

Course development and evaluation of a virtual instrument measurement technology

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ABSTRACT: Virtual instruments using new measurement technology were built by a set of hardware and software with computers. The hardware aspect uses a data acquisition card and a workstation. The software aspect utilises LabVIEW to design the front panels of virtual instruments and data processing programs. This makes users operate the computers in the same way as operating the traditional electronic instruments designed by them. The main purpose of this study is to develop and arrange the teaching materials and laboratory equipment of virtual instrumental measurement technology. Further, the results of the research will be integrated into a three-hour technical class each week. The students who take this course can use the technology in other lab classes to obtain multi-measurement assistance and increased efficiency. In the research process, following the literature research, consultation with experts and interviews with students, the laboratory facility, class outline, order and time arrangement of topics and course plan were built. In addition, expert examination will help amend the teaching materials and any unsuitable design.

INTRODUCTION

A virtual instrument, with computer technology and modern acquisition measurement technology, is a new and stylish high-tech product. This is the most up-to-date virtual instrument available, today. The virtual instrument makes the best use of active computer resources, closely aligns with constructive instrument hardware and proprietary software, and achieves all the functions of the traditional instrument, as well as some impressive specific functions that cannot be performed with traditional instruments. A virtual instrument adds a set of software and hardware to a general-purpose computer while the user operates this computer as if operating self-designed special traditional equipment. The appearance of virtual instrument technology breaks through the traditional instrument mode defined by the manufacturer that does not allow the user to change it. Given sufficient space to utilise their ability and imagination, users can design own instrument system to satisfy various application demands.

Today, the emphasis in engineering labs is on implementing devices that provide a graphical computer interface, a range of input/output devices, the ability to record results and feedback [1-2]. These devices provide a set of virtual instruments that are not only applicable to laboratory work but industrial applications as well [1-4]. Figure 1 shows the appearance of traditional and virtual measurement instruments.

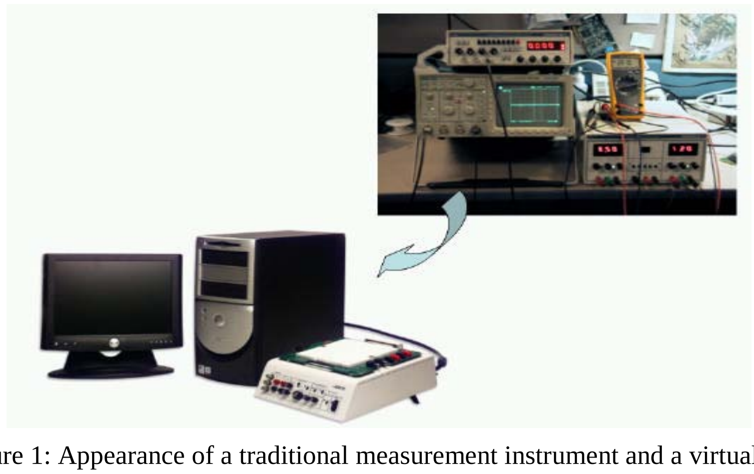

Figure 1: Appearance of a traditional measurement instrument and a virtual one.

LabVIEW is a programming environment based on the concept of data flow programming. This programming paradigm has been widely used for data acquisition and instrument control. There are three important components involved in test and measurement applications, namely data acquisition, data analysis and data visualisation. LabVIEW features an easy-to-use graphical programming environment covering these vital components [5-6]. Many exciting experiments can be designed and demonstrated by integrating these powerful virtual instrument technology products in a flexible laboratory environment, with enormous possibilities of expansion and experimentation [7-8]. Figure 2 shows the statistical data of software used in virtual instrument design research in the IEEE database from 2004 to 2007. Data shows 65.7% of users prefer LabVIEW as their design software.

