

REPORT
OF THE
EDUCATION STRATEGY DEVELOPMENT COMMITTEE

August 2000

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1. The Education Strategy Development Committee (ESDC, “the committee”) was established to achieve the following goals:

1. Review IUPAC's current and immediately planned activities in the field of chemical education, including programs of the Committee on Teaching of Chemistry, the other Operational Committees, and the Scientific Divisions.
2. Recommend areas in which IUPAC should and realistically can make meaningful contributions toward worldwide chemical education. Provide advice as to areas where IUPAC should not be involved.
3. Recommend ways by which IUPAC can realistically contribute toward the public understanding of chemistry and the scientific method.
4. Recommend any organizational and/or operational changes within IUPAC to facilitate the implementation of the recommendations proposed by the Committee.
5. Report to the Bureau by August 31, 2000—preferably a final report if feasible, or an interim report otherwise.

The membership of this *ad hoc* committee is listed in Appendix 1.

Preliminary remarks

2. The committee met twice, first at the Royal Institution in London, 20–21 February 2000, and then at IUPAC's headquarters in North Carolina, 22–23 July 2000. Between these two meetings, the committee separated into three working groups to review in detail the interim proposals and to report to the full committee where their amendments and suggestions were assessed and incorporated into this document by the chairman. Broadly speaking, the deliberations and report of the committee follow the sequence of topics in the terms of reference. The recommendations of the committee are summarized at the end of this document.

3. At its first meeting, the committee considered the current activities of the Committee on Teaching of Chemistry (CTC) in detail, and wishes to record its thanks to Professor Bradley, the Chairman of the CTC, for his very full, frank, and helpful assessment of the current and recent projects. As many of the ESDC had little experience of the CTC's activities, this immersion was particularly useful.

4. The committee decided that it was desirable to discover the views of outside interested bodies. The chairman therefore wrote to a wide range of institutions, principally the National Adhering Organizations (NAO), chemical societies when these were not the NAO, and a range of organizations active in chemical education and the public understanding of science, and current members of the CTC. Because the committee considered that this letter presented an opportunity to publicise the activities of the ESDC, the CTC, and IUPAC in general, and perhaps to seed the thought that, with value added, countries not currently within the Union might in due course wish to join, letters were not confined to the current membership. The letter, the recipients, and a digest of the replies are included as Appendix 2. These responses were considered by the committee at its second meeting and used to mould the final report.

5. The committee took the view that, provided it worked within its terms of reference, then no aspect of the work of the CTC should be regarded as sacred, and that to fulfil its role effectively, the ESDC should be able to disregard any existing organizational structure, program, project, or attitude, and come to the task as though presented with a blank sheet of paper. In particular it had in mind that the CTC evolved from its involvement with secondary education, and that origin was still present in the perception of the CTC to those outside the Union. It considered that a primary goal of any reorganization was that that attitude must be overcome and that the CTC should be perceived as a vigorous committee that could enhance education at all levels and contribute to the broader issues relating to the public appreciation of chemistry.

6. Indeed, the ESDC considered that the timing of its deliberations could not be better. The Internet provides a whole new regime of communication, and the public appetite for information about the achievements of science, and of chemistry in particular, while driven perhaps by anxieties, has never been more potent. The committee saw at once that IUPAC had to build on this new infrastructure and thirst for information. It formed the view early in its discussions (as described in more detail below) that the Internet offered opportunities for reaching out to the world-wide chemical community, and although not everyone today has adequate access, in the medium term the Internet will penetrate everywhere and be the *expected* vehicle of communication. The committee perceived that the time was ripe for IUPAC to become more fully involved with chemists and chemical organizations in less developed countries, especially but not only in Africa. The committee also responded warmly to the charge that it should expand the frontier of IUPAC's activities more proactively into the field of public understanding. It formed the view (as is also elaborated below) that IUPAC should raise its head above the academic and industrial battlements and find a way of using its well-informed, powerful, transcultural, and transnational membership to further the public appreciation of the extraordinary, continuing achievements of chemistry. The committee noted that IUPAC, through its strategic plan, has set itself the *obligation* to reach out to the public in this new way. Its recommendations are designed to help the Union achieve this laudable objective. Moreover, the committee took the view that the time was ripe for a significant expansion of the activities and realignment of the mission of the CTC, and that its numerous and important activities required organizational and administrative underpinning.

