

Course and technique development of virtual physiological signal measurement instrument technology

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ABSTRACT: The main purpose of this study is to develop teaching material and laboratory experimental equipment for the most advanced physiological signal measurement that is programmable by integrating virtual instruments. Further, the results of the research will be arranged into a three-hour technical class each week. 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 set of measurement circuits. The software aspect utilises LabVIEW to design the front panels and physiological signal processing programs. This makes users operate the computers in the same way as traditional physiological measurement instruments designed by themselves. 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. Also, expert examination will help correct the teaching materials and any unsuitable design.

INTRODUCTION

Physiological measurement systems are required as equipment for diagnosis in hospital. They are used to measure patients' physiological status such as electrocardiogram (ECG), electroencephalogram (EEG), blood pressure, respiratory ventilation and so on. Doctors can base these on measured information to both diagnose and treat. These physiological measurement systems are extremely important in the medical industry. Although these instruments and equipment have been widely used, combining virtual instrument technology to achieve a physiological measurement purpose is a very advanced technological endeavour. Utilising virtual instruments to achieve physiological measurement will decrease the cost and have diverse applications such as making the instruments programmable, remote measurement, nursing senior citizens and remote medical diagnosis.

A virtual instrument, with computer technology and modern acquisition measurement technology, is a new and stylish high-tech product. 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 special traditional equipment he/she designed. The appearance of the virtual instrument technology breaks through the mode of the traditional instrument being defined by the manufacturer and the user not being able to change it. Given sufficient space to utilise their ability and imagination, users can design their own instrument systems to satisfy various application demands [1].

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. These 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. Many exciting experiments can be designed and demonstrated by integrating these powerful virtual instrument technology products in a flexible laboratory environment with enormous possibilities for expansion and experimentation [2][3]. Based on research reported in the literature, some related education theories of course arrangement and design are collected and shown in Table 1.

COURSE DEVELOPMENT PROCESS

The Analysis, Design, Development, Implementation and Evaluation (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 possible. According to the various course development theories, a new course development theory has been constructed and named the *spiral-ADDIEE&R model*

[4-8]. It is designed to develop an up-to-date technical course. The six phases of the *spiral-ADDIEE&R model* are designed and applied throughout training programme. After building the training programme, the other phases do not end once the training programme has been carried out. The six phases work like a spiral loop. They are continually repeated to see if further improvements can be made. Figure 1 shows the instructional design process.

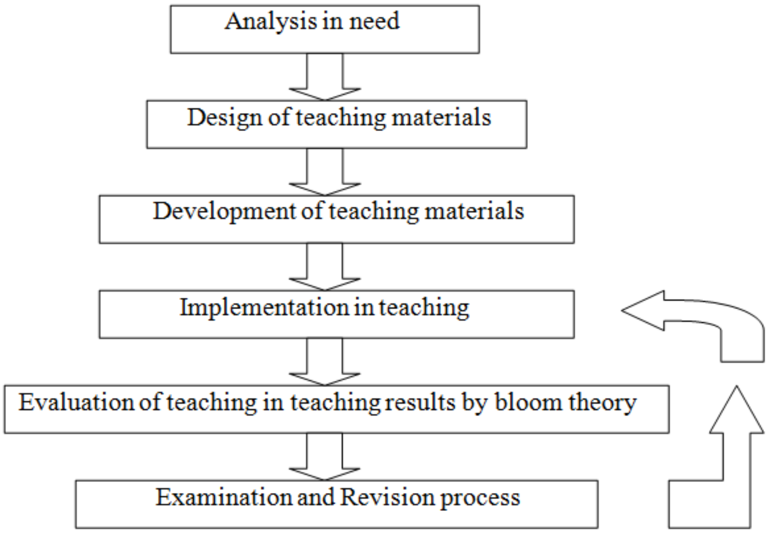

Figure 1: The flow chart of the development process, *spiral-ADDIEE&R method*.

Table 1: Comparison of different course development theory.

