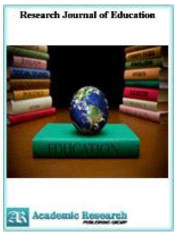

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Curriculum Design, Implementation and Evaluation of Chemical

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Abstract: Curriculum design can be understood as that the sum of a teacher's personal efforts in preparing and finishing each lesson, which normally includes design, implementation and evaluation. To ensure teaching efficiency: (1) the teacher should elaborately design each lesson basing on teaching objectives; (2) actualize it with feasible teaching method; (3) inspect and assess the teaching effectiveness according to appropriate method. In this paper, the curriculum design, implementation and evaluation for a 72hour Chemical Engineering Basic course was investigated and discussed. It included the main knowledge units of course basic methods, fluid flow and machine, heat transfer process, mass transfer process, gas absorption, distillation, reactor flow Model, design and calculation. Teaching practices have testified that the careful planning, thorough implementation and scientific assessment cannot only obviously improve teacher's teaching level, but also ensure teaching quality.
Keywords: Curriculum design; Implementation; Teaching quality evaluation; Chemical Engineering Basic. Knowledge unit.

1. Introduction

Curriculum means study or syllabus. Its wider definition is all the planned learning experiences of a school or educational institution. While, curriculum design is the sum of a teacher's personal efforts in preparing and finishing each lesson. A curriculum plan should include four parts of the purpose of the curriculum (goals for learning), content and sequence (the order of the learning), teaching methods and instructional resources, evaluation approaches (Lattuca and Stark, 2009).

Chemical Engineering Basic is an important engineering fundamental professional cause, which is offered for scientific students of chemistry and related majors. It investigates chemical engineering basic principle and equipment of various chemical engineering unit operations involved in industrial processes (Smith *et al.*, 2004; Wang, 1992; Wuhan University, 2009), and acts as a bridge of chemical engineering theory and chemical industry production. Therefore, Chemical Engineering Basic course is normally set as a 72hour required basic cause. To ensure students master the basic principle and calculation method of typical operation units, the scientific curriculum design is very important. In this paper, the course design, implementation and evaluation of Chemical Engineering Basic course are built and investigated. It includes the main knowledge units of course basic methods, fluid flow and machine, heat transfer process, mass transfer process, gas absorption, distillation, reactor flow model and design, calculation. Teaching practices have testified that implementation based on this system can not only ensure teaching quality, but also help to improve teacher's teaching level.

2. Curriculum Design, Implementation and Evaluation Embodiment of Chemical Engineering Basic Course

The curriculum design system of a 72hour Chemical Engineering Basic course was severally embodied as per unit operation.

2.1. Implementing Embodiment of Unit 1: Course Basic Methods

Unit Description: This unit focuses on introducing the basic design and calculation methods in the study of chemical engineering principle, conversion between engineering unit system and SI unit. The specific design contents and implementation methods of Unit 1 are shown in Table 1.

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2.2. Implementing Embodiment of Unit 2: Fluid flow and Transportation Machine

Unit Description: This unit focuses on the introduction of fluid characteristics, microcosmic and macrocosmic flow rules, transportation and metering. The specific design contents and implementation methods of this unit are shown in Table 2.

2.3. Implementing Embodiment of Unit 3: Heat Transfer Process

Unit Description: This unit aims to introduce the heat transfer importance, function and basic mode, heat transfer rate equations of conduction, convective, radiation and the total heat transfer rate of the wall type heat exchange, heat-exchange calculation and equipment. The specific design contents and implementation methods of this unit are shown in Table 3.

