STUDY ON TEACHING PRACTICE OF CDIO-ORIENTED EDUCATION IN THE COURSE OF CHARGE INTERACTION

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ABSTRACT

CDIO emphasizes that students involved in the engineering study in an active, practical and comprehensive way. In this paper, charge interaction teaching is to be discussed as a case for the CDIO educational concept on how to train students to master the basics of engineering, improve personal ability and teamwork effectively, and enhance engineering system capabilities and so on. The teaching content designed around Coulomb's law is divided into four parts: ① Ideas. Students are required to access in advance to other scientists' viewpoint about the force of the charge, which enable students to understand the importance of thinking of previous work on refining. In other words, "Conceive" is not groundless. ② Experimental design. Students are required to find that how Coulomb utilized his professional expertise to design Coulomb Twist balance, and how to use the principle of leverage and torque balance to make micro amount being magnified. It should be emphasized that engineering design is usually affected by the comprehensive ability of individuals. ③ Analogy Method. Analogy Method is an important method of scientific research. The students should understand the analogy relationship of Coulomb's law and Newton's law of gravitation, consider the method connotation behind the Coulomb experiment. ④ Discussions. Group discussions is used in pre-class step aiming at improving students teamwork, each member of the group should finish his corresponding work assigned in advance before the class, discuss in class, and eventually present a PPT report. Compared with traditional electromagnetic theory teaching, this paper emphasizes the idea premise of establishing scientific experiments, the design and implementation of the experiment as well as other aspects. This method avoids the traditional teaching of Coulomb's law on the theory learning only and gives more attentions on developing innovative ideas. As for operation in classroom teaching, discussion stimulates students' initiative of active learning and makes them teamwork effectively. All these works can fully reflect the significance of applying CDIO concepts into the teaching reform in the field of electromagnetic theory.

KEYWORDS

CDIO; Personal ability; Teaching reform; Coulomb's law；CDIO Standards: 1, 2, 3, 7, 8, 9, 10, 11, 12

1. INTRODUCTION

Nowadays, people around the world are more connected to each other than ever before because of modernization and information. Communication is more frequent, and cooperation is commonplace regardless of people's skin color, race or place. Teamwork is becoming one of the basic human capabilities. It needs every individual to acquire the appropriate knowledge and skills. It is noted that modern knowledge is so complicated and extensive that a man who wants to master all knowledge is impossible. Knowledge of the individual is being towards specialization. The necessary engineering education is being more and more important. So, how to acquire knowledge actively, how to train the individual skills targeted, and how to improve the individual quality effectively? Only the correct understanding of the three relations can make education effective. In fact, we have never stopped exploring for education (Reynolds, et al. 1993, Manli Li. 2008). In 1983, the World Council and Assembly on Cooperative Education is established to foster co-operative education and other work integrated learning programs worldwide. It was renamed as the World Association for Cooperative Education (WACE) in 1991, and merged with the National Commission for Cooperative Education (NCCE) in 2010 (http://www.waceinc.org/). In the 2000s, the CDIO (Conceive – Design – Implement – Operate) was developed by the Royal Institute of Technology (KTH), Chalmers and Linköping University and Massachusetts Institute of Technology (MIT)(M Kans. 2012). Recently, CDIO is introduced by Chinese universities (Gu Peihua, et al. 2014), such as Shantou University, Tsinghua University and Yanshan University, and so on. However, CDIO standards are not all uniform standards of professional engineering education. The CDIO-oriented curriculum must be designed according to the specific characteristics of the specialty (Manli Li. 2008). "When we pay attention to reform engineering education according to CDIO concept, we must require a combination of actual situation and explore the road of higher engineering education with our characteristics" (Bai Jianfeng, et al. 2013). Just based on this point, the teaching of interaction with the charge is studied in this paper as a case to illustrate the combination of electromagnetic field specialty features with the CDIO concept. The main explorations lie in how to train students to master the basics of engineering, improve personal ability and effective teamwork, and enhance engineering system capabilities, and so on.

The rest of paper is organized as follows: in section Ⅱ, the features of teaching content around Coulomb's law are analyzed carefully, and then an appropriate lesson plan was developed. Section Ⅲ describes the CDIO initiative. Then the conclusion on CDIO for the educational program is done in section Ⅳ.

2. THE FEATURES OF TEACHING CONTENT AND LESSON PLAN

Coulomb's law is the theoretical basis of charge interactions. Its main features are summarized in Table-1. These features had been analyzed carefully. We think that the teaching content of this part is very suitable for CDIO. So a corresponding teaching plan is developed in Table-2.

