AC 2010-1184: ESTABLISH AN IMPORTANCE INDEX OF BASIC CHEMISTRY COMPETENCE IN THE UNIVERSITIES OF SCIENCE AND TECHNOLOGY IN TAIWAN

Pao-Chi Chen, Lunghwa University Science and Technology

Professor Chen is the Dean, College of Engineering at Lunghwa University of Science and Technology.

Kwannin Kuo, Lunghwa University of Science and Technology

Kwannin Kuo is a lecturer in the department of Chemical and Materials Engineering at Lunghwa University of Science and Technology in Taiwan. He is also an EdD candidate in TESOL program at Queen's University, Belfast.

Meei-Ruey Hsu, Ming-Chuan University

Meei-Ruey Hsu is a professor in the department of Tourism at Ming-Chuan University in Taiwan.

To Establish an Importance Index of Basic Chemistry Competence in the Universities of Science and Technology, Taiwan

1. Introduction

In order to facilitate the intellectual industry and innovation ability, the government in Taiwan has proclaimed a "National Development Plan" since 2002 (Council for Economic Planning and Development, 2005). One of the targets in the plan is to increase highly qualified manpower, to fuel the desperate demands from the electronic engineering, green energy, chemical engineering, and biotechnology fields. From the viewpoint of the future development, nanotechnology, communication technology, green energy, environmental industry, optoelectronic industry and biotechnology are seen as rising industries in 21st century. These industries have great influence on national security, society and people's livelihood. Fundamental scientific competences, e.g. mathematics, physics, chemistry or biology are essential to the qualified manpower of these emergent industries. As a consequent, how to enhance the basic scientific competence of college students in order to strengthen the core competitiveness of Taiwan is an inevitable issue of Taiwanese higher education.

In particular, chemistry competence is highlighted in the present study. The development of the emergent industries such as semiconductor industry, optoelectronic industry, green energy, environmental industry and biotechnology, as well as traditional petroleum, plastic, rubber, and textile industries are profoundly related to fundamental chemistry ability. Nonetheless, there is a common perception within Taiwanese industries that the basic chemistry competence of many graduates from universities of science and technology could not satisfy the industry demand. More efforts should be made on devising appropriate curricula and finding effective learning approach. However, it is difficult to assess whether students' chemistry competence in the universities of science and technology is appropriate for industries or not; as a result, we may need some indicators to be observed (Gabel, 1999). From this point of view, establishing a basic chemistry competence index in terms of employment prospect for the engineering students in the universities of science and technology is a crucial issue for engineering education in Taiwan.

In the present study, a modified Delphi method was used for establishing the importance index of chemistry competence in terms of occupation domain. Additionally, a number of semi-structured interviews with experts were conducted in order to investigate the experts' views about chemistry education. The findings of this study might be implied in the assessment of current curriculum design and teaching contents of chemistry in the universities of science and technology in Taiwan. By the same token, the findings could be further utilized in an Importance-Performance Analysis (IPA).

2. Literature Review

Ample of literature was found to improve the education of chemistry including teaching and learning (Eilks and de Jong, 2009; Mahaffy, 2004; Gilbert et al., 2004; Tsaparlis, 2003; Nelson, 2003; Coll et al., 2002; Sirhan and Reid, 2002; Canning and Cox, 2001; Kettle, 2001; Gabel, 1999). Why they wanted to improve the education of chemistry？The major reason is that misconceptions. For example, the difference between an element and a compound is taught to student at the macroscopic level is that elements cannot be decomposed by ordinary chemical means, whereas compounds can be (Gabel, 1999). However, the explanation used to make the distinction is abstruse. Due to this, basic concepts for the education of chemistry were reported in these literatures, such as basic chemical concepts (Nelson, 2003; Barke and Wirbs, 2002; Kettle, 2001; Taber, 2001), the development of the chemistry attitudes and experiences (Coll et al., 2002), and the future of chemistry education (Mahaffy, 2004; Gilbert et al., 2004). Additionally, water and air pollutions (Stavridou and Marinopoulos, 2001), quantum-chemical concepts (Tsaparlis and Papaphotis, 2002; Sanxhez Gomez and Martin, 2003), biological chemistry (Canning and Cox, 2001), and linking physics with chemistry (Toomey and Garafalo, 2003) were also explored for the education of chemistry. In order to learn the complex nature of chemistry, the concepts of threefold representation of matter was considered to convey to their students, while students have difficulty relating analogies and models to chemical phenomena. Because the three levels can be interpreted in more than one way, and because teachers unwittingly move from one level to another in lecturing, students fail to integrate the levels, which lead to a fragmented view of chemistry with many puzzling parts that do not seem to fit together (Gabel, 1999). How to enhance students has an effective learning of chemistry and become successful problem solvers. Due to this, chemistry education researchers need to think of the future and move forward in the areas that will be of greatest importance in the coming century. Through the information processing model and social constructivist theory, chemistry education research should accompany curriculum development in future. At the beginning of the 21st Century, many forces shape the teaching and learning of chemistry (Mahaffy, 2004). Therefore, Mahaffy (2004) he proposed human contexts for learning chemistry and replaced triangle of learning levels in chemistry education concept with tetrahedral chemistry education concept. The tetrahedral metaphor may help us integrate content and content, instead of emphasizing one at the expense of the other. These include fundamental changes in the contours of chemistry as defined as new interfaces and research areas including chemistry fuelling modern life, chemistry of our planetary support system, chemist-creators, seeing and understanding the chemical world, and chemistry of life. These materials will give students and teachers a challenge for chemistry learning and teaching, respectively. Therefore, how to establish an Importance Index of Basic Chemistry Competence in the Universities becomes interesting in chemistry education, especially for professional consideration.

