AN INVESTIGATION OF THE GOALS OF THE LABORATORY PROGRAMME IN SECONDARY SCHOOL CHEMISTRY COURSES IN BRITISH COLUMBIA

by

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Abstract

In 1965 and 1966 a modified version of the Chem Study programme was introduced into Grades 11 and 12 in British Columbia secondary schools, to replace Chem 90 and Chem 91, which were based on Dull, Brookes and Metcalfe's text, Modern Chemistry. As a result of this change, a traditional, text-book centred course was replaced by a contemporary laboratory-centred course. In Chem Study, laboratory experience replaces the text as the primary source of information and the information gathered in the laboratory is used as the basis for the development of theoretical concepts. It is considered most important by Chem Study that the teacher recognises the goals of the laboratory programme and that he works towards these goals in practice. In addition, it is necessary for both teacher and student to recognise the relationship existing between laboratory observations and the development of theory if the major goals of the course are to be realised.

This thesis describes an attempt to determine whether British Columbia secondary school chemistry teachers are indeed aware of the goals of the laboratory programme and whether they and their students think these goals are being achieved.

Q-analysis procedures and techniques were used to gather and analyse the data. Three groups of interested people, namely, specialists, chemistry teachers and students were requested to describe the goals of the laboratory programme by rank-ordering a comprehensive list of items, each describing one goal of laboratory work. The items, which were gathered from a wide variety of sources, were arranged by each subject into a predetermined (modified normal) distribution pattern. The item scores for each subject were correlated and the correlation matrix factor analysed. Each factor

identified by the computer programme represented a group of persons with similar viewpoints. In addition a hierarchy of item acceptance was established for each factor on the basis of item z-scores. This enabled the viewpoint of each factor and the differences between viewpoints to be described.

It has been shown that teachers are aware of the goals of the Provincial Chem Study programme and that they believe that they work towards these goals in practice. However, students perceive the priorities of the goals of the laboratory course to be different from those described by the teacher. The differences that exist between the viewpoints of teachers and students are in part differences in emphasis and in part differences in substance.

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Chapter 1

Introduction

1.1 Purpose of the Study

Three important groups can be expected to have an influence on the outcome of the laboratory programme in any chemistry course. They are teachers, students and curriculum writers. Each group can be expected to have a particular focus of interest and, possibly, different viewpoints concerning the intended learning outcomes of the laboratory programme. These differences of opinion may create an educational problem if the achievement of certain goals, intended by the curriculum writers, is desired. If teachers, students and curriculum writers do not share the same views, those intended goals are not likely to be achieved. There is some evidence that this, in fact, may be the case.

The purpose of the present study is to determine whether British Columbia secondary school teachers are aware of the goals of the laboratory activities of the Provincial Chem Study Programme and whether they and their students perceive these goals as being achieved in classroom practice.

1.2 Statement of the Problem

Four specific problems were investigated.

1.21 What are the intended goals of the laboratory activities in the Provincial Chem Study Programme as interpreted by specialists in chemistry teaching?

Statements and suggestions concerning the intended goals of the laboratory activities are incorporated in the Chem Study literature and in the Provincial curriculum guides (4:5). A definitive interpretation of these goals was obtained by soliciting the opinions of a panel of specialists. This panel was composed of University Science Education professors in British Columbia who were very familiar with the Provincial Chem Study course. The opinions thus obtained were used as a basis for comparing the opinions of other groups.

1.22 Do teachers of the Provincial Chem Study programme perceive the intended goals of the laboratory in the same way as curriculum specialists in this area?

When a teacher is faced with the task of teaching a ready-made course, such as the Chemical Bond Approach or Chem Study, he must first understand what it is the course is attempting to accomplish and how it sets about achieving its end. In other words, he must be concerned with interpreting the philosophy of the course and identifying its priorities. In the sciences, and in chemistry in particular, this requires a clear understanding of the relationship between laboratory work and theory. Failure to recognise this relationship in the Provincial Chem Study programme and to apply it in the classroom would result in failure to attain the major goals of Chem Study, for the programme is at least as much concerned with method as it is with content. Indeed, it would be possible to change the content without upsetting the basic philosophical pattern, but a change in the method of presenting the content would transgress the philosophical guidelines of the course and such a course could no longer be truly called Chem Study.

1.23 In the opinion of the teachers using the Provincial Chem Study programme, are they working towards the intended goals of the laboratory in practice?

In his application of the laboratory materials in the classroom, the teacher may be strongly influenced by factors other than his interpretation of the philosophy of the course and its priorities. He may consider, for example, the nature of the public examinations, his own ideas concerning the role of laboratory work or his view of the particular needs of his students to be more important. Consequently the goals of the laboratory programme taught in a school may not be consistent with the teacher's interpretation of the intended goals of the laboratory programme.

1.24 In the opinion of the students, are the intended goals of the laboratory being achieved?

One important reason for teaching chemistry is to make students aware of the nature of the subject. The Chem Study programme is particularly concerned with making students aware of the role which experimental work plays in the development of concepts in chemistry. What the student perceives to be the role of the laboratory activities in the course is therefore an important factor in assessing its success or failure.

1.3 Research Hypotheses

The basic hypotheses of this study are as follows:

1.31 Teachers using the Provincial Chem Study programme will not perceive the intended goals of the laboratory in a significantly different way from curriculum specialists.

1.32 There will be no significant difference between what teachers perceive to be the intended goals of the laboratory and their perception of goals they are working towards in practice.

1.33 There will be no significant difference between the opinions of students and the opinions of teachers with respect to the goals of the laboratory programme being achieved in practice.

1.4 Rationale for the Study

Growing disenchantment with the traditional text-book approach to the teaching of science reached a climax in the U.S.A. in the years immediately following the launching of Sputnik in 1956. This historic event stimulated action which led to the reassessment of science teaching methods and the content of science courses, especially at the high school level, and to the production of new courses in physics (PSSC), chemistry (CBA, Chem Study) and biology (BSCS). These new courses all emphasised the experimental nature of science and the importance of laboratory experience in the education of science students.

In 1964 the Chemistry Committee of the British Columbia Department of Education Curriculum Division recommended to the Director of Curriculum that a somewhat modified form of the Chem Study programme be adopted for the Grade 11 and Grade 12 chemistry courses in the Province, to replace the previous course based on the text Modern Chemistry by Dull, Brookes and Metcalfe. This recommendation was accepted and the modified Chem Study course was prescribed for Grade 11 chemistry in 1965 and for both Grades 11 and 12 in 1966. The modifications are discussed in Section 2.3.

The decision to adopt the Chem Study approach presented chemistry teachers of the Province with a formidable task. To make the administrative decision effective in the classroom, chemistry teachers were required to reorient their approach from a traditional, text-book centred course which emphasised factual knowledge, to a laboratory-based course which emphasizes the development and the application of theoretical models. In addition they had to familiarise themselves with a considerable amount of new, particularly theoretical, subject matter.

There has been little work undertaken to assess the effects of the Chem Study programme on the teaching of chemistry. Heath and Stickell (11:45-46) compared students in newer chemistry programmes (CBA and Chem Study) with students in traditional programmes. They established that students in the newer programmes performed better in tests designed for these programmes than did the control groups and that the control groups achieved higher scores on tests designed for traditional courses. They argued that these results showed that the content of the new courses was undoubtedly different from that of the traditional courses.

Rainey (22:539-544) taught two groups of high school chemistry classes, using a conventional approach for one of the groups and the Chem Study course for the other. His results were similar to those of Heath and Stickell; the Chem Study group achieved higher scores on the Chem Study test and the conventional group achieved higher on an ACS-NSTA (traditional) test. He also noted that students in conventional classes consistently produced better write-ups of experiments but that those in the Chem Study group seemed to enjoy the laboratory work more.

Hein (12:245-249) surveyed all Missouri chemistry teachers in an attempt to determine the effects of the new chemistry courses (Chem Study, CBA) on teaching practice. He found that teachers of the new courses devoted a greater proportion of class time to laboratory work and placed a greater emphasis on 'open-ended' experiments, on the discovery of principles from experimental data and on quantitative laboratory work. About one half (53.3%) of the teachers of the newer chemistry programmes employed 'open-ended' experiments - a rather low figure, because both courses claim to have open-ended experiments. This result may be an indication that the laboratory activities for the courses were not being used as intended or it may be due to a misunderstanding of the term 'open-ended', which is not clearly defined in the paper.

There has been no study of the effects of introducing the modified Chem Study programme on teaching practice in British Columbia secondary school chemistry classes. In view of the implications of the decision to adopt Chem Study as the basis of the Provincial Chemistry programme for Grades 11 and 12, especially with respect to its effect upon teaching methods, and in view of the scarcity of information in this area in the literature, it would appear that a study of the situation in the secondary schools of British Columbia is warranted.

1.5 Descriptions of Terms Used

1.51 Role of the Laboratory in Traditional Courses in Chemistry

Courses based on Dull, Brookes and Metcalfe's text have been labelled "traditional" (Walker, 25:603-609; Bennett, 2:823-830) or "conventional" (Rainey, 22:539-544) when compared with contemporary programmes, such as Chem Study, Chemical Bond Approach and Nuffield Chemistry. Traditional courses are characterised by

1. their emphasis on using the text-book to teach factual knowledge,
2. their use of the laboratory to illustrate facts described in the text,
3. their historical approach, and
4. their lack of continuity.

These characteristics are discussed below in more detail.

1.511 Emphasis on using the Text-book to Teach Facts

Traditional courses are centered on the text-book as the source of knowledge to the extent that they "can be, and are, taught without a laboratory." (Walker, 25:603-609) Questions at the end of each chapter demand recall of definitions, statements and descriptions used in the text. For example, in Dull, Brookes and Metcalfe's text, (9:84, 101) the terms "oxidation" and "combustion" are defined and, at the end of the chapter, the student is asked to distinguish between the two terms. The authors stress the importance of this aspect of the work in the preface to the text (Dull, 9:v, vi):

> Chemical words and terms are defined and pronounced in a short glossary at the beginning of each chapter and again, when the word or term appears in the text, it is printed in boldface italics and defined. These words and terms are also listed at the end of each chapter in the material entitled "Test Yourself on these Terms". . . . At the end of each unit there appears two sets of more difficult exercises. . . . The former contains an abundance of drill material. . . .

1.512 Use of the Laboratory to Illustrate Facts Described in the Text

Rainey (22:539-544) taught two groups of chemistry students using a "conventional" approach and two other groups using the Chem Study materials and compared the results. His "conventional" approach utilised laboratory work in a manner typical of traditional courses: "text assignments and class recitation-discussion preceded all laboratory work. All laboratory work was an outgrowth from class material . . .". In traditional courses, laboratory work usually consisted of "preparing" X, "showing the properties of" Y or "proving" Z and, to this end, the laboratory manuals provided recipe-like instructions on procedure.

Laboratory work was clearly of secondary importance and typically between ten and twenty experiments were done in a year. Rainey used eighteen experiments. In British Columbia a minimum of twenty experiments were stipulated for Chemistry 91, at least twelve of which were to be performed by the pupil. Of these experiments ten were specified and ten optional. The titles of the specified experiments listed below are typical of those of laboratory experiments in traditional chemistry courses:

Experiment 23* Preparation of insoluble salts
Experiment 29* Sulphuric acid
Experiment (not in laboratory manual) Show the effects of various factors on the speed of chemical change

(* the experiment numbers refer to the laboratory manual (Black, 3).)

1.513 Historical Approach

This approach gives rise to two features characteristic of traditional text books:

(a) The use of historical examples to illustrate the gradual development of modern ideas in science. Typical of this is the discussion of the classification of elements which begins with Dobereiner's work (1917) in which a relationship between chemical properties and atomic weights was first recognised. This is followed by a description of Newland's Law of Octaves (1864) and Mendeleef's Periodic Table in which the idea of using atomic weights as the basis for the classification of elements was further developed. Finally, the work of Mosely (1913) led to the experimental determination of atomic numbers and to their replacement of atomic weights as the basis of the periodic classification of elements (Dull, 9:55-63).

(b) The inclusion of examples of industrial processes, often described in great detail and often obsolete before they were included in the text.

The Lead Chamber process for the manufacture of sulfuric acid is an example of this (Dull, 9:390). Frequently, detailed diagrams of the apparatus are also included, as in the description of the Hooker Cell for the preparation of chlorine (Dull, 9:362).

1.514 Lack of Continuity

Walker (25:603-609) observes that in Dull, Brookes and Metcalfe's book, "the ideas, the facts, etc. are presented as little tiny packets . . . entities unto themselves." This is exemplified in Unit 3 in the text which consists of these four chapters:

Chapter 7	Oxygen
Chapter 8	Hydrogen
Chapter 9	The Gas Laws
Chapter 10	Water

The discussion of the Gas Laws makes no reference to oxygen or hydrogen, even though they are the only gases studied up to that point in the text. Neither are the Gas Laws mentioned in the chapter on water which follows. The Gas Laws chapter is quite isolated and no attempt is made to link it up to the rest of the unit.

In contrast with traditional chemistry courses, Chem Study rejects the historical approach and de-emphasises the learning of descriptive chemistry. It stresses the role of laboratory experimentation in introducing modern theories of chemistry directly and uses the theoretical models so developed to provide continuity and to tie together practical observations made by the students.

These characteristics are discussed in more detail in Chapter 2.

1.52 The Role of Laboratory Work in the Chem Study Programme

The Chem Study programme is unique in the way it proposes to use the laboratory for instructional purposes. Merrill (18:69-73) states that "Chem Study uses the laboratory more and it uses it differently."

Laboratory work sets the scene and provides the foundation for the whole course. Observations are made in the laboratory and from these, theoretical models are developed. The models are first applied directly to a limited number of chemical problems and are then further articulated to arrive at generalizations. Thus, the key to the successful implementation of the Chem Study programme is in identifying the relationship that exists between laboratory experiment and chemical theory and in using this relationship as the basis of the teaching process. Carefully chosen laboratory experiences are critical to the whole programme and theoretical discussions arise from these experiences. Theory is not developed until the appropriate data are acquired by students, usually by means of laboratory experiments. In other words, relevant laboratory experience precedes theoretical discussion.

1.53 The Goals of the Laboratory

It is possible that the laboratory be used in a variety of ways in a chemistry course. For example, laboratory exercises may be intended to provide concrete examples of theory, to develop investigative skills, to confirm predictions and/or to introduce phenomena to be discussed in class. These and other general applications of laboratory work within the framework of the course are referred to as the goals of the laboratory.

1.54 The Characteristic Items of a Factor

The analysis of the results of this project has produced a number of factors, representing groups of individuals with similar viewpoints. Each factor is associated with a hypothetical viewpoint concerning the sixty statements in the item sample used in the study. The viewpoints of each factor were established by taking the twelve most favored (most positive) and the twelve least favored (most negative) statements or items on the factor's ordered list of items. These twenty-four items together constitute the Characteristic Items of the factor.