Mode	Scholar	Process
Goal mode	Tyler	1. teaching goal analysis 2. choosing teaching content 3. course arrangement and teaching materials arrangement 4. teaching and evaluation
Composite mode	Kerr	1. goal 2. knowledge 3. experience 4. evaluation
Circumstance mode	M. Skilbeck	1. circumstance analysis 2. setting goal 3. course design 4. implementation 5. evaluation
Development of vocational course mode	Finch & Crunkilton	1. course design 2. content construction 3. teaching course
Circle mode	Wheeler	1. analysis in teaching goal and experience 2. choosing teaching content 3. organising teaching content 4. teaching and evaluation 5. return to the first step
ADDIE mode (ISD)	Macchia	1. analysis 2. design 3. development 4. implementation 5. evaluation
Teaching system design mode (ISD)	Dick & Carey	1. decide class goal 2. characteristics analysis of learner and teaching 3. behaviour goal 4. development on teaching strategy, teaching material and teaching evaluation scale 5. formative evaluation 6. summative evaluation

Analysis in Need

Five steps are followed: (1) Literature analysis, manpower analysis and equipment analysis; (2) Restriction analysis; (3) Consulting experts; (4) Student interview; (5) Content analysis. In the research process, after literature probe, consulting with experts and interviews with students. A clear and definite arrangement is shown below:

1. *Virtual physiological measurement instruments*: contain the often seen physiological measurement instruments such as EOG, ECG and EEG.
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 physiological measurement instruments such as multi-function ECG; moreover, enable make students to apply it in the remote monitoring and control systems.
4. *Laboratory equipment*: computer Pentine IV, DAQ card PCI-6251 M Series and LabVIEW7.1.

Design of Teaching Materials

Five steps are followed: (1) Class outline; (2) Order of subjects; (3) Section topic and time arrangement; (4) Chapter arrangement; (5) Course plan design. In this process, class outline, order of subjects, chapter arrangement and time arrangement of topics and course plan are built. Table 2 shows the design.

Table 2: Class outline design.

Ch.	Subject	Content	h
1	Introduction	Introduction to Physiological Signal Measurement Technology	3
2	Virtual instrument and LabVIEW	(1) Introduction to virtual instrument (2) LabVIEW	3
3	Introduction to experimental equipments	(1) KL-720 (2) Operation platform (3) Introduction to experimental boards (4) Quiz	3
4	RS-232 interface	(1) Introduction to serial port (2) Connection test of serial port (3) Quiz	3
5	Software setting and introduction	(1) Serial port setting (2) Data reading and transfer (3) Quiz	3
6 to 14	*Operation, design and experiment of virtual body impedance measurement instrument *Operation, design and experiment of respiratory measurement instrument *Operation, design and experiment of virtual pulse measurement instrument *Operation, design and experiment of virtual blood pressure measurement instrument *Operation, design and experiment of virtual photo-plethysmography measurement instrument *Operation, design and experiment of virtual electromyography measurement instrument *Operation, design and experiment of virtual Electroencephalography measurement instrument *Operation, design and experiment of virtual electro-oculography measurement instrument *Operation, design and measurement experiment of virtual electrocardiography measurement instrument (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) Experimental equipments (4) Measurement experiment (5) Discussion (6) Homework and report (7) Quiz	33
15	Measurement data Saving design (advanced design I)	(1) Data saving design (2) Quiz	3
16	Data loading, printing, exit and close functions design (advance design II)	(1) Data loading design (2) Printing design (3) Exit function design (4) Close function design (5) Quiz	3

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

Development of Teaching Materials

Six steps were followed: (1) Technical experiment; (2) Writing demonstration section; (3) Participation and presenting papers at national and global congresses; (4) Expert examination; (5) Development of evaluation scale forms; (6) Pre-test. The complete teaching materials are written based on Chapter 14 as indicated in Table 2, to set an example of consistency. When the lecture materials were complete, seven experts and scholars were invited to correct the developed teaching lectures and any eliminate unsuitable design. Table 3 shows the results of expert examination. Moreover, according to the revised opinions given by these experts and scholars, the material is corrected and modified.

Implementation in Teaching

The class will be offered as an elective in the 2010 spring semester in the Department of Industrial Education and Technology, National Changhua University of Education, Changhua, Taiwan. This course will be named Programmable Physiological Signal Measurement Technology, will last for three hours and be worth three credits. In the class, a quasi-experimental design will be performed. The developed evaluation scale forms will be used by applying Bloom's theory to evaluate the cognitive domain, affective domain and psychomotor domain.

Examination and Revise Process

In the final process, the examination will be performed based on the evaluation results and defects will be revised. After completing this step, the overall course development process will return to its implementation in teaching for further improvement as shown in Figure 1.

Table 3: Results of expert examination.

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

Remark: The maximum score for each evaluation item is 5 points.

DESIGNED PROGRAMMABLE PHYSIOLOGICAL SIGNAL MEASUREMENT TESTS

Figure 2 shows the locations of the electrodes and practical measurement test of the constructed virtual electro-myography instrument in Chapter 11 in Table 2. Figure 3 shows the locations of the electrodes and practical measurement test of the constructed virtual electro-encephalogram instrument in Chapter 12 in Table 2. Figure 4 shows the locations of the electrodes and practical measurement test of the constructed virtual electro-oculogram instrument in Chapter 13 in Table 2. Figure 5 shows the locations of the electrodes and practical measurement instrument test of the constructed virtual electro-cardiogram using Lead I method in Chapter 14 in the same table.