Table-1 The Features of Teaching Content

Features	Examples	Issues
Background	1. Social situation 2. Early studies	How to conceive?
Experimental Methods	1. Coulomb twist balance 2. Cavendish experiment	How to design? How to implement?
Theoretical approaches	Analogy law of gravity	What is analogy? And how?

Table -2 The Plan of Teaching Content

Steps	Methods	Contents	Goals
Pre-class preparation	Read books and online search	1. Social situation 2. Early studies 3. Coulomb twist balance 4. Cavendish experiment 5. Analogy law of gravity 6. Production: PPT	Collecting data abilities
Discussion in class	PPT report and discussion	1. How to conceive 2. How to design? 3. How to implement? 4. How dose team work?	CDIO and Oral skills
Summary after class	Report	Feelings, experiences and Application of Analogy	Understanding of analogy

3. THE CDIO INITIATIVE

CDIO emphasizes that students are involved in the engineering study in an active, practical and comprehensive way. The teacher must have an understanding of the concept of CDIO, and make the teaching approach developing from the teacher-centeredness towards the student-centeredness. The CDIO initiative designed around Coulomb's law is divided into four parts as follows.

3.1 Ideas

Students are divided into 10 groups (G1~G10). They are required to access in advance to other scientists' viewpoint about the force of the charge. All the data (D1~D9) gathered by students (see appendix A) enable students to understand the importance of thinking of previous work on refining. In fact, Coulomb's experiment is just aiming at verifying the inverse square law. It is evident that these data affect Coulomb's "conceives". In other words, "Conceive" is not groundless. As Chairman Mao's famous quote: "no investigation, no right to speak."

3.2 Experimental design

In this part, students are required to find that how Coulomb utilized his professional expertise to design Coulomb Twist balance, and how to use principle of leverage and torque balance to make micro amount being magnified. All the data gathered by students are listed as follow:

- Coulomb was initially dedicated to the research on torsion and friction.
- 1781, due to the published papers about twisting Coulomb was elected to the French Academy of Sciences.
- Coulomb designed the Coulomb Twist balance based on the principle of leverage and torque balance.
- Coulomb improved experimental design based on the deviation

It is easy to see that Coulomb gave full play to his own strengths. It is that micro amount being magnified that is his core design. Coulomb experimental design can be seen as a case that engineering design is usually affected by the personal expertise.

3.3 Analogy Method

Analogy is a form of logic in the reasoning. It can evolve the knowledge of certain aspects of a particular object to a new object through similar or identical comparison between them. It plays an important role in the process of cognitive science of physics and the theory being established. However, People who is good at using the analogy is required to study the object with a deep understanding and sensitive response capability. The students should understand the analogy relationship of Coulomb's law and Newton's law of gravitation, and consider the method connotation behind the Coulomb's experiment. The data gathered by students is as follows:

- Analogy of Coulomb's law and Newton's law of gravitation(shown in the appendix B).
- Error calculation (1.96→2.0) and correction according to the inverse square law.

It is evident that the inverse square law is the direction for Coulomb's experiment. "2" is a standard numerical value of his measured values.

3.4 Discussions.

Discussion is divided into group discussion and class discussion. Group discussions is used in pre-class aiming at improving students teamwork, each member of the group should finish his corresponding work assigned in advance before the class, and eventually present a PPT report. All the above-mentioned steps within the group will be examined in class discussion. Evaluation will be made by the teacher and students together around several issues as follows:

Issue A: How to collect data correctly?
All the data (D1~D9) collected by students are assumed as a basis. The ability of students to collect data is Initially evaluated by the number of data collected contrast to the basis (see Table-Ⅰin appendix C). However, there are some students point out that D9 is not suitable for "the other scientists' viewpoint", and suggest that the corresponding group should be punished one point. All students accept it. Then a new evaluation is made again (see Table-Ⅱin appendix C).

Issue B How to choose data correctly around Coulomb' law ?
In order to choose data correctly, the first thing is to analyze the correlation between the data and the topic. All the data relevance to the inverse square law is considered to be suitable. It is worth to note that D8 was published so late that it could not affect Coulomb to design his experiment. There are three groups (G1, G3, G8) that do not choose D8. All students suggest that the corresponding group should be added one point, and the others zero. Thus the final results of the evaluation is done well(see Table-Ⅲ in appendix C). As for data acquisition, students conclude that the man with qualities such as being logical, careful, good at retrieving means and refining is suitable.

Issue C How to complete a project ?
Here only gives the results obtained by discussion:

- Conceive.
  What you want to do is the most important thing. (2/3 students approve)
- Basis.
  What you have (knowledge and skills) is the most important thing. (1/3 approve)

- Partner.
  The partner should have the abilities you need but you do not have.(All approve)
- Implement.
  No problem! There are so many capable people together here.