1.6 Experimental Design

1.61 Selection of Subjects

Teachers from three major geographical areas of British Columbia were contacted and their participation in the project requested. All those who agreed to participate made up the teacher sample. The teachers in each school visited also provided from one to six students for the student sample. Curriculum specialists from Faculties of Education in British Columbia Universities formed the sample of specialists in the project. Altogether, three specialists, thirty-two teachers and fifty-three students were interviewed in the project.

1.62 Method of Research Used

The study utilises Q-methodology and techniques to analyse and identify viewpoints with respect to the goals of laboratory work. The instrument for measuring individual perceptions of the goals of laboratory work was a Q-sort, which consisted of a deck of sixty cards, each card bearing a single unique item, or statement, describing one possible goal of laboratory work. Additional information was collected from participating teachers by means of structured interviews (Appendix II).

1.63 Method of Collecting Data

The researcher personally interviewed all subjects and supervised all Q-sorts. Each subject was presented with a stack of sixty shuffled item-cards and was instructed to sort these, on the basis of their order of importance, into a predetermined pattern of distribution. Each item was scored and the item scores recorded. After completing the Q-sorts, teachers were interviewed and the data recorded on the questionnaire sheets (Appendix II).

1.64 Method of Analysis

A computer programme was prepared to analyse the data. First, a Pearson product-moment coefficient correlation matrix was formed from the raw data. This matrix was factor analysed to yield principal axis factors, which, in turn, were subjected to a varimax rotation. The rotated factors obtained represented groups of persons with similar viewpoints. An item array of weighted responses was then determined for each factor and the item arrays converted to z-scores. The z-scores were then used to determine a hierarchy of item acceptance for each factor and the differences between factors in order to provide the basis for differentiating the factors from one another.

1.65 Assumptions Made

Teachers were requested to do two Q-sorts of the items. The first (Q-sort 2) to express their perception of the intended goals of the laboratory and the second (Q-sort 3) to express their perception of the goals of the laboratory programme as it was applied to their own classrooms. These sorts were done consecutively and it has been assumed that the sorting of items in Q-sort 3 was not influenced by the sorting of items in Q-sort 2.

1.7 Limitations of the Study

The sampling procedure cannot be considered to have provided a random sample of teachers and students in British Columbia. However, the samples obtained are such that, with caution, the results may be used as strong indicators of the views of specialists, teachers and students in the Province.

Chapter 2

Analysis of the Chem Study Course and the Modifications Introduced in the British Columbia Secondary School Curriculum

2.1 Introduction

Chem Study and a number of other contemporary courses in high school chemistry, physics and biology were developed in response to urgent demands by the scientific community. Texts and courses in science in use prior to 1956 evidently did not reflect the outlook and practice of modern science and it was felt that this deficiency could have a detrimental impact on scientific and technical progress. Vast financial resources were made available to the scientific community to develop appropriate science programmes for the schools. Chem Study is one course which emerged from this era of curriculum reform.

In Sections 2.2 and 2.3 respectively, the major features of the Chem Study programme and the modifications that were made in adapting it for use in British Columbia secondary schools are discussed.

2.2 The Nature of the Chem Study Course

The authors of Chem Study consider it most important that the course should present chemistry to students in such a way as to reflect the nature and processes of science:

> It (the course) should serve as a reasonable presentation of science for those who should seriously consider a professional future in any scientific field. (J.A. Campbell in Merrill and Ridgeway, 19:17)

That the course should serve as a "reasonable presentation of science" is a key consideration. Other decisions concerning the nature and development of Chem Study follow, almost as a matter of course. First the "activities of science" are carefully defined and the pattern thus developed is used as the model for the development of the topics in the course. The basic activities of science are given (Pimentel, 20:2) as:

> to accumulate information through observation,
> to organise this information and to seek regularities in it,
> to wonder why the regularities exist,
> to communicate the findings to others.

The chemist, as a scientist, is involved in these activities in those areas of science of interest to chemists.

Four major features of the course make it quite different from the traditional high school courses:

1. The course de-emphasises the learning of descriptive or factual chemistry.
2. It emphasises laboratory experimentation (Campbell, 7:51-62).
3. It emphasises the teaching of contemporary ideas in chemistry (McClellan, 17:49).
4. It uses modern theroetical models to tie together the chemical information that the student observes (Campbell, 7:51-62).

These features are discussed in more detail below.

2.21 <u>The Course De-emphasises the Learning of Descriptive or Factual Chemistry</u>

Walker (25:603-609) describes Chem Study as a "thinking" course in which the emphasis is placed on ideas, with the facts serving as the "vehicle" for the ideas. Discussion in the text centers on the development of theoretical models and their scope, and questions at the end of the chapters test the students' understanding through applications to real situations. Students are required to use rather than recall information. This is illustrated in the following two examples:

> Q1. If a piece of copper metal is dropped into a solution containing Cr^{+3} ions, what will happen? Explain using E^os. (The E^o values are contained in the text.) (Pimentel, 20:222)
>
> Q2. Knowing the orbitals carbon uses for bonding, use the periodic table to predict the formula of the chloride of silicon. What orbitals does silica use for bonding? (Pimentel, 20:298)

2.22 <u>The Emphasis on Laboratory Experimentation</u>

> A valid picture of chemistry must include direct laboratory experience (McClellan, 17:43).

This quotation summarises succinctly the philosophy of the authors of Chem Study and their approach to chemistry reflects this philosophy. It is a course based on an experimental approach to chemistry, as advertised clearly in the title of the text: "Chemistry - An Experimental Science." Campbell (7:51-62) expresses his reasons for this approach in the following words:

> The experimental approach seems highly desirable since chemistry is a science which deals with things as well as ideas, and it has been rather well established that students remember much longer what they see and physically manipulate . . . . "

The whole course, then, is centered on the laboratory. Results obtained by students in the laboratory provide the basis for the development and discussion of chemical theory. Consequently, experiments have been carefully designed to provide the desired observations and students frequently receive detailed instructions to ensure that the "correct" observations are made (Pode, 21:98-103). The laboratory experiments are carefully integrated into the programme to show the relationship between practical observations and the development and understanding of theoretical models.

2.23 The Emphasis on Teaching Contemporary Ideas in Chemistry

> It is important to make the student keenly aware that he is preparing himself to deal with the scientific problems of today; not those of Dalton's time (McClellan, 17:49).

The development of topics in "traditional" chemistry texts was along historical lines. Discussions of the atomic theory, for example, evolved from a study of chemical changes and the properties and identification of substances. These studies led to the establishment of weight relationships (Laws of Constant Composition, Multiple Proportions) which in turn enabled Dalton to postulate the existence of atoms. Dalton's ideas about atoms were then applied to the study of gases and led to the recognition of the existence of molecules.

The Chem Study authors have rejected this approach in favor of a more direct and less confusing route. They first postulated the existence of atoms on the basis of evidence from volume relationships in gaseous reactions and then extended the concept to weight relationships and the properties of solids.

The logic of the development as it appears in Chem Study is just about the opposite of what appears in the historical approach. The authors ignore historical chronology in favor of a more direct approach made possible by today's knowledge. In the "Teacher's Guide" McClellan (17:77) justifies this action in these words:

> If it is intended only to clarify the logic by which chemical evidence supports the atomic theory, there is no obligation to display the tortuous process by which the logic was recognised... There is no need to drag the student through half a century of confusion that beclouded the acceptance and effective use of the theory. Indeed, if one's interest is to ensure that the student understands logic, it is undesirable to relate logic to chronology because it accents difficulty.

This absence of the historical approach is characteristic of the Chem Study course. One notable exception is found in Chapter 15 (Pimentel, 20: 252-273), which discusses electrons and the energy states of atoms. Another aspect of "traditional" courses significantly occupies a very minor role in Chem Study. It is the applications of chemistry in industry. For example, technical descriptions of manufacturing processes are omitted. Such processes are continually being replaced by updated and improved techniques and, as a result, many of the descriptions in "traditional" texts are obsolete. The Lead Chamber Process for the manufacture of sulphuric acid is a classic example of this. The same reaction is discussed in Chem Study but in a quite different context, where it provides an example of a gas volume calculation (Pimentel, 20:227).

2.24 The Use of Modern Theoretical Models to Tie Together the Chemical Information the Student Observes

> Science could not advance if our overwhelming mass of knowledge were not ordered with the aid of theories. (McClellan, 17:45)

The origin and function of theory in science is well illustrated and emphasised throughout the course. Theories, or working models, are developed on the basis of direct experimental evidence and, once established, the models are applied to situations beyond the scope of the original supportive data. Thus the theories are extended and the extensions justified by further laboratory work. Theories, then, are used to organise knowledge in the course.

This approach is illustrated by the treatment of equilibria and related topics. The concept of equilibrium (Pimentel, 20:142-162) is developed on the basis of the reaction between carbon monoxide and nitrogen dioxide, a reaction the students had met earlier in the course. Once established the principles of equilibrium are applied to a number of other systems, such as vapor pressure, solubility and to other chemical phenomena. These examples lead to a generalisation of the observations, known as the Le Chatelier Principle. Equilibrium is then discussed quantitatively and the idea is developed of the equilibrium state as a compromise between the states of minimum energy and maximum randomness. In the chapters which follow, the equilibrium concept is used as the basis for the discussion of solubility, solution and precipitation (Pimentel, 20:163-178) and the dissociation of aqueous acids and bases (Pimentel, 20:179-198). In this way, the equilibrium state is the unifying theme linking together a number of apparently diverse observations and seemingly unrelated concepts.

The student has, in these three chapters, been taken through the process of creating a theoretical model and then using it to organise and extend his knowledge. This procedure is the basis of scientific progress.

2.3 Modifications of the Chem Study Course in the British Columbia Secondary School Chemistry Programme

Chem Study forms the basis of the secondary school chemistry programme in British Columbia, but it was deemed necessary to make some relatively small changes to make the course more suitable for British Columbia students. The Introduction to the Chemistry 11 (Revised) Curriculum Guide (4:3) summarises these changes as follows:

> Since experience has shown that the Chem Study programme cannot be used to its fullest advantage in a single school year, it has been adapted for the reorganised British Columbia Curriculum as a two-year sequence under the name Chemistry 11 and Chemistry 12. Some industrial chemistry has been added to the programme, and greater emphasis has been placed on reaction chemistry and problem-solving.

The most widespread changes were made in the Chem 11 programme. The division of the Chem Study course into two one-year courses was coupled with a rearrangement of the sequence of teaching some of the chapters. The Chemistry 11 course consists of Chapters 1 to 7, followed by Chapters 14, 18 and 25. This rearrangement made it desirable, for example, to "strengthen the introduction to chemical bonding." This is achieved by employing pictorial representation of bonds, using a simplified electron-dot picture.

The content of Chemistry 11 has further been enriched by (a) providing additional experiments on the chemistry of the halogens and (b) including some examples of applications of chemical principles in industries in British Columbia. Both Chemistry 11 and Chemistry 12 have been modified by placing more emphasis on problem solving and calculations.

It is stressed, however, that these and other minor changes are not departures from the Chem Study course, but are supplements to it. The philosophy of the course remains unchanged and every effort is made to present the additional material in accordance with the general principles of the Chem Study programme.

2.4 Philosophical Context of the Chem Study Course

Thomas Kuhn classifies research in science into "normal" and "revolutionary" activities (Kuhn, 14:5-6). Normal science consists of research which is firmly based on one or more past achievements in science acknowledged by the scientific community as a basis for further practice; that is activities based on established paradigms. Revolutionary science, on the other hand, is concerned with the creation of new paradigms to replace those no longer satisfactory.

Long periods of normal science alternate with short periods of revolutionary science. Thus most scientists are involved with the undertakings of normal science, because the bulk of science activities are those of concern to normal scientists. The fraction of revolutionary scientists in the total population of scientists has always been a very small one.

This implies that efforts in science education, to be of greatest value, should be directed towards the preparation of science students for their most likely role as practitioners of normal science. The Chem Study course is very concerned with preparing students for possible careers in science (Merrill and Ridgeway, 19:2) and consequently concentrates exclusively on what Kuhn (14:47) refers to as "finger exercises," i.e. learning the paradigms through "problem solving activities both with pencil and paper and with instruments in the laboratory." Considerable scope is given to the more imaginative and creative students. Open-ended questions encourage the student to articulate and/or extend the paradigms to new areas of application. This feature in particular reflects the nature of normal science research, in which most research chemists are engaged. This approach makes students aware of the nature of theory and its role in the development of ideas in science. Chem Study can fairly be said to be concerned with the education of what Kuhn would call "normal" chemists.

Since activities of normal science are firmly based on currently held paradigms, the science educator should be concerned with familiarising students with these paradigms. The chemistry student should be taught the theories, working hypotheses, models, etc., upon which current research in chemistry is based. Kuhn makes it clear, however, that paradigms are not presented in isolation, but in the context of supporting evidence and some of its applications.

He (Kuhn, 14:46) writes:

> Scientists ... never learn concepts, laws and theories in the abstract and by themselves.... A new theory is always announced together with its applications to some concrete range of natural phenomena; without them it would not even be a candidate for acceptance.

In Chem Study, theories are introduced in the manner suggested by Kuhn and it is here that the laboratories play their most important role. Theory is discussed only after the student has made observations in the laboratory. The data gathered there form the basis of class discussions which lead to the development of a theory. Once established, the theory is discussed in the context of further applications and extensions. These, wherever possible, are supported by laboratory exercises, pencil and paper exercises and thought problems. The student is introduced to the theory in the light of its supporting evidence (which is kept to a minimum) and it is then applied to other examples and further articulated to include additional observed phenomena. These indeed are the activities of normal science.

Kuhn's conception of the structure of science strongly implies that students of chemistry should be taught the basic paradigms of chemistry and the physical and mental techniques commonly used by practising chemists. Chem Study strongly emphasises both these aspects throughout the course. The authors, in designing the course, have surely taken the structure of the subject into account.

2.5 Psychological Context of Chem Study

It is instructive to examine the structure of the Chem Study programme in the context of Piaget's theory of knowledge. The course is intended for students in Piaget's "formal operational" stage of development. Students at this stage are capable of great mobility of thought. They are no longer dependent upon concrete experiences, but are able to think abstractly and to manipulate ideas systematically without the necessity of concrete experiences to justify the manipulations (Almie, 1:18; Furth, 10:31-32). However, when faced with a new or difficult situation the student tends to regress in his level of thought to a lower stage - to the "concrete operational" and even to the "preoperational" stage on occasions (Shayer, 23:182-186; Almie, 1:136). When this happens, it may be necessary to provide the learner with relevant concrete operational experiences before he is able to cope with the new or difficult material at the formal operational level.

