RESEARCH ARTICLE

Study of Essential Norms and Standards for Electrical and Electronical Experiment Teaching

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Abstract: To realize the teaching goals in cultivating students'ability of conducting self-study,freely implementing of knowl- edge,developing scientific research skills,establishing team collaborative spirit,nurturing the innovative capacity and comprehensive quality,four universities led by Southeast University have conducted joint survey and design. Finally,we formulate the essential experi- ment teaching norms and standards regarding the required knowledge for experiment,experiment skills,technical methods for experi- ment,practice capacity and comprehensive qualification. The norms and standards have proven to generate fruitful and positive effects on experiment teaching.

Keywords: Electrics and electronics; experiment teaching; teaching norms and standards

The experimental teaching of Electrotechnics and electronics basic course is oriented to electrical engineering, electronic information, automation, computer and other specialties. It has the characteristics of serving a large group of students, cooperating with many theoretical courses and teaching hours of experimental teaching.

However, the current electrician and electronic experiment teaching lacks the system integrity, the clear detailed experiment teaching standard request, the teaching lacks the instruction norm rule. Most of the teachers based on their own understanding of the teaching objectives, organized to carry out teaching; teachers lack of comprehensive and systematic learning ways, mainly rely on their own experience accumulation and mutual exchange; students in learning and practice to obtain experimental basic knowledge, In the open and autonomous teaching practice, students can not get timely and effective guidance when they encounter problems.

A research group composed of the national and provincial electrician and electronic experimental teaching demonstration centers of Southeast University, Nanjing University of posts and Telecommunications, Nanjing normal University and Nanjing Institute of Engineering, in order to train students to study independently and carry out practical projects, The aim of exploring and innovating comprehensive ability quality is to develop it from several aspects, such as the basic teaching requirement, the teaching implementation scheme, the construction of environmental conditions, and so on.

The research and design of the basic standard of electrical and electronic experiment teaching.

1. Subject research method

The schools of the members of the research group are the comprehensive universities with the characteristics of engineering, the universities of engineering majoring in electricity, the comprehensive universities of arts and science, and the universities of applied undergraduate, etc. The training items have their own characteristics. The research group makes full use of its own advantages, collects widely statistical teaching objectives and training requirements, and develops the practice of teaching and learning.

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1.1 Collect samples of teaching needs

According to the teaching requirements of electrical engineering and electronic information specialties in different types and different levels of schools at the level of basic courses[1], according to the requirements of electrical engineering and electronic information industry for personnel training specifications[2], according to the requirements of engineering education professional certification, according to the experimental teaching training Students'basic abilities and accomplishments of self-study, knowledge application, scientific research, engineering practice, teamwork, and exploration and innovation enable them to learn to study independently, learn to do learning, learn to research and explore and learn to design innovative goals in practice, and widely collect requirements and objectives from all aspects.

1.2 Basic standards of design teaching

According to the sample information collected, combined with the current educational ideas, teaching system contents, the transformation and renewal of teaching technology and methods, statistics, induction, summary and formation of experimental knowledge, experimental skills, technical methods, practical ability, Comprehensive quality of five aspects of the development of experimental teaching comprehensive, clear, detailed basic standard of the subject research objectives[3].

1.3 Designing teaching facilities

The purpose of establishing teaching standard is to use the standard to guide teaching content setting, teaching process design, teaching mode reform, examination mechanism construction and so on in order to achieve the basic goal of experimental teaching. The project group designed a whole

The system of electrician and electronic experiment demonstration teaching is applied in their respective schools, and the basic teaching standards are adjusted and perfected in teaching practice.

1.4 Summarize the research results

Through the teaching practice test, the paper summarizes and condenses, forms the elementary achievement of the basic standard of teaching, and puts forward the requirements of the practice environment.