According to Fernald, Solomon and Bradley's (1999) study, 64 per cent of manufacturers believe entry-level workers lack the necessary skills to positively impact their company; the statistics implies that when students graduate from schools, they are still far behind the requirements of industries. This could be the genuine cases for Taiwanese engineering students graduating from universities of science and technology. Over a long period of time, there is a common complain from the Taiwanese industries that the basic chemistry competence of many graduates from universities of science and technology could not satisfy the industry demand. In order to fill the learning gap, a closer relationship between academy and industries should be promulgated (Cervantes, 1998; Danielmeyer, 1997; Jacob et al. 2000). Ruth (1996) indicated that schools and enterprises are closely connected individuals, whose resources have to be combined for the students to meet the challenges in their career development. Weng et al. (2005) pointed out some advantages of the collaboration between enterprises and universities, which might enable enterprises to attain the professional guidance and latest innovative knowledge from academic scholars. Additionally, the enterprises might find qualified students as their potential employees and then save the training expenses. On the other hand, it is beneficial to the relationship between academy and industry if we are able to explore what industrial experts and academic scholars thinking about students' competence should be in order to match the industry demand. Due to this, obtaining some viewpoints regarding chemistry education was required from enterprises, researchers and universities. However, we must face a lot of information from them and collect them into useful information, an Importance Index of Basic Chemistry Competence.

In order to capture the collective knowledge and experience of experts in a given field to improve decision making and giving predictions about the future, one such technique is Delphi's method, which has been extensively used in planning, policy analysis, and long-range forecasting in both public and private sectors (Gupta and Clarke, 1996). Delphi is one of the most popular forecasting techniques for technological and industry-wide forecasting and it is estimated that 90% of technological forecasts and studies are based on Delphi (Yuxiang et al., 1990). According to the literature, the three most popular areas for Delphi applications are education, business, and health care (Gupta and Clarke, 1996). Delphi's goal is not to elicit a single answer or to arrive at a consensus, but simply to obtain as many high-quality responses and opinions as possible on a given issues from a panel of experts to enhance decision making (Gutierrez, 1989). According to data analysis flow model (Miles and Huberman, 1994), however, we must face data collection period, data reduction, data displays, and conclusion drawing/verification. All the procedure is significantly affected the qualitative data analysis.

3. Methodology

The methodology adopted in this study was a modified Dephi method (Murry and Hammons, 1995) as well as semi-structured interviews. The Delphi method was originally developed in the 1950s by the RAND Corporation. This approach consists of an expert survey conducted in two or more rounds and in the second and later rounds of the survey the results of the previous round are given as feedback (Cuhls, 2003). In here, therefore, we adopted three rounds including interviews developing structured questionnaires for 1st round, questionnaire surveys for 2nd and 3rd rounds; until the primary purpose of the Delphi method is to obtain the most common consensus of opinion of a group of experts by a series of intensive questionnaires (Dalkey and Helmer, 1963; Duffied, 1988; Gupta and Clarke, 1996).

