealed as the competence indicators for Automatic Measurement Platform; and 6) Four items were revealed the competence indicators for Automatic Measurement Applications. These indicators will be utilised and developed into suitable teaching material.

## INTRODUCTION

The concept of automatic measurement is that instantaneous and automatic measurements of the environment, system and object can be undertaken. Traditionally, automatic measurement is more often seen with physical instruments for industry, such as monitoring boiler temperatures, measuring humidity in a flower nursery or sensing of the extent of shaking of a working machine. These measuring functions and applications are indispensable for monitoring essential procedures or technical applications in product manufacturing processes or in the product itself for industry. For example, the characteristic of measurement was conducted by the use of diodes or transistors in the manufacturing process and quality management testing, as well as in fabricating a variety of sensing and measuring devices for up-to-date machines [1]. On the other hand, automatic measurement aimed at measuring and storing values, and instigating treatment and applications are especially in demand.

Included here is automatic measurement technology that requires programming, facilities integration, control application, function, maintenance technology, and so forth. The challenge is how to develop a s uitable teaching syllabus and a teaching material unit with industry-orientation that can meet the requirements of the Automatic Measurement Technology Course (AMTC). This should be regarded as the research direction of this study.

With regard to data acquisition, automatic measurement was to measure real signal processes (such as a voltage), to take the signal into a computer to process, analyse, store or provide other treatments. In the real world, objects are based on physical or chemical phenomena, such as velocity, temperature, humidity, pressure, flow velocity, pH (i.e. power of Hydrogen ions) value, switch, radiation, luminosity, etc, which all could be subjects of measurement [2]. The transducer or sensor can bring forth physical phenomena to obtain proportional electrical signals. For instance, thermocouples are able to transform temperature into voltage magnitude, and afterwards the object can be measured by a D/A converter. Other transducers included a strain gauge, flow meter, manometer, and so on, which might gauge stress, flow velocity and pressure separately.

Virtual instrument technology was made up of computer technology and instrument technology, which have now made modern technology and techniques more convenient and better. In the hospital, laboratory, factory and in outdoor work, sometimes in order to undertake measurement and maintenance tasks, it was necessary to use many apparatuses, such as an ECG analyser, oscilloscope, spectrum gauge, voltmeter, spectrum analyser, etc. These instruments were so expensive, large in volume, occupying considerable space that the reciprocal link was quite troublesome [3]. Accordingly, virtual instruments demanded a PC, a workshop, an instrument interface platform and suitable software to accomplish the desired functions. In view of this, more advanced virtual instruments have taken the place of many classical instruments and equipments on hand.

To sum up the above analysis, the purpose of this study was focused mainly at training the elites by matching technology-oriented industry needs with the set of industry needs for AMTC. In addition, there is a need to provide a suitable teaching syllabus and teaching material unit, to provide higher-grade students in universities and colleges with the opportunity to learn about modern sensors and measurement components, and then improve their practical knowledge and technology literacy for electrical and electronic technology. For this reason, the specific purposes of this study can be described as follows:

1. Investigate the professional skill needs for the automatic measurement industry;
2. Identify and confirm appropriate competence indicators for the automatic measurement industry; and
3. Integrate the planning teaching syllabus and teaching material unit for AMTC.

METHODOLOGY

In order to achieve the research purpose, the methodology of this study needed to address several aspects in order to establish a set of competence indicators of automatic measurement for industry needs. As a consequence, the following methods were used to carry out the study: 1) Literature Analysis; 2) Expert Consultations; 3) Delphi Technique; and 4) Kolmogorov-Smirnov One Sample Test. Next, this study conducted the process of analysis as shown in Figure 1:

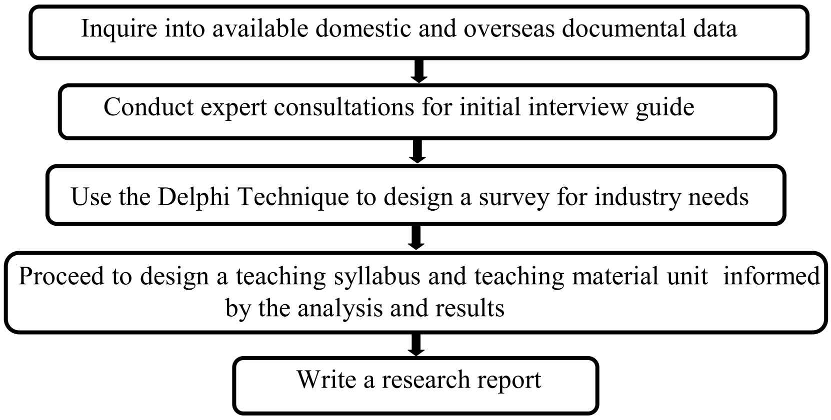


Figure 1: The flow chart of the development process.

Inquire into available domestic and overseas documental data: Data on automatic measurement, curriculum planning, and practice teaching material were collected and analysed. In addition, the principles and development models of teaching materials were taken into account, in order to provide the basis of design reference of a Delphi questionnaire and expert consultations.

Conduct expert consultations for the initial interview guide: Through this study a deeper understanding of the identified and suggested practical competence indicators for AMTC was to be achieved. Based on the results of the interviews, a Delphi questionnaire was developed that was regarded as one of the design references, and its respondents were industrial supervisors, engineers and university scholars. The following procedure was carried out for expert consultations: a) Send out interview invitations and identify a list of interviewees; b) Develop an initial interview guide; c) Carry out interviews concerning the practical competence indicators for AMTC; and d) Modify and confirm the practical competence indicators for AMTC.

Use the Delphi Technique to design and administer a survey for industry needs: Within this context, design, using open-ended questions, a Delphi questionnaire that adopts a 5-point Likert-type scale (i.e. a scale of 1 to 5) from *Not Important* to *Most Important*. It allowed researchers to develop views and opinions, based on the results of analysis and conclusions from literature reviews and expert interviews. Moreover, ten experts were asked to accept and confirm the Delphi survey, and were subsequently sent an e-mail requesting their opinions about the identified practical competence indicators [4]. The investigation process for the Delphi questionnaire was as follows:

- Proceed to design a teaching syllabus and teaching material unit informed by the data analysis and results: The Kolmogorov-Smirnov One Sample Test was carried out. Through the third Delphi questionnaire for data analysis, the consistency degree of ten experts opinions regarding practical competence indicator for AMTC were identified. Also, in order to improve the design of teaching syllabus and teaching material unit, the spiral-ADDIEE&R model (Analyse, Design, Develop, Implement and Evaluate) of instructional design was adopted. This model has five phases: analysis, design, development, implementation, evaluation and examination, and can be reviewed and revised [1].
- Write a research report: As shown in Table 1, virtual instrument technology was built on AMTC, which demanded knowledge skills, methods, procedures, as well as experimental equipment to write a research report in the light of the Delphi survey for industry needs in order to develop suitable teaching materials and teaching aids.

RESULTS AND DISCUSSIONS

The obtained data was used for qualitative analysis and quantitative statistics as follows:

- Qualitative analysis was used to integrate the opinions of all experts assessing the questionnaire with the indicators. This study was compared with the literature review again, to establish if the expert had different viewpoints for the indicator and, further, it was decided whether to increase, delete or amend the list of indicators.
- Quantitative statistics were derived by using SPSS version 12.0 statistical software, in order to estimate the mode, mean and standard deviation of frequency distribution; to understand the distribution of expert responses and assess opinions for fitness degrees; to conduct the Kolmogorov-Smirnov One Sample Test; and to confirm the consistency degree of all expert opinions regarding practical competence indicators for AMTC.

The statistical analysis concerning the questionnaire may be described as follows:

For measuring these indicators, every question was evaluated against a five-point Likert Scale, on which responses of *Not Important*, *Less Important*, *Neutral*, *Very Important*, and *Most Important* were accorded values of 1 to 5, respectively. The questionnaire results were used to compute modes, means and standard deviations. Mode (Mo) referred to the most frequently appeared values in a group of data. Mean (M) represented the most common trends of experts opinions, whereas standard deviation (SD) showed the discrete level of all experts opinions, where the maximum value represented those more inconsistent with their opinions, and the minimum value represented those more consistent with their opinions.