Table-1. Design and implementation of Unit 1

Knowledge units	Goals	Contents	Teaching methods	Evaluation approaches
1.1 Mass balance method	Master the mass balance method.	1.1.1 Mass balance for batch process 1.1.2 Mass balance for continues process	Give typical examples such as mass balance for batch evaporation, continues evaporation.	Application of mass balance in the subsequent unit operations.
1.2 Energy balance method	Master the energy balance method.	1.2.1 Heat balance 1.2.2 Mechanical energy balance	Give the typical heat balance equation and energy balance equation based on the conservation law of energy.	Heat balance in heat transfer and mechanical energy balance in fluid flow.
1.3 Equilibrium state and process rate	Familiar with the process rate equation.	Equilibrium state and process rate	Give the general equation of process rate and explain its importance through unit operation instance.	Give special process rate equation and point out its importance in chemical production.
1.4 Dimensional analysis	1.4.1 Master the dimension symbol of fundamental physical quantity 1.4.2 Understand the dimensional analysis method	1.4.1 Dimension symbol 1.4.2 Dimensionless number 1.4.3 Dimensional analysis method	Give the SI unit and dimension symbol of mass, length, time and temperature, and judge dimensionless number such as dimensionless time (θ), Reynold's number (*Re*), and relative density (d_4^{20}) and relative roughness ($\frac{\varepsilon}{d}$).	Judge dimensionless number such as θ, *Re*, d_4^{20} and $\frac{\varepsilon}{d}$.
1.5 Process optimization	Understand the optimizing method.	1.5.1 Purpose 1.5.2 Program 1.5.3 Method	Give an example to illuminate the optimization method.	Process optimization in the subsequent unit operations.
1.6 Unit systems and their conversion	Master the conversion between engineering unit and SI unit.	1.6.1 SI unit 1.6.2 Engineering unit and its conversion to SI unit	Giving typical example such as the conversion of kgf/cm^2 to *Pa*	Unit conversion between engineering unit and SI unit for the subsequent unit operation parameters.

Table-2. Design and implementation of Unit 2

Knowledge units	Goals	Contents	Teaching methods	Evaluation approaches
2.1 Characteristic parameters of fluid	2.1.1 Master viscosity parameter 2.1.2 Master the conversion of pressure units, absolute pressure and gauge pressure 2.1.3 Master the calculation of flow rate	2.1.1 Density and the relative density 2.1.2 Pressure units and forms 2.1.3 Neuton's viscosity law 2.1.4 Flow process rate	2.1.1 Give typical fluids such as water and oil, and compare their physical parameters 2.1.2 Give a picture to show air pressure, absolute pressure and gauge pressure	2.1.1 Density and pressure are check in the mechanical energy balance equation 2.1.2 Viscosity is used in the momentum balance 2.1.3 Flow rate is check in mass balance of fluid
2.2 Fluid flow phenomena	2.2.1 Master the forms of stable flow, calculation of equivalent diameter (*de*) and *Re*, judgment for laminar flow and turbulence flow 2.2.2 Familiar with the principles of velocity distribution, boundary layer, momentum transfer	2.2.1 Stable flow forms 2.2.2 Calculation of *de* and *Re* 2.2.3 Velocity distribution and boundary layer 2.2.4 Momentum transfer of the Newtonian fluid	2.2.1 Laminar flow and turbulence flow phenomena are demonstrated by flash animation 2.2.2 Calculation of *de* is given a series of examples	2.2.1 The influence of flow forms on heat transfer and mass transfer is introduced in the study of heat transfer and mass transfer processes 2.2.2 Calculation of *de* is checked and reviewed in the flow form judgment of fluid in annular pipe
2.3 Mass balance in continuous flowing fluid	Master the continuity equation and its application.	2.3.1 Continuity equation for continuous flowing fluid 2.3.2 Application of continuity equation	2.3.1 Deduce continuity equation based on mass conversion law 2.3.2 Design a typical flowing process, then calculate the flow rate at different section	A typical flowing process is given to calculate the flow rate in different flowing section.
2.4 Mechanical energy balance equation	Master the mechanical energy balance equation, and use it to solve problems such as kinetic energy, pressure-energy, potential energy, lift of pump.	2.4.1 Forms of mechanical energy 2.4.2 Mechanical energy balance equation for continuous and incompressible fluid 2.4.3 Mechanical energy balance equation for continuous and compressible fluid 2.4.4 Application of mechanical energy balance	2.4.1 Give conditions and then obtain different forms of mechanical balance energy equations 2.4.2 Design a typical flowing process, then calculate the kinetic energy, pressure energy, potential energy, lift of pump 2.4.3 Emphasis the application notices such as the unit uniform, form accordance of	A typical fluid flowing process is given for the calculation of kinetic energy or velocity, pressure-energy or pressure, potential energy or height, lift of pump.

