

RESEARCH ON CURRICULUM DESIGN OF THREE-IN-ONE SCIENTIFIC WRITING BASED ON CDIO

Wenxing Xu, Wengang Ji, Bo Dai

College of Information Engineering, Beijing Institute of Petrochemical Engineering

Cai Liu, Qianwen Zhang

College of Chemical Engineering, Beijing Institute of Petrochemical Engineering

ABSTRACT

As an important cultivating part in "excellent engineer" program in department of automation in Beijing Institute of Petrochemical Technology (BIPT), the *Scientific Writing* course is a compulsory course, which belongs to ability cultivation module in discipline of control system. The fundamental goal of this course is to enable students to achieve the improvement of knowledge, ability, awareness, quality, potential and so on. In view of the shortcomings of the traditional *Scientific Writing* course, such as the inconsistency between content setting and ability training and difficult to mobilize students' subjective initiative, considering the mutual relations among the three courses of information retrieval, technical writing, and specialized English, a novel three-in-one course of *Scientific Writing* is proposed. Then within the context of the department of automation at BIPT, research and exploration on specific plans of curriculum design for the novel three-in-one course of *Scientific Writing* are carried on. The design process is based on the curriculum system of automation, of which the main line is to build engineering ability and quality. To achieve this goal, the engineering educational concept of CDIO and the system engineering theory of "design target exploration-teaching content confirmation-evaluation content refining-evaluation system construction" are applied. The basic idea of curriculum design is to construct integrated curriculum system based on the main line of ability cultivating and to take use of practice driving teaching mode, in order to make students not only learn knowledge including English and Chinese information retrieval and utilization, scientific writing skills, and how to read, write and translate scientific papers in both Chinese and English, but also establish the communication consciousness both in English and Chinese. After more than five years' implementation, the new designed three-in-one course helps students in automation develop competence in international perspective of academic and scientific exchanges, improve the engineering quality of communication in both English and

Chinese writing, develop their potential of further development in professional and related fields.

KEY WORDS

Scientific writing, Three-in-one, CDIO, Automation, Specialized English

INTRODUCTION

In recent years, some ideas, such as "Student-Centered" and "Outcome-Based Education (OBE)" (Spady, 1994), gradually become the mainstream of Education reform, and is used in the engineering education accreditation standard by Accreditation Board for Engineering and Technology (Husna et al., 2009). Dai et al. (2014) constructed and put forward the strategy, procedure and key points of reverse design with application cases. Their researches focused on several key issues involved in reverse design, such as, how to determine the training objectives, graduation requirements, indicators, how to build the curriculum system, and how to prepare teaching syllabus, etc. As a college of science and engineering with the target of cultivating high-level applied talents, since 2007 BIPT has implemented a professional reform named "regression mechanical or electrical engineering undergraduate talents in the ministry of education into training model innovation experimental area". Four majors have gradually established an cultivating mode of "one main line, two levels of matrix, higher education cooperation". As an important training link of "excellent engineer" in automation, *Scientific Writing* is a required course, which belongs to direction ability module. How to improve knowledge, ability, consciousness, quality, potential and other aspects of students after completing this course is the fundamental goal of teaching reform.

For many years, the automation teaching team in the school of information engineering has been carrying out a series of teaching reform and practice activities around this goal. In view of the traditional *Scientific Writing* course, content setting and ability training are mismatched, and it is difficult to motivate students' interesting. Based on the relationship among information retrieval, technical writing, and specialized English, we put forward the trinity of new technical writing course. Automation at BIPT as the research background, used automation curriculum system and CDIO engineering education concept, in accordance with the "exploring the reform target, determining the reform content, examining assessment method in details, and building evaluation system", we study and explore the teaching reform of *Scientific Writing*.