In order to identify the competence indicators of industry needs for AMTC, the Kolmogorov-Smirnov One Sample Test was used to test the Z-value of results from the Third Delphi Questionnaire. The results obtained are shown in Table 1. Almost all the competence indicators obtained demonstrated the consistency level with all experts' points of view, except that there were three more items of indicators included in the questionnaire such as 2-7, 2-10 and 6-1. In conclusion, the research indicated that all experts agreed on these competence indicators.

Table 1: Competence indicators analysed by Kolmogorov-Smirnov One Sample Test Results for the Third Delphi Questionnaire.

| Dimensions | Competence Indicators | All experts result | | | K-S One Sample Test | |
|---|---|---|---|---|---|---|
| | | Mo | M | SD | P | Z |
| Virtual Instrument | 1-1.The introduction of Virtual Instrument related knowledge | 4.00 | 4.40 | 0.516 | 0.001 | $1.897^{**}$ |
| | 1-2.The introduction of LabVIEW related knowledge | 4.00 | 4.30 | 0.483 | 0.000 | $2.214^{***}$ |
| | 1-3.The operation of LabVIEW | 5.00 | 4.80 | 0.422 | 0.000 | $2.530^{***}$ |
| | 1-4.The combination of LabVIEW and other software and hardware | 4.00 | 4.50 | 0.527 | 0.013 | $1.581^{*}$ |
| LabVIEW Programming Design | 2-1.LabVIEW programming | 5.00 | 4.60 | 0.516 | 0.001 | $1.897^{**}$ |
| | 2-2.The program establishment and test for various loop structure | 4.00 | 4.50 | 0.527 | 0.013 | $1.581^{*}$ |
| | 2-3.The program establishment and test for array and data clustering | 4.00 | 4.30 | 0.483 | 0.000 | $2.214^{***}$ |
| | 2-4.The program establishment and test for graphics and charts | 5.00 | 4.70 | 0.483 | 0.000 | $2.214^{***}$ |
| | 2-5.The program establishment and test for string and file I/O function | 4.00 | 4.00 | 0.667 | 0.001 | $1.897^{**}$ |
| | 2-6.The combination and test for PLC | 4.00 | 4.50 | 0.527 | 0.013 | $1.581^{*}$ |
| | 2-7.The combination and test for 8051 | 4.00 | 3.80 | 0.632 | 0.820 | 1.265 |
| | 2-8.The combination and test for MATLAB | 4.00 | 4.40 | 0.516 | 0.001 | $1.897^{**}$ |
| | 2-9.The combination and test for C Language | 4.00 | 4.40 | 0.516 | 0.001 | $1.897^{**}$ |
| | 2-10.The combination and test for Single Chip | 4.00 | 4.30 | 0.675 | 0.820 | 1.265 |
| The Interface of Signal Transmission | 3-1.The principle, property and test for USB Communication Interface | 5.00 | 4.70 | 0.483 | 0.000 | $2.214^{***}$ |
| | 3-2.The principle, property and test for RS232 Communication Interface | 5.00 | 4.90 | 0.316 | 0.000 | $2.846^{***}$ |
| | 3-3.The principle, property and test for DAQ Communication Interface | 5.00 | 4.70 | 0.483 | 0.000 | $2.214^{***}$ |
| | 3-4.The principle, property and test for Remote Network | 5.00 | 4.90 | 0.316 | 0.000 | $2.846^{***}$ |