		equation	section pressure	
2.5 Fluid statics equation	Familiar with the hydrostatic equation and its application in pressure difference detection with U tube manometer.	2.5.1 Hydrostatic equation 2.5.2 Application of hydrostatic equation	Set the velocity as zero, hydrostatic equation is obtained from mechanical energy balance equation.	2.5.1 Calculation of pressure difference detected with U tube manometer 2.5.2 Calculation of liquid level, height of liquid seal
2.6 Mechanical energy loss	Familiar with the calculation method of mechanical energy loss and the influence factors.	2.6.1 Sorts of resistance and energy loss 2.6.2 Calculation of pipeline friction loss 2.6.3 Calculation of local resistance loss 2.6.4 Calculation of total loss	2.6.1 A analogy method is used for fluid with turbulence flow state in pipeline 2.6.2 A analogy method is used for local resistance loss of equivalent length and local resistance factor	Give some measures to reduce mechanical energy loss.
2.7 Fluid measurement	Familiar with the measuring instrument of fluid flow and pressure.	2.7.1 Measurement of fluid flow 2.7.2 Measurement of pressure or pressure difference 2.7.3 Measurement of velocity	Picture and flash animation are employed to show structure, principle and installation requirements of flowmeter.	Comparison between orifice meter, venture meter and rotameter of structure, principle, installation, correction.
2.8 Centrifugal pump	2.8.1 Familiar with the structure, working principle, aerial binding phenomenon and cavitation phenomena of centrifugal pump 2.8.2 Master the performance parameter and selection of centrifugal pump	2.8.1 Sorts of transportation machine 2.8.2 Structure, principle, performance parameter of centrifugal pump 2.8.3 Aerial binding phenomenon and cavitation phenomena 2.8.4 Sorts and the correct selection	Structure, principle, aerial binding phenomenon and cavitation phenomena of centrifugal pump are demonstrated by related pictures and flash animations.	A typical fluid transportation is given for the calculation of lift of pump, and the correct selection.
2.9 Other transportation machines	Understand the working principle of compressor and injection pump.	2.9.1 Positive displacement machine and its fluid flow control 2.9.2 Injection pump	Structure and principle of compressor and injection pump are demonstrated by flash animations.	Comparison of fluid flow control between centrifugal pump and positive displacement machine.

Table-3. Design and implementation of Unit 3

Knowledge units	Goals	Contents	Teaching methods	Evaluation approaches
3.1 Importance of heat transfer	Understand the importance of heat transfer.	Importance and function of heat transfer.	Give examples of heat transfer in evaporation, distillation and chemical reaction.	Application of heat transfer in evaporation, distillation and chemical reaction.
3.2 Basic mode of heat transfer	Familiar with the basic mode of heat transfer.	3.2.1 Conduction 3.2.2 Convective 3.2.3 Radiation	Heat transfer in still fluid, flowing fluid, and a high temperature metal.	Point out the heat transfer mode in wall-type heat exchange of two fluids.
3.3 Process rate for heat transfer	Master the concept of heat transfer rate and velocity.	3.3.1 Heat transfer rate 3.3.2 Heat transfer velocity	An analogy studies between fluid flowing rate and heat transfer rate.	Point out the similarity between flow process rate and heat transfer process rate.
3.4 Fourier law	Master the Fourier law, its application condition and thermal conductivity.	3.4.1 Concept of temperature field 3.4.2 Fourier law and its application condition 3.4.3 Thermal conductivity	3.4.1 Assisted by pictures to explain the concept of temperature field and Fourier law 3.4.2 Unit and physical significance of thermal conductivity	Compare thermal conductivity of air, water and steel, and give the application in heat transfer.
3.5 Heat conduct equation in wall-type heat exchange	Master the general equation of heat conduct.	3.5.1 Heat conduct equation of single wall 3.5.2 Heat conduct equation of multilayer walls 3.5.3 Heat conduct equation of a tube 3.5.4 Heat conduct equation of multilayer tubes	3.5.1 Based on Fourier law, the series heat conduct equations are deduced in the order of from simplicity to complexity and from particular to ordinary 3.5.2 An analogy method is used in the inference of heat conduct equations	3.5.1 Comparison between electric current of series current and heat conduct rate of multilayer walls 3.5.2 Point out the relationship between thermal resistance and driving force in stable state heat transfer
3.6 Heat convective equation	Familiar with convective equation and the influence factor of heat convective coefficient.	3.6.1 Heat transfer by convection without phase change 3.6.2 Heat transfer by convection with phase change	An analogy method can be used between heat transfer by conduction and heat transfer by convection.	Compare the unit and physical significance of thermal conductivity and heat convection coefficient.
3.7 Total heat transfer rate in wall-type heat exchanger of two fluids	Master the total heat transfer rate equation.	3.7.1 Analysis of wall-type heat exchanger of two fluids	An analogy method and appending pictures are used in the inference of total heat transfer equation.	3.7.1 Comparison between electric current of series current and total heat transfer rate in wall-type heat exchanger of two fluids