The interviewees invited in here as experts-interviewed must have two-required conditions: at least ten-year work experience and chemistry-related areas. A total of twenty experts-interviewed, including experts in industry, academic scholars, and researchers in institutes, were invited to be interviewees. The researchers screened the interview data for obtaining axial coding. Underpinned by the findings from the interview data as well as other references such as textbooks, literatures, and curricula, a questionnaire was devised as an importance index of basic chemistry competence. Subsequently, the questionnaire was sent to 20 experts-interviewed to mark the importance of each item for a pilot study. After that, the questionnaire was sent to 110 experts to evaluate the importance of basic chemistry competence further. More detailed depictions are delineated as follows:

3.1 Interview

20 experts-interviewed according to their rich experiences in teaching, research, and industrial performance were invited to be the interviewees. Seven of them are from industries; eight of them are academic scholars and five are from research institutes. Most of experts-interviewed are invited in Taiwan, while 2 of 20 experts-interviewed are invited from India and America, respectively. The profile of interviewees is shown below:

1. 12 experts-interviewed with PHD degree
2. 17 experts-interviewed have working experience over 20 years: 5 in industry, 7 in universities and 5 in Research Institutes

Underpinned by employment and certificate guidance, fourteen questions (as tabulated in Appendix 1) were listed to be used for the interviews. These questions put emphasis on basic chemistry competence, occupation, and certificate. Semi-structured interviews can not only have the flexibility of non-structured interview but also allow researchers to concentrate on the main focus simultaneously. Time for each interview was within a range of 1 to 2 hours. All the interviews have been recorded and then transcribed into word manuscript. The massive interview data thus analyzed from word manuscript, carefully, without using qualitative software packages. In order to concentrate and consensus the message from coding, meeting of committee was required, which is composed of a five-member of experts-interviewed. We collected subjects by means of open coding and then the subjects were converged further in order to find out the main axis of this work. A schematic diagram describing the coding process was shown in Figure 1.

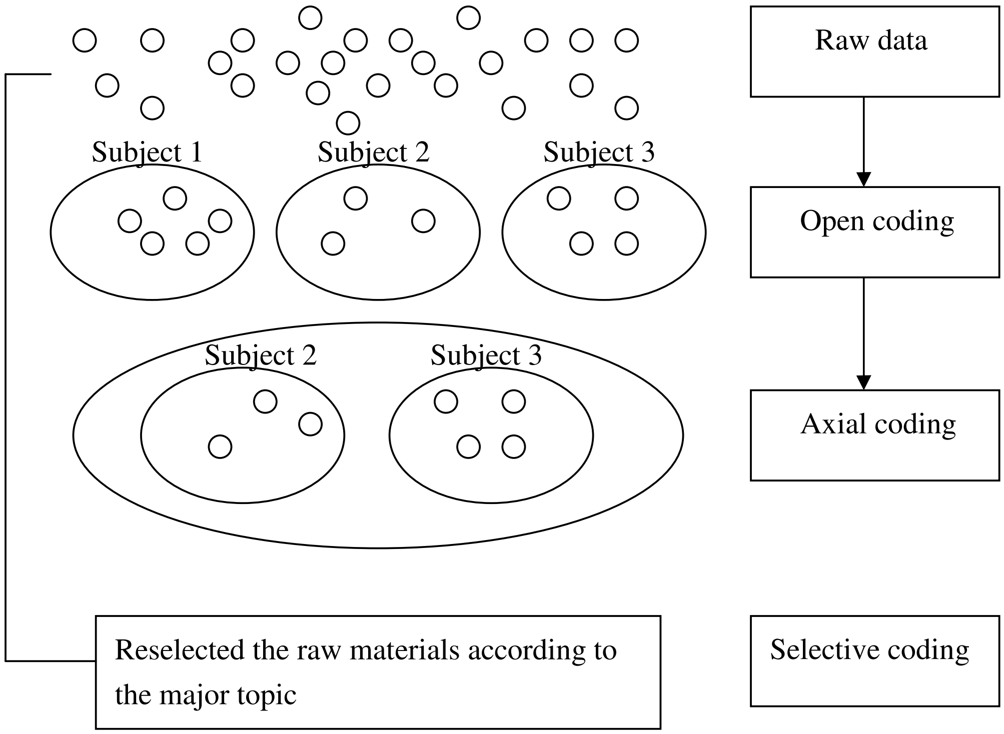

Figure 1 A schematic diagram describing the coding process of interview data.