DESIGN TARGET EXPLORATION

Current Situation and The Proposal Of “Three-In-One” Scheme

In tradition, scientific writing is an important way of sharing results of scientific research and technical development. Good ability of scientific writing is a necessary and basic skill for scientist (Ye et al., 2010). In rapid growth of science and technology information, scientific writing plays a more and more important role, and gradually developed into an important emerging discipline along with the progress, rise and development of science and technology. In the context of cultivating high-quality creative talents, many universities have opened course of *Scientific Writing*. But it is still a public course for learning science research methodology in high school, and the teaching goal is to make students master and apply the basic theory of scientific writing, to accurately express their understanding of science and technology related concept. The previous report indicates that lack of teachers and improper content setting are common problems in *Scientific Writing* courses. Some researchers attempt to cultivate and train students' scientific research ability, especially knowledge innovation ability, in teaching process. But it is not systematic (Matthews et al., 2014). On the other way, although solutions are proposed in the literature, they are limited to the traditional *Scientific Writing* course itself.

In addition, *Information Retrieval* is also a course of scientific method. Usually, this course mainly focuses on basic retrieval knowledge, skills and methods. But with the development of computer technology and the emergence of network information environment, the teaching goal of *Information Retrieval* course has enriched. Therefore, it is proposed to combine it with *Scientific Writing* course, to conceive the merger plan (Guydish et al., 2016). Previous research shows that the information retrieval course is a practical course which has to be combined with the students' professional course. Only when students' professional information demands are stimulated, it can attract students' learning enthusiasm and initiative, so as to truly reflect the status and role of this course (Dressen-Hammouda, 2014; Hyatt et al., 2017). At the same time, *Information Retrieval* are supposed to be combined with specialized courses to enhance the effectiveness of the course and give practical help to students in their Profession.

However, according to statistic result, more than 40% of the world's population is learning and using English and more than 85% of science and technology information published in books, periodicals, patent specification and internal technical report are written in English. These lead to making specialized English importance for scientific writing and information retrieval. Specialized English is practical English with a specific purpose that focuses on a particular area and is an extension of Basic English. *Specialized English* course is a course belonging to professional skills module (Curwood et al., 2014), which aims to cultivate students' ability to use English to carry out the work in a specific environment, and to help students graduate, look for a job,

go abroad for further study, or engaged in scientific research, all of these will rely on the professional skills.

Generally speaking, information retrieval is the premise of scientific writing, and it is the auxiliary tool of specialized English. Scientific writing is the purpose of information retrieval, and it is the application of specialized English. Specialized English is the basis of information retrieval and scientific writing. The three are interrelated, as shown in Figure 1. Three courses, such as *Information Retrieval*, *Technical Writing*, and *Specialized English* are integrated for trinity Scientific writing course. It can help students obtain and make use of information in both Chinese and English literature at the same time, and improve the ability of reading, writing and translating the scientific papers in English and Chinese, all of which lay a solid foundation for students to advance in their career in the professional and related field

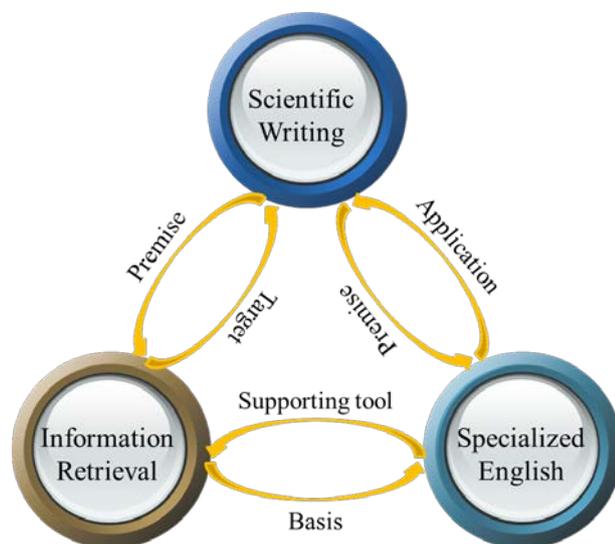


Figure1. The relationship between Scientific Writing, Information Retrieval and Specialized English