		3.7.2 Heat conduct equation in wall 3.7.3 Two-film theory and heat convective equation 3.7.4 Total heat transfer equation		3.7.2 Point out the relationship between thermal resistance and driving force of heat transfer in stable state heat transfer
3.8 Calculation of heat transfer process	Master the calculation of total heat transfer rate, logarithmic mean temperature difference, heat transfer coefficient and heat transfer area.	3.8.1 Calculation of total heat transfer rate 3.8.2 Calculation of logarithmic mean temperature difference 3.8.3 Calculation of heat transfer coefficient 3.8.4 Calculation of heat transfer area	Give typical examples to introduce the calculation of total heat transfer rate, logarithmic mean temperature difference, heat transfer coefficient and heat transfer area.	Comparison between exothermic rate, endothermic rate, heat conduct rate, heat convective rate and total heat transfer rate.
3.9 Optimization of heat transfer parameter	Familiar with the optimization of fluid flow direction, course, and velocity.	3.9.1 Optimization of reverse flow and parallel flow 3.9.2 Optimization of tube and shell 3.9.3 Optimization of fluid velocity	It's the application of process optimization in the selection of fluid flow direction, course, and velocity to ensure the lowest fee.	Give typical examples to show the selection of reverse flow or parallel flow, tube or shell to ensure the lowest fee.
3.10 Measures to strengthen heat transfer rate	Familiar with the measures of strength of heat transfer rate.	Improvement of heat transfer area, mean temperature difference and heat transfer coefficient.	Base on the total heat exchange equation, the related measures are given.	Give the methods to improve area in per unit volume and heat transfer coefficient.
3.11 Heat carrier	Familiar with the popular heat carrier.	3.11.1 The popular heating agents 3.11.2 The popular coolants	Give the popular coolants and heating agents.	Selection of heat carrier and calculation of its dose for a heat exchange process.
3.12 The typical wall-type heat-	Familiar with the	3.12.1 Popular	Assisted by pictures or flash animations,	A typical heat exchange example is given for the

exchange equipment and selection	typical wall-type heat-exchange equipment.	wall-type heat-exchange equipment 3.12.2 Heat-exchange equipment selection	show structure, principle of popular wall-type heat-exchange equipment.	calculation of heat transfer area, and the correct selection of equipment.

2.4. Implementing Embodiment of Unit 4: Mass Transfer

Unit Description: This unit aims to introduce the mass transfer principle, transfer rate, influence factors and typical equipment. The specific design contents and implementation methods of this unit are shown in Table 4.

Table-4. Design and implementation of Unit 4

Knowledge units	Goals	Contents	Teaching methods	Evaluation approaches
4.1 Mass transfer in homogeneous phase	Master the molecular diffusion mass transfer mechanism shown as Fick law.	4.1.1 Fick law and mass transfer coefficient 4.1.2 Eddy diffusion mass transfer and transfer coefficient	An analogy method is used in the study of the Fick law, Neuton's viscosity law and Fourier law.	Comparison between Fick law, Neuton's viscosity law and Fourier law.
4.2 Mass transfer between phases	Understand the mass transfer process between two phases.	4.2.1 Mass transfer in homogeneous phase 4.2.2 Interphase mass transfer and two-film theory	With the assist of related pictures, the analogy method is used in the study of the mass transfer between two phases and heat-exchange of fluids by wall.	Comparison between Two-film theory in interphase mass transfer and Two-film theory in wall-type heat exchange.
4.3 Phase equilibrium relation	Master the forms of phase equilibrium relation.	Several forms of the Henry's law.	An analogy method is used in the study of Henry's law and Raoult's law.	Comparison between Henry coefficient, solubility coefficient, and phase equilibrium constant.
4.4 Interphase mass transfer rate equation	Familiar with the forms of mass transfer rate equations.	4.4.1 Mass transfer rate equations in homogeneous phase 4.4.2 Total mass transfer rate equations	With the assist of related pictures, the analogy method is used in deducing the total mass transfer rate equation as total heat transfer equation.	Point out the relationship of mass transfer driving force and resistance in homogeneous phase and two phases.
4.5 Mass transfer equipment	Understand the popular mass transfer equipment.	4.5.1 Packed tower 4.5.2 Plate tower	Study with the assist of related pictures and flash animation.	Realize the popular padding, packed tower, plate tower.