A framework for the CTC: an action plan

7. In preparing IUPAC to meet its strategic obligations and, specifically, adding sinew to the activities of the CTC, the committee considered what aspects of the activities of the CTC should be retained, what encouraged, and what replaced. The committee members identified a number of themes that gave them cause for disquiet in an otherwise vigorous program of activities. For completeness, Appendix 3 lists some specific comments made by the committee on current projects of the CTC.

8. *Too many projects have been coordinated by too small a number of people.* The committee was particularly struck by the frequency with which the same names appeared time and again over the several projects scrutinized. They considered that the burden of carrying forward multiple projects was too great for the individuals involved and that a mechanism should be in

place for a more equitable distribution of responsibilities. It was noted that in general National Representatives (NR) have been encouraged to participate but have responded rather weakly; they have rarely sought to be more than passive by-standers and that, as a result, the pool of active participants has been too small. The new project-driven mode of IUPAC's activities should eliminate this problem. A related problem is that too many projects depend on the enthusiasm of a single, motivating individual; when that individual moves from the project, for whatever reason, all too often the incoming Coordinators let slip their grip and the project founders. We conclude that the CTC needs to have much more regulated systems for submission of progress reports on projects. A plan for periodic assessment of the progress of a project and for the subsequent distribution should also be required so that the CTC can intervene if necessary and therefore improve chances of success. The specific recommendation is expressed in Section 10.

9. *Too many projects have stumbled when confronted by the problems of distribution.* The committee was struck by the number of times a project had been brought successfully to a conclusion but had failed to be distributed. This failure was particularly conspicuous in relation to printed books but also applies to low-cost apparatus, where material that had cost countless hours of well-meaning voluntary labour had languished in warehouses and never reached its intended audience. The underlying causes of this failure are the low profit margins, which make distribution unattractive to commercial companies, the cost of distribution by volunteers, the lack of a commercial infrastructure for marketing and sales, and—in short—an unsatisfactory conflict of amateur volunteers and commercial pressures. The establishment of an appropriate IUPAC web site (see Section 22) will go part way to solving this problem (in relation to verbal matter). However, it is unlikely to be effective in all developing countries. Indeed, the web site may solve the publishing problem but does not solve the dissemination problem because the web is largely a passive medium that waits for visitors. As many businesses that have ventured into the web have discovered, a web site becomes successful only if it is advertised widely. The publication and distribution of educational material being developed through projects related to CTC could also be done by involving NAOs and national and regional chemical societies. The same copyright rules could apply to such material as to the material published in PAC. Regional interests could be served very well in this way without involving the whole IUPAC organization. Whatever modes are adopted, the committee considers that it is essential to channel effort away from fruitless pursuits and to conserve that effort for viable enterprises. It therefore makes the following recommendation:

R1. *No project should be accepted unless the proposal includes a plausible, costed, and detailed business plan for the distribution of the resulting material.*

In relation to the points made here, the committee notes that distribution costs are a major barrier in many developing countries. It is recommended that IUPAC accept distribution costs in developing countries and countries in transition as a valid budget item in all new CTC project proposals.

R2. *IUPAC should accept distribution costs in developing countries and countries in transition as a valid budget item in all new chemical education project proposals.*

10. *Too many projects have been proposed with insufficient market research and terminated with too little analysis of their success.* Although project applications go through a process of peer review, the committee is not convinced that the procedures are strong enough in the sense of echoing the requirements of a broad community. Nor does the committee discern any mechanism for following up and assessing the impact and success of a completed project. It seems to the committee that these are two intrinsic deficiencies of quality control that need to be addressed if the CTC is to have an impact commensurate with the effort that its members put into their projects. The web-based bulletin board (Section 22) will be one way of encouraging client feedback as will regional conferences. The committee is aware of the existence and duties of the Project Evaluation Committee, but considers that project assessment and post-completion analysis need to be strengthened in order that future projects be more soundly based. The committee considers that the monitoring of outcomes should be not only an assessment of final outcomes but interim too. To tighten the reins on ongoing projects, the committee recommends that regular reports should be submitted (perhaps at six-month or yearly intervals) while a project is in progress. It also considers that the CTC should reserve the right to terminate a project on the basis of inadequate progress.