2. Basic standards of experimental teaching

After more than two years of research and practice, the formation of experimental knowledge, experimental skills, technical methods, The basic standard of electrician and electronic experiment teaching is composed of the index system of 130 detailed rules of 38 major categories and 5 aspects of practical ability and comprehensive quality. As shown in tables 1 to 5.

experiment specification	Power generation and transmission	Electrical energy generation, power transmission, voltage level, electrical equipment and facilities
	Electricity safety knowledge	Power supply facilities and circuits in experimental sites
		Safety voltage, safe current, electric shock prevention and rescue
		Grounding of electrical equipment, shielding
	Experimental operation specification	Access to laboratory requirements, equipment access, safety and hygiene
		Preview, booking, allocation, acceptance, examination
		Equipment operation, circuit test, electrification test

Electronic element characteristics	Device recognition	Resistors, potentiometers, capacitors, inductors, diodes, Triode MOS transistors, keys, switches, displays
	characteristic parameter	
	parameter measurement	
	Application characteristics	
Structure and Application of Electrical equipment	structure function	Contactors, buttons, fuses, autotransformer, relays, delay relays, DC motors, AC three-phase motors
	Parameter specification	
	Application condition	
	Application characteristics	
Object and method of measurement	Electric energy parameter	Current, voltage, power
	Electrical signal feature	Waveform, amplitude, frequency, phase, noise logic state
	circuit parameter	I / O impedance, quality factor, device parameters, gain, distortion
	characteristic curve	Transmission characteristic, volt-ampere characteristic, frequency characteristic, load characteristic
	measuring method	Direct measurement, indirect measurement, combined measurement, comparative measurement

Table 1. Experimental knowledge

Universal instrument and equipment	Instrument and equipment	Function classification, application object, range, precision,
	DC voltage stabilized source	Working principle, Application method: independent, Series, parallel
		Function parameters: voltage, output power, output stability, load adjustment rate, ripple noise
	digital multimeter	Implementation principle, usage method: wiring method, function selection, working mode
		Selection method: measuring object, range, accuracy

Table 2. Experimental skills General purpose equipment	Digital scope	Working principle,application:Frequency, voltage noise, Electromagnetic radiation measurement,pectrum analysis
		Operation method : range , accuracy , input impedance , input voltage range ; Pattern , coupling , spirit Sensitivity , time base , trigger , measurement ; Waveform , amplitude , frequency , phase
	signal source	working principle
		Function selection:resolution, range , output impedance , output power;Frequency,amplitude,wave Shape,DC offset , duty cycle,modulation, sweep output
	Meter	Measurement object : Current , voltage , power , phase angle, power factor

dedicated equipment	Transistor characteristics Tester	Diode , Zener , Bipolar Transistor , Field Effect Tube Characteristics Test
	logic analyzer	Sampling trigger mode , storage depth
	Digital sweeper	Passive RCL Network,active amplifier amplitude-frequency characteristics,phase-frequency characteristics test
	High voltage isolation probe	Measuring range , measurement accuracy
	Programmable voltage source	Voltage range , current output capability , voltage accuracy , voltage stability , ripple
	Spectrum Analyzer	Measuring range , center frequency , frequency resolution ; Tracking source
Cable	Cable category	Single-strand hard wire , multi-strand flexible wire , shielded cable
		Cable impedance characteristics and applications
Connector	Classification and characteristics	BNC,DIP Socket,banana plug,phoenix terminal,air connector
	use	Power connection (current) , circuit connection (lap mode) , channel connection (Signal strength , frequency Range , impedance matching)
design Simulation software	Application software classification	Spice , Multisim , Matlab , Protel , Labview , FilterPro , SwitchPro Wait
	Basic use	
	Application skills	
Common circuit	Signal generation	555 Oscillator,Venturi oscillator circuit,crystal oscillator circuit,
	Signal conversion	Voltage and current conversion , isolation coupling , voltage divider , current limit , V / F , F / V , ADC , DAC , difference Points / Common mode , impedance conversion , zero-crossing com-
	signal input	Switch input , press button lose Into, elimination shake Dynamic and electric level turn Change , logic Series Electricity Flat and poor Minute letter Number , Bridge
	Display circuit	Status display , data display , curve display
	Drive circuit	Voltage amplification , current drive , LED Drive , relay drive , DC motor drive , step Into motor drive , audio power drive , digital tube drive