2.5. Implementing Embodiment of Unit 5: Gas Absorption

Unit Description: This unit is the typical application of mass transfer in gas absorption. It introduces an effective separation method for gas mixture with solubility difference in solvent, including the selection of solvent and calculation of its dosage, optimization of operation conditions, mass balance, calculation of number of overall transfer units (NTU) and height of a mass transfer unit (HTU). The specific design contents and implementation methods of this unit are shown in Table 5.

2.6. Implementing Embodiment of Unit 6: Distillation

Unit Description: This unit is the typical application of mass transfer in distillation. It introduces an effective separation method for liquid mixture with volatility difference, including equilibrium balances of the ideal two-component liquid/vapor system, material mass balance, calculation of theoretical plate number (N_T) , plate efficiency and overall plate efficiency, practical plate number (N), optimization of operation conditions, typical distillation equipment. The specific design contents and implementation methods of this unit are shown in Table 6.

2.7. Implementing Embodiment of Unit 7: Basic Principle and Calculation of Chemical Reaction Engineering

Unit Description: This unit introduces the research objects, methods and basic concepts in chemical reaction engineering (Walker, 1937). The learning mainly focuses on industrial reactor flow model, design, calculation and optimization. The specific design contents and implementation methods of this unit are shown in Table 7.

Table-5. Design and implementation of Unit 5

Knowledge units	Goals	Contents	Teaching methods	Evaluation approaches
5.1 Overview	Understand the principle and application of absorption.	5.1.1 Principle of absorption 5.1.2. Sorts of absorption	Give typical gas mixtures, such as air and ammonia, air and SO_2 for the purpose of separation.	Application of absorption in gas purification, products preparation such as hydrochloric acid and sulfuric acid.
5.2 Selection of solvent	Master solvent selection principles.	5.2.1 Concept of selectivity 5.2.2 Solvent selection principles	Give heuristic problems such as how to reduce solvent dosage and ensure absorption efficiency.	How to improve solvent selective in gas absorption.
5.3 Equilibrium relation in absorption	Mater the solubility's equilibrium relation.	5.3.1 Several forms of equilibrium relation 5.3.2 Application	Table and Figure are used to show solubility's equilibrium relation in absorption.	How to judge the mass transfer direction and the solute maximum concentration in absorption.
5.4 Rate equations of absorption	Familiar with the rate equations and their relationship.	5.4.1 Rate equation in phase 5.4.2 Equilibrium relation between interphases 5.4.3 Total mass transfer rate equations	5.4.1 Related figure is used to show change of solute concentration 5.4.2 Application of two-film theory 5.4.3 Analogy method is used	5.4.1 Point out the relationship between mass transfer driving force and resistance in homogeneous phase or two phase 5.4.2 How to improve total mass transfer rate
5.5 Calculation for gas absorption process with lower concentration	Master the calculation of overall materials balance, the solvent dosage and NTU with logarithmic mean driving force method.	5.5.1 Overall materials balance and operating line equation 5.5.2 Minimum liquid-gas rate and solvent dosage 5.5.3 Calculation of NTU and HTU	5.5.1 Graphic method is used in the calculation of overall materials balance, solvent dosage and NTU 5.5.2 Analogy method is used in the calculation of NTU in gas absorption and number of theoretical plate (N_T) in distillation	5.5.1 How to confirm the maximum solute concentration in solvent and the minimum solvent dosage 5.5.2 Comparison between graphic method obtaining the NTU in gas absorption and N_T in distillation
5.6 Gas absorption Tower	Understand the popular	5.6.1 Padding	Study with the assist of related	Realize the popular padding, packed tower

	absorption tower.	absorption tower 5.6.2 Plate tower	pictures and flash animation.	and plate tower in gas absorption.