Design Target for Scientific Writing based on CDIO Engineering Education Mode

From the perspective of China's current universities, more emphasis is placed on the cultivation of knowledge ability, but according to the needs of the society, it is more important to improve the ability and quality of engineering application for most students. The cultivation of ability and quality needs to adapt to the cultivation plan. The education mode of CDIO engineering is built on education culture scheme with the concept of modern products, design, implementation, operation and other life cycles. From the perspective of ability and quality, "conceive" is to build engineering way of thinking, "design" is to have the ability to integrated design, "implementation" is to grasp the technical implementation means, and "operation" is for organization and coordination ability. The cultivation of different abilities will form different types of

goals. After years of exploration and application, the orientation to cultivate high-level applied talents has been formed in BIPT. And the educational objective of automation major is "Automation system engineer for production line". Therefore, based on the CDIO syllabus, 12 graduation requirements for automation major are concluded and decomposed. (Dai et al., 2017)

On the macro level, the scientific and technological writing based on the CDIO engineering education model has the following reformation goals of two aspects:

- Explore a new model of teaching for the Trinity technology writing curriculum, integrate information retrieval, technology writing and specialized English three courses, in order to make the three courses confirm, invoke and support each other.
- Validate and revise the new teaching mode by practice in order to achieve the goal of training students in five aspects: knowledge, ability, consciousness, quality and potential.

Thus, the cultivating goals are as follows:

- Knowledge: help students to retrieval and use the basic knowledge of Chinese and English information, and grasp scientific and technological writing.
- Ability: train students to obtain and use the Chinese and English literature information, master the abilities to read, write and translate the literature information.
- Consciousness: help students to establish a sense of communication by Chinese and English, open up a vision of international scientific and technological exchange.
- Quality: cultivate engineering quality of English and Chinese communication and writing.
- Potential: develop students' potential for further development in the field of professional and related fields.

On the microcosmic point of view, the reformation goal of the new three-in-one *Scientific Writing* should support the cultivation goal of the whole major, which is "automation system engineer for production line". According to 12 standards of graduation requirements and three-level index system formulated for major of Automation based on the four aspects of CDIO syllabus, main graduate requirement index supported by the new three-in-one *Scientific Writing*, is shown in Table 1. (Dai et al., 2017)

Table 1. Main Graduate Requirement Index Supported By The New Three-In-One *Scientific Writing*

Graduation requirements (1-level index)	Index point (2-level index)	Teaching points (3-level index)
2.Problem analysis: be able to identify, refine, define, express, analyze, demonstrate and study automation system engineering design, product integration, operation maintenance and technical service complex engineering problems, using related knowledge, and be capable of obtaining the effective conclusion	2.4 Be capable of literature review and research for automatic products and automatic system engineering Be capable of using information technology tools to develop and use different kinds of modern website resources	① Related references, technical documents, databases and common information sources of automation products and system engineering. ② Systemization, classification and research on references, technical documents and all kinds of information for effective conclusions.
5.Use modern tools: in the solution of automation system engineering design, product integration, operation and maintenance, technical service of complex engineering problems, be able to design, select and use appropriate technology, resources, modern engineering tools and information technology tools for engineering practice which contains the prediction and simulation of complex engineering problems, and can understand the tools' limitations	5.4 Construction and strategy for effective communication Be capable of written and graphic communication, oral and personal communication, electronic and multimedia communications with industry peers and the public on complex engineering problems in automation Be capable of communication using foreign languages , having international perspective, be able to communicate In the cross-cultural context	② Methods for information retrieval. ③ Commonly used website resources of automation , such as databases, references and websites, etc. ④ Collection, filter, processing and reasonable and effective application of cyber resources.
10.Communicate: be able to effectively communicate with the industry peers and the public on complex engineering issues in the field of automation, including writing reports, designing presentations, presenting statements, clearly expressing and responding to instructions, have a certain international perspective and foreign language communication skills, be able to communicate with others in a cross-cultural context	10.1 Understand time, cost, quality risk and human resource management, and be able to use them in engineering practices in the environment of multi-discipline Be capable of literature review and research for automatic products and automatic system engineering Be capable of using information technology tools to develop and use different kinds of modern website resources 10.2 Construction and strategy for effective communication	① Proposal of logical and persuasive argument. ③ Selection of related, credible and precise favorable evidences. ④ Usage of concise, understandable, precise and clear language , analysis of rhetorical elements (e.g. considering preferences of audiences). ① Display coherence, fluency, hierarchy and