In this manner, five subjects were obtained by open coding on one hand, while two convergent subjects were observed by axial coding on the other hand. The outcomes of open coding and axial coding are tabulated in Table 1.

Table 1 Open coding and axial coding list

Open coding	Axial coding
1. Promoting the basic chemistry competence of students	1.Basic chemistry competence in occupation domain
2. Occupation domain	
3. Basic Chemistry Competence in work place and performance of student	
4. The viewpoint about attaining certificate(s) or certificate in vocational education system	2.Curriculum of Chemistry
5. Credits of Chemistry courses and curriculum of Chemistry	

It turns out that basic chemistry competence in occupation domain and curricula of chemistry were the major axial subjects. The results was similar to that reported by the literatures (Nelson, 2003; Barke and Wirbs, 2002; Taber, 2001), since they emphasis on precise definitions of matters, knowing about properties of substances, and the relationship between chemical structure and chemical bonding.

3.2 Questionnaire

Underpinned by the findings of interviews as well as other references such as textbooks (Silberberg, 1996; Hill & Petrucci, 1999; Masterton & Hurley, 2001), literatures (Roam et al., 2007; Liu, 2006; Kim et al., 2008; James et al., 2008) and current curricula (Shy, 2009), the researchers devised a questionnaire, through meeting of committee, covering the basic chemistry competence in terms of occupation domains, in which 28 topics have been indentified as illustrated in Table 2. It is necessary to clarify that the concept of basic chemistry competence in the present study is primary about the chemical knowledge which the researchers can link to curriculum design or teaching content of chemistry in the universities of science and technology.

In addition, every topic was further divided into several items within a range from 2 to 7. As a result, 94 chemistry items were listed in the questionnaire as shown in Appendix 2. In order to conduct a pilot study, the 94-item questionnaire was sent to 20 experts-interviewed who were the interviewees in the previous semi-structured interviews. A total of 18 experts were sent the questionnaire back. These experts marked the importance of each item in light of their individual opinion. Then, the outcomes of the first round and the questionnaire were sent to experts again; a total of 14 experts were sent the questionnaire back, because Delphi method is an expert survey in two or more rounds and in the second and later rounds of the survey, the results of the previous round are given as feedback. Finally, the questionnaire was sent to 110 experts in order to find out the importance of basic chemistry competence for engineering graduates from universities of science and technology based on experts' perspectives.

Table 2 the basic chemistry competence

Category	**Topics**
General Concept	**1.** Chemistry and Measurement
	2. Atom, Molecules and Ions
	3. Stoichiometry
	4. Gas and Gas Laws
	5. Thermochemistry
Atomic and Molecular Structure	**6.** Quantum Theory
	7. Electron Configuration and the Periodic Table
	8. Ionic Bonds and Covalent Bonds

	9. Molecular Structure and Bonding Theory
States of Matter	**10.** Liquids and Solids
	11. Solutions
	12. Metals and Nonmetal Materials
Chemical Kinetics and Equilibrium	**13.** Chemical Kinetics
	14. Chemical Equilibrium
	15. Acids and Bases
	16. Acid-Base Equilibrium
	17. Solubility and Equilibria Involving Complex Ions
	18. Thermodynamic
	19. Electrochemistry
Chemistry of the Elements	**20.** Chemistry of the Elements
	21. The Transition Elements and Coordination Compounds
Chemistry and Life	**22.** Nuclear Chemistry
	23. Organic Chemistry
	24. Polymer Chemistry
	25. Biochemistry
	26. Environmental Chemistry
	27. Energy
	28. Simulation of Chemistry

4. Results and Discussions

4.1 Interview

As a result of the interviews, basic chemistry competence in occupation domain and curriculum of chemistry are the major axial subjects. Six major industrial categories were identified to be the main occupation domains, i.e. petroleum industry, semiconductor industry, optoelectronic industry, energy industry, environmental industry and biotechnology industry, which are close to the future shape of chemistry education as reported by Mahaffy (2004). As for the curriculum, general chemistry, organic chemistry, physical chemistry, analytical chemistry, instrumental analysis, and inorganic chemistry were most frequently mentioned by the experts. Indeed, these courses quite coincide with the current curricula in the universities of science and technology in Taiwan. Apart from those courses, environmental chemistry and biochemistry are two secondary mentioned courses. They could respectively connect to the occupation domain of environmental industry and biotechnology industry.