Table-6. Design and implementation of Unit 6

Knowledge units	**Goals**	**Contents and sequence**	**Teaching method and resources**	**Evaluation approach**
6.1 Overview	Understand the principle of distillation and its application.	6.1.1. Principle of distillation 6.1.2 Sorts of distillation	6.1.1 Give typical liquid mixtures for the purpose of separation 6.1.2 Idea-solution and Raoult's law 6.1.3 Dalton law	Give the simple method for the separation of ethyl and n-propanol, benzene and toluene mixtures.
6.2 Two component equilibrium relation	Master the equilibrium relations of the ideal two component liquid/vapor system, especially the balance relation equation.	6.2.1 The law of degree of freedom 6.2.2 Several forms of two component equilibrium relation	6.2.1 Give tables and figures to illuminate the liquid/vapor equilibrium relation 6.2.2 Analogy method is used in equilibrium relation of absorption and distillation	6.2.1 Point out the necessary condition of distillation separation 6.2.2 Illuminate the difference between evaporation and distillation
6.3 Calculation for continuous distillation of two component	Master the calculation of material mass balance, N_T and practical plate number N.	6.3.1 Overall mass balance 6.3.2 Total condenser mass balance and reflux ratio (R) 6.3.3 Rectifying section mass balance and operating line equation 6.3.4 Stripping section mass balance and operating line equation 6.3.5 The feed plate operating line equation 6.3.6 Calculation of N_T 6.3.7 Plate efficiency and calculation of N	6.3.1 Study with the related pictures and flash animation to show flow direction of liquid and vapor, structure of plate, change of concentration 6.3.2 Give example to show the calculation of vapor and liquid flow of rectifying section and stripping section 6.3.3 Give example to show the calculation of N_T and N	6.3.1 Point out the physical significance of R 6.3.2 Illuminate the relationship between y_1 and x_d 6.3.3 How to describe the material state 6.3.4 Point out the relationship between vapor flow of rectifying section and stripping section 6.3.5 Point out the relationship between liquid flow of rectifying section and stripping section 6.3.6 How to confirm the feed-plate location 6.3.7 Point out the influence factors of plate efficiency
6.4 Optimization of operating conditions	Familiar with the selection of R, thermal state parameter of charge in, vapor/liquid velocity	6.4.1 Influence of R on N_T, minimum R (R_{min}), maximum R (R_{max}) 6.4.2 Optimization of	Study with the assist of related figures and flash animation to show the influence of parameter on mass transfer,	6.4.1 What is R_{min}, how to calculate it. How about the separating capability under R_{min} 6.4.2 What is R_{max}. How about the operating line

		thermal state parameter 6.4.3 Optimization of vapor/liquid velocity	separation ability and total cost.	(equation) and the separating capability under R_{max}
6.5 Distillation equipment	Familiar with the popular distillation equipment.	6.5.1 The popular plate tower 6.5.2 The popular padding and packing tower	6.5.1 Study with the assist of related pictures and flash animation to show the structure, operation principle 6.5.2 Contrast method is used	6.5.1 Comparison between bubble-cap tower, valve tower and sieve-plate tower 6.5.2 How to describe the separation ability of padding?