R3. *Regular reports should be submitted while a project is in progress, and the CTC should reserve the right to terminate a project on the basis of inadequate progress.*

11. It appears to the committee that there is an untapped source of information and advice which, if suitably deployed, could help to overcome both deficiencies mentioned in Section 10. Educational conferences are the ideal venues for soliciting, testing, and dispersing projects. We have in mind, in particular, the biennial ICCEs, but not forgetting other related conferences, particularly the biennial in North America, the European Conferences on Chemical Education, the education Gordon Conferences, and various regional meetings. The view of the committee is that the CTC should aim to have specific sessions at appropriate conferences, the ICCE in particular, at which projects are discussed. In particular, the CTC should use such a session to solicit views from participants as to which new projects should be initiated, report on the progress of ongoing projects, and aim to devise presentations and follow-up of completed projects. The committee regards the use of regional conferences as particularly apposite in this regard, for in that way projects of special relevance to developing countries will be identified, possible participants identified, and the long-term success of the endeavour assessed. Thus, the committee recommends as follows:

R4. *The CTC should do its best to exploit conferences on chemical education, the ICCE and regional meetings in particular, to encourage an environment for the generation of new ideas for projects. It should use conferences to present interim and final reports on projects, and use the information obtained at conferences to help assess the success of projects.*

12. The CTC currently oversees the organization of the ICCE, and the committee assumed that this activity would continue. However, in the course of its consideration of the role of

conferences, the committee could not help noticing the unfortunate collision of the timing of major conferences focused on chemical education, in particular the ICCE, the Biennial Conference on Chemical Education (BCCE), and the European Conference on Chemical Education (ECCE). It took the view that strong encouragement should be given to the organizations responsible for these important events to resolve the clash in dates. One possibility is for the BCCE and ECCE to share a year, with the ICCE using the intervening year; another is for the cycle to be three years. In any event, to resolve the matter before it drifts too far, the committee recommends as follows:

R5. *The CTC should, within the next 12 months, initiate an exchange of letters of intent between itself (as overseer of the ICCE) and the organizers of the BCCE and the ECCE, with a view to establishing a rational timetable for the three conferences within 5 years.*

13. The committee broadened its assessment of the current activities of the CTC to include the activities of the Divisions that have a strong educational component. These activities are somewhat difficult to identify, but those considered are included in Appendix 3. It was a cause of considerable concern to the committee that there should be separate educational activities originating within Divisions, sometimes without formal reference to the CTC. A large part of the reason may be the historical origin of the CTC in secondary education, leaving a vacuum in the realm of tertiary education that was inevitably filled by the admirable enthusiasm of the Divisions. The committee recognizes, moreover, that the Divisions provide a depth of resource that is essential to incorporate into the general educational activities of the Union; it also recognizes that a high proportion of the members of Divisional committees are academics, and in many cases as well qualified to consider educational questions (at the tertiary level at least) as the members of the CTC. Nevertheless, it struck the committee as inappropriate for manifestly educational activities to be pursued in such an uncoordinated and therefore, to the outside observer, confusing manner as at present. The committee came to the view that the only way for IUPAC to make a coherent, coordinated contribution to chemistry education is for all such activities to be carried out in consultation with the CTC. The committee had some concern that the CTC was not always informed about, or did not always appreciate that, a project was primarily of educational content. It took the view, moreover, that everything was to be gained if the CTC and the Divisions were to be jointly involved in the generation of mutually interesting projects, and therefore recommends as follows:

R6. *Divisional projects of primarily educational content should be referred to the CTC at their submission stage. Conversely, where relevant, CTC projects should be referred to the appropriate Division.*

14. The committee considered the kinds of projects that the CTC should not approve unless there were exceptional circumstances. In the committee's view, the CTC should be highly selective when considering projects that result in the preparation of printed material (specifically books), for as indicated above, the committee takes the view that IUPAC is ill equipped for successful distribution of printed educational matter on its own. This scepticism would not extend to articles in journals, including *Chemistry International* but does include the preparation of low-cost

printed books. Dissemination could be easier if *Chemistry International* and/or *Pure and Applied Chemistry* were to have a significant amount of educational material (of quality and utility similar to material found in, say, the *Journal of Chemical Education*), if the subscription cost were heavily subsidized in transitional and technologically developing countries, and if there were a way to guarantee that every educator in need would have a copy on their desks. None of these is easy to accomplish and there are financial consequences for the IUPAC, but these are ways in which IUPAC can pursue the issue proactively using a mechanism of dissemination that is already in place (*Chemistry International* and/or *Pure and Applied Chemistry*). Among other ideas for the development of *Chemistry International*, the committee would like to suggest that it be used to advertise at an early stage the proposals for new projects, brief reports on completed projects written with a view to encouraging the public appreciation of science, designs for low-cost equipment, and an indication of material that may be found on the web. Thus, the committee recommends as follows, having in mind that a review of *Chemistry International* is currently under way:

R7. *Chemistry International should be developed as a vehicle for the discussion and dissemination of, among other things, CTC activities; it should play a role in encouraging the public appreciation of science.*

15. The committee was concerned that insufficient credence was given in general to chemical education as a legitimate scholarly activity. It took the view that the CTC was well placed to develop its support of chemical education and considered that one of the CTC's major activities should be to find ways of underpinning this vital activity. The committee did not wish to urge additional funding, except in so far as worthwhile projects came forward in the normal way, but it did wish to emphasize the crucial role that the CTC should play in the dissemination of good practice and the results of projects relating to chemical education. Thus, the committee recommends as follows:

R8. *Chemical education should be recognized as a scholarly activity, and the CTC should use its best endeavours to ensure the worldwide dissemination of good practice and research results.*

16. The committee considered the role of IUPAC in the development of curricula. On the one hand it recognized that the origins of the CTC lay in secondary education, and therefore historically it had considerable interest and expertise in curriculum development. On the other hand, the committee took the view that national needs were so disparate that it is impractical for IUPAC, and the CTC in particular, to attempt to impose a rigid framework, and that most national organizations were perfectly competent to identify the essential components of a chemical education and to identify their local needs. The committee recognized that courses driven by local requirements and specific local interests could be highly successful, and that it would be unwise and unwelcome for the Union to tread insensitively in this area. Furthermore, many national organizations already have in place apparatus for the identification and authentication of curricula, and the committee considered it inappropriate to add yet another layer to this pursuit. Finally, it added into its considerations the fact that, as stated above, the Divisions

are a rich source of expertise within their own domain, and any activity in curriculum development should normally be a joint activity between the Divisions and the CTC.

17. To find a way forward, the committee distinguished core curricula from regional needs. It considered that the Divisions and the CTC should have a central role to play in the definition of core curricula, particularly at the tertiary level, but that regional interests in curriculum development were best treated as projects. The use of the project system should ensure that local interests were fully represented, particularly if they were to include regional conferences. The Committee hopes that in the future CTC will encourage chemists and their organizations in technologically developing regions to address issues of particular local relevance and thereby enrich their educational curricula. Moreover, the committee considers that it would be useful if IUPAC were to establish a directory of curriculum resources that had been compiled at national level (as distinct from possibly idiosyncratic institutional and personal level). Thus, the committee recommends as follows:

R9. *IUPAC should encourage projects defining curricula development in chemistry and its branches, with particular relevance to and input from local regions.*

R10. *IUPAC, through its Divisions and the CTC, should be willing to provide curriculum planning expertise at the request of National Adhering Organizations or bona fide educational organizations and institutions within member states, in particular by establishing a directory of curriculum resources at national level.*

18. The committee identified certain activities of the CTC as particularly effective, but nevertheless considered that a certain refinement was appropriate. In this regard it had in mind the continuing need to recognize that chemistry is fundamentally an experimental subject, and that education in chemistry must have an ineluctable experimental component. The committee, however, recognized that legislation (in some countries), safety, and increasingly universally but especially in developing countries the cost of acquisition and disposal of apparatus and chemicals, was gnawing away at this crucial foundation. It is in this context that the committee considered projects of the CTC relating to the provision of low-cost equipment and small-scale experiments. As will be apparent from Appendix 3, the problem with the provision of low-cost equipment is the all too familiar one of the failure to distribute. This experience convinced the committee that it should not encourage the CTC to participate in commercial activity of this kind but that the potentially excellent rewards of providing low-cost equipment should be confined to the provision of expertise and design and that involvement in actual manufacture should be avoided. Although the CTC should be free to try to encourage commercial companies to become involved in ventures of this kind, we consider that it should not become involved directly in production. Thus, the committee recommends:

R11. *The provision of low-cost equipment and small-scale experiments should be limited to advice, expertise, and design; IUPAC should not normally become directly involved in the provision of equipment.*