4.2 Questionnaire

In the pilot study, there were 18 experts returning the questionnaire at the first round and 14 experts replied in the second round. The questionnaire was devised under a Likert Scale for experts to mark the importance of 94 items. Accordingly, 5 points were given for each mark of the most importance. In the same line, an important mark was given as 4 points, neutral as 3 points, less important as 2 points and least important as 1 point. It turns out that two runs of pilot study converge significantly as manifested by both the results of SPSS correlation (Pearson coefficient $r=0.837$, $p<0.001$) and quartile deviation (69% of quartile deviation less than or equal to 0.5, the rest within the range between 0.5 and 1.0). According to Faherty's (1979) conception, he indicated that it could be viewed as highly convergent if quartile deviation is less than or equal to 0.6 and as relatively convergent if quartile deviation is between 0.60 and 1.0.

As for the main study, 105 experts replied their questionnaires. The profile of these 105 experts is 51% academic scholars, 44% industrial experts and 5% from research institutes. Likewise, the results of the main study were tabulated in Appendix 2. The gaps of average points between pilot and main studies were merely 0.037. Furthermore, between the pilot and main studies, expert's perspectives with the importance of basic chemistry competence were convergent significantly as proved by the Pearson coefficient $r=0.802$, $p<0.001$. Likewise, 65% of quartile deviations equal to 0.5 and 35% are 1.0 in the main study. The percentage of highly convergent quartile deviation slightly slid; nonetheless, it is still a rather convergent result when we consider the much large survey base in the main study. Table 3 shows the percentage of number of items for the criteria of consensus using QD and average (M) in pilot and main studies. From the distribution of criteria, we found that consensus is good for both values.

Table 3 Percentage of number of items for QD and average (M)

Criteria	Pilot study(94 items)	Main Study(94 items)
$QD \leq 0.6$	64(68.1%)	61(64.9%)
$0.6 < QD < 1.0$	30(31.9%)	33(35.1%)
$QD > 1.0$	0(0)	0(0)
$4.0 \leq M < 5.0$	55(58.5%)	51(54.3%)
$3.0 \leq M < 4.0$	39(41.5%)	43(46.9%)
$M < 3.0$	0(0)	0(0)

With regard to individual items, "1-1 Knowing chemistry" and "1-2 Measurement and unit" were marked the highest scores among the 94 items. This indicates that the topic "Chemistry and Measurement" was the most important chemistry competence based on the average score. Likewise, other topics such as "Atom, Molecules and Ions", "Stoichiometry", "Periodic Table", "Acids and Bases", "Liquids and Solids" were also acknowledged by the experts as the important chemistry competence. Generally speaking, the items under the category of general concept were broadly supported by the experts as the important chemistry competence. This implies that from the points of experts' view, the chemistry competence that engineering students should acquire is indeed rather basic.

On the other hand, the topics such as "Quantum Theory", "Molecular Structure and Bonding Theory", and "The Transition Elements and Coordination Compounds" won less support from the experts to be the important basic chemistry competence. These topics are more theoretical orientation. Within occupation domain, it may not surprise that they gained relative low average points.

5. Conclusion

A modified Delphi method was successfully used to obtain an importance index of basic chemistry competence underpinned by experts' perceptions. In summary, there are several work have been done:

1. Six major industrial categories, namely petroleum industry, semiconductor industry, optoelectronic industry, energy industry, environmental industry and biotechnology industry were confirmed to be the important occupation domain for Taiwanese engineering students in the universities of science and technology in the future.
2. Twenty-eight chemistry topics have preliminary been selected as the basic chemistry competence underpinned by the findings from interviews as well as other references.
3. Two rounds of expert survey have been completed for the pilot study of the questionnaire.
4. The importance index of basic chemistry competence has been investigated with the aid of 105 experts. Topics such as "Chemistry and Measurement", "Atom, Molecules and Ions", "Stoichiometry", "Periodic Table", "Acids and Bases", "Liquids and Solids" were revealed by the experts as the much important basic chemistry competence.

With the comparisons of the average points obtained from the expert survey, the importance of basic chemistry competence in terms of occupation domain could be identified. Once the index of the basic chemistry competence was attained, we may further conduct an Importance-Performance Analysis (IPA) to investigate the comparisons of the importance of basic chemistry competence and students' performance. More importantly, the index of the basic chemistry competence itself could provide useful information for other chemistry teaching programs and remedy the gap between industrial demand and academic instructions.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the financial supports provided by the National Science Council of the Republic of China under grant NSC 97-2511-S-262-007-MY3.