	Be capable of written and graphic communication, oral and personal communication, electronic and multimedia communications with industry peers and the public on complex engineering problems in automation Be capable of communication using foreign languages , having international perspective, be able to communicate In the cross-cultural context	logicality of paper content, writing technical report and papers using correct grammar.
		③ Using proper language, style, time and procedure to prepare report and corresponding supporting media.
		⑤ Effectively answering questions.
	10.3 Understand time, cost, quality risk and human resource management, and be able to use them in engineering practices in the environment of multi-discipline Be capable of literature review and research for automatic products and automatic system engineering	① Reading and understanding foreign technical information.
		② Expression of ideas in written and oral foreign languages.
12.Lifelong learning: be aware of independent learning and lifelong learning ,and be able to learn and adapt to development	12.3 Be capable of using information technology tools to develop and use different kinds of modern website resources	① Definition, sequencing, time estimation, scheduling and time control of engineering projects.
		② Resource allocation, cost estimation and control of engineering projects.

The first column shows the four graduation requirements which students should have at graduation after taking this course. The second and third column are the decomposed second-level and third-level indicators respectively, which shows the specific abilities student should have at graduation after taking this course.

TEACHING CONTENT CONFIRMATION

For the above teaching goals, We propose the OBE (learning output) concept to firstly clarify curriculum teaching objectives and teaching points, then reversely design curriculum teaching links and teaching methods, and finally continuously improve curriculum teaching according to teaching effect. The results are as follows:

- Curriculum objectives: relevant to teaching points; train the students to use the modern tools for literature review and arrangement; help the students to acquire the ability of effective cooperation and communication between Chinese and English.

- Curriculum design principles: combine teaching and practice, using Problem Based Learning, such as project application, proposal, resume, presentation and panel production, etc.; combine teacher evaluation and student evaluation; integrate modern educational technology and traditional theory teaching; improve communicative competence in listening, speaking, reading, writing and translation by practice.
- Course teaching process: In classes, teachers combine the tools and texts that need to be used in the study work. The report adopts the form of group mutual assistance. The students' scores are composed of the score by the teachers, the ranking results of the group leader and the personal completion of the report and the performance.
- Teaching links: classroom teaching, model presentation, group report, retrieval and literature review, Chinese and English abstracts and final exams. The relationship between these teaching links and the requirements of graduation is shown in Table 2.

Table 2. The Relationship Between Graduation Requirements Index Points And Curriculum Teaching And Assessment Links

Course		Scientific Writing								
Graduation requirements	Index point	2.4	5.4	10.1	10.2	10.3	12.3	Σ		
	Weight coefficient of index points	0.3	0.4	0.1	0.1	0.2	0.3	1.5		
Teaching and assessment links		Teaching and assessment links						Σ	Score s	
Pattern	Pattern									
Classroom Teaching		√	√	√	√	√	√	/	/	
Cases presentation		√	√	√	√	√	√	/	/	
Classroom questioning	0.10		0.4		0.1	0.5		1		
Project application	0.2		0.4		0.2		0.4	1		
Project proposal	0.2	0.4		0.3			0.3	1		
Final Exam	0.5	0.36	0.1		0.1	0.44		1		
WeightΣ	1	0.76	0.9	0.3	0.4	0.94	0.7	4		
Index point achievement										

During implementation, while designing the trinity *Scientific Writing* course, the most important problem is the mobilization of students' subjective initiative. *Scientific Writing* is a required course for undergraduates of automation major in our college, which is a

40-hours course arranged in the last semester of the third year of school. The curriculum is carried out on the basis of the completion of *College Public English*. The basic courses that have been studied are signal and system, automation and so on. As a result of just finished learning public English and some basic courses, some students may not pass CET-4 at the end of the sophomore year. Many students have weak English foundation and fear of learning specialized English. Difficulty in understanding professional vocabulary in the study of specialized English, further leads to lack of self-confidence and low learning enthusiasm for those students. On the other hand, most of the students think they will not be engaged in scientific research. What's more, in the future job interview, the recruitment unit will not be mandatory for master document retrieval, technical writing and specialized English. Postgraduate English is mainly aimed at basic public English. Therefore, some students have no enthusiasm and interest in learning these three courses. How to make the students realize that the importance and the universality of use of the three aspects of literature search, technology writing and specialized English, and how to inspire them to learn the subjective initiative of this course, are the problems that we should solve and improve. Based on this, the following aspects of the reform are put forward and implemented.