19. The committee considers that the propagation and encouragement of the experimental basis of chemistry is so important that IUPAC should encourage the establishment of, and sponsor, a series of regional courses and workshops on the development and use of low-cost equipment and small-scale experiments. Such a series would propagate the use of the equipment, generate ideas, and identify sources of supply. The committee took the view that whereas it is instructive for students to build apparatus, that activity could be perceived as a distraction from the acquisition of skills in experimental chemistry: it is far better, the committee considered, for an educational institution to have a bank of equipment that can be deployed in a practical course, than for each student to reiterate its construction. However, the committee recognizes that this view should be left to the educational philosophy of individual institutions, and does not wish to incorporate it into a recommendation. The sole recommendation in this context is therefore as follows:

R12. *IUPAC, through the CTC, should establish and facilitate regional courses and workshops on the development and use of low-cost and small-scale equipment.*

20. The committee considered at length the question of mobility of students and faculty, particularly between technologically developed and developing nations. It recognized that any encouragement to such mobility had to be sensitive to the positive impact of visitors and of the mixed impact of schemes that take students overseas, on indigenous courses and institutions. The committee noted that it could be helpful for a particular institution or country to know which experts or faculty were available; however, the committee understands that UNESCO has a program of exchange, and instead of trying to duplicate their effort recommends that IUPAC should strengthen its relations with UNESCO in this regard. The committee also noted the existence of regional societies and organizations, such as the African Academy of Sciences and the Federation of Asian Science Academies, as well as international organizations such as the Third World Academy of Sciences (TWAS) in Trieste, which is funded by UNESCO. The TWAS has mechanisms for funding regional centres, low cost equipment development, and the exchange of scholars (both South-South and North-South), with concomitant funds. The committee considered that a collaboration between IUPAC and TWAS would be highly beneficial to both parties. In this vein, the committee considers that the best way to assist technologically developing nations to retain their research and teaching personnel is to encourage contacts, particularly by encouraging regional conferences. The committee makes no further recommendation in this regard, for it accepts that net migration is a major sociological problem outside the grasp of IUPAC. However, it hopes that by encouraging regional conferences, IUPAC will lay the foundations for a more attractive and stable intellectual environment that may encourage each country's nationals to stay or return. A more practical contribution to the encouragement of intellectual stability may be for IUPAC to broker deals with national chemical societies so that membership of the "home" society results in lowered subscriptions to overseas societies. The committee regrets that it has little to offer on this awesomely complex problem, and that its recommendation can be little more than a platitude. It may be appropriate for IUPAC to consider the problem of migration in a global context in collaboration with UNESCO and the other Unions.

R13. *IUPAC should strengthen its relations with UNESCO to facilitate visits of experts to technologically developing countries, and use its good offices to*

encourage the establishment of stable intellectual infrastructures in these countries.

The public appreciation of chemistry

21. The committee was charged to consider a broader canvas for the activities of the Union, in particular to recommend ways by which IUPAC can realistically contribute toward the public understanding of chemistry and the scientific method. Such an activity is not alluded to specifically in the current terms of reference of the CTC, and indeed that committee has had no discernable explicit activity in this area. The committee considered that the public understanding of chemistry, as a natural extension of the meaning and context of “education”, should be an important component of the CTC’s future activity, and accordingly refers to the CTC as well as IUPAC in the following remarks. As a further gloss on the charge to the ESDC, the committee considered that “the public understanding of chemistry” should be construed as not merely public understanding (which may be too much to achieve if taken literally) but as the public *appreciation* of chemistry and in particular the benefits brought to society as a whole by the discovery and application of chemical knowledge.¹ The committee also considered that, because the propagation of the scientific method extends well beyond chemistry, IUPAC should explore opportunities for collaborating with other Unions.

22. The committee considered that the principal activity of IUPAC in the domain of the public appreciation of chemistry should be as a resource of reliable information. To achieve this objective, the committee considered that IUPAC should establish, under the guidance of the CTC, a web site to act in four ways.