Chem Study effectively meets the possibility of regression by providing the student with carefully selected experiences at the concrete operational level in the laboratory before introducing new concepts. The experiments the students perform afford results and observations that provide the basis for the development of chemical principles and theoretical models. The author of the laboratory manual (Malm, 16:43) writes:

> He (the student) should have the opportunity to discover the principles for himself, through his own laboratory work. Through prior participation in appropriate experiments, a student will fully realise how principles are derived and why they are retained.

After the students have received this concrete experience the Chem Study authors rapidly develop the theories and extend the application of the models to other specific examples. The ideas are then further manipulated to include data which, at first sight, might appear to be unrelated to the original experiences. The manipulations are justified by relating them to yet more examples. The text is the vehicle for this treatment, but the laboratory experiences are carefully integrated with the text to help the programme develop smoothly. Students are expected to create their own hypotheses on the basis of their laboratory experiences; they are expected to understand the logic of the development of the model in the text and of the further manipulation of this abstract model to include other, more remote applications. The development of theory and its further manipulation are exercises at the formal operational level, but as is the practice in science, the results of these manipulations are confirmed by experiment in the laboratory.

In terms of Piaget's theory, then, the Chem Study approach to teaching chemistry appears to be based on sound psychological principles.

In addition to the above, J.S.F. Pode (21:98-103) observed that the authors of Chem Study appeared to apply four criteria when selecting and ordering ideas for the text. These are:

1. Is the idea so important that no first course is complete without it?
2. Can the idea be developed honestly at a level comprehensible to high school students?
3. Can it be developed out of experimental evidence that high school students can gather, or at least understand?
4. Does it tie into other parts of the course so that its use can be reinforced in practice?

These, Pode comments, are educational considerations, not chemical ones.

2.6 Specific Goals of the Laboratory

In Chem Study, laboratory work plays a key role by providing the practical observations and experimental data necessary for the logical development of theoretical models. Observation is the basic activity of science and it is the basic activity of Chem Study in the sense that the development of theoretical models is justified in terms of prior observations made in the laboratory. Whenever possible the student carries out relevant experiments in the laboratory before the subject is discussed in class. This practice gives the student the opportunity to make his own discoveries, to make a tentative search for regularities and to develop his own working hypotheses (Campbell, 6:2-5).

The results of the laboratory exercises are critical to the development of the programme. Great care is taken to ensure that the desired data and observations are obtained, by carefully selecting reliable experiments and providing students with detailed procedural instructions. Very little opportunity is given to students to develop their own procedure or to devise their own experiments.

About three-quarters of the experiments are quantitative and students are expected to get results within about a 5% accuracy. Laboratory techniques must therefore be given adequate attention and, to this end, teachers are instructed to devote the prelab discussion largely to experimental and manipulative details (McClellan, 17:4). While the laboratories are not intended specifically to teach technique, a reasonable technique is necessary to give the student reasonably accurate results. The accuracy of the data is also improved by using combined class results rather than individual results as the basis for class discussion. This technique avoids the need for time consuming repetition of experiments while it emphasises the advantages of duplicating one's data.

In some instances the laboratory is used to provide justification for the extension of a working model. The principles of chemical equilibria are discussed on the basis of a minimum of direct evidence. The model thus developed is then applied in the discussion of solubility and the equilibrium constant, applied to precipitation reactions, is called the solubility product. The laboratory determination of the solubility product of silver acetate helps justify this treatment. Another application of the equilibrium model is to acid-base reactions in aqueous solution. This also is supported by laboratory experiments. In both these cases, laboratory work justifies specific manipulations and extensions of the original theory.

One of the four basic activities of science, listed in Section 2.2 of this thesis, concerns the communication of the findings of science to others. The laboratory manual (Malm, 16:v) stresses the importance of this activity:

> It is a laboratory-centered course which ... stresses the preparation of well-organised tables for recording data and the results of calculations so that you can more readily make deduction and recognise the regularities which exist.

The laboratory manual contains a number of features to help the student prepare good reports. First the student receives general instructions which apply to all laboratory reports (Malm, 16:ix). These are supplemented for each experiment by including sample tables (Malm, 16:6) for the data to be collected and/or a list of the measurements that must be made (Malm, 16:13). Also, students are carefully led through the calculations by a series of sequential questions or instructions (Malm, 16:17-18). The student is given enough assistance to ensure that the results he obtains are adequate to justify the development of the theoretical model which follows.

Finally, the labs are used as the basis of a variety of discussion questions, to encourage students to apply the principles observed in the experiments to new situations (Malm, 16:v).

Chapter 3

Method of Study

3.1 Introduction

This project is concerned with investigating the beliefs of curriculum specialists, teachers and pupils with respect to the goals of the laboratory programme in British Columbia secondary school chemistry courses. It was proposed to classify individuals on the basis of their beliefs, to describe the group characteristics and to discuss the similarities and differences between the groups.

Other studies which have been concerned with determining types or groups within a population and with describing group characteristics have adopted Q-methodology to achieve their objectives (Tiller, 24; Ignatovich, 13). In this method, subjects perform a Q-sort on selected items, which involves arranging a collection of items into a specified number of ranked piles, usually according to a modified normal distribution. Appropriate statistical treatment (see 3.8 below) establishes clusters of individuals with similar response patterns. Supplementary information is also obtained from the subjects by conducting structured interviews. The information obtained enables groups of individuals with similar belief characteristics to be identified in a population, and the group characteristics to be described.

Q-analysis thus appears to provide the kind of information required in this study and it was decided to adopt Q-methodology and techniques for the project.

3.2 Selection of the Subjects

Three major geographical areas in British Columbia were chosen for the project - Vancouver Island, the Lower Mainland (including Vancouver) and the Southern interior of the Province from Princeton to Nelson. These areas were chosen (a) because they provide a sample of schools in city, town and rural situations, and (b) because of their ready accessibility to the interviewer.

Regional Research Associates of the Educational Research Institute of British Columbia (ERIBC) in these major geographical areas were contacted and requested to locate teachers of Chemistry 11 and 12 who would agree to participate in the research programme and who would, in addition, provide a small number of Grade 12 chemistry students to make up the student sample. Curriculum specialists were obtained from Faculties of Education in the University of British Columbia and in the University of Victoria. These were faculty members who were very familiar with the Chem Study approach.

A total of three curriculum specialists, thirty-two teachers and fifty-three Grade 12 chemistry students participated in the project. The thirty-two teachers represent approximately 10% of the teachers of Grades 11 and 12 chemistry in the Province.

3.3 Selection of the Items for the Q-sort

A review of literature concerned with the goals of laboratory work in science and/or chemistry teaching programmes was undertaken. This review included writings of chemists, chemistry teachers, textbook authors, curriculum designers, psychologists and philosophers of science from the 1930's to the present. A wide variety of statements and opinions about laboratory work was collected and, after editing, these provided more than eighty items, each describing a single goal of laboratory work. Care was taken to ensure that the items collected were representative of the views of proponents of both traditional and modern chemistry courses.

The sample was reduced to sixty items by removing ambiguous and duplicate items. The items were then examined by six Science Education professors and chemists who were asked to evaluate the items for possible redundancies and clarity of expression. A list of the sample of sixty items is recorded in Appendix I.

3.4 The Q-sorts

The sixty items in the item sample were printed on cards, one item to a card. The Q-sorts therefore involved the sorting of a deck of sixty cards into a specified number of piles or categories.

Subjects were instructed to sort the items into nine categories, ranging from "most important" (Category 1) to "least important" (Category 9). The required distribution of items between the categories is shown in Table I. A copy of this modified normal distribution was placed in view of all subjects during the sort. Subjects were advised to divide the sixty items into three piles initially, having (a) important, (b) neutral, and (c) unimportant statements of the goals of laboratory work respectively, then to further subdivide the three piles to give the required distribution of items. Subjects were instructed not to rank the items within the categories.

Four Q-sorts were conducted, corresponding to the four specific problems given in Section 1.2.

Q-sort 1 (Problem 1.21) Curriculum Specialists were instructed to sort the statements printed on the item cards to indicate the intended order of importance of the goals of the laboratory programme in the British Columbia secondary school chemistry courses.

Q-sort 2 (Problem 1.22) Teachers of Grades 11 and 12 were instructed to sort the items to indicate the intended order of importance of the goals of the laboratory programme, based on their interpretation of the rationale of the course as described in the Chem Study literature and in the Provincial Curriculum Guide.

Q-sort 3 (Problem 1.23) The same teachers were instructed to sort the sample of items to indicate the order of importance of the goals of laboratory work in their own teaching of the chemistry curriculum.

Q-sort 4 (Problem 1.24) Grade 12 chemistry students were instructed to sort the items to indicate what they perceive to be the order of importance of the goals of the laboratory activities in the Provincial Chem Study programme, based upon the way the laboratories were conducted in the course.

3.5 The Structured Interview

The information obtained from Q-sorts 2 and 3 was supplemented by conducting a structured interview with the teachers concerned. This provided additional information of a more personal nature which has been used to describe the individuals who share similar beliefs about the goals of laboratory work. A copy of the interview questionnaire is included in Appendix II.

3.6 Administration of the Q-sorts and Structured Interviews

The researcher visited every subject and conducted and supervised all Q-sorts personally, to ensure a more consistent presentation of instructions and to encourage a more genuine effort by the subjects. For the teachers, Q-sort 2 was administered first, followed by Q-sort 3 and, finally, the structured interview.

3.7 Scoring the Items

Each item in the Q-sort was assigned a score and this was recorded on a master sheet (Appendix III). Items in Category 1 (most important) each received a score of 9, those in category 2, a score of 8 and so on to the items in Category 9 (least important), each of which received a score of 1. (See Table I)

3.8 Analysis of the Data (Tiller, 24; Ignatovich, 13; MacLean, 15)

3.81 An intercorrelation matrix was first formed by correlating every person's sort of items with every other person's sort of items.

3.82 The resultant matrix was factor analysed, so that persons were variables and items were observations. The principal factors were submitted to varimax rotation for ease of interpretation.

Each rotated factor corresponds to a hypothetical type of person; i.e. each factor represents a group of persons with similar patterns of belief with respect to the objectives of laboratory work. The factor loadings are a measure of each person's correlation with each of the hypothetical types, or factors. The higher a person's loading on a factor the greater the correlation between the individual and the hypothetical type of person the factor represents. Individuals were then grouped according to the factor on which they had the highest factor loading. In this way they were placed with the hypothetical type of person they most closely resemble. The population of each factor thus consists of a unique group of similar individuals.

3.83 Item responses were then analysed to establish a hierarchy of item acceptance (from most important to least important items) for each hypothetical type of person (or factor). This was done as follows:

3.831 Each person was assigned a weighting constant (W) by selecting his highest factor loading (r) and applying the formula

$$W = \frac{r}{1 - r^2} .$$

	Most Important								Least Important
Category	1	2	3	4	5	6	7	8	9
Number of Cards in Category	2	3	6	11	16	11	6	3	2
Category Score	9	8	7	6	5	4	3	2	1

Table I Distribution of Items in Q-sort and Item Scores

3.832 Each person's item scores were then weighted by multiplying his item scores by his weighting constant (W). For each factor, the weighted item scores of all the individuals comprising the factor population were summed, item by item, to give an item array of weighted responses for each factor.

3.833 The raw scores on the items in the arrays were converted to z-scores for purposes of comparison and the resulting item-scores ordered. This provided a hierarchy of item or goal acceptance for each factor. Differences between item z-scores for the different types were used to differentiate between the factors. A difference of 1.0 in z-scores for an item was considered significant.

Chapter 4

Results and Conclusions

4.1 Introduction

This chapter presents a principal-axis solution to the problem of identifying types of viewpoints concerning the goals of the laboratory in teaching chemistry at the secondary school level. Statements which serve to differentiate one viewpoint from another and areas of agreement and disagreement between the different viewpoints are identified and discussed.

4.2 Results of Factor Analysis

Q-scores for the subjects - specialists, teachers and students - were assembled into an item x subject data matrix in which the columns were distributions of Q-scores for individual subjects. This data matrix is included in Appendix III. Correlations between columns were computed and the resulting Pearson product moment correlation coefficients arrayed in a subject x subject matrix of intercorrelations. This intercorrelations matrix was subjected to factor analysis. Four factors were selected on the basis of the magnitude of the latent roots and rotated to varimax rotation. Table II gives the rotated factor structure for the four factor solution.

Each factor, F1, F2, F3 and F4, represents a grouping of subjects around a common pattern of sorting items. Hence, each factor represents a type of person whose viewpoint can be characterised by the pattern of sorting items. The coefficients given in Table II represent the degree to which the subjects' sort of items were associated with the four different viewpoints. Subjects were placed in the factor in which they had the highest factor coefficient or loading.