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Appendix 1 questions for semi-structured interview

No.	Contents of questions
1	Would you please reveal what kinds of basic Chemistry Competence are required for graduates who major in Chemical and Material Engineering? And why do you think so?
2	What kinds of occupation domain are appropriate for the graduates majoring in Chemical and Material Engineering?
3	{Continue with question 4} Please indicate the basic Chemistry Competence which Chemical and Material Engineering graduates should acquire if they want to pursue their career in the aforementioned occupation domains, respectively (e.g. photoelectricity, plastics, commodity industry, semiconductor, environmental engineering, energy, etc.).
4	What kinds of basic Chemistry Competence will be beneficial to graduates' employment?
5	Would you please to tell us what kinds of basic Chemistry Competence are required for the employees and how to evaluate their performance in your department or unit?
6	Is there any employee graduating from vocational education system in your unit or department? What are they in charge of? Is it possible to talk about their characteristics, professional knowledge and their advantage or disadvantage?
7	How do you react when employees' professional knowledge is insufficient? Is there any in-service training in your unit or department?
8	Do you agree to stipulate professional indices of basic Chemistry Competence for graduates from vocational education system? Which items do you think should be taken into account as top priorities?
9	what kinds of basic competence students should attain in order to encounter the future industrial development?
10	Is there any difference between the teaching contents when you studied in the university and the needs in your current job? Which parts of teaching content you think are crucial and which parts you think is irrelative?
11	Have you acquired certificate(s) when you were student? Do you think certificate(s) are useful in employment?
12	What are your opinions about students attaining certificate(s) or certificate in vocational education system?
13	Would you please mention what you learned in the university is helpful to enhance research ability?
14	How many credits in chemistry courses are reasonable in university?

Appendix 2

	Pilot Study		Main Study	
Items	Average	Q. D.	Average	Q. D.
1-1 Knowing Chemistry	4.25	0.5	4.41	0.5
1-2 Measurement and unit	4.468	0.5	4.53	0.5
2-1 Atomic theory and structure	4.375	0.5	4.09	0.5
2-2 Chemical formula and nomenclature	4.468	0.5	4.37	0.5
2-3 Chemical Equations	4.468	0.5	4.30	0.5
3-1 Mass and the mole of matter	4.625	0.5	4.34	0.5
3-2 Mass relations in chemical formulas	4.406	0.5	4.18	0.5
3-3 Stoichiometry	4.593	0.5	4.18	0.5
4-1 Gas laws	4.406	0.5	4.07	1
4-2 The kinetic-molecular theory	4	0.25	3.82	1
5-1 Knowing Energy	4.468	0.5	4.06	1
5-2 Heat of reaction	4.406	0.5	4.08	1
5-3 The application of the heat of reaction	4.312	0.5	3.97	1
6-1 The nature of light, photons and Bohr model	3.531	0.5	3.65	0.5
6-2 Quantum Theory and quantum numbers	3.281	0.625	3.52	0.5
7-1 Electron configuration	4.093	0.5	3.84	1
7-2 Periodic table	4.312	0.5	4.37	0.5
8-1 Ionic bonds	4.125	0.625	4.04	1
8-2 Covalent bonds	4.093	0.625	4.10	1
9-1 Molecular structure and bonding theory	3.468	0.5	3.72	1
9-2 Molecular orbitals	3.5	0.5	3.66	0.5
10-1 The change of states of matter	4.375	0.5	4.16	1
10-2 Liquid state	4.312	0.5	4.24	0.5
10-3 Solid state	4.281	0.5	4.24	0.5
11-1 Solution formation	4.187	0.5	4.10	0.5
11-2 Colligative properties	4.031	1	3.80	1
11-3 Colloids	3.593	0.5	3.77	0.5
12-1 Metal and metallurgy	3.687	0.625	3.82	1
12-2 Nonmetal materials	3.718	0.625	3.90	1
13-1 The definition and determination of reaction rate	4.343	0.5	4.05	0.5
13-2 The rate law and reaction mechanisms	4.218	0.5	4.07	0.5
13-3 The factors affecting reaction rate	4.25	0.5	4.04	1