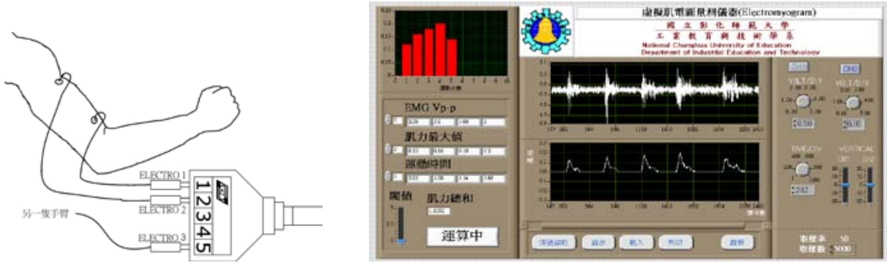

Figure 2: Virtual electro-myography measurement instrument test.

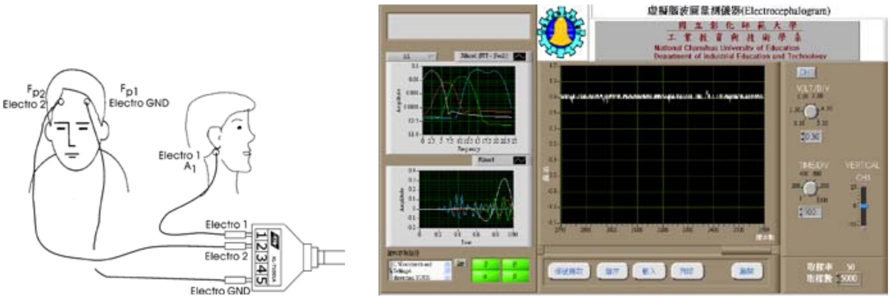

Figure 3: Virtual electro-encephalogram measurement instrument test.

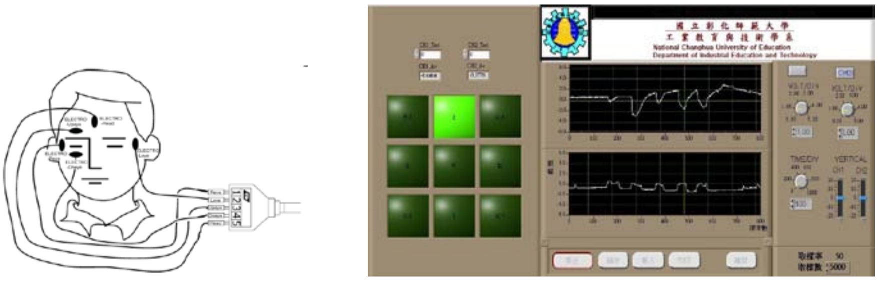

Figure 4: Virtual electro-oculogram measurement instrument test.

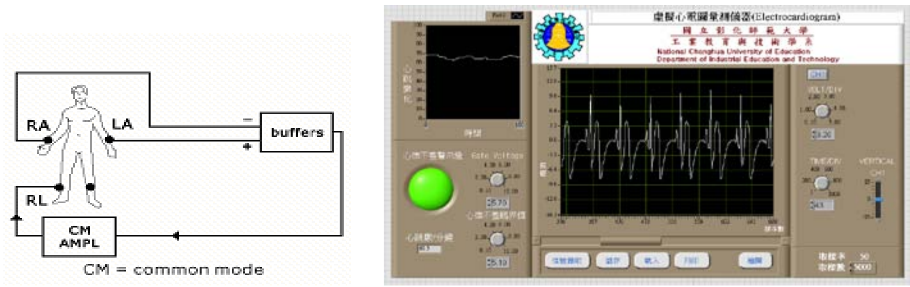

Figure 5: Virtual electro-cardiogram measurement instrument test.

CONCLUSION

This research contains industry-needs oriented technology – physiological measurement of the medical industry, advanced technology – virtual instrument, integrated medical knowledge – physiology, course arrangement and design, teaching and evaluation proposal. An industry-needs oriented virtual physiological signal measurement instrument course is developed in this research. This proposed development process, spiral-ADDIEE&R, ensures the teaching materials will satisfy students, instructors and industry people. This developed course not only provides professional knowledge, software design practice and technical operation but also gives students a chance to learn modern physiological measurement technology. The completion of this research will make students learn both electrical technology and physiological science. This will promote the technology literacy of technological and vocational university students in Taiwan.

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