Table II

Rotated Factor Structure of Four Factors Corresponding to the Four Largest Values of the Latent Roots

	Subject	F1	F2	F3	F4
Q-sort 1 (Specialists)	1	0.805*	-0.055	-0.028	0.138
	2	0.747*	0.320	-0.147	-0.025
	3	0.663*	0.279	-0.205	0.096
Q-sort 2 (Teachers)	4	0.636*	0.236	-0.328	0.158
	5	0.637*	0.058	-0.204	0.227
	6	0.282	0.427*	-0.276	0.016
	7	0.394*	0.323	-0.028	-0.182
	8	0.659*	0.153	-0.131	0.118
	9	0.522*	0.217	0.490	-0.019
	10	0.586*	0.195	0.116	0.223
	11	0.667*	0.419	-0.022	0.127
	12	0.775*	0.193	-0.056	0.065
	13	0.484*	0.407	0.290	0.078
	14	0.708*	0.217	-0.162	0.188
	15	0.513*	0.488	-0.301	0.051
	16	0.666*	0.181	0.039	0.024
	17	0.612*	0.156	0.240	0.310
	18	0.656*	0.308	-0.005	0.334
	19	0.752*	0.330	0.135	0.065
	20	0.139	0.463*	-0.087	0.193
	21	0.705*	0.159	-0.203	0.123
	22	0.715*	0.140	-0.237	0.085
	23	0.496	0.542*	0.075	0.056
	24	0.716*	0.229	-0.210	0.045
	25	0.367	0.432*	0.223	0.207
	26	0.575*	0.230	-0.070	0.278
	27	0.332	0.108	-0.166	0.406*
	28	0.672*	0.212	0.158	0.259
	29	0.509	0.205	-0.569*	0.085
	30	0.800*	-0.112	-0.146	0.254
	31	0.745*	0.224	-0.184	-0.205
	32	0.832*	-0.007	-0.132	0.039
	33	0.598*	0.354	-0.131	0.094
	34	0.796*	0.257	-0.105	0.099
	35	0.617*	0.090	-0.164	0.165
Q-sort 3 (Teachers)	36	0.550*	0.192	-0.343	0.186
	37	0.274	0.409*	-0.120	0.034
	38	0.409*	0.181	0.201	0.032
	39	0.502*	-0.041	-0.231	-0.022
	40	0.426*	0.081	0.019	0.167
	41	0.356	0.291	0.237	0.427*
	42	0.559*	-0.006	-0.425	0.064

* Subject's highest factor loading

Table II (Continued)

	Subject	F1	F2	F3	F4
	43	0.661*	0.079	-0.240	-0.054
	44	0.422	0.044	-0.647*	0.122
	45	0.675*	0.301	-0.216	0.200
	46	0.582*	0.447	0.019	-0.146
	47	0.561*	0.410	0.062	-0.168
	48	0.544*	0.073	0.255	0.329
	49	0.600*	0.313	-0.097	0.311
	50	0.790*	0.238	-0.047	0.041
	51	0.180	0.407*	-0.027	0.235
	52	0.279*	-0.014	-0.039	0.187
	53	0.225	0.151	-0.219	0.276*
	54	0.323	0.412	-0.422*	0.012
	55	0.518*	0.154	0.252	0.107
	56	-0.090	0.389*	0.196	-0.007
	57	0.219	0.194	0.042	0.421*
	58	0.232	-0.116	-0.264	0.403*
	59	0.668*	-0.016	0.262	0.288
	60	0.430*	0.108	-0.250	-0.235
	61	0.745*	0.014	-0.078	0.218
	62	0.675*	-0.050	-0.356	-0.206
	63	0.597*	-0.088	-0.423	-0.154
	64	0.394	0.568*	-0.009	0.274
	65	0.589*	0.007	-0.333	0.322
	66	0.662*	0.324	0.106	0.212
Q-sort 4 (Students)	67	0.195	0.384*	-0.233	0.196
	68	-0.098	0.498*	-0.031	0.207
	69	0.040	-0.116	-0.326*	0.208
	70	0.069	0.725*	-0.122	0.184
	71	0.072	0.595*	-0.044	0.183
	72	0.027	0.332	-0.351*	-0.220
	73	0.300	0.073	-0.619*	0.437
	74	0.010	0.731*	-0.050	-0.050
	75	-0.051	-0.085	-0.082	0.732*
	76	0.209	0.499*	0.147	0.421
	77	0.159	-0.060	-0.799*	0.120
	78	0.336	0.700*	-0.165	-0.041
	79	0.170	0.647*	0.151	0.236
	80	0.257	0.802*	-0.111	-0.012
	81	0.219	0.662*	0.028	0.283
	82	0.380	0.174	-0.272	0.425*
	83	0.080	0.789*	0.036	0.026
	84	0.176	0.142	-0.515*	0.306
	85	0.128	0.682*	-0.056	0.333
	86	0.152	0.375	-0.377*	0.048
	87	0.024	0.464*	0.349	0.171

* Subject's highest factor loading

Table II (Continued)

Subject	F1	F2	F3	F4
88	0.291	0.748*	-0.163	-0.096
89	0.377	0.521*	0.013	0.393
90	0.186	-0.040	0.373*	0.058
91	0.391*	0.377	-0.197	-0.048
92	0.100	0.755*	-0.066	-0.045
93	0.093	0.516*	-0.334	0.162
94	0.239	0.404*	0.229	0.054
95	-0.011	0.313*	0.072	0.062
96	0.361	0.281	0.147	0.601*
97	0.396*	0.075	-0.172	0.078
98	0.170	0.222	-0.217	0.307*
99	-0.035	0.521*	-0.265	-0.039
100	0.034	0.765*	-0.222	0.307
101	0.080	0.557*	-0.119	0.136
102	-0.211	0.056	0.480*	0.069
103	0.471	0.263	-0.637*	0.130
104	0.278	0.332	0.372*	0.120
105	0.337	0.598*	-0.086	0.120
106	0.328	0.578*	-0.098	-0.018
107	0.330	0.520*	0.022	0.051
108	0.064	0.112	-0.143	0.500*
109	0.010	0.443*	-0.221	-0.118
110	0.116	0.546*	0.292	0.363
111	0.302	0.707*	-0.067	-0.019
112	0.155	0.770*	-0.289	-0.080
113	0.164	0.688*	0.090	-0.090
114	0.463	0.378	-0.479*	0.194
115	0.384	0.638*	-0.325	-0.012
116	0.062	0.236	0.008	0.489*
117	0.300	0.486*	-0.359	-0.038
118	0.125	0.593*	0.065	0.050
119	-0.020	0.831*	0.172	0.182
120	0.176	0.474*	0.233	0.293
Eigenvalues	36.1604	10.7055	6.5908	4.2757
% Variance	30.1	8.9	5.5	3.6
% Total Variance	48.11			

*Subject's highest factor loading

The first three factors in the four-factor solution accounted for 109 out of 120 subjects. Thus, three different viewpoints about the goals of the laboratory in the teaching of chemistry characterise the opinions of the 109 subjects. The fourth factor was neglected and is not included in further discussions.

The sorting pattern of the items which is associated with each different viewpoint was then determined. The factor loading of each subject was used to weight the subject's item scores. For each factor, the weighted item scores were then summed, item by item, for all subjects belonging to the factor. The totals were arrayed in an item x factor matrix. The columns of scores in this matrix are referred to as factor arrays. To facilitate comparison of the factor arrays, the scores were transformed to standardised scores or z-scores. The factor arrays of z-scores for the first three factors of the four factor solution are given in Table III.

The z-scores in each array, F1, F2, and F3, were then ordered according to size and direction (+, -). Only the twelve items having the highest positive scores and the twelve items having the highest negative scores in each array were used for comparing the three viewpoints. The twenty-four items in each factor array, selected according to this criterion, are referred to as the characteristic items of each factor or viewpoint. Tables IV and V give the characteristic items of F1, Tables VI and VII give those of F2, and Tables VIII and IX give the characteristic items of F3.

Table III

Factor Array of Item z-Scores

Item	F1	F2	F3
1	0.90	0.64	-0.41
2	-0.54	0.46	0.28
3	-2.12	0.41	0.62
4	-0.65	1.37	-0.14
5	0.94	0.69	-0.48
6	-0.54	0.40	0.19
7	0.56	1.59	-0.17
8	-0.08	1.00	0.25
9	0.26	1.51	-0.50
10	-1.97	0.79	0.94
11	0.98	1.17	0.03
12	0.90	0.71	-0.31
13	-0.47	1.26	0.35
14	0.20	-0.23	0.59
15	-0.30	-1.06	1.32
16	-1.07	-1.53	2.07
17	0.34	-0.11	0.76
18	-0.14	0.19	0.38
19	-1.98	-2.17	2.31
20	0.48	0.79	-0.30
21	-0.15	-0.14	0.53
22	-0.35	-1.17	1.61
23	0.54	0.01	0.75
24	-0.06	0.08	-0.04
25	2.00	1.41	-0.55
26	-0.41	-0.40	-1.52
27	0.00	0.78	-1.51
28	-0.29	0.78	0.51
29	1.13	0.02	-0.56
30	1.65	0.57	-0.57
31	2.50	0.78	-0.63
32	0.98	-0.04	0.56
33	0.45	0.35	-0.81
34	0.79	0.49	-0.09
35	0.70	0.51	0.08
36	1.24	0.32	0.02
37	-0.13	-1.03	1.23
38	0.31	-0.76	0.90
39	-0.31	1.00	0.15
40	-1.08	1.15	0.60
41	-0.18	-0.96	-1.21
42	-0.65	-2.25	0.55
43	-0.04	-0.53	-1.74
44	-0.40	-1.57	-1.42
45	0.22	-0.37	-1.24

Table III (Continued)

Item	F1	F2	F3
46	-0.29	-1.29	-1.35
47	0.39	-0.05	-1.53
48	-0.29	-0.92	-1.51
49	0.67	-0.75	-0.10
50	1.24	0.73	-1.40
51	0.70	-0.29	-1.56
52	0.33	0.59	-1.48
53	-0.09	1.03	-0.15
54	-1.30	-0.95	0.97
55	-1.93	-1.70	1.71
56	-2.42	-1.87	2.38
57	1.08	0.62	0.45
58	-1.74	-2.37	0.72
59	-0.77	-0.14	-0.13
60	-0.61	0.43	-0.39

Table IV Differentiation Between Factors 1, 2 and 3 in Terms of the z-scores of the Twelve Most Important (Positive) Items for F1

Most Important (+) Items for F1	z-score F1	z-score F2	Δ(1, 2)*	z-score F3	Δ(1, 3)**
31 Encourages students to search for regularities	2.50	0.78	1.72	-0.63	3.13
25 Teaches students to interpret experimental results	2.00	1.41	0.59	-0.55	2.55
30 Trains students to observe accurately	1.65	0.57	1.08	-0.57	2.22
36 Illustrates the nature of experimental science	1.24	0.31	0.92	0.02	1.22
50 Teaches students to reason logically	1.24	0.73	0.51	-1.40	2.64
29 Encourages unbiased observation	1.13	0.02	1.11	-0.56	1.69
32 Teaches students to classify information	0.98	-0.04	0.44	0.56	0.42
57 Illustrates the uncertainty of experimental results	1.08	0.62	0.46	0.45	0.63
11 Provides a basis for understanding scientific models	0.98	1.17	-0.19	0.03	0.95
5 Leads to development of theoretical models	0.94	0.69	0.25	-0.48	1.42
1 Introduces theoretical discussion	0.90	0.64	0.26	-0.41	1.31
12 Emphasises the importance of experimental work	0.90	0.71	-0.19	-0.31	1.21

* Δ(1, 2) = z(F1) - z(F2)

** Δ(1, 3) = z(F1) - z(F3)

Table V Differentiation Between Factors 1, 2 and 3 in Terms of the z-scores of the Twelve Least Important (Negative) Items for F1

Least Important (-) Items for F1	z-scores F1	z-score F2	Δ(1, 2)*	z-score F3	Δ(1, 3)**
42 Teaches students to be honest	-0.65	-2.25	1.60	0.56	-1.20
4 Confirms predictions made by theory	-0.65	1.37	-2.02	-0.14	-0.51
59 Helps students understand chemical terminology	-0.77	-0.14	-0.63	-0.13	0.64
16 Teaches students how to use a balance properly	-1.07	-1.53	0.46	2.07	-3.14
40 Reinforces the learning of facts in chemistry	-1.08	1.15	-2.23	0.60	-1.68
54 Provides a way to assess student performance in the course	-1.30	-0.95	-0.35	-0.97	-2.27
58 Gives students an opportunity to relax and enjoy themselves	-1.74	-2.37	0.63	0.72	-2.46
55 Helps students get a good grade in the course	-1.93	-1.70	-0.23	1.71	-3.64
10 Verifies statements made by teacher or textbook	-1.97	0.79	-2.76	0.94	-2.91
19 Teaches students to keep their lab bench neat and clean	-1.98	-2.17	0.19	2.31	-4.29
3 Proves theory is correct	-2.12	0.41	-2.53	0.62	-2.74
56 Helps students pass the departmental examination	-2.42	-1.87	-0.55	2.38	-4.80

* Δ(1, 2) = z(F1) - z(F2)

** Δ(1, 3) = z(F1) - z(F3)

Table VI <u>Differentiation Between Factors 1, 2 and 3 in Terms of the z-scores of the Twelve Most Important (Positive) Items for F2</u>

Most Important (+) Items for F2	z-score F2	z-score F1	Δ(2, 1)*	z-score F3	Δ(2, 3)**
7 Makes the principles of chemistry easier to understand	1.59	0.56	1.03	-0.17	1.76
9 Illustrates the close relationship between theory and observation	1.51	0.26	1.25	-0.50	2.01
25 Teaches students to interpret experimental results	1.41	2.00	-0.59	-0.55	1.96
4 Confirms predictions made by theory	1.37	-0.65	2.02	-0.14	1.51
13 Provides justification of theoretical treatments	1.26	-0.47	1.73	0.35	0.91
11 Provides a basis for understanding scientific models	1.17	0.98	0.19	0.03	1.14
40 Reinforces the learning of facts in chemistry	1.15	-1.08	2.23	0.60	0.55
53 Provides a basis for further study in chemistry	1.03	-0.09	1.11	-0.15	1.18
8 Shows that theory explains observation	1.00	-0.08	1.08	0.25	0.75
39 Provides an interesting way of presenting scientific facts to students	1.00	-0.31	1.31	0.15	0.85
20 Teaches experimental techniques	0.79	0.48	0.31	-0.30	1.09
10 Verifies statements made by teacher or textbook	0.79	-1.97	2.76	0.94	-0.15

* $\Delta(2, 1) = z(F2) - z(F1)$

** $\Delta(2, 3) = z(F2) - z(F3)$

Table VII <u>Differentiation Between Factors 1, 2 and 3 in Terms of the z-scores of the Twelve Least Important (Negative) Items for F2</u>

Least Important (-) Items for F2	z-score F2	z-score F1	Δ(2, 1)*	z-score F3	Δ(2, 3)**
41 Teaches students to be self-reliant	-0.96	-0.18	-1.04	-1.21	0.25
37 Shows how scientists work	-1.03	-0.13	-0.90	1.23	-2.26
15 Teaches orderly work habits	-1.06	-0.30	-0.76	1.32	-2.38
22 Teaches the skills of good report writing	-1.17	-0.35	-0.82	1.61	-2.78
46 Teaches students to be imaginative	-1.29	-0.29	-1.00	-1.35	0.06
16 Teaches students how to use a balance properly	-1.53	-1.07	-0.46	2.07	-3.60
44 Teaches students to be creative	-1.57	-0.40	-1.17	-1.42	-0.15
55 Helps students get a good grade in the course	-1.70	-1.93	0.23	1.71	-3.41
56 Helps students pass the Departmental examination	-1.87	-2.42	0.55	2.38	-4.25
19 Teaches students to keep their lab bench neat and clean	-2.17	-1.98	-0.19	2.31	-4.48
42 Teaches students to be honest	-2.25	-0.64	-1.61	0.55	-2.80
58 Gives students an opportunity to relax and enjoy themselves	-2.36	-1.74	-0.62	0.72	-3.08

* Δ(2, 1) = z(F2) - z(F1)

** Δ(2, 3) = z(F2) - z(F3)

Table VIII Differentiation Between Factors 1, 2 and 3 in Terms of the z-scores of the Twelve Most Important (Positive) Items for F3