Table-7. Design and implementation of Unit 7

Knowledge units	**Goals**	**Contents**	**Teaching methods**	**Evaluation approaches**
7.1 Research objects, methods of chemical reaction engineering	Understand the research objects and methods, and realize the importance of chemical reaction design.	7.1.1 Research objects 7.1.2 Research contents 7.1.3 Research methods	Show the difference of laboratory and chemical industry in carrying out a chemical reaction.	Point out the difference of a reaction implement in laboratory and industry production.
7.2 Basic concepts in chemical reaction engineering	7.2.1 Familiar with the basic concepts about reaction thermodynamics and kinetics, especially the concept of volume expansion factor (δ), reaction time(t), residence time(t), mean of residence time ($\bar{t}$), space time (τ) and space velocity (Sv) 7.2.2 Understand the differences of mixing and backmixing, differences of flow models	7.2.1 Concepts of reaction thermodynamics 7.2.2 Concepts of reaction kinetics 7.2.3 Concept of mixing and backmixing 7.2.4 The popular ideal reactor 7.2.5 The popular flow models	7.2.1 Study with the assist of related pictures and flash animation 7.2.2 Analogy method is used in the teaching such as time concept, volume concept	7.2.1 How to judge the extent of simple reaction and complex reaction? 7.2.2 How to show volume change in gas reaction? 7.2.3 Comparison between t, $\bar{t}$, τ and Sv
7.3 Detection of residence time and residence time distribution	Familiar with the detection method of residence time, especially the relationship between residence time distribution function F(t) and residence time distribution density function E(t).	7.3.1 Residence time distribution function 7.3.2 Detection of residence time distribution 7.3.3 Digital characteristics of residence time distribution	7.3.1 Study with the assist of related pictures and flash animation 7.3.2 Analogy method is used in the study of F(t) and E(t)	7.3.1 Comparison between F(t) and E(t), and how to get them? 7.3.2 How to calculate digital characteristic parameters?
7.4 Flow model and residence time distribution of ideal reactor	Master the flow model and residence time distribution rules of	7.4.1 Plug flow reactor and plug flow model 7.4.2 Continuous	7.4.1 Study with the assist of related pictures and flash animation	Comparison between plug flow model, complete

	ideal reactors.	stirred tank reactor and complete mixing model 7.4.3 Multistage complete mixing model 7.4.4 The axial diffusion plug model	7.4.2 Analogy method is use.	mixing model, multistage complete mixing model and axial diffusion plug model.
7.5 Verification of flow model in reactor based on residence time distribution detection	Master the verification method of flow model in a reactor.	7.5.1 Inspection of flow model based on F(t) or E(t) curve 7.5.2 Method of F(t) or E(t) equation 7.5.3 Method of digital characteristics	The analogy and induction methods are used.	Give the popular methods of judging flow model in a reactor.
7.6 Calculation of ideal reactors	Master the calculation of ideal batch stirring tank reactor (IBSTR), ideal continuous stirring tank reactor (ICSTR), plug flow reactor (PFR), and multistage ICSTR (N-ICSTR).	7.6.1 The calculation of IBSTR 7.6.2 The calculation of PFR 7.6.3 The calculation of ICSTR 7.6.4 The calculation of N-ICSTR	The analogy and induction methods are used.	Comparison between the characteristic equations of IBSTR, PFR, ICSTR, N-ICSTR.
7.7 Calculation of practical reactors	Understand the calculation methods of practical reactors	7.7.1 Calculation of practical reactors based on multistage complete mixing model N-ICSTR 7.7.2 Calculation based on axial diffusion plug model	The analogy method is used.	Is there any difference between ideal reactors and practical reactors in finally synthesis conversion?
7.8 Optimization of reactor	Familiar with the optimization and selection of reactors.	7.8.1 Selection of reactor for simple reaction 7.8.2 Selection of reactor for complex reaction	The analogy and induction methods are used.	7.8.1 What's the optimizing object of simple reaction, and point out the main effect parameters? 7.8.2 What's the optimizing object of complex reaction?

3. Discussion and Conclusion

In this research, a knowledge system and evolution approach has been built in the teaching of 72hour Chemical Engineering Basic curriculum. It not only introduces the detailed knowledge units, but also presents the detailed course designing, implementing and evaluating methods. It can be characterized by several points. At first, the design, implementation and evaluation system pays more attention to the internal relation of knowledge, and it's in favor of the "teaching" and "learning". Second, with the detailed implementing suggestion or easy understandable examples, it makes complicated matters simplified and understood easily. Finally, it shows the practical characteristics of Chemical Engineering Basic curriculum, the used methods and examples regard the connection between theory and practice.

Teaching practice has testified that students who majored in chemistry, material chemistry, polymer materials and engineering and trained by this system show comprehensive quality of study and apply chemical engineering knowledge. It comes out that their satisfaction about the course teaching is above 95% over the past three years. Furthermore, teaching basing on this system can easy grasp teaching goal and emphasis. It has help cultivating two assistant professors of Chemical Engineering in our department. The author hopes it can provide some experiences in the teaching of Chemical Engineering Basics course.

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