4. THE CONCLUSION

The paper finishes with some concluding remarks on the usefulness of CDIO for the creation of an innovative educational program. The CDIO-oriented curriculum designed according to the specific characteristics of the specialty can make the teaching do well. Students can deepen understanding on “how to conceive”, “how to design”, and “how to teamwork”, and so on. Compared with traditional electromagnetic theory teaching, this paper emphasizes the idea premise of establishing scientific experiments, the design and implementation of the experiment as well as other aspects. This method avoids the traditional teaching of coulomb’s law on the theory learning only and gives more attentions on developing innovative ideas. As for operation in classroom teaching, discussion can stimulate students’ initiative of active learning. All these remarks can fully reflect the significance of applying CDIO concepts into the teaching reform in the field of electromagnetic theory. However, the CDIO initiative is not all uniform standards of professional engineering education, and specific questions should be specific analyzed.

Appendix A

Table-A The Other Scientists’ Viewpoint

Data	Era	Name, nationality	achievement
D1	1600	W. Gilbert, British	Charge attraction in book: <On the loadstone and magnetic bodies, and on the great magnet, the earth >
D2	Uncertain	O.V.Guericke, Germany	Pointed out that the charge can attract or repel
D3	1755	B.Franklin, British	Empty jar experiment, The concept of positive and negative charges, Explain lightning mystery
D4	1759	F.U.T.Aepinus, Germany	Assuming the charge repulsion and attraction between the charged object increases with the reduction of the distance
D5	1760	D. Bernoulli, Swiss	First guess: obey the inverse square law
D6	1767	J.Priestley, British	Analogy, electrical attraction obey the same law of gravitation
D7	1769	Robinson, British (friend of Priestley)	First quantitative experimental of the inverse square power, Error ±0.06, but published in 1801
D8	1773	H.Cavendish, British	Cavendish experiment, Error ±0.02, until 1879, published by Maxwell
D9	1785	C.A.Coulomb,	Basic theory: Coulomb's law

Appendix B

Table-B Analogy of Coulomb's Law and Newton's Law of Gravitation

Law	Formula	Common	Difference	Error
Newton's	$F = G\frac{Mm}{r^2}$	①The same form ②The inverse square law	Attract	0
Coulomb's	$F = k\frac{Q_1Q_2}{r^2}$		Attract or repel	-0.04

Appendix C

Table-Ⅰ The Other Scientists' Viewpoint Based on the Group

	D1	D2	D3	D4	D5	D6	D7	D8	D9	Ratio
G1	√	√	√	√	√	√	√	√	√	9/9
G2	√	×	√	√	√	√	√	√	×	7/9
G3	√	×	√	√	√	√	√	√	×	7/9
G4	×	×	×	×	×	×	√	√	×	2/9
G5	√	×	√	√	√	×	√	√	×	6/9
G6	√	×	√	×	×	√	√	√	×	5/9
G7	√	×	×	√	×	√	×	√	√	5/9
G8	√	×	√	×	×	√	×	√	×	4/9
G9	√	×	×	√	√	√	√	√	×	6/9
G10	√	×	√	×	×	×	√	√	×	4/9

Table-Ⅱ The Ability of Students to Collect Data Thinking of D9 Defect

	D1	D2	D3	D4	D5	D6	D7	D8	D9	Ratio
G1	√	√	√	√	√	√	√	√	−	6/8
G2	√	×	√	√	√	√	√	√	×	7/8
G3	√	×	√	√	√	√	√	√	×	7/8
G4	×	×	×	×	×	×	√	√	×	2/8
G5	√	×	√	√	√	×	√	√	×	6/8
G6	√	×	√	×	×	√	√	√	×	5/8
G7	√	×	×	√	×	√	×	√	−	3/8
G8	√	×	√	×	×	√	×	√	×	4/8
G9	√	×	×	√	√	√	√	√	×	6/8
G10	√	×	√	×	×	×	√	√	×	4/8

Table-Ⅲ The Ability of Students to Collect and Choose Data

	D1	D2	D3	D4	D5	D6	D7	D8	D9	total
G1	×	×	×	√	√	√	√	+	−	B^+
G2	×	×	×	√	√	√	√	×	×	B^+

G3	×	×	×	√	√	√	√	+	×	A
G4	×	×	×	×	×	×	√	×	×	C^{-}
G5	×	×	×	√	√	×	√	×	×	B
G6	×	×	×	×	×	√	√	×	×	C^{+}
G7	×	×	×	√	×	√	×	×	×	C^{+}
G8	×	×	×	×	×	√	×	+	×	C^{+}
G9	×	×	×	√	√	√	√	×	×	B^{+}
G10	×	×	×	×	×	×	√	×	×	C^{-}

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BIOGRAPHICAL INFORMATION

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