- The principle of "from easy to be difficult" is adopted in the organization of content. At the beginning, teachers use a simple example, explain vocabulary knowledge as little as possible to make the students understand the grammatical features commonly used in English, gradually collapse students' psychological fear. Then, we introduce a variety of related words through specific examples of scientific style, help students to master professional vocabulary as much as possible in class. In this way, the students would grasp the emphasis and strengthen their confidence in continuing to study deeply.
- Professional training and assessment for teachers are carried out. Various teaching methods to arouse students' interest in learning are applied in class, such as questions, demonstrations, analogies and various teaching media such as words, images, sounds, animations, etc.
 - Teachers use the cases and the practice under their guidance, teach students analysis specific application, and help them understand, consolidate the knowledge and solve the problem. The following practices of three kinds of typical scientific writing style are implemented: project application, project proposal and Chinese and English abstract writing. All the completed practices are reviewed and evaluated by the students and teacher together. The students' scores are composed of the score by the teacher, the ranking results of the group leader and the personal completion of the report and the performance.

EVALUATION CONTENT REFINING

Curriculum assessment is constituted by classroom questioning (10%) project application (20%), project proposal (20%) and closed book final exam (50%), final score is 100 percent. Since 2009, the curriculum has been continuously implemented and improved. At present, for each assessment link, the criteria for assessing the degree of realization of relevant teaching points are formulated. An example of the assessment standards for project application is shown in Table 3. Teaching points are

the third-level graduation requirements shown in Table 1. All the completion status are evaluated in five levels of “Excellent, Good, Medium, Pass and Fail”, for easily deduce the finally score. Points are spelled as pts in tables below.

Table 3. Assessment Standards for Project Application (Full: 20 pts)

Teaching and Assessment Links			Project Application						
No.	Teaching Points	Weight	Assessment Standards	Completion Status					
				A	B	C	D	E	Score
1	5.4-②④	40%	1) The arrangement, classification and analysis of the data are reasonable. 2) The literature search and information inquiry are fully.						0-8
2	10.2-①③	20%	1) The application writing has a distinct argument, a correct view, a full and strong argument. 2) The rules are clear and the language is fluent. 3) Writing specifications, including drawings, tables and formulae are standard.						0-4
	12.3-①②	40%	1) The estimation time and schedule of the application are reasonable. 2) The allocation of resources and the cost budget are reasonable						0-8
Overall assessment									

EVALUATION SYSTEM CONSTRUCTION

Since in the second sector of “Design target exploration”, the indicators of graduation requirements for the new course of three three-in-one *Scientific Writing* have been shown in Table 1, the “evaluation method for graduation requirement achievements based on scoring points” (Dai et al., 2017) is used to evaluate the implementation effect of this course.

Take the evaluation process of *Scientific Writing* in 2015-2016 spring semester as an example. First the teaching points achievements are calculated according to the assessment standards shown in Table 3. The results are shown in Table 4. Then the index point achievement of the whole course could be obtained according to Table 2, the relationship between index points and course teaching assessment link, as shown in Table 5.

Table 4. The Teaching Points Achievement of Assessment Pattern of Project Application

Class	A11-1, 2, 3			Assessment Pattern: Project application						Full mark: 20 pts
No	1			2			3			Overall
Index	5.4			10.2			12.3			
Teching points	5.4-②④		0.4	10.2-①③		0.2	12.3-①②		0.4	
Weight	0.4			0.2			0.4			
Name	Score (Full: 8 pts)	Teaching points achievement	Index point achievement	Score (Full: 4 pts)	Teaching points achievement	Index point achievement	Score (Full: 8 pts)	Teaching points achievement	Index point achievement	Score
...	7	0.875	0.88	4	1.000	1.00	7	0.875	0.88	18
Student 1	6	0.750	0.75	3	0.750	0.75	6	0.750	0.75	15
Student 2	7	0.875	0.88	3	0.750	0.75	6	0.750	0.75	16
...
Average	6.6744 19	0.834302	0.834302	3.3953 49	0.848837	0.848837	6.5465 12	0.818314	0.818314	16.616 28
Index point achievem ent	0.834302326			0.848837209			0.818313953			