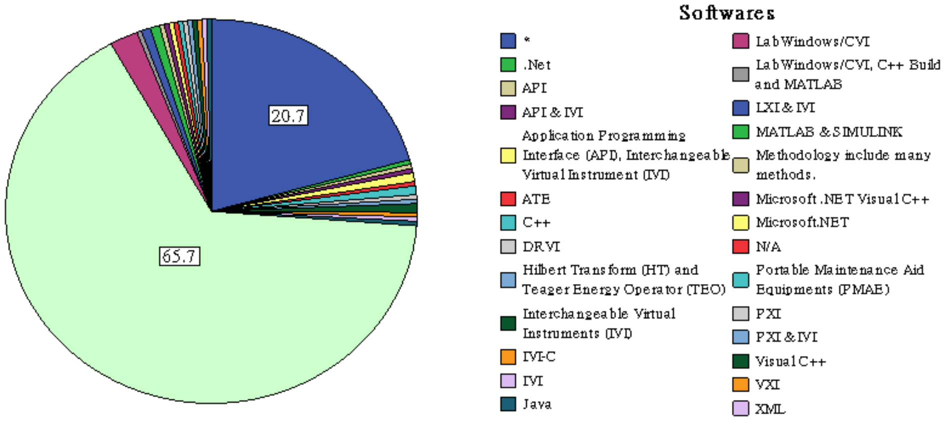

Figure 2: The statistical data of software used in virtual instrument design research in the IEEE database from 2004 to 2007.

Instructional Systems Design (ISD) is a process to ensure that learning does not occur haphazardly, but is developed using a process with specific measurable outcomes. The responsibility of the instructional designer is to create an instructional experience, ensuring that learners will achieve the goals of the instruction. The ADDIE model is a generic, systematic approach to the instructional design process, providing instructional designers with a framework to ensure their instructional products are effective and their creative processes are as efficient as they can possibly be. The phases are: (1) Analyse: define the needs and constraints; (2) Design: specify learning activities, assessment, and choose methods and media; (3) Develop: begin production, formative evaluation and revision; (4) Implement: put the plan into action; (5) Evaluate: evaluate the plan from all levels for the next implementation [9].

DEVELOPMENT PROCESS

The five phases of the ADDIE model are ongoing activities continuing throughout the training program. After building the training program, the other phases do not end once the training program is carried out. The five phases work like a loop. They are continually and regularly repeated to see if further improvements can be made. The following chart shows the instructional design process:

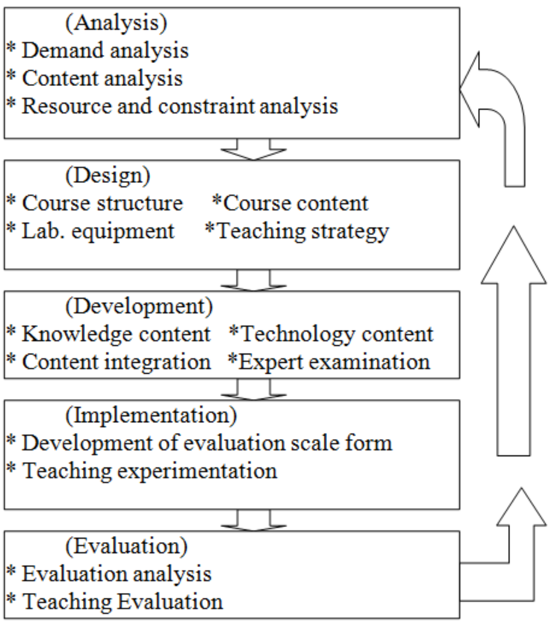

Figure 3: The flow chart of the development process.

Analysis

In the research process, analysis occurs after a literature probe, consulting with experts and interviews with students. A clear and definite arrangement is shown below:

1. Virtual measurement instruments: contain the measurement equipments of the electrical and electronic laboratory at the college level of technological and vocational education;
2. Students: must have basic design ability in LabVIEW program;
3. Goal of course: train the student to be able to design and construct the desired measurement instruments such as a signal generator and power supply. Moreover, make students be able to apply it to the monitoring and control systems;
4. Laboratory equipment: computer Pentium IV, DAQ card PCI-6251 M Series, LabVIEW7.1 and NI ELVIS system.

Design

In this process, class outline, order of subjects, chapter arrangement and time arrangement of topics, and course plans are built. Table 1 shows the design.

Table 1: Class outline design.