Voltage source selection	Voltage source circuit	Linear DC voltage source , series regulator circuit , integrated voltage regulator circuit , switching power supply , photovoltaic power supply
	Voltage source Main characteristic parameter	Voltage stability , voltage accuracy , ripple , load regulation , voltage regulation
	Use of voltage source	Digital circuit power supply , analog circuit power supply , isolated power supply , reference power supply

Table 2. (Continued)

Circuit basis[4]	Linear component	R , C , L Component volt-ampere and frequency characteris-
	Instrument and equipment characteristics	Scope of application , measurement object and range accuracy
	Circuit law application	Circuit Theorem Verification Circuit Design , Parametric Testing and Verification
	Passive network characteristics	Passive dual port network volt-ampere and frequency characteristics
	Active network characteristics	Active network equivalent analysis and volt-ampere , frequency characteristic test
	Resonance circuit research	Resonance realization condition and quality factor
	Controlled source circuit	Controlled source feature analysis , implementation method and effective range
	Voltage source characteristics	Accuracy , stability , power , noise , voltage regulation , load regulation , power Pressure source implementation method
	Current source characteristics	Accuracy , stability , voltage range
	AC circuit test	AC circuit current , voltage , power measurement and analy-
	Power factor and its djustment	Power factor adjustment method and adjustment degree
	AC circuit control	AC circuit design , implementation and commissioning
Analog circuit Design[5]	Diode characteristics and applica-	Rectification , detection , voltage regulation , illumination , variable volume
	Triode circuit asic parameters	Static operating point adjustment,input and output impedance,signal distortion cause analysis,transmission Sex,frequency characteristics

	Transistor characteristics and Typical application circuit	Common circuit , common-emitter circuit , common-base circuit application characteristics
	FET characteristics and Typical appli-	Common source circuit , common drain circuit , common gate circuit application characteristics
	Differential amplifier circuit	Differential mode common mode signal , basic differential amplifier circuit characteristics , current source circuit
	Multi-level feedback amplification circuit design	Multi-stage amplifier function setting , input impedance design , gain distribution , output power setting Meter, feedback de-
	Power amplification	Class A and Class B amplifiers , C and D Class power amplifier , set success, etc
	Signal generation and conversion	Signal generation and sine wave , pulse wave , triangle wave , pulse wave conversion
	Operational amplifier basic applica-	Co-directional , reverse proportional amplification , basic arithmetic circuit , comparator , detection rectification
	Op amp gain con-	Multiple gain control methods
	Multi-stage operational amplifier circuit design	Input and output impedance , impedance matching , gain distribution , bandwidth , bandwidth gain product , band Internal gain fluctuation
	Filter circuit design	Low pass , high pass , band pass , band stop filter ; Multi-order , high-order filter , with internal wave Dynamic and out-of- band attenuation
	Linear power supply design and implementation	Buck , rectification , filtering , voltage regulation , voltage regulation
	DC/DC Voltage conversion circuit	Rise / Buck , isolation / Non-isolated circuit basic configuration , input voltage range , output power Pressure control
digital Logic circuit	Gate characteristics	Level and voltage , sink current / Pull out current , rise and fall edge time , door power Road delay , output voltage and current relationship
	Combinational logic design	Driver , buffer , tri-state gate characteristics and uses , level Shifting,
		Logical combination,conversion,coding / Decoding,logic operation circuit,
		Logical operation,simplification
	Sequential logic design	Trigger,shift register,counter,variable range counter,variable step counter