Table5. The Index Point Achievement of New Three-In-One *Scientific Writing* In Spring Semester of the School Year 2014-2015

Course		Scientific Writing							
Graduation requirements	Index point	2.4	5.4	10.1	10.2	10.3	12.3	Σ	
	Weight coefficient of index points	0.3	0.4	0.1	0.1	0.2	0.3	1.5	
Teaching and assessment links		Weight coefficient of teaching and assessment links						Weight htΣ	Score
Pattern	Weight								
Classroom	0.1	0.40		0.10	0.50			1	8.27
		0.78		1.00	0.83				
Project application	0.2	0.40		0.20		0.40		1	16.62
		0.83		0.85		0.82			
Project proposal	0.2	0.40		0.30		0.30		1	16.72
		0.83		0.86		0.82			
Final exam	0.5	0.36	0.10		0.10	0.44		1	66.24
		0.58	0.36		0.62	0.80			

Weight Σ	1	0.76	0.90	0.30	0.40	0.94	0.70		74.73
Achievement		0.71	0.76	0.86	0.83	0.82	0.82		

The index point achievement of new three-in-one *Scientific Writing* shown in Table 5 can subsequently be used to calculate the graduation requirements achievement. Thus it can be evaluated that whether the graduates of this major meet the quality standards set by graduation requirements, which helps analyze and find the weak items during cultivation. Accordingly, the continuous improvement of teaching activities is realized.

CONCLUSION

Considering the mutual relations among the three courses of information retrieval, technical writing, and specialized English, a novel three-in-one course of *Scientific Writing* is proposed according to the engineering educational concept of CDIO. The four implementation steps of “design target exploration-teaching content confirmation-evaluation content refining-evaluation system construction” are explained in detail. The curriculum design process has been applied to the teaching reform and continuous improvement of *Scientific Writing* in automation in our school, and has been approved to be effective.

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BIOGRAPHICAL INFORMATION

Wenxing Xu, Ph. D. is an associate professor and Learning and Assessment Specialist in the Department of Automation at Beijing Institute of Petrochemical Technology, China. She taught the undergraduate courses of *Scientific Writing* and *Introduction to Artificial Intelligence* and the graduate course of *Adaptive Control*. She is a co-author of *Evaluation Report for Automation Engineering Education Professional Certification* (Beijing Institute of Petrochemical Technology, 2016), *Evaluation Method Of The CDIO Syllabus Achievements Based On The Examination Scoring Point* (Proceedings of the 13th International CDIO Conference, 2017) and *Exploration and Practice of the Engineering Education Reform Control System* (Proceedings of the 10th International CDIO Conference, 2014). She collaborates regularly with universities in China on topics related to curriculum design and the improvement of teaching and assessment. Her current scholarly activities focus on modeling, optimization and decision support.

Wengang Ji, Ph. D. is a Professor in Automation and Associate Dean of College of Information Engineering at Beijing Institute of Petrochemical Engineering, China. His current work focuses on the integration of curriculum system based on the CDIO syllabus.

Cai Liu, Ph. D. is an Electrochemical Specialist in the Chemical Engineering College at the Beijing Institute of Petrochemical Technology, China. His current research focuses on electrochemical energy storage and conversion devices, such as fuel cell, Lithium ion batteries, and supercapacitors. He taught the undergraduate courses of *Instrumental Analysis and Experiment* and *Scientific Research Training*.

Qianwen Zhang, Ph. D. is a Professor in the Chemical Engineering College at the Beijing Institute of Petrochemical Technology, China. His current work focuses on clean energy utilization and industrial catalysis.

Bo Dai is a Professor of Automatic Control in the Department of Automation and director of Academic Affairs Office at Beijing Institute of Petrochemical Technology, China. He taught the course of automatic control theory. His current research focuses on industrial process control and on curriculum development methodology.

Corresponding author

Prof. Bo Dai
Beijing Institute of Petrochemical
Technology
19 Qingyuan North Road, Daxing
District
Beijing, China 102617
86-10-8129-2030
daibo@bipt.edu.cn



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