14-1 Chemical equilibrium	4.343	0.5	4.22	0.5
14-2 The application of equilibrium constant	4.218	0.5	3.99	1
14-3 Qualitative treatment of equilibrium: Le Chatelier’s Principle	4.375	0.5	4.05	1
15-1 Acids and bases	4.375	0.5	4.34	0.5
15-2 Strengths of acids and bases	4.437	0.5	4.40	0.5
15-3 Neutralization reactions	4.312	0.5	4.31	0.5
15-4 Dissociation of water and pH value	4.375	0.5	4.35	0.5
16-1 Equilibrium in the solutions of weak acids and bases	4.156	0.625	4.16	0.5
16-2 Equilibrium in solutions with other solutes of weak acids and bases	4.093	0.625	4.09	1
16-3 Buffer solution and their applications	4	0.625	4.09	1
17-1 Solubility and Ksp	3.812	0.5	4.10	0.5
17-2 The equilibrium of complex ions	3.625	0.5	3.75	1
17-3 The application of solubility equilibrium	3.75	0.625	3.96	1
18-1 The first law of thermodynamics and its application	4.187	0.625	4.10	0.5
18-2 Spontaneous process and entropy	4.125	0.625	3.91	1
18-3 The concept of Free Energy	3.968	1	3.90	1
18-4 The relationship between free energy and equilibrium constant	4	1	3.85	1
19-1 Half reactions	4.031	0.625	3.90	1
19-2 Oxidation-reduction	4.156	0.625	4.17	0.5
19-3 Voltaic cell and its principles	4.062	0.625	4.10	0.5
19-4 Electrolysis and its application	4	0.25	4.09	0.5
20-1 Chemical properties of the metals	3.937	0.625	4.03	0.5
20-2 Chemical properties of the nonmetals	3.906	0.625	3.98	0.5
21-1 The properties of transition elements	3.343	0.625	3.65	0.5
21-2 Composition of complex ions	3.218	0.625	3.58	0.5
21-3 Nomenclature of coordination compounds	3.125	1	3.57	0.5
21-4 Structures of coordination compounds and isomers	3.093	1	3.55	0.5
22-1 Radioactive materials	3.5	0.5	3.50	0.5
22-2 Nuclear reaction and its application	3.281	0.5	3.40	0.5
22-3 The application of radioactive isotopes	3.125	0.5	3.40	0.5
22-4 Nuclear energy and its application	3.25	0.5	3.56	0.5

23-1 Carbon and chemical bond	4.031	0.25	4.07	0.5
23-2 Hydrocarbons	4.093	0.25	4.15	0.5
23-3 Aromatic compounds	4.62	0.25	4.11	0.5
23-4 Functional groups and their characteristics	4.187	0.5	4.24	0.5
23-5 Hydrocarbon derivatives	4.031	0.125	4.07	0.5
24-1 Properties and categories of polymers	3.875	0.5	4.11	0.5
24-2 Addition polymers	3.718	0.5	4.10	0.5
24-3 Viscoelastic bodies	3.468	0.5	3.70	0.5
24-4 Condensation polymers	3.593	0.5	3.68	0.5
24-5 Copolymers	3.531	0.5	3.67	0.5
24-6 Elastomers	3.531	0.5	3.65	0.5
25-1 Stereoisomer	3.625	0.5	3.61	0.5
25-2 Carbohydrates	3.718	0.5	3.95	0.5
25-3 Polysaccharides	3.656	0.5	3.85	1
25-4 Fats and fatty acids	3.531	0.5	3.80	1
25-5 Cholesterols	3.406	0.5	3.60	0.5
25-6 Proteins	3.593	0.5	3.65	0.5
25-7 Enzymes	3.656	0.5	3.73	1
25-8 Nucleic Acids	3.656	0.625	3.70	1
26-1 Air and Air pollution	4.062	0.625	3.95	1
26-2 Water and water pollution	4.062	0.625	4.00	1
26-3 The toxic in biosphere	4	0.625	3.93	1
26-4 The concept of green chemistry	4.218	0.625	4.16	0.5
27-1 Fossil fuel	4.156	0.625	4.04	0.5
27-2 Energy and power	4.125	0.25	4.10	0.5
27-3 Fossil fuel resources and energy crisis	4.125	0.25	4.09	0.5
27-4 The development of new energy	4	0.25	4.15	0.5
28-1 The concept of molecular chemistry	3.25	0.5	4.05	0.5
28-2 Basic principles and theory	3.312	0.5	4.21	0.5
28-3 Atomic orbitals and quantum chemistry	3.093	0.625	3.83	1
28-4 Molecular structure and bonding	3.156	0.5	3.91	1
Total Average	3.935		3.972	