Hybrid logic design	Calculator , state machine , controller , memory	

Table 3. Technical method Digital model Hybrid circui

	Analog to digital converter ADC	Conversion mode , conversion speed , conversion accuracy , input voltage range , reference voltage
	Digital to analog converter DAC	Conversion speed , conversion accuracy , output mode (Voltage / Current) The output voltage / Electricity Flow range
	Gain control	Digital potentiometer , analog switch switching resistor , relay switching resistor
	Voltage control	Digital potentiometer , analog switch switching resistor , relay switching resistor
FPGA application	Hardware description language design	VHDL , Verilog
	Design simulation software use	Quartus , ISE
	Digital system design method	System structure design , top-down , bottom-up design method , human-computer interaction channel design
electronic system design	Electronic system design method	Electronic system structure , system design method
	Microprocessor selection and application	MCU , embedded processor , DSP
		Digits , frequency , command system , IO Interface , power consumption , memory configuration , debugging surroundings
	Sensor characteristics and detection circuit	Temperature , humidity , illuminance , gas , weight , speed , acceleration , position , position Shift , angle , electric field , magnetic field sensor and detection method thereof
	Actuator and its driver	Voltage amplification , power drive , motor control , electromagnetic mechanism control
	Human-computer interaction channel	Buttons , switches , knobs , dials , touch screens ; Indicator light , digital tube display , LCD , vibration , sound

Table 3. (Continued) experimental design

	Basic Information	Course name , experiment name , time , location , class , student number
	Experimental principle	Theoretical basis, experimental ideas
	Experimental program	Implementation method , experimental steps , expected goals

	Circuit design	Circuit design , component selection , simulation optimiza-
	Measurement methods	Measuring method , measuring instrument , measuring cir- instrument selection
	Experimental process	Experimental procedure , operation , measurement sequence
	data record	Data table design , data record
	Result analysis	Data processing , error analysis , performance analysis
Circuit design	Circuit selection	Typical application circuit structure model selection
	Circuit design	Circuit modification , homemade design
	Device selection	Specifications , parameters , accuracy , power , material , withstand voltage , current , package
	Module selection	Existing device , circuit , module selection
	Matching parameter	Input and output parameters
Circuit imple- mentation	Way of realization	Breadboard , universal orifice , printed circuit board
	Implementation	Component selection , circuit layout , component plug-in , wire bonding
Debug test	Debugging method	Unit circuit debugging , module debugging , cascade de- bugging , system joint debugging
	Debug content	Circuit continuity , voltage status , operating point , circuit function ,
	Circuit test	Static test , dynamic state , limit test
Troubleshooting	Fault type	Power supply and ground , instrumentation failure , circuit connection , poor contact , device damage , impedance Matching , electromagnetic interference
	Failure analysis	
	Troubleshooting	
	Troubleshooting check analysis	Power open circuit , short circuit , over current , frequency range , over voltage , under voltage , power line voltage drop , total Ground and grounding point ; Instrument self-test , input and output impedance , coupling mode , attenuation ratio , insurance Wire state , probe open circuit ; Wiring error , not connected , disconnected cable , poor contact , virtual Soldering ; device damage , component blown , capacitor short circuit ; Power supply ripple , device noise , environmental drying Disturbance; Inter-stage parameter coordination and distribution parame- ters
Parameter measurement	Instrument selection	Excitation source , frequency , amplitude , output imped-
	Parameter Type	Resistance measurement , capacitance measurement , in-
	Measuring circuit	