| | | | | | | |
|---|---|---|---|---|---|---|
| Sensing and Measuring Devices | 4-1.The application of sensing and measuring devices for industrial circles | 5.00 | 4.90 | 0.316 | 0.000 | 2.846*** |
| | 4-2.The sensor was in common use for industrial circles | 5.00 | 4.90 | 0.316 | 0.000 | 2.846*** |
| | 4-3.The measuring device was in common use for industrial circles | 5.00 | 4.90 | 0.316 | 0.000 | 2.846*** |
| | 4-4.The application of Image Acquisition Devices for industrial circles | 5.00 | 4.70 | 0.483 | 0.000 | 2.214*** |
| Automatic Measurement Platform | 5-1.The system structure of Automatic Measurement Platform | 5.00 | 4.80 | 0.422 | 0.000 | 2.530*** |
| | 5-2.The hardware structure of the external circuit for Automatic Measurement Platform | 4.00 | 4.40 | 0.516 | 0.001 | 1.897** |
| | 5-3.The software structure of Automatic Measurement Platform | 4.00 | 4.50 | 0.527 | 0.013 | 1.581* |
| Automatic Measurement Applications | 6-1.Signal Filter Manufactures in Automatic Quality Measurement System | 4.00 | 4.10 | 0.568 | 0.820 | 1.265 |
| | 6-2.Diode Manufactures in Automatic Quality Measurement System | 4.00 | 4.40 | 0.516 | 0.001 | 1.897** |
| | 6-3.Motor Monitoring and Control System | 4.00 | 4.10 | 0.316 | 0.000 | 2.846*** |
| | 6-4.Indoor Environment Monitoring and Control System for the Flower Nursery | 4.00 | 4.50 | 0.527 | 0.013 | 1.581* |
| | 6-5.Irregular Heartbeat Detector in Wireless Remote Monitoring and Control System | 4.00 | 4.50 | 0.527 | 0.013 | 1.581* |

*p<0.05**; p<0.01***; p<0.001

Based on the outcomes of the data analysis, planning of the course development included both the design of teaching syllabus and a teaching material unit for this subject. The material developed may be described and characterised as follows [5-9]:

- Teaching Syllabus Design: From the analytical results, syllabus items were identified on the basis of the property and difficulty of this course and, then, assorted by use of hardware equipment, while arranged in order of teaching in three steps:

    1. The basic concepts and skills, inclusive of *The introduction of Virtual Instrument and LabVIEW related knowledge* and *LabVIEW Programming Design*;
    2. The expanded concepts and skills, inclusive of *The Interface of Signal Transmission* and *Tensing and Measuring Devices*;
    3. The advanced applications, inclusive of *Automatic Measurement Platforms* and *Automatic Measurement Applications.*

- Teaching Material Unit Planning: The teaching material development took into account the quantity and the degree of difficulty for each of the units on Thematic Unit, Content Outline and Lessons/Time, as shown in Table 2; it projected the condition of the content and the allocated lessons for each unit.

Table 2: Scheme of thematic unit, content outline and lessons/time.

| Unit | Subject | Content Outline | Lessons/Time |
|---|---|---|---|
| 1 | The introduction of Virtual Instrument and LabVIEW related knowledge | 1-1.The introduction of Virtual Instrument related knowledge<br>1-2.The introduction of LabVIEW related knowledge<br>1-3.The operation of LabVIEW<br>1-4.The combination of LabVIEW and other software and hardware | 1wk/3hrs |
| 2 | LabVIEW Programming Design | 2-1.LabVIEW programming<br>2-2.The program establishment and test for various loop structure<br>2-3.The program establishment and test for array and data clustering<br>2-4.The program establishment and test for graphics and charts<br>2-5.The program establishment and test for string and file I/O function<br>2-6.The combination and test for PLC<br>2-7.The combination and test for MATLAB<br>2-8.The combination and test for C Language | 4wks/12hrs |

| | | | |
|---|---|---|---|
| 3 | The Interface of Signal Transmission | 3-1.The principle, property and test for USB Communication Interface<br>3-2.The principle, property and test for RS232 Communication Interface<br>3-3.The principle, property and test for DAQ Communication Interface<br>3-4.The principle, property and test for Remote Network | 2wks/6hrs |
| 4 | Sensing and Measuring Devices | 4-1.The application of sensing and measuring devices for industrial circles<br>4-2.The sensor was in common use for industrial circles<br>4-3.The measuring device was in common use for industrial circles<br>4-4.The application of Image Acquisition Devices for industrial circles | 3wks/9hrs |
| 5 | Automatic Measurement Platform | 5-1.The system structure of Automatic Measurement Platform<br>5-2.The hardware structure of the external circuit for Automatic Measurement Platform<br>5-3.The software structure of Automatic Measurement Platform | 3wks/9hrs |
| 6 | Automatic Measurement Applications | 6-1.Diode Manufactures in Automatic Quality Measurement System<br>6-2.Motor Monitoring and Control System<br>6-3.Indoor Environment Monitoring and Control System for the Flower Nursery<br>6-4.Irregular Heartbeat Detector in Wireless Remote Monitoring and Control System | 3wks/9hrs |