Ch.	Subject	Content	h
1	Introduction to virtual instrument and LabVIEW	(1) Introduction to virtual instrument (2) LabVIEW	3
2	Introduction to experimental equipments	(1)Equipment use (2) Marks of prototype circuit board (3) DAQ card (4) Signal connection (5) Bypass Mode (6) Software (7) Adjustment (8) Quiz	3
2	Data acquisition device	(1) DAQ introduction (2) DAQ installation (3) Quiz	3
3 13	* Virtual digital multi-meter operation, design and measurement experiment * Virtual thermometer operation, design and measurement experiment * Virtual impedance analyser operation, design and measurement experiment * Virtual signal generator operation, design and measurement experiment * Virtual oscilloscope operation, design and measurement experiment * Virtual bode analyser operation, design and measurement experiment * Virtual digital writer operation, design and measurement experiment * Virtual digital reader operation, design and measurement experiment * Virtual arbitrary signal operation, design and measurement experiment * Virtual two-wire operation, design and measurement experiment * Virtual three-wire operation, design and measurement experiment (Every subject is arranged for a 3 hours class)	All the subjects contain the following outlines in the left square: (1) Goal (2) Related knowledge (3) Measurement experiment (4) Programmable design (5) Discussion (6) Homework and report (7) Quiz	33
14	Magnetic field measurement experiment	(1) Goal (2) Fundamental knowledge (3) Magnetic measurement test (4) Discussion (5) Homework and report (6) Quiz	3
15	Mechanical movement measurement experiment	(1) Goal (2) Fundamental knowledge (3) Motor speed measurement test (4) Discussion (5) Homework and report (6) Quiz	3

Remark: excluding mid-term and final exams, there are 48 hours in total.

Development

All the teaching materials are written based on Chapter 3 to ensure consistency. When the lecture materials are completed, seven experts and scholars are invited to amend the developed teaching lectures and any unsuitable design. Table 2 shows the results of expert examination. Moreover, according to the revised opinions given by these experts and scholars, the material is corrected and revised.

Table 2: Results of expert examination.

Evaluation Item	Reference Index	Statistical results
1. Publication Features	1.1. easy to understand	4.7
	1.2. easy to read	4.7
	1.3. printing is clear	4.6
	1.4. neatly printed pages	4.8
2. Goals of Course	2.1. meets the new-tech. demand	4.7
	2.2. meets the demand of the industry	4.2
	2.3. meets the demand of departmental development	4.5
	2.4. the goal is clear	4.9
	2.5. involves the cognitive domain, affective domain and psychomotor domain	4.6
	2.6. fits the student learning level	4.4
3. Content	3.1. the content can achieve the goal of the course	4.4
	3.2. the content includes the fundamental concepts and professional skills	4.7
	3.3. the content is correct and the writing is smooth	4.6
	3.4. the content meets the demand of skill learning	4.7
	3.5. the amount of content is appropriate	4.4
	3.6. the difficulty level of the content is appropriate	4.8
4. Organisation	4.1. the structure is suitable	4.8
	4.2. the content progresses from the fundamental to difficult level	4.5
	4.3. the content is expandable and associable	4.7
	4.4. good connection with every teaching element	4.3
	4.5. the content is logical and well organised	4.8
	4.6. the content is concerned with theory and practical skills	4.6
5.Teaching	5.1. the content excites students' interest	4.7
	5.2. the content gives students the ability to be able to think and explore	4.2
	5.3. the content gives student the chance to learn about the modern profession	4.3
	5.4. the content excites students to create and solve problems	4.2
	5.5. the quiz can reflect the learning results	4.2
	5.6. the course can be a feature in the department	4.3
6. Supplementary	6.1. every subject clearly describes the key learning points	4.4
	6.2. the amount of quiz design, homework and reporting is appropriate.	4.6
	6.3. the content fits the experimental equipments	4.9

Remark: Each evaluation item is worth 5 points.

Implementation

This class was offered as an elective in the fall semester, 2007 in the Department of Industrial Education and Technology, National Changhua University of Education, Changhua, Taiwan. The course is called Programmable Virtual Instrument Technology and lasts for 3 hours and is worth 3 credits. There were 39 students enrolled. Figure 4 shows the course inquiry system of the NCUE indicating the status of this course.

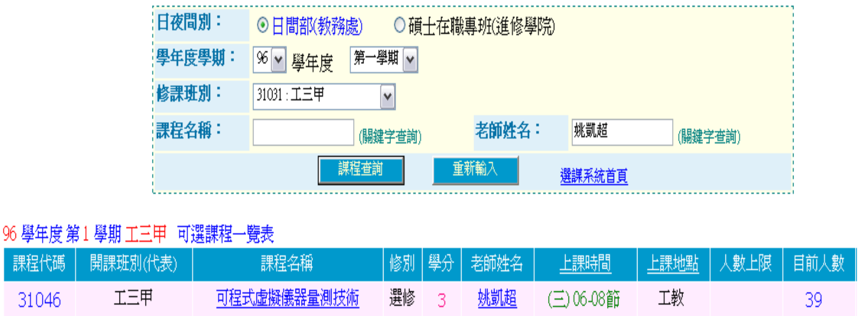

Figure 4: Course inquiry system of NCUE (https://aps.ncue.edu.tw/qry_course.php)