	Measurement methods	ductance measurement , DC voltage and current measurement , AC voltage and current Measurement , waveform measurement , high frequency signal , Q Value , gain , input impedance , output impedance
data processing	Form design	Structural design , parameter selection (direct , indirect) The data unit
	data record	Digital selection , recording order
	data analysis	Authenticity , rationality
	data processing	Calculation , processing (average , denoising, etc.) , sorting , display
	Data representation	Data list , curve , histogram , pie chart ,
Error Analysis	effective number	The number of digits read by the instrument is selected , and the number of digits in the data is selected.
	Error category	Absolute error , relative error , reference error
	Source analysis	Instrument accuracy , device parameter accuracy , observation error, contact resistance , power supply noise , line division Cloth parameter loss , impedance matching , electromagnetic coupling interference
	Error estimate	
	Error elimination	Correction , Substitution , Cancellation , Transform Range , Average , Root Mean Square , Smoothing Filter , Bad Value Eliminate
system design	demand analysis	Engineering social application background , technical method research status , expected target function index , application measurement Test method
	Environmental establishment	Instrument equipment , device modules , processing and production , software tools , development environment , financial sup-
	System planning	Functional indicators , implementation methods , program demonstrations ; System software and hardware structure , module division , implementation Process; Project process , manpower allocation
	hardware design	Circuit design , component selection , simulation optimiza-
	System implementa-	Software design , hardware installation , soldering , debug-
	software design	Standardization , generalization , modular design , commissioning
	System test	Module function debugging , system joint debugging , functional testing , indicator testing ; Operability , stability Sex and reliability testing ; System Optimization
	analysis Summary	Implementation method design optimization,expected target achievement,results expansion and promotion prospects

	Show speech	Design summary report , exhibition board , PPT Design , speech design

Table 5. Comprehensive quality

Table 4. Practical ability Innovative thinking and	Sensitivity,comprehension,creative idea,creative passio; Creativity,logic,deductive reasoning
Literature search data analysis	Literature search , data retrieval , information statistics , comprehensive analysis
Problem analysis engineering modeling	Active learning , lifelong learning , a combination of theory and practice
Program design evaluation	Information resources , self-ability , knowledge structure , environmental conditions , core issues , difficulties ,
Knowledge integration system design	Self-learning , acquiring knowledge , flexible use , and fusion of knowledge methods
Software design simulation optimization	Theoretical derivation , modeling analysis , system design , simulation optimization
Strive for resources to create conditions	Query information , create conditions , build environments , get help , seek support
Engineering implementation of comprehensive testing	Project implementation , engineering implementation , functional commissioning , performance testing
Comprehensive evaluation of project performance	R&D , operational cost accounting , effectiveness , cost performance , reliability , stability analysis
Integrated project management	Task division , targ*et al*location , resource use , manpower allocation , process scheduling
Teamwork communication and coordination	Organizational leadership , relationship coordination , academic exchange , creating an atmosphere
System summary speech expression	Design summary , performance analysis , project outlook , written , language expression , self-presentation

3.Comprehensive environmental requirements for experiments

The Electrotechnics and electronics experiment teaching should fully meet the needs of students'information retrieval, self-study, research and exploration, design simulation, production test, summary and exchange, such as research, design, analysis, simulation, experiment, production, welding, test, extra-curricular research, subject competition and so on. Full openness should be achieved in time, space, content and resources. Students can study and practice independently anytime and anywhere, and can receive guidance, support and help[6]. In order to implement the basic standards of experimental teaching, the requirements for comprehensive environment construction, such as experimental teaching conditions, equipment conditions, teaching resources, operation mechanism, open management and information management, are put forward.

3.1 Requirements for experimental equipment and teaching resources.

3.1.1 Experimental teaching conditions

The laboratory should have the functions of teaching demonstration, discussion speech, information inquiry, installation and welding, debugging and testing, writing reports and other teaching and practical forms.

3.1.2 Experimental instruments and equipment

The laboratory should be equipped with voltage source, digital multimeter, signal generator, digital oscilloscope and other general experimental instruments, as well as logic analyzer, frequency sweeper, transistor tester, bridge, RCL tester, virtual instrument and other special equipment. And equipped with electronic circuits, alternating current circuits, FPGA/CPLD, microcontroller/embedded systems, and electronic circuits, alternating current circuit design, analysis, simulation, debugging and production of software tools, temperature, humidity, illumination, weight, sound, speed, angle and displacement as the object of measurement or Control objects, etc.

3.1.3 Requirements for teaching resources

The experimental center should construct a website of experimental teaching information resources which is often updated to provide teaching contents, curriculum arrangement, electronic teaching plans, teaching videos, knowledge and methods, technical programs, engineering cases and other auxiliary teaching resources.