Remark: There were 18 weeks of teaching schedule deducted from the midterm and the final examination for this semester courses, and the number of teaching lessons and time totaled to 16 weeks/48 lessons.

## CONCLUSIONS AND SUGGESTIONS

Based on the literature analysis, outcomes of the interviews and expert advice, a Delphi questionnaire was devised as a research tool. After the Delphi survey was carried out over three rounds, the consistency of the experts' opinion was tested and proved via frequency distribution and Kolmogorov-Smirnov One Sample Test.

This study established practical competence indicators for AMTC only through the Delphi survey and analysis. Other competence indicators obtained all experts' agreement, except that *The combination and test for 8051*, *The combination and test for Single Chip*, and *Signal Filter Manufactures in Automatic Quality Measurement System* did not gain the consistency of opinion of all experts. Overall, the practical competence indicators were divided into six dimensions for AMTC. The total 27 competence indicators, included in different groups, are shown below:

- Virtual Instrument: There are four items of competence indicators, including *The introduction of Virtual Instrument related knowledge*; *The introduction of LabVIEW related knowledge*; *The operation of LabVIE*; and *The combination of LabVIEW and other software and hardware* for the first dimension.
- LabVIEW Programming Design: There are eight items of competence indicators, including *LabVIEW programming*; *The program establishment and test for various loop structure*; *The program establishment and test for array and data clustering*; *The program establishment and test for graphics and charts*; *The program establishment and test for string and file I/O function*; *The combination and test for PLC*; *The combination and test for MATLAB*; and *The combination and test for C Language* for the second dimension.
- The Interface of Signal Transmission: There are four items of competence indicators, including *The principle, property and test for USB Communication Interface*; *The principle, property and test for RS232 Communication Interface*; *The principle, property and test for DAQ Communication Interface*; and *The principle, property and test for Remote Network* for the third dimension.
- Sensing and Measuring Devices: There are four items of competence indicators, including *The application of sensing and measuring devices for industrial circles*; *The sensor was in common use for industrial circles*; *The measuring device was in common use for industrial circles*; and *The application of Image Acquisition Devices for industrial circles* for the fourth dimension.
- Automatic Measurement Platform: There are three items of competence indicators, including *The system structure of Automatic Measurement Platform*; *The hardware structure of the external circuit for Automatic Measurement Platform*; and *The software structure of Automatic Measurement Platform* for the fifth dimension.
- Automatic Measurement Applications: There are four items of competence indicators, including *Diode Manufactures in Automatic Quality Measurement System*; *Motor Monitoring and Control System*; *Indoor Environment Monitoring and Control System for the Flower Nursery*; and *Irregular Heartbeat Detector in Wireless Remote Monitoring and Control System* for the sixth dimension.

The results of this study were useful in identifying and accepting a set of competence indicators, which were further used to develop a suitable teaching syllabus and a teaching material unit by establishing related technology literacy for this course. Moreover, the methodology used and the adopted research scheme may increase the interest of other researches to use it in order to improve the effect of learning. Furthermore, it could conserve low-cost laboratory hardware to cut a s uccession of maintenance and update issues. Therefore, the accomplishment of this study could contribute to future curriculum development, with suitable content selection for college automatic measurement technology, becoming a suitable reference guide. It should be pointed out that this research and development was conducted under the spiral-ADDIEE&R curriculum development model leading to the achievement of the experimental teaching scheme, program evaluation and inspection, as well as its revision.

ACKNOWLEDGMENTS

This study was funded by a grant provided by the National Science Council (NSC), Taiwan, under the grant number NSC100-2511-S-018-002.

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