Evaluation

In teaching experimental design, a quasi-experimental design is applied. Pre-test and post-test design method is used in this course evaluation [10]. Bloom proposed a taxonomy for educational objectives in 1956 [11]. According to this theory, the evaluation involves three domains. The evaluation forms that were developed and designed were the cognitive test, affective scale form and psychomotor scale form. Figure 4 shows the schedule of formally evaluating the three domains. These three evaluation tools can be designed and developed during the development and implementation phases.

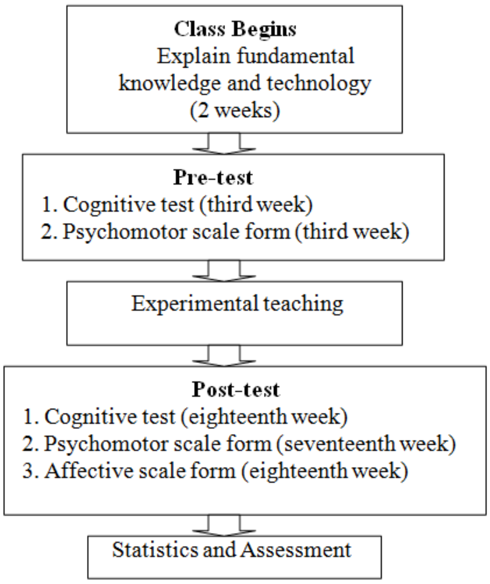

Figure 5: Chart showing the schedule of formally evaluating the three domains.

For the results of the affective domain, Table 3 shows the result of the questionnaire in the affective domain. Thirty-nine students attended the class. The questionnaire was examined by three experts for validity and the Cronbach's alpha value of reliability was calculated to be 0.949.

Table 3: Results of questionnaire of the affective domain.

D	№	Statistical results
一	1	94.8% think the content of teaching material is correct and easy to read
	2	92.3% think the amount of content is appropriate
	3	76.9% think the difficulty of the teaching material is suitable
	4	89.7% think the content of teaching material is logical and well organised
	5	84.6% think the teaching material has a good connection with the teaching
	6	92.3% think the teaching material clearly explains professional concepts in all aspects
	7	89.8% think the teaching material is concerned with theory and practical skills
二	8	97.4% think the goal of each chapter clearly expresses the key points of learning
	9	89.7% think the teaching material can stimulate the personal learning motivation and interest
	10	84.6% think the teaching material can provide personal learning desire and exploration
	11	94.9% think the teaching material can provide a opportunity to learn a different technical profession
	12	89.7% think the quiz properly assesses the learning
	13	97.4% think the teaching material corresponds with the experimental equipment
	14	84.7% think the teaching material includes enough professional knowledge in virtual instrument measurement
三	15	84.6% think the course helps to increase the ability of LabVIEW programming and analysis
	16	89.8% think this course promotes personal knowledge and skills in a new measurement field
	17	92.3% think the course promotes knowledge and skills in understanding the structure of computer measurement instrument
	18	76.9% think this course promotes personal knowledge and skills in measurement operation
	19	89.7% think this course promotes personal multidimensional profession
	20	87.2% think this course promotes personal competing ability in profession
	21	87.1% think this course offers a personal professional advantage for future jobs
四	22	97.4% think the virtual instrument is superior in cost than the traditional one
	23	89.7% think the virtual instrument is superior in repairing to the traditional one
	24	97.4% think the virtual instrument is superior in function update to the traditional one
	25	87.2% think the virtual instrument is superior in convenience to the traditional one
	26	87.1% think the virtual instrument is superior in application to traditional one
	27	92.3% think the virtual instrument is superior in adding functions to traditional one
	28	87.1% think the virtual instrument will replace the traditional one

CONCLUSIONS

This research combines the theory of technological vocational education and practical programming skills to develop a modern and industry-needed oriented virtual instrument technical course and teaching materials. This development process ensures the teaching materials will satisfy students, instructors and industry people. This course not only provides professional knowledge, software design practice and technical operation, but also gives students a chance to learn modern industrial technology. The completion of this research will increase the technological literacy of the measurement field of technological vocational students and will give students advanced professional knowledge and higher technological ability, helping them to compete for future jobs.

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