3.2 The operation and management mechanism of experimental teaching.

3.2.1 Laboratory Configuration

The experimental center should set up comprehensive laboratories at different levels, such as functional basis, professional basis and professional level, so as to improve the utilization of space and equipment resources.

3.2.2 Operation and management system

Establish the maintenance and maintenance system of instruments and equipment to ensure the equipment intact rate; establish a variety of post responsibility system to ensure the order of experimental teaching.

3.2.3 Open management mechanism

There should be plenty of open time and open space; there should be open management mechanism such as reservation, assignment, login, withdrawal, and so on; there should be the use mechanism of instruments and equipment, experimental platform, components and other resources suitable for personalized experiments.

3.2.4 Safety guarantee mechanism

Establish safety and accident emergency handling mechanism, equipped with security, fire fighting facilities and accident handling supplies.

3.3 Information management in experimental teaching

In view of open individualized experiment teaching, information aided teaching is adopted.

With the process management system, it should cover the implementation of the curriculum organization plan, the overall arrangement of the teaching process, the statistics of the examination and evaluation results, the multiple channels of interaction between teachers and students, the management of appointment and assignment, the approval and issuance of device applications, the collection of experimental information on the spot, the submission and correction of electronic reports, the management of the process of practical projects, and the test questions. Educational management and quality assurance functions such as volume survey, equipment and equipment management.

4. Implementation of research results

4.1 The basic standards of electrical and electronic experimental teaching are applied and tested in the schools of the research group members first

The Electrotechnics and electronics experimental center of Southeast University aims at cultivating students'abilities of independent research, knowledge synthesis, innovative design and engineering realization. It focuses on improving the quality of research and exploration, innovative thinking, communication and teamwork. It reforms the innovative curriculum system, carefully designs experimental projects, optimizes the teaching process and integrates them. To

create a practical environment, to create an information management system, to create both innovation, practicality and popularization, highlighting the independent study of electrical and electronic practice courses. The construction of the project has broken the situation that many electrician and electronics experimental courses are independent of each other and difficult to carry out comprehensive engineering practice; solved the problems of simple experimental verification knowledge, students'self-study, analysis and research pressure and space shortage; solved the problems of direct teaching in the past, inadequate analysis and guidance, task gradient and task gradient. There are many problems such as the unity of levels and the lack of teaching students in accordance with their aptitude. In the course of teaching practice, curriculum reform and teachers try to change propositions and conditions to guide students to explore, construct knowledge and understand rules independently and cultivate students'autonomous learning ability. Let students understand the functions and principles of the system.

4.2 Appropriate variants, promote divergence

The purpose of variants is to guide students to explore physical problems from various angles. The experimental design aims to guide students from the "changeable" physical quantity and conditions to discover the essence of "unchangeable" physical laws, explore its principles and laws from the "unchangeable" nature, cultivate students'divergent thinking and develop their creativity.

4.3 Problem Leadership, Enlightenment Wisdom

Expanding the problem around the construction of binary phase shift keying frequency band transmission system model, meticulous questioning, flexible questioning, stimulate students'enthusiasm for inquiry, cultivate students' thinking quality, guide students to grasp research and solve the problem of multiple strategies for students to build a scaffold for thinking, Let students build their own knowledge. Under the guidance of the problem, students carefully observe the simulation results, start thinking to a deeper level, the ability to improve.

5. Concluding remarks

Through the combination of software simulation and theory in the digital signal frequency band transmission experiment, the students'enthusiasm and initiative are aroused, so that they can grasp the relevant concepts and principles more systematically and profoundly. Simulation technology has changed the form and content of experimental teaching of communication principle course, made up for the deficiency of traditional experimental teaching in teaching means, provided abundant perceptual materials, and made abstract physical laws more visualized. Practical ability has been trained, and remarkable teaching results have been achieved. At the same time, it has laid a good foundation for students to continue to work and study in relevant professional fields.

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