- *Media Resource.* One function of the site would be to provide an infrastructure for national organizations, including the media, to use as a resource. It would seek to display commentary and chemical background on relevant news items. Such news is often based on regional issues; therefore strong links with national chemical societies would need to be developed and encouraged. The site should seek to establish itself as a reliable information source/route for the primary news communicators: TV, radio, and newspapers. As news is often sourced nationally, national societies should be encouraged to generate commentary on regional events. Indeed, the information pool would be driven in the short term by contributions from national societies and education groups. A function of IUPAC could be to provide the global web audience with pointers to these primary sources. The committee is aware that various organizations already exist for responding to queries from the media and the public (eg, Science Line in the UK), and sees the IUPAC web site as a valuable adjunct. Such organizations would be informed of the existence of the web site and could give advice on the type of content. As well as providing access to authentic, reliable information, such a site would have the secondary function of bringing IUPAC to the attention of a broader worldwide audience. National Adhering Organizations should be encouraged to provide links from their own sites to the

¹ It has not escaped the notice of the committee that the acronym formed from the public appreciation of chemistry, PAC, renders IUPAC in a new light!

IUPAC site.

- *Information archive.* The second function of the site, which would grow from the accumulated content of its first function, would be to act as an archive of information on current issues (environmental, materials science, genetic, medicinal, etc.) when its immediate newsworthiness has passed. This information could be of great educational value, to students and to the general public.
- *Information exchange.* The committee perceives a third function of the web site as being a conduit for flow of chemical information between active educational organizations, including NAOs and COCI. Many of these organizations have their own publications and the web site could act as a bulletin board for communicating programs, conferences, etc. and for sharing significant articles that have generic value. The overall aim should be to bring the IUPAC site to the stage at which it is regarded as the initial gateway to related sites around the world.
- *Access to existing information resources.* The committee is aware that there is much accumulated educational experience and knowledge that could be made more readily and freely available. A fourth function of the web could be to provide teachers and students with vectors to available information and resources (e.g. other web sites, bibliographies, review articles, etc.). This function would facilitate access and minimise the time and cost for individual educators who seek this information (e.g. a library of good material on the greenhouse effect, DDT, the ozone layer, eutrophication, uses of C₆₀ compounds, etc.). In drawing attention to this aspect, the committee is indicating that the emphasis of the CTC should not be solely on new activity: IUPAC's role should be both as collator of material that is available and generator of new material. This function of the web site would promote continuing education for the educators.

Thus, the committee recommends:

R14. *IUPAC, acting through the CTC, should establish relationships with NAOs and COCI with the intention of setting up a web site that would have the following functions: (a) a resource of regionally originating commentaries on developing news, (b) an archive of information on current issues, (c) a bulletin board for flow of information on chemical matters between regional groups, (d) a vector to established educational resources on central themes in chemistry.*

23. The committee has two further remarks in this connection. First, it is sensitive to the advantages of translations being available in local languages. It considers that the local NAO should be responsible for producing translations, and that it would be impractical for IUPAC itself to perform this activity. Secondly, it considers that the web site should not escape the normal procedures of quality control and assessment, in ways to be devised (perhaps by a Director of Education, see Section 33), of its impact and usefulness.

24. The committee notes that the more traditional methods of communication should not be overlooked. In some countries these media may be more accessible than the web. For example,

although commercial TV programs are expensive to produce, many poorer communities may have better access to TV than to computers, and large groups can be accessed at once; there are many educational TV programs that can be sourced from industries, national chemical societies, instrument manufacturers, etc. The CTC could collaborate with national societies and industry on this issue. In addition, videos produced by individual chemistry departments will, in most cases, be produced at very low cost, and there are many popular science writers and presenters around the world. These writers make regular contributions to newspapers, to science programs, in journal editorials etc. The committee considered whether IUPAC could establish a mechanism to encourage the wider dissemination of these commentaries, perhaps by notification through *Chemistry International*. Indeed, it sees here a possible opportunity for project proposals, and accordingly recommends as follows:

R15. *The CTC should encourage projects that draw on conventional media to propagate the public appreciation of science.*

25. The committee noted that there are new educational activities being encouraged around the world, some facilitated by the Internet but others drawing on conventional resources. These lifetime-learning activities include continuing education, general audience courses, and in-service education for teachers. The committee considers that projects relating to these activities, which all step outside the formal educational environment, should be encouraged in order that IUPAC move forward and respond to these new opportunities. Indeed, the suggested appointment of a Director of Education (Section 33) may lead to the identification of other activities and opportunities of this kind. Thus, it recommends as follows:

R16. *The CTC should encourage projects relating to lifetime learning and related activities.*

26. The committee recognized the great importance of encouraging younger people to enjoy science, and chemistry in particular. It was aware of the considerable and excellent impact of the International Chemical Olympiad, and considers that such initiatives require every encouragement. It is aware of an initiative to provide a web-based magazine for young people, and hopes that it, and initiatives like it, will have the success they deserve. The committee has no recommendation in this area, but considers that it will present a major opportunity for the proposed Director of Education (see below).