Most Important (+) Items for F3	z-score F3	z-score F1	$\Delta(3, 1)$*	z-score F2	$\Delta(3, 2)$**
56 Helps students pass the departmental examination	2.38	-2.42	4.80	-1.87	4.25
19 Teaches students to keep their lab bench neat and clean	2.31	-1.98	4.29	-2.17	4.48
16 Teaches students how to use a balance properly	2.07	-1.07	3.14	-1.53	3.60
55 Helps students get a good grade in the course	1.71	-1.93	3.64	-1.70	3.41
22 Teaches the skills of good report writing	1.61	-0.35	1.96	-1.17	2.78
15 Teaches orderly work habits	1.32	-0.30	1.62	-1.06	2.38
37 Shows how scientists work	1.23	-0.13	1.36	-1.03	2.26
54 Provides a way to assess student performance in the course	0.97	-1.30	2.27	-0.96	1.92
10 Verifies statements made by teacher or textbook	0.94	-1.97	2.91	0.79	0.15
38 Teaches students to think like scientists	0.90	0.31	0.59	-0.76	1.66
17 Emphasises accuracy in measurement	0.76	0.34	0.42	-0.11	0.87
23 Teaches methods of presenting data clearly	0.75	0.54	0.20	0.01	0.73

* $\Delta(3, 1) = z(F3) - z(F1)$

** $\Delta(3, 2) = z(F3) - z(F2)$

Table IX Differentiation Between Factors 1, 2 and 3 in Terms of the z-scores of the Twelve Least Important (Negative) Items for F3

Least Important (-) Items for F3	z-score F3	z-score F1	Δ(3, 1)*	z-score F2	Δ(3, 2)**
41 Teaches students to be self-reliant	-1.21	-0.18	-1.03	-0.96	-0.25
45 Teaches students to be curious	-1.24	0.22	-1.46	-0.37	-0.87
46 Teaches students to be imaginative	-1.36	-0.29	-1.06	-1.29	-0.06
50 Teaches students to reason logically	-1.40	1.24	-2.64	0.73	-2.13
44 Teaches students to be creative	-1.42	-0.40	-1.02	-1.57	0.15
52 Stimulates interest in chemistry	-1.48	0.33	-1.81	0.59	-2.07
48 Teaches students to show initiative	-1.51	-0.29	-1.22	-0.92	-0.59
27 Provides maximum opportunity for discovery learning	-1.51	0.90	-2.41	0.78	-2.29
26 Encourages students to design their own experiments	-1.52	-0.41	-1.11	-0.40	-1.12
47 Teaches students to be inquisitive	-1.53	0.39	-1.92	-0.05	-1.48
51 Teaches students to think clearly	-1.56	0.70	-2.26	-0.29	-1.27
43 Teaches students to be resourceful	-1.74	-0.04	-1.70	-0.53	-1.21

* Δ(3, 1) = z(F3) - z(F1)

** Δ(3, 2) = z(F3) - z(F2)

4.3 Description of the Viewpoints

The description of the viewpoints of the first three factors shown in Table II, based on the characteristic items of those factors, is presented below.

4.31 Description of the F1 Viewpoint - The Chem Study Viewpoint

The Characteristic Items (the twelve most important and twelve least important items) of the F1 viewpoint are recorded in Tables IV and V respectively, together with their z-scores.

According to the F1 viewpoint it is most important that the laboratory course should illustrate the nature, importance and uncertainty of experimental science. It should teach students to be unbiased and accurate in their observations, to search for regularities in their observations and to classify and interpret the information obtained. On the other hand, the teaching of chemical terminology and specific experimental techniques should be among the least important aspects of laboratory work. In the F1 viewpoint, it is not considered important that laboratory work should reinforce or verify facts and theories described in the text or by the teacher, or that it should confirm theoretical predictions. Nor is it considered important that laboratory work should be concerned with assessing student performance or helping students improve their performance in examinations.

The F1 viewpoint is representative of opinions expressed in fifty-two (52) individual sorts, of which fifty (50) were sorts performed by specialists and teachers (Q-sorts 1, 2 and 3). Only two (2) pupil sorts (Q-sort 4) are included in the factor. This factor may justifiably be labelled the Chem Study Viewpoint. The breakdown of the factor population is as follows:

	Number of Subjects belonging to F1 in each Q-sort	Total number of subjects participating in each Q-sort
Q-sort 1 (Specialists)	3	3
Q-sort 2 (Teachers)	26	32
Q-sort 3 (Teachers)	21	31
Q-sort 4 (Students)	2	53

The characteristics of the F1 viewpoint are thus representative of the opinions of specialists and teachers. Specialists (3 of 3) and teachers (26 of 32) have very similar interpretations of the intended goals of the laboratory programme for British Columbia secondary school chemistry courses. Further, about two-thirds (21 of 31) of the same teachers think that they work towards these same objectives in practice.

4.32 Description of F2 Viewpoint - The Student Viewpoint

The Characteristic Items of the F2 viewpoint are listed in Tables VI and VII respectively, together with their z-scores.

One of the most important goals of the laboratory course, according to the F2 viewpoint, is to illustrate the close relationship that exists between observation and theory. Laboratory experience provides a basis for the understanding and justification of theoretical models and confirms theroetical predictions. Another important goal of the laboratory course is to present facts in an interesting way, and to verify and reinforce factual knowledge and statements made in the text or by the teacher. Laboratory work is also considered important in teaching practical techniques and in helping prepare the student for further studies in chemistry. In contrast, the teaching of clean and orderly work habits and of the skills of good report writing are considered to be among the least important goals of laboratory work. In the F2 viewpoint the contribution of the laboratory course to the development of such personal attributes as creativity, self-reliance, honesty, imaginativeness and its role in assessing student performance and in helping to improve this performance, is also considered to be unimportant.

The F2 viewpoint represents the opinions expressed in 43 individual sorts, of which 35 were the sorts of pupils (Q-sort 4) and only 8 were the sorts of teachers, (Q-sorts 2 and 3). The composition of the population of this factor is as follows:

	Number of subjects belonging to F2 in each Q-sort	Total number of students participating in each Q-sort
Q-sort 1 (Specialists)	0	3
Q-sort 2 (Teachers)	4	32
Q-sort 3 (Teachers)	4	31
Q-sort 4 (Students)	35	54

The characteristics of the F2 viewpoint are thus representative of the opinions of nearly 65% of the students. They evidently have a significantly different ciew of the goals of the laboratory course in the Provincial Chem Study programme.

4.33 Description of F3 Viewpoint - The Traditional Viewpoint

The Characteristic Items of the F3 viewpoint are listed in Tables VIII and IX respectively, together with their z-scores.

A most important goal of the laboratory course, in the F3 viewpoint, is to demonstrate how scientists work and to encourage students to model their activities along similar lines. To this end, the laboratories emphasise the development of clean and orderly work habits, the importance of accuracy in measurement and the presentation of good, clear reports. The contributions of the laboratory course to the improvement and assessment of student performance and its use in verifying statements made by the teacher or text are also considered to be very important. The application of laboratory work to teach students to be curious, to show initiative, to think clearly, and to develop other desirable personal attributes is placed among the least important aspects of the course. According to the F3 viewpoint little or no opportunity is provided for students to engage in discovery learning or to design their own experiments.

The F3 viewpoint represents the opinions of 14 individuals. Of these, 3 are teachers and 11 pupils. The population is made up as follows:

	Number of subjects belonging to F3 in each Q-sort	Total number of subjects participating in each Q-sort
Q-sort 1 (Specialists)	0	3
Q-sort 2 (Teachers)	1	32
Q-sort 3 (Teachers)	2	31
Q-sort 4 (Students)	11	54

The characteristics of the F3 viewpoint are representative of 20% of the students sampled.

4.4 Information from Interviews

The information gathered from the interviews of teachers is summarised in Table X. The teachers who are members of F2 and F3 did not show any special characteristics with respect to experience or qualifications.

(a) Only 4 teacher responses to Q-sort 2 and 4 teacher responses to Q-sort 3 were classified as F2 responses. A total of 5 individual teachers accounted for these 8 responses. (3 individuals responded in the same way to both Q-sorts). Of these 5 teachers, 3 had taught for 10 years or more and 2 had taught for 5 years or less. Only 1 of the 5 had less than 5 chemistry courses in his degree programme.

(b) Three teacher responses were represented in the F3 (traditional) viewpoint. One of these had taught for 12 years and had taught the Dull and Metcalfe course, while the other two had taught for only three years and had not taught the Dull and Metcalfe course.

4.5 <u>Agreements and Disagreements Between the Viewpoints</u>

In order to compare and contrast the various viewpoints an analysis of the items which differentiate each factor from all the other factors was made. Tables IV to IX give the items and differentiations. Following the example of H.B. Tiller (24), a difference in z-scores of 1.0 or greater was considered to represent a significant difference in opinion.

With respect to the Characteristic Items of the F1 (Chem Study) viewpoint (Tables II and III) and those items considered least important by the F2 (student) viewpoint (Table V), the two factors or viewpoints show a considerable degree of agreement. In only one-third (12 of 36) of the above items do significant differences appear between the factors. However, of the items considered most important in the F2 viewpoint (Table IV) three-quarters (9 of 12) differ significantly from the selections of F1.

Teachers and specialists (F1) emphasise the role of the laboratory course in teaching the major processes of science, namely observation, classification, interpretation, as preliminary stages in the logical development of theoretical models. Students (F2) tend to place more emphasis on the details of the relationship between observation and theory and on the utility of laboratory work in substantiating theory and making it easier to understand. In this

Table X Experience and Qualifications of Teachers and Their Distribution Among the Factors*

Number of years teaching chemistry	Number of subjects	Distribution of subjects in F1, F2 and F3 for Q-sorts 2 and 3				Whether subject taught Dull and Metcalfe course		Number of chemistry courses in degree programme	
			F1	F2	F3	Yes	No	5+	less than 5
0 - 4	11	Q-2	10	0	1	0	11	8	3
		Q-3	7	1	1				
5 - 9	10	Q-2	8	1	0	3	7	7	3
		Q-3	7	1	0				
10 +	11	Q-2	7	3	0	10	1	10	1
		Q-3	6	2	1				

* Apparent discrepancies in the totals of the numbers of subjects are due to the fact that F4 has not been included in this analysis.

respect the difference between the two factors is one of emphasis rather than of substance. However, a substantial difference between the two groups is evident in their attitude towards the use of laboratory work to teach techniques, to present facts and to verify statements made in the text or by the teacher. Teachers and specialists place these among their least important objectives of the laboratory course while students include them in their selection of most important items.

Much wider differences of opinion occur between the F3 (traditional) viewpoint and the viewpoints of the other two factors. The comparison of the Characteristic Items of F1 and F2 with those of F3 show that significant differences occur between F1 and F3 and between F2 and F3 in 16 of the 24 items considered for each factor. When compared with the Characteristic Items of F3, the item sorts of F1 and F2 display significant differences in 19 and 16 items respectively.

Little common ground is apparent between the opinions expressed by the viewpoints of F1 and F3, while the opinions expressed by the F2 viewpoint are intermediate between the two extremes and overlap both to some extent. This is illustrated diagramatically in Fig. 1. The divergence of opinion between the F3 and F1 viewpoints is illustrated by the fact that half (6 of 12) of the items considered most important by F3 are included in the list of least important items selected by F1. These items are concerned with the use of the laboratory to verify statements made by the teacher or in the text, to improve student performance in examinations and to develop good laboratory work habits and techniques. The viewpoints of F2 and F3 are similar in that both consider the use of laboratory work to teach practical skills and to verify statements made by the teacher or in the text to be important. However

Fig. 1 Agreement and Disagreement Between the Three Viewpoints

	Goals of the Laboratory				
	To teach the processes of science	To provide background for development of theory	To show the relationship between labs and theory	To teach skills and to provide verification of statements	To improve performance in examinations
F1 (Chem Study) Viewpoint	Items: 30,31,32,29,26	Items: 5,11,25,50			
F2 (Student Viewpoint)		Items: 11,25	Items: 4,7,8,9,13	Items: 10,20,39,40	
F3 (Traditional Viewpoint)				Items: 10,15,16,17,19 22,23,37,38	Items: 17,54,55

they differ widely in their attitude towards the use of the laboratory course to help students perform well in examinations. The F3 viewpoint includes the relevant items among its most important selections while, in the F2 viewpoint, they are included in the least important items.

4.6 Conclusions

The sample of specialists provided a definitive opinion of the goals of the laboratory for the purpose of this study. By this standard, it is apparent that the majority of teachers correctly interpret the intent of the laboratory course and are of the opinion that they apply the laboratory exercises accordingly in practice. Hypotheses 1.31 and 1.32 (page 3) are thus confirmed.

However, hypothesis 1.33 has been shown to be untenable. Students seem to perceive that the intended goals of the laboratory exercises are to justify theoretical treatments, to help them understand scientific models and to make the principles of chemistry easier to understand. In Piagetian terms, students appear to believe that their laboratory experiences are intended to provide the concrete operational experiences which enable them to cope with abstract ideas. Kuhn (14:111) noted that teacher and student must be expected to see things differently.

> Looking at a contour map, the student sees lines on paper, the cartographer a picture of a terrain. Looking at a bubble-chamber photograph, the student sees confused and broken lines, the physicist a record of familiar subnuclear events. Only after a number of such transformations does the students become an inhabitant of the scientist's world, seeing that the scientist sees and responding as the scientist does.

An important goal of the Chem Study is to make students aware of the role of laboratory work in the course (Section 1.24). It is evident, however, that the programme has been only partially successful in this regard. The extent to which the course has clearly failed to achieve this goal corresponds to the overlap between the Student Viewpoint (F2) with the Traditional Viewpoint (F3).

4.7 Suggestions for Further Research

4.71 This study should be repeated in British Columbia and elsewhere with random samples of secondary school chemistry teachers and students.

4.72 Similar studies, where courses other than Chem Study are being taught, might be undertaken.

4.73 Further investigations into the differences between the viewpoints of teachers and students in chemistry and in other subject areas would be of value. A greater understanding of these factors would assist the teacher in presenting his subject with greater sympathy for the student viewpoint. This would likely improve teacher-student communication.

