GENERAL PREFACE

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Chemistry is the branch of science concerned with the properties and interactions of the substances of which matter is composed. The ideas that make up chemistry play major roles in many of the decisions that humans have to take. In personal decisions, for example the composition of a diet conducive to health, where the nature of the substances involved (carbohydrates, proteins, fats, vitamins) and the mechanisms for their metabolism underpin rational choices. In social decisions, for example on the location of a garbage incinerator, where public acceptance of the means of control of emissions used depends on an understanding of ideas of combustion, chemical adsorption, and catalytic conversion. In economic decisions, for example about whether to establish a biotechnology-based industry, where an understanding of the chemical basis of genetics and genetic modification, coupled to that of environmental risks, is needed. The emergence of chemistry as a science has been a great cultural achievement in recent centuries, whilst new substances to which it has given rise (paints, adhesives, plastics) permit an increased range of cultural expression.

Given this importance, it comes as a great shock to realise that education in and about the ideas of chemistry, what is usually called 'chemical education', currently faces a range of challenges, even threats, throughout the world. The increased range of knowledge competing for inclusion in formal education (in schools, universities, vocational colleges) is leading to the separate major sciences (chemistry, physics, biology) being compressed into one unit, and a smaller unit at that, of the curriculum. In these circumstances, the amount and proportion of time devoted to chemical education is gradually being eroded, not least because the ideas of chemistry are found difficult to understand by many students. Indeed, what chemistry should be taught, and how, to the majority of students, is still very problematic. The pace at which chemical research and chemical technologies advance are making it difficult to decide what should be included in the education not only of future specialists in chemistry but also of the general public. Lastly, it has become evident that the ideas of chemistry are badly

under-represented in the provision of opportunities for informal chemical education, through books, TV programmes, science and technology centres.

The editors of this book believe that, given its utilitarian and cultural importance, the place of chemistry in opportunities for both formal and informal education must be reasserted. Existing provision needs to be reformulated whilst new provision must be devised. This book is intended to support these processes. It is based on three principles. First, that all aspects of chemical education should be clearly associated with research. Second, the development of opportunities for chemical education should be both continuous and be linked to that research. Third, the professional education and training of all those associated with chemical education should make extensive and diverse use of that research.

The book must address the concerns of the major 'stakeholders' in chemical education if it is to effectively support the future development of the field. These stakeholders will be associated with all branches of formal chemical education (primary and secondary schools, vocational colleges, universities) and of informal chemical education (science and technology centres, books, TV). It is therefore simultaneously addressed to the following groups and for specific purposes:

- practising chemists and chemical technologists. So they can consider the implications of changes in chemistry for all aspects of the education of both future specialists and non-specialists;
- designers and managers of the formal chemical curriculum. So they can consider what the substantive content of chemical education for specific purposes should be and how it should be organised;
- chemistry teacher educators. So they can consider the implications of changes in provision for the pre- and in-service education of teachers at all levels of the formal educational system;
- pre-service and practising teachers and lecturers. So they can consider what they can most effectively do to support the learning of chemical ideas by their students;
- informal chemical educators. So they can consider the implications of changes in chemistry and chemical education for the focus, nature, and mode of realisation, of their work;
- chemical education researchers. So they can consider what research into chemical education needs to be done, how it should be done, and how the most effective use can be made of the outcomes of that research;
- authors of textbooks and other books. So they can see the implications of research for what they include in their books and how it might be presented.

In order to address this range of purposes, explicit approaches to the structure, authorship, and production, of the book were arrived at.

In deciding what to include in the book, the editors balanced several issues. It was thought necessary to address both themes that are of continuing importance in chemical education as well as those of rising significance. An address to themes on which a substantial research base already exists was obviously possible, but it was thought undesirable to neglect themes where the research base was thin or non-existent. Whilst most of the research to be reviewed was to be explicitly about chemical education, research into the more diffuse area of science education was only to be used where unavoidable. It was decided to omit the topic of assessment because little of the detailed research that has been done is distinctive to chemical education. The broad topic of organic chemistry was omitted on the grounds that (with the possible exception of 'visualisation') it is reducible to the other topics addressed. The mole and stoichiometry were thought best viewed as manifestations of 'problem solving'.

The outcome is a book in five sections. Section A addresses the implications of the history and philosophy of chemistry for chemical education. Section B deals with the complex set of issues surrounding decisions on the nature of the curriculum in chemical education when constructed for different purposes. Section C is concerned with teaching and learning about chemical compounds. Section D addresses issues in the teaching and learning about chemical change. The final section, Section E, deals with issues in the education and training of chemistry teachers and with the future of research and development in chemical education.

It was decided to invite individuals to contribute on the basis of proven experience of publishing chemical education research in English at international level. Moreover, every chapter would have, wherever possible, two authors in order to promote a degree of creative tension between them. This arrangement was achieved in the great majority of cases. Thirty individuals participated: 13 from Europe, 10 from North America, 6 from Australasia, 1 from Latin America. Of these, 20 are male and 10 female.

Each set of authors was invited to write a chapter that, wherever possible, took all of the following five perspectives on their chosen topic:

- The role of it in chemical education.
- The history of the provision hitherto made for it in the curriculum.
- The conduct and conclusions of research into the current curriculum, teaching, and learning, of it.

- The conduct and conclusions of research into the nature and effectiveness of existing solutions to the problems that research has identified.
- The nature of the research and development that needs to be done in the future.

They were asked to use, as far as was possible, the outcomes of research related to students of all ages and circumstances. As the book is intended to have world-wide relevance, they were asked to draw on the literature from across the world. Each draft of every chapter was considered by at least two of the editors. Authors were asked to reconsider their contributions in the light of the comments made. This cycle had between 2 and 4 iterations for particular chapters.

During the writing of the book, several general trends emerged. The great bulk of the research undertaken so far has been into teaching and learning about chemical compounds and chemical change. Some specific enquiries into the professional development of chemistry teachers and the conduct and use of research in chemical education have taken place. It is only lately that enquiries specifically into the implications of the history and of the philosophy of chemistry (collectively, epistemology) for chemical education have begun. However, sub-themes within both areas have received attention: laboratory work to a great extent; models and modelling to a much lesser extent. The whole area of the nature and development of the curriculum in chemistry for specific groups of students and specific purposes has been badly neglected until very recently. It is not surprising that, given the very small role played by chemical education in the primary (elementary) school, very little research has been carried out there. The great bulk of the enquiries have been conducted at the secondary (high) school level. Two areas has been badly neglected. First, relatively few genuine enquiries have been conducted at university (college) level. Second, informal chemical education has received no attention. These generalisations, borne out by reading through the chapters of the book, point to revised priorities for research and associated development.

The editors suggest several criteria for the success of this venture:

- the book is consulted by individuals from each of the stakeholder groups, who each find it relevant to their concerns;
- innovations in curriculum, teaching, and learning stem from what has been written;
- new areas of research are conducted and reported.

The editors would be glad to know of instances where these criteria are met.

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