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APPENDIX I

List of Statements in Item Sample

List of Statements in Item Sample

1. introduces theoretical discussion
2. illustrates new applications of theory
3. proves theory is correct
4. confirms predictions made by theory
5. leads to development of theoretical models
6. solves problems posed by theory
7. makes the principles of chemistry easier to understand
8. shows that theory explains observations
9. illustrates the close relationship between theory and observation
10. verifies statements made by teacher or textbook
11. provides a basis for understanding scientific models
12. emphasises the importance of experimental work
13. provides justifications of theoretical treatments
14. emphasises the importance of quantitative lab work
15. teaches orderly work habits
16. teaches students how to use a balance properly
17. emphasises accuracy in measurement
18. familiarises students with apparatus and chemicals
19. teaches students to keep their lab bench neat and clean
20. teaches experimental techniques
21. teaches students to follow instructions accurately
22. teaches the skills of good report writing
23. teaches methods of presenting data clearly
24. gives practice in problem solving

25. teaches students to interpret experimental results

26. encourages students to design their own experiments

27. provides maximum opportunity for discovery learning

28. illustrates the properties of matter

29. encourages unbiased observation

30. trains students to observe accurately

31. encourages students to search for regularities

32. teaches students to classify information

33. teaches students how to formulate testable hypotheses

34. teaches students to discriminate between important and unimportant observations

35. teaches scientific method

36. illustrates the nature of experimental science

37. shows how scientists work

38. teaches students to think like scientists

39. provides an interesting way of presenting scientific facts to students

40. reinforces the learning of facts in chemistry

41. teaches students to be self-reliant

42. teaches students to be honest

43. teaches students to be resourceful

44. teaches students to be creative

45. teaches students to be curious

46. teaches students to be imaginative

47. teaches students to be inquisitive

48. teaches students to show initiative

49. teaches students to be discriminating

50. teaches students to reason logically

51. teaches students to think clearly

52. stimulates interest in chemistry

53. provides a basis for further studies in chemistry

54. provides a way to assess student performance in the course

55. helps students get a good grade in the course

56. helps students pass the Departmental examination

57. illustrates the uncertainty of experimental results

58. gives students an opportunity to relax and enjoy themselves

59. helps students understand chemical terminology

60. introduces research techniques

APPENDIX II

Questionnaire for Teachers

Questionnaire for Teachers

Reference No. ....

Number of years teaching chemistry ....

Number of chemistry courses in degree ....

Chemistry courses now taught ....

Did you teach the Dull and Metcalfe course? ....

Which course do you prefer teaching? ....

Reasons: ....

....

....

Do you believe you are teaching the Chem Study lab activities as suggested in the course literature and in the curriculum guide? ....

Yes entirely 5 4 3 2 1 Not at all

If not, why not? ....

What modifications have you made? ....

....

What factors other than the course materials and the curriculum guide influence your teaching of the labs?

(a)	Provincial exams	Yes	5	4	3	2	1	No
(b)	Personal beliefs		5	4	3	2	1	
(c)	Science methodology courses at university		5	4	3	2	1	
(d)	Needs of students		5	4	3	2	1	
(e)	Lab facilities		5	4	3	2	1	
(f)	Other		5	4	3	2	1	

Briefly explain: ....

....

Now that provincial examinations are being abolished, will you change your approach to the use of labs in the chemistry courses? ....

What changes will you make? ....

....

....

APPENDIX III

Q-scores: Subject x Item Data Matrices

Table I	Q-sort 1
Table II	Q-sort 2
Table III	Q-sort 3
Table IV	Q-sort 4

Table 1

Q Scores: Subject x Item Data Matrix for Q-sorts 1

Item Scores of Specialists, Based on their Interpretation of the Intended Goals of the Laboratory in the Provincial Chem Study Programme

Subject Code*	Computer Number	Item 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
S1	1	4	2	1	3	5	3	5	4	4	2	4	7	4	8	6	4	8	5	3	6	6	5	5	5	9	5	7	5	6	6
S2	2	7	6	3	6	9	6	5	6	7	4	8	5	4	5	4	3	5	4	1	5	5	4	5	3	8	5	6	4	7	7
S3	3	7	5	3	3	7	5	6	4	6	1	7	7	4	5	2	4	5	6	2	5	3	3	4	6	9	4	5	7	6	6

Table 1 (Continued)

Subject Code*	Computer Number	Item 31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
S1	1	9	6	6	7	4	6	5	5	4	3	5	5	6	5	6	5	7	5	6	7	7	4	5	4	4	2	8	1	3	3
S2	2	8	5	6	6	7	9	6	7	4	3	5	5	5	4	5	4	5	5	5	6	6	4	3	2	2	1	6	2	3	4
S3	3	8	6	9	6	4	7	4	4	6	5	5	5	4	4	6	5	5	4	6	5	5	8	5	3	2	1	8	5	5	3

*Explanation of Code: S = Specialist

Table 2

Q Scores: Subject x Item Data Matrix for Q-sort 2

Item Scores of Teachers, Based on their Interpretation of the Intended Goals of the Laboratory in the Provincial Chem Study Programme

Subject Code*	Computer Number	Item 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
TA1	4	8	5	3	6	5	5	5	3	6	2	6	6	5	3	3	4	6	4	2	6	3	3	5	3	7	4	6	4	5	8
TB1	5	5	3	4	4	5	3	5	6	6	2	6	9	3	3	5	3	4	4	2	4	4	6	6	4	7	6	5	5	6	7
TB2	6	4	6	5	5	5	5	9	5	5	3	4	7	4	2	4	1	3	2	2	7	5	4	4	5	8	3	4	8	6	6
TB3	7	6	7	3	5	5	8	5	8	8	1	7	9	7	7	1	2	2	3	1	7	3	3	7	8	8	4	4	7	2	7
TC1	8	6	3	1	2	8	3	9	7	6	1	6	7	5	3	4	2	2	5	4	5	4	4	7	3	9	2	5	1	8	5
TC2	9	6	3	2	6	3	6	8	6	4	2	6	5	7	7	6	7	8	5	3	5	8	6	7	7	7	7	5	1	6	9
TD1	10	2	6	5	5	5	6	5	5	5	2	6	9	4	4	5	4	8	6	5	7	6	4	6	6	6	6	4	5	1	7
TD2	11	7	3	2	7	7	5	6	7	5	3	9	8	7	6	5	5	5	5	2	5	4	4	5	4	8	4	6	6	6	6
TE1	12	6	6	1	5	4	5	7	5	6	1	7	7	4	3	4	3	5	3	2	6	5	6	7	5	8	3	6	4	8	9
TF1	13	6	4	4	5	7	5	4	5	5	4	5	6	4	6	5	4	6	4	3	4	5	5	6	6	6	2	8	6	6	7
TG1	14	4	7	3	5	5	5	5	4	8	2	8	4	3	4	5	3	6	5	2	6	4	6	7	5	9	4	7	3	6	7
TG2	15	7	5	3	5	7	4	6	9	8	6	8	7	5	6	3	3	4	4	2	4	3	2	4	5	6	6	5	7	7	6
TH1	16	5	5	3	6	9	5	4	5	3	2	8	4	4	8	5	4	6	4	4	4	6	5	7	4	7	4	9	3	6	6
TH2	17	5	2	2	4	7	5	5	4	4	3	4	6	4	8	5	5	5	5	4	7	6	4	7	5	6	3	6	5	5	8
TH3	18	5	3	1	5	3	3	6	6	6	3	5	5	4	5	7	3	6	4	2	6	6	3	6	6	8	4	6	5	7	7
TI1	19	6	5	3	3	5	5	6	4	6	4	6	5	5	6	6	3	7	3	1	5	4	5	7	6	8	5	3	5	7	9
TI2	20	5	7	6	6	6	4	7	7	8	3	5	5	5	2	5	4	5	5	5	4	3	2	4	5	4	3	6	7	6	6
TJ1	21	4	3	2	2	8	4	6	3	5	2	9	7	5	7	2	4	7	5	1	6	6	3	5	5	7	4	8	7	5	7
TK1	22	9	4	1	4	8	3	6	3	7	2	6	4	6	6	4	5	7	6	3	6	4	5	6	4	6	5	9	4	7	6
TL1	23	5	6	4	6	9	4	8	5	9	5	7	4	6	4	5	2	4	6	5	6	5	5	5	7	8	4	3	4	7	7
TM1	24	7	8	3	4	9	4	4	5	4	3	6	5	5	4	5	3	6	5	2	5	5	4	5	5	8	5	9	5	6	7
TM2	25	9	5	2	5	4	4	5	7	8	6	5	5	9	5	5	5	6	7	2	6	6	5	7	6	8	4	4	4	7	8
TN1	26	5	5	3	3	5	4	6	5	6	5	6	6	4	4	6	5	6	3	2	5	7	4	4	4	7	6	9	5	7	6
TN2	27	7	6	3	3	3	4	3	4	6	7	3	6	6	5	4	8	5	6	2	9	5	5	5	4	5	6	6	5	8	6
TO1	28	5	4	4	2	6	3	7	5	6	2	8	9	5	6	4	6	7	7	3	7	5	3	6	6	8	5	6	6	7	5
TP1	29	6	5	5	6	7	5	5	5	7	4	6	5	5	5	4	3	2	5	2	5	4	2	5	4	7	6	7	3	8	6
TQ2	30	9	5	3	5	8	5	5	4	5	1	8	6	3	6	5	3	6	4	2	5	3	6	5	5	7	7	8	5	6	7
TQ1	31	5	4	1	3	6	4	5	4	4	2	7	7	2	5	5	4	4	5	3	6	4	4	6	6	8	6	5	5	8	9
TQ3	32	9	3	2	3	8	3	5	5	4	1	5	7	3	5	5	3	5	5	2	4	6	5	5	4	7	4	9	5	7	6
TS1	33	6	4	2	5	7	3	7	5	8	4	7	9	5	8	5	3	8	6	3	6	1	4	5	3	6	6	7	5	7	6
TT1	34	6	4	1	3	6	4	6	6	6	3	7	4	4	4	3	3	7	5	3	5	5	5	6	5	7	5	7	4	6	8
TT2	35	6	2	5	5	5	3	5	3	4	3	4	5	5	4	5	4	4	5	3	7	6	6	3	3	9	6	3	3	7	8

* Explanation of Code: Digit 1: T = Teacher
Digit 2: Code letter of school
Digit 3: Identification number of teacher in the school

Table 2 (Continued)

Subject Code*	Computer Number	Item 31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
TA1	4	7	6	5	7	6	5	6	7	5	5	7	1	7	5	5	5	5	4	8	9	9	5	4	3	2	1	4	2	4	5
TB1	5	7	7	6	4	5	9	8	8	5	4	5	4	5	5	7	7	8	6	5	5	5	5	5	3	1	1	6	2	4	5
TB2	6	6	6	6	6	7	5	5	5	7	7	6	4	8	4	5	5	5	6	6	6	5	7	9	5	5	3	4	1	3	4
TB3	7	8	5	5	5	5	9	5	2	4	2	2	3	3	4	6	6	6	6	6	6	6	2	3	5	6	5	9	4	6	6
TC1	8	9	8	3	6	2	5	5	6	7	3	7	4	5	4	6	3	6	4	5	7	5	6	6	1	1	1	8	5	4	6
TC2	9	9	7	6	5	6	4	6	6	6	3	3	3	3	1	4	3	6	3	4	6	6	3	6	6	4	4	7	2	5	3
TD1	10	9	7	6	7	8	8	4	4	4	4	5	3	5	4	5	3	6	3	5	6	5	5	4	2	3	3	7	3	1	5
TD2	11	9	6	7	3	5	6	5	5	5	4	4	3	3	4	3	4	5	5	6	8	5	5	6	2	1	1	6	4	4	4
TE1	12	9	6	5	5	5	7	5	8	5	3	4	4	5	6	4	4	4	5	4	6	7	6	5	4	2	3	6	2	5	5
TF1	13	9	8	9	5	8	7	7	7	4	5	2	1	2	1	4	2	5	2	4	4	4	6	6	4	3	3	4	3	3	7
TG1	14	9	7	4	7	6	8	3	4	5	4	6	5	5	4	5	5	5	4	6	6	6	6	5	2	1	1	6	5	3	5
TG2	15	9	6	6	5	5	5	5	5	6	3	5	4	4	5	4	5	7	5	4	8	4	6	4	1	1	1	5	2	3	6
TH1	16	6	7	6	7	7	8	6	7	3	3	5	1	5	5	5	5	5	3	6	5	5	5	6	4	2	2	6	1	4	5
TH2	17	8	5	7	4	9	6	7	9	5	5	3	3	3	4	7	5	5	3	5	4	4	5	5	4	2	1	6	1	5	5
TH3	18	8	5	7	8	9	9	4	4	5	6	4	2	4	5	5	4	5	4	5	7	6	5	5	4	2	1	7	4	5	5
TI1	19	9	7	5	7	6	8	3	5	5	5	4	4	4	1	5	4	5	4	6	7	6	5	6	3	2	2	8	3	4	2
TI2	20	7	6	5	5	9	5	6	6	5	4	4	1	3	5	4	4	6	5	1	5	8	5	9	4	3	3	5	2	8	6
TJ1	21	9	5	6	4	5	6	5	4	4	4	5	5	5	6	6	6	5	6	6	6	6	5	5	4	4	1	8	3	3	5
TK1	22	8	6	7	4	4	5	5	6	4	5	5	5	5	5	7	6	8	3	6	6	6	6	5	3	2	1	7	2	4	5
TL1	23	8	7	6	4	6	5	5	5	6	5	5	2	5	3	3	3	4	4	5	4	7	6	5	3	1	2	6	1	4	3
TM1	24	7	6	7	6	6	7	6	8	5	4	5	3	4	6	6	5	7	5	5	6	5	5	4	3	1	1	6	2	2	3
TM2	25	6	5	4	6	2	7	5	4	7	6	3	3	3	4	3	3	3	4	5	4	5	6	5	5	1	1	6	5	6	4
TN1	26	8	4	4	4	8	8	5	7	4	3	4	3	9	2	7	3	4	4	6	6	6	5	4	5	2	1	7	1	5	5
TN2	27	5	5	6	4	7	9	4	4	5	4	6	7	5	6	7	4	4	5	5	7	2	8	5	1	1	1	5	2	4	5
TO1	28	8	6	3	4	5	6	5	7	5	2	4	4	4	4	5	5	4	5	5	6	4	5	5	4	4	1	9	1	5	3
TP1	29	9	4	7	8	4	6	3	5	4	3	5	5	6	6	9	5	6	5	7	6	6	8	3	4	1	1	3	4	5	5
TQ2	30	9	6	7	7	6	6	5	4	5	1	4	2	5	6	4	4	5	4	6	7	4	5	5	3	2	4	4	3	4	4
TQ1	31	9	4	4	5	6	7	5	7	3	3	6	7	5	5	6	5	6	5	6	5	6	7	5	3	2	1	8	4	5	3
TQ3	32	8	6	6	7	6	7	5	7	5	1	5	5	5	4	6	4	6	5	6	6	6	6	4	4	4	2	8	3	4	4
TS1	33	9	5	6	6	5	5	3	4	4	6	5	6	4	4	5	5	5	5	5	5	4	6	4	3	2	2	7	1	4	4
TT1	34	8	8	6	7	9	6	5	5	3	4	5	5	5	4	4	5	6	4	5	9	5	6	5	3	2	2	7	1	5	4
TT2	35	9	8	3	8	6	3	4	4	4	4	3	2	6	6	7	6	6	6	7	7	7	4	6	3	1	1	4	2	3	3

* Explanation of Code: Digit 1: T = Teacher
Digit 2: Code letter of school
Digit 3: Identification number of teacher in the school

Table 3

Q Scores: Subject x Item Data Matrix for Q-sort 3

Item Scores of Teachers, Based on the Goals of the Laboratory as Applied in their Own Classrooms

Subject Code*	Computer Number	Item 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
TA1	36	6	4	3	6	6	5	6	5	6	4	5	5	5	5	4	5	6	5	3	7	2	3	3	3	5	5	8	5	5	8
TB2	37	4	7	6	6	7	5	5	4	7	3	4	7	6	6	4	2	3	1	4	7	2	5	5	6	9	4	8	5	5	9
TB3	38	9	1	2	4	5	5	3	6	3	2	4	9	5	7	1	4	4	6	2	7	3	4	8	7	8	4	3	1	4	7
TC1	39	7	1	1	3	8	6	9	7	5	1	6	6	6	3	5	2	3	5	4	4	4	2	9	5	9	2	5	1	5	4
TC2	40	9	5	4	9	3	8	7	8	4	2	5	5	5	5	5	6	6	7	3	5	7	5	6	6	7	3	4	5	4	9
TD1	41	3	5	5	5	6	4	6	5	5	6	6	6	5	6	7	6	8	7	6	8	5	4	5	3	8	4	5	5	7	9
TD2	42	5	4	3	7	7	3	5	5	5	2	7	8	6	5	5	5	5	5	1	6	3	5	5	6	6	6	6	4	7	6
TE1	43	5	5	1	2	5	5	8	4	4	1	5	5	5	2	3	3	4	3	3	7	3	5	7	5	8	2	9	6	7	6
TF1	44	8	3	4	4	6	4	4	4	5	3	5	5	4	5	2	3	5	5	2	5	4	2	3	4	6	9	6	5	6	6
TG1	45	5	4	3	6	4	3	8	4	8	2	7	5	4	5	4	3	5	4	2	6	3	6	6	6	9	3	7	4	7	7
TG2	46	8	5	1	5	9	5	7	5	6	4	9	7	7	6	5	2	5	5	4	6	5	4	5	5	7	4	3	8	3	7
TH1	47	8	7	4	4	9	8	5	5	5	4	9	7	5	7	5	5	6	5	4	5	5	5	5	4	7	8	7	5	6	5
TH2	48	6	3	2	3	4	1	6	5	5	3	5	5	4	8	4	5	5	8	4	7	7	7	4	5	9	2	4	5	5	7
TH3	49	4	5	2	6	5	6	5	5	6	5	4	5	4	4	6	4	3	5	3	6	7	2	6	6	7	3	6	5	7	8
TI1	50	5	4	2	4	6	5	5	6	6	3	6	6	5	5	6	1	5	3	1	5	5	5	6	5	9	5	4	3	7	8
TI2	51	6	6	9	5	6	5	7	5	7	6	5	6	9	5	4	6	5	5	3	4	4	3	5	5	6	3	5	5	4	7
TJ1	52	5	6	5	4	5	6	4	4	7	4	4	5	4	4	2	6	4	9	1	5	7	2	6	6	8	3	3	7	7	7
TK1	53	5	2	1	8	5	2	7	6	6	5	8	3	7	6	5	4	5	5	1	5	3	5	5	4	5	6	4	4	6	6
LT1	54	7	5	3	5	8	7	6	5	6	5	6	4	5	3	4	2	4	5	4	5	5	5	5	9	6	9	8	4	6	6
TM1	55	9	4	3	4	5	4	4	6	3	5	7	5	5	5	5	1	8	8	6	8	6	7	6	5	5	2	5	5	6	7
TM2	56	7	5	3	6	5	4	5	6	6	8	7	5	6	5	5	1	6	9	1	4	7	8	7	5	5	4	5	6	5	5
TN1	57	5	4	2	4	5	3	7	4	4	3	5	6	3	6	8	6	3	9	7	8	6	4	5	6	6	5	5	6	5	5
TN2	58	5	2	4	6	5	5	3	6	6	5	5	8	5	4	4	4	3	7	5	7	6	2	7	4	6	3	4	4	7	5
TO1	59	5	2	3	4	5	3	5	5	5	1	5	8	5	6	8	5	6	6	6	7	7	4	5	6	9	4	5	5	6	7
TP1	60	7	5	1	5	9	4	8	7	6	1	4	4	7	5	5	3	5	6	3	5	5	3	4	5	4	4	7	5	6	6
TQ2	61	6	6	2	4	6	4	5	4	3	3	5	5	5	4	3	5	5	4	1	5	4	6	6	5	9	8	5	5	6	7
TQ1	62	5	5	1	2	6	6	6	4	3	2	8	7	3	6	5	4	4	6	2	6	4	3	6	5	7	4	7	3	8	9
TQ3	63	9	8	2	3	9	4	5	2	5	1	5	5	3	3	4	3	2	5	1	5	5	5	5	4	6	4	7	5	8	6
TS1	64	6	4	3	6	6	4	7	5	9	4	6	9	8	7	5	3	7	6	2	7	2	5	5	4	7	5	5	6	5	6
TT1	65	6	4	1	6	4	3	4	5	5	3	4	6	4	6	5	3	4	5	3	6	5	5	4	6	5	6	7	4	7	8
TT2	66	8	3	4	4	4	3	6	5	6	4	4	6	5	6	4	5	5	5	3	7	5	5	7	6	9	4	2	6	6	8

* Explanation of Code: Digit 1: T = Teacher
Digit 2: Code letter of school
Digit 3: Identification number of pupil in the school

Table 3 (Continued)

Subject Code*	Computer Number	Item 31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
TA1	36	7	7	6	7	7	6	6	5	4	5	6	2	7	7	5	4	4	4	8	9	9	4	3	2	1	1	3	3	4	4
TB2	37	5	6	3	5	8	8	4	4	5	5	5	4	5	5	6	5	3	5	1	6	3	5	6	5	4	3	6	2	6	7
TB3	38	7	6	1	3	6	3	2	2	7	5	4	2	4	1	7	4	4	4	5	5	5	3	2	8	3	5	8	2	6	2
TC1	39	9	9	6	5	5	5	8	9	5	4	7	5	4	8	8	5	8	7	6	8	9	9	6	5	5	5	5	4	5	8
TC2	40	8	8	4	5	6	5	3	8	5	5	4	4	7	3	6	5	6	7	8	8	8	6	2	1	8	1	7	5	6	2
TD1	41	4	7	4	7	6	5	5	4	5	2	4	4	3	3	4	5	4	4	5	3	3	9	6	2	2	1	7	1	5	6
TD2	42	8	5	5	4	2	7	4	3	4	3	6	7	6	6	3	6	7	6	8	9	9	5	5	2	4	1	4	5	5	4
TE1	43	8	6	6	7	6	7	6	5	5	3	5	4	6	4	6	4	5	6	7	9	6	5	5	5	4	4	4	4	4	6
TF1	44	7	6	6	6	5	4	4	5	5	4	7	1	9	7	6	7	6	7	6	8	8	5	5	5	3	1	4	5	6	5
TG1	45	9	6	4	8	5	6	4	4	6	5	5	5	5	4	5	5	5	5	6	7	5	7	5	2	1	1	6	5	3	6
TG2	46	9	6	6	7	6	8	5	6	5	5	3	4	6	4	6	4	6	4	5	7	6	5	6	4	4	4	3	1	2	6
TH1	47	6	6	7	6	6	6	6	4	5	3	3	3	4	3	4	3	3	4	6	5	5	5	5	2	2	2	6	1	1	4
TH2	48	6	7	4	3	5	9	7	6	6	5	4	4	4	3	6	6	6	3	5	6	8	6	5	5	2	4	5	1	6	5
TH3	49	8	7	5	9	9	6	3	3	4	4	4	2	5	5	5	5	5	5	7	8	6	5	6	4	1	1	7	3	4	4
TI1	50	9	8	6	7	7	8	4	3	4	4	4	5	5	4	5	4	5	4	7	6	5	6	6	3	2	2	7	5	3	4
TI2	51	8	5	3	2	7	5	8	5	3	5	4	6	6	4	6	4	5	4	2	7	6	7	8	4	1	1	4	2	5	3
TJ1	52	8	6	5	5	5	5	5	6	3	3	5	6	5	3	4	6	6	5	7	4	5	4	5	5	6	1	4	9	3	8
TK1	53	6	4	4	6	7	4	3	5	6	6	6	5	7	2	7	4	7	7	6	5	4	9	5	4	3	3	8	9	4	3
TL1	54	6	6	5	4	5	4	4	3	5	5	7	2	7	3	6	7	6	4	5	4	6	8	6	3	1	2	5	1	4	7
TM1	55	6	7	4	7	9	6	5	4	3	5	6	5	5	4	3	4	6	4	5	7	5	4	5	6	2	3	6	1	4	2
TM2	56	4	5	4	6	3	5	3	3	6	8	3	2	5	4	2	4	4	2	5	4	4	9	5	6	6	7	6	7	4	3
TN1	57	6	5	5	5	2	5	4	4	7	7	6	2	6	3	5	5	6	4	5	4	5	7	8	1	1	4	7	1	9	6
TN2	58	5	5	5	6	5	5	2	6	3	3	8	9	8	4	3	4	7	7	5	6	5	6	4	1	1	2	6	9	4	6
TO1	59	7	7	3	4	5	6	4	6	6	3	5	7	3	4	4	5	4	4	5	8	6	5	4	4	3	2	9	1	5	2
TP1	60	6	6	6	8	3	7	4	2	6	3	3	5	5	5	5	5	4	7	7	9	6	8	2	5	6	6	4	4	4	2
TQ2	61	8	8	9	7	5	5	4	2	3	1	7	5	6	7	6	6	6	5	7	7	6	4	5	2	3	4	5	4	4	3
TQ1	62	9	4	3	6	5	8	6	7	5	3	5	5	5	5	5	4	6	5	5	5	5	7	6	4	4	1	7	4	5	4
TQ3	63	8	5	7	6	5	5	4	4	5	3	6	7	6	5	6	5	6	7	5	5	7	6	4	4	5	3	7	6	4	4
TS1	64	6	4	4	6	6	5	3	6	5	7	4	5	4	4	4	3	4	5	3	5	5	8	5	3	1	2	8	1	5	5
TT1	65	5	7	7	4	9	6	3	8	4	3	5	5	7	6	5	5	5	5	7	8	9	6	5	2	2	1	4	2	5	6
TT2	66	9	7	5	7	6	6	5	3	5	5	3	2	5	4	5	4	4	5	8	7	7	4	6	3	1	1	5	2	6	5

* Explanation of Code: Digit 1: T = Teacher
Digit 2: Code letter of school
Digit 3: Identification number of pupil in the school

Table 4 (a) Subjects PA1 to PL4

Q Scores: Subject x Item Data Matrix for Q-Sort 4

Item Scores of Students, Based on Their Perception of the Goals of the Laboratory in the Provincial Chem Study Programme

Subject Code*	Computer Number	Item 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
PA1	67	5	5	6	9	6	5	7	7	7	6	5	4	4	5	5	1	6	8	1	6	4	4	4	6	6	3	5	5	6	6
PA2	68	1	5	9	8	1	4	4	9	8	8	4	5	6	5	3	2	4	6	2	5	5	5	3	4	6	6	5	5	2	5
PB1	69	4	5	5	4	4	5	6	5	7	5	4	7	4	5	2	3	5	6	1	5	5	5	4	5	6	5	4	5	5	5
PB2	70	6	6	7	7	6	5	6	6	7	5	7	5	7	3	4	5	4	5	1	6	5	1	5	4	6	4	9	7	5	5
PB3	71	5	5	5	5	6	8	8	5	5	8	5	7	5	3	3	2	5	7	1	5	4	3	6	5	4	3	4	4	4	6
PB4	72	3	3	5	5	6	7	8	5	7	4	6	4	4	6	2	2	6	5	1	5	6	6	3	7	6	7	8	4	7	6
PB5	73	3	5	3	5	5	4	5	4	5	4	5	5	3	4	3	4	6	6	5	6	6	3	5	4	5	6	9	4	5	6
PB6	74	7	7	7	8	6	9	7	8	8	7	6	3	7	3	2	5	5	5	2	5	5	5	5	6	5	4	6	6	6	5
PD1	75	3	4	4	4	3	3	5	4	4	5	5	7	4	7	7	7	5	9	6	6	5	4	5	6	5	5	8	5	2	6
PD2	76	4	7	5	7	6	4	2	9	8	6	8	7	6	6	6	6	4	6	5	6	7	3	5	3	3	2	4	8	5	7
PD3	77	6	5	4	5	6	5	6	5	5	4	4	5	4	4	3	1	4	4	1	5	4	3	3	5	5	6	6	5	5	5
PE1	78	8	5	5	6	8	5	8	7	5	6	9	4	7	5	4	3	3	4	2	6	6	3	6	5	7	3	9	5	6	5
PE2	79	3	3	5	8	6	5	5	8	8	9	4	4	9	5	4	4	7	5	1	5	6	5	6	6	7	3	3	7	5	7
PG1	80	9	5	5	7	5	5	9	5	6	6	7	7	8	6	3	1	5	4	2	6	5	3	5	5	7	5	6	5	6	6
PG2	81	6	5	3	5	4	4	9	3	7	8	6	6	6	3	5	4	7	7	1	8	5	4	5	5	9	5	5	7	4	5
PG3	82	5	5	3	4	5	4	4	5	5	5	5	5	4	3	3	1	5	8	2	5	4	5	4	4	6	1	8	8	5	6
PG4	83	5	6	7	7	7	6	9	8	7	6	9	6	7	6	4	3	5	5	4	5	4	4	4	8	6	5	5	5	5	5
PH1	84	4	4	5	7	3	5	3	5	5	3	5	5	5	4	4	1	2	3	4	6	7	4	6	5	6	8	5	5	4	7
PH2	85	6	6	4	6	4	6	7	7	8	6	6	6	7	4	5	4	4	7	2	6	5	5	6	5	5	4	9	8	5	5
PH3	86	6	5	3	6	7	4	5	4	5	5	5	4	6	3	5	3	4	5	2	7	5	3	4	5	5	6	7	5	6	9
PH4	87	6	6	5	7	6	6	6	7	7	5	8	5	7	4	3	3	5	5	3	6	6	5	5	6	9	2	3	5	5	8
PI1	88	4	4	6	7	5	4	2	5	4	3	4	5	5	6	4	5	6	7	2	6	5	2	7	4	4	1	7	8	6	5
PI2	89	4	5	5	5	6	6	6	4	4	4	4	8	5	7	3	2	4	4	1	6	5	6	5	6	8	9	6	4	3	5
PL1	90	5	5	6	6	5	4	5	6	6	5	5	9	5	6	4	4	4	7	1	7	9	3	7	4	5	5	5	5	4	6
PL2	91	9	6	6	5	8	6	6	5	6	5	7	5	9	5	4	4	5	7	2	7	4	1	4	6	7	5	5	6	6	6
PL3	92	7	5	5	7	5	7	8	6	7	5	8	7	5	4	3	2	4	3	2	5	3	3	4	5	6	5	9	6	6	5
PL4	93	5	5	7	8	6	5	7	8	6	8	7	4	5	6	4	3	4	5	2	6	5	7	5	5	9	7	6	6	4	5

* Explanation of Code: Digit 1: P = Student
Digit 2: Code letter of school
Digit 3: Identification number of student in the school

Table 4 (a) (Continued)

Subject Code*	Computer Number	Item 31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
PA1	67	4	3	6	4	5	4	5	7	8	3	3	5	5	4	7	7	8	3	5	9	6	3	4	2	2	2	5	4	5	5
PA2	68	7	5	7	5	5	7	5	6	4	7	5	3	3	4	4	3	6	4	6	7	6	4	5	6	4	3	6	1	6	5
PB1	69	3	6	3	7	6	2	8	3	8	4	9	1	7	6	4	3	6	7	9	6	6	8	5	2	7	3	4	6	6	4
PB2	70	6	6	5	5	5	6	4	4	9	5	2	3	4	2	5	2	8	4	4	4	3	8	8	5	3	3	5	3	4	6
PB3	71	5	4	6	6	6	5	7	6	6	9	3	1	4	5	6	5	5	4	4	7	4	7	7	3	6	2	9	2	4	6
PB4	72	4	4	7	4	3	3	2	4	3	6	5	5	5	5	5	5	5	5	5	5	5	9	8	4	9	6	4	1	4	6
PB5	73	7	6	6	4	5	5	2	2	5	5	8	2	7	6	7	7	8	9	4	8	7	7	4	3	1	1	5	4	6	6
PB6	74	5	5	5	5	5	6	3	4	9	6	4	4	6	4	4	4	4	4	4	4	3	3	6	3	1	2	6	1	5	5
PD1	75	3	4	2	4	6	5	5	5	8	5	2	2	7	8	6	5	4	6	5	4	7	9	6	3	1	1	5	9	6	6
PD2	76	9	7	4	4	8	6	5	5	5	6	5	1	5	2	4	2	4	5	5	8	5	7	9	3	1	1	4	1	6	4
PD3	77	4	3	6	4	5	6	3	2	5	3	7	7	9	9	8	7	7	8	5	7	7	6	6	4	2	2	6	8	6	5
PE1	78	7	5	4	5	5	4	3	2	7	6	4	2	5	4	5	4	4	4	6	7	5	6	6	6	3	1	5	1	4	5
PE2	79	6	6	6	6	5	6	4	4	6	7	3	2	5	4	5	3	4	4	6	5	5	5	4	4	2	1	7	2	5	5
PG1	80	6	5	7	7	5	5	4	4	9	8	4	2	4	4	4	4	4	4	4	6	6	6	8	4	3	3	7	2	5	5
PG2	81	6	5	6	6	6	5	3	4	5	8	3	1	4	2	5	2	7	4	5	7	4	6	5	3	2	4	6	4	6	5
PG3	82	6	5	5	5	6	6	3	6	6	3	3	5	4	3	7	6	7	7	7	7	7	9	6	4	2	2	9	6	4	6
PG4	83	5	5	5	7	5	6	4	1	6	8	4	3	3	2	3	3	4	3	4	5	4	6	6	2	2	1	6	4	5	5
PH1	84	6	4	6	6	6	6	3	5	4	5	5	2	6	7	4	7	9	9	3	5	8	8	6	5	2	1	6	5	4	7
PH2	85	6	7	5	5	5	4	3	3	8	7	3	2	5	3	4	3	5	2	3	5	5	9	5	4	1	1	6	5	4	4
PH3	86	5	4	6	4	8	4	3	4	7	7	2	3	6	6	7	8	8	4	1	9	6	6	6	5	5	5	2	1	5	4
PH4	87	4	4	8	4	4	6	4	9	4	5	4	1	2	3	4	7	6	4	5	6	7	5	4	5	3	1	5	2	5	5
PI1	88	3	5	5	6	8	6	5	7	4	6	8	3	5	4	9	5	4	6	5	7	2	9	6	6	5	1	5	5	5	5
PI2	89	3	5	8	7	6	3	2	4	4	7	5	2	3	5	5	4	5	5	3	5	5	9	7	7	6	6	5	1	6	7
PL1	90	7	5	3	4	8	8	4	6	5	7	2	1	2	1	1	1	3	2	2	6	5	6	7	4	3	3	4	6	3	8
PL2	91	7	4	7	8	6	5	2	4	5	5	3	1	3	3	4	4	4	4	5	7	4	5	5	3	3	3	6	3	5	8
PL3	92	6	5	6	6	5	4	4	4	6	6	4	1	4	2	5	3	5	5	3	7	6	8	9	5	5	4	4	1	4	6
PL4	93	6	7	5	5	6	6	3	4	4	5	3	3	4	2	5	2	5	4	4	6	4	1	6	3	3	3	5	1	4	9

*Explanation of Code: Digit 1: P = Student
Digit 2: Code letter of school
Digit 3: Identification number of student in the school

Table 4 (b) Subjects PL5 to PT3

Q Scores: Subject x Item Data Matrix for Q-sort 4

Item Scores of Students, Based on Their Perception of the Goals of the Laboratory in the Provincial Chem Study Programme

Subject Code*	Computer Number	Item 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
PL5	94	6	5	3	5	5	4	7	4	7	2	6	5	4	6	3	5	4	6	1	7	2	3	5	4	6	8	9	4	6	4
PL6	95	6	7	4	6	8	5	7	5	5	5	8	6	5	5	3	2	4	4	3	6	5	3	5	5	9	7	6	6	5	8
PL7	96	4	6	5	5	3	5	5	3	6	6	6	9	5	5	6	5	6	8	9	4	8	1	4	4	7	5	6	3	5	7
PM1	97	8	9	3	4	6	8	5	7	9	3	6	4	6	4	4	2	5	4	4	7	5	3	5	3	6	5	6	5	4	5
PM2	98	5	6	7	8	9	4	5	7	6	6	7	5	5	4	4	3	5	5	4	6	7	2	5	4	8	5	5	9	6	6
PM3	99	5	5	9	8	5	6	8	6	6	9	5	6	8	6	4	4	5	5	2	7	5	4	4	5	7	4	6	6	5	6
PM4	100	5	4	4	7	6	5	6	7	8	5	5	6	5	4	6	6	6	8	2	7	4	1	7	5	7	3	6	6	2	5
PM5	101	6	5	4	5	4	4	9	6	4	7	5	7	5	5	6	2	5	6	3	6	5	5	7	4	5	1	4	5	4	5
PN1	102	7	7	5	6	7	4	8	6	8	7	6	6	8	5	1	3	6	3	3	4	5	2	5	4	9	5	6	5	4	5
PN2	103	4	5	2	7	5	5	4	5	6	5	5	8	6	5	3	4	6	8	1	9	6	4	6	6	8	3	5	6	4	9
PN3	104	5	5	5	5	5	5	5	5	3	5	5	2	2	7	6	9	6	7	6	4	6	8	5	3	7	3	5	6	4	4
PP1	105	7	5	4	5	6	4	8	5	9	3	5	6	4	8	4	3	7	5	3	5	8	5	5	2	6	4	4	5	4	7
PP2	106	5	7	4	7	6	8	6	7	9	5	7	5	8	3	4	3	5	6	2	5	3	4	4	5	6	4	5	9	5	5
PQ1	107	5	7	7	6	7	5	6	6	6	6	6	4	5	4	4	3	5	5	2	5	4	4	4	4	5	6	5	7	5	5
PQ2	108	3	5	5	5	5	6	9	4	5	4	4	6	5	5	5	3	5	5	4	6	9	7	8	6	7	1	4	5	6	6
PQ3	109	4	5	5	5	7	6	3	6	5	5	5	5	4	4	2	5	4	7	3	7	4	5	7	9	6	9	2	6	4	5
PO4	110	4	4	5	5	5	4	5	3	6	4	7	6	4	5	5	5	9	7	4	8	6	3	3	2	8	4	5	6	3	6
PR1	111	5	4	3	3	3	4	8	6	5	6	4	4	3	5	6	4	4	5	2	8	5	7	7	6	6	2	7	5	9	5
PR2	112	2	3	3	3	2	3	7	3	7	4	5	5	5	5	5	5	6	5	2	5	6	4	5	4	5	9	8	5	6	5
PR3	113	5	5	6	6	4	6	9	6	8	4	6	6	5	3	2	1	2	4	4	5	5	3	7	5	8	6	7	8	5	4
PR4	114	4	4	6	9	5	5	6	7	7	6	8	7	6	4	2	3	5	5	2	6	4	3	5	5	4	5	9	6	5	4
PR5	115	4	5	6	8	5	6	8	6	6	6	9	6	6	5	5	5	5	7	5	7	5	2	4	3	8	5	9	6	3	7
PS1	116	5	4	3	3	5	5	4	5	6	4	6	3	4	5	7	6	6	8	7	6	6	7	5	5	5	4	5	5	5	3
PS2	117	6	5	4	4	5	4	4	5	6	3	5	6	5	5	5	2	4	5	1	6	4	3	3	6	8	6	9	3	5	5
PT1	118	6	6	4	4	5	5	6	5	5	6	4	3	5	9	4	4	6	6	6	7	8	7	7	4	7	3	5	4	2	7
PT2	119	6	6	4	6	6	5	6	5	7	5	5	9	5	9	3	2	5	6	4	7	7	3	6	5	7	5	5	5	8	6
PT3	120	9	5	5	6	5	5	7	5	7	4	6	7	6	5	5	3	6	6	1	8	4	1	4	4	9	7	6	3	5	6

*Explanation of Code: Digit 1: P = Student
Digit 2: Code letter of school
Digit 3: Identification number of student in the school

Table 4 (b) (Continued)

Subject Code*	Computer Number	Item 31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
PL5	94	8	5	6	7	6	6	4	3	5	4	5	3	6	5	4	5	6	5	5	5	7	9	7	3	2	1	4	1	4	8
PL6	95	5	4	5	7	6	5	2	3	4	6	6	2	4	3	7	4	7	5	4	9	4	6	6	5	1	3	4	1	4	5
PL7	96	6	5	6	3	7	6	2	4	5	5	7	3	4	2	5	4	4	4	2	7	5	8	5	3	5	1	3	4	7	5
PM1	97	5	7	6	6	5	5	3	2	5	6	7	4	7	7	5	5	6	4	4	6	4	5	8	3	2	1	6	1	5	5
PM2	98	7	5	6	1	7	5	4	4	5	4	5	4	6	2	5	3	3	3	1	6	5	3	8	3	4	4	6	2	6	5
PM3	99	6	4	5	5	7	6	5	5	7	7	2	1	4	3	4	3	4	2	3	5	4	5	4	3	3	3	6	1	5	7
PM4	100	8	4	4	4	5	5	5	5	9	4	3	1	6	3	3	2	3	3	7	4	6	6	5	4	5	5	9	4	5	5
PM5	101	5	3	3	6	9	7	5	5	7	6	4	4	3	3	4	2	4	3	2	5	5	9	8	8	6	6	7	1	5	5
PN1	102	6	5	6	7	5	5	3	4	6	6	5	3	5	2	5	4	4	4	5	9	5	4	7	3	4	2	5	1	5	4
PN2	103	6	7	5	4	7	5	3	2	7	6	6	1	4	5	4	4	5	4	5	7	5	5	5	4	3	2	6	3	3	7
PN3	104	7	8	7	7	5	4	4	3	4	4	3	2	6	3	5	4	4	6	6	5	4	1	5	8	1	4	9	6	5	6
PP1	105	7	6	6	9	3	5	1	2	5	6	7	2	6	5	6	5	6	6	7	6	4	5	5	4	4	3	3	1	4	5
PP2	106	8	5	5	6	4	5	4	4	5	6	3	1	5	2	6	5	7	4	3	4	3	6	6	4	2	6	6	1	5	7
PQ1	107	6	4	5	5	4	8	5	2	3	6	3	1	7	1	9	3	9	8	5	6	5	8	7	4	3	2	5	3	6	4
PQ2	108	4	6	5	7	5	5	4	3	4	7	4	3	3	2	6	2	6	1	7	8	7	6	8	5	6	3	4	2	4	5
PQ3	109	6	5	4	6	8	5	3	4	4	7	4	1	6	3	5	2	4	5	6	6	3	1	8	5	5	3	5	7	6	8
PQ4	110	5	6	4	5	8	6	7	7	6	5	4	3	5	2	7	2	7	4	5	5	6	6	5	3	1	1	9	4	5	6
PR1	111	6	4	5	6	7	5	1	2	4	4	6	6	5	6	4	6	5	5	7	9	8	7	4	5	5	3	5	1	3	5
PR2	112	6	4	9	4	4	6	5	6	7	7	5	1	1	5	6	5	6	4	4	8	6	7	3	4	3	4	5	4	6	8
PR3	113	5	4	7	5	4	4	1	5	9	7	6	5	4	3	5	3	7	2	3	4	7	6	4	3	5	5	6	6	5	5
PR4	114	5	3	5	5	6	7	4	5	7	8	4	2	5	3	5	3	6	4	5	6	4	7	8	4	3	1	6	1	6	5
PR5	115	5	3	5	5	6	6	1	2	7	6	7	4	4	4	4	4	5	7	5	5	3	3	4	4	2	4	5	1	3	4
PS1	116	5	5	5	6	8	5	4	4	6	6	1	1	3	4	4	2	3	2	4	4	2	7	6	6	7	9	5	9	7	8
PS2	117	8	4	8	5	5	4	2	4	5	5	6	3	6	6	7	7	7	7	6	9	7	7	4	4	3	2	5	1	5	6
PT1	118	9	7	5	3	6	5	4	1	8	6	5	1	4	2	5	3	4	5	5	6	5	5	5	6	5	3	8	3	4	2
PT2	119	5	5	8	7	5	3	2	3	4	8	4	3	5	4	4	4	5	4	4	7	4	4	6	3	1	2	6	1	5	6
PT3	120	6	5	7	8	6	5	4	6	8	5	3	2	3	4	4	4	4	5	5	6	5	5	4	3	5	5	5	3	5	7

* Explanation of Code: Digit 1: P = Student
Digit 2: Code letter of school
Digit 3: Identification number of student in the school