Organizational and operational changes

27. The enlargement of the CTC's activities to embrace the public appreciation of science and the increased scope of its mission in general implies that its name should be changed. An additional advantage of a new name is the implication of a fresh start and an eradication of the perceived tradition that the CTC is a child of secondary education. The committee suggests that the CTC should be renamed the Committee for Chemical Education (CCE). The committee therefore recommends:

R17. *The Committee on Teaching of Chemistry (CTC) should be renamed the Committee for Chemical Education (CCE).*

28. The committee was asked to recommend any organizational and operational changes within IUPAC that would facilitate the implementation of any recommendations it proposed. As a prelude to their discussion, the committee considered whether the CCE (as we shall call it in the remainder of this document) was better left as an Operational Committee (OC) or whether it should become a Division. The committee understands that projects may emerge from the CCE in its current form, and that therefore the CCE is not at a fiscal disadvantage compared with Divisions. The chairman of the CCE now sits on the Bureau, so the voice of the CCE is heard. Whereas there are no disadvantages in being an OC, its membership structure is somewhat more flexible and broadly based (largely through the presence of numerous NRs). More importantly, its classification as an OC gives it the status of being a bridge spanning the entire range of IUPAC's activities whereas as a Division it would seem to be more isolated in its activities. The committee therefore recommends that:

R18. *The CCE should remain as an Operational Committee and not become an Educational Division.*

29. The current terms of reference of the existing CTC are as follows:

- (1) To advise the President and the Executive Committee on educational matters.
- (2) To coordinate the educational activities of all IUPAC bodies.
- (3) To act as an informational and coordinating body for chemical education activities throughout the world and to establish a system of National Representatives as a channel of communication.
- (4) To develop liaison with international organizations such as UNESCO and with national chemical societies or chemical education committees.

In the light of its many recommendations, the committee considers that these terms of reference need to be rephrased, particularly to accommodate the extended role of the CCE in the public appreciation of chemistry. In the spirit of encouraging the evolution of these terms of reference rather than putting them to the guillotine, the committee makes the following suggestions. (1) To accommodate the wider role of the CCE, the committee considers that the phrase "and the public appreciation of chemistry" should be added to this charge. (2) The current somewhat weak role of the CCE in regard to coordination will be strengthened by our recommendations, and we see no need to change this charge materially, except to add an explicit requirement about its ongoing activities. (3) Here we consider that broader aspects of communication should be recognized, both by extending the term "chemical education" and by recognizing that electronic media are now an important alternative to the somewhat variable effectiveness of National Representatives. That is not to denigrate the latter: the committee considers that NRs are potentially enormously valuable channels of two-way communication between IUPAC and member countries. Yet their task needs to be made more specific and be augmented by other modes of communication. For the specific implementation of this change, see the recommendation below. (4) Here, too, the aim

is laudable but needs to be augmented to include organizations concerned with the public appreciation of science. We consider that the “or” could be construed as exclusive and needs to be changed: see below. In the light of these considerations, the committee recommends as follows:

R19. *The revised terms of reference of the CCE should be:*

(1) To advise the President and the Executive Committee on matters relating to chemical education, including the public appreciation of chemistry.

(2) To maintain a portfolio of educational projects and to coordinate the educational activities of IUPAC.

(3) To monitor chemical education activities throughout the world and to disseminate information relating to chemical education, including the public appreciation of chemistry.

(4) To develop liaisons with international organizations such as UNESCO, national and regional chemical societies, chemical education committees, and organizations concerned with the public appreciation of science.

30. A consequence of the enlarged activity of the CCE is the additional burden put on its active members, particularly its chairman.² This committee has already drawn attention to the thin resources available in an otherwise bulky committee, and it is inappropriate to suppose that an even greater burden could be shouldered by the chairman. At this stage the committee envisages that the restructured (and renamed) CCE will consist of a chairman (who will be a member of the Bureau), with responsibility for overall policy, and two deputy chairmen, with responsibilities for educational activities and the public appreciation of chemistry, respectively. The executive arm of the committee will consist of the chairman, the two deputy chairmen, the secretary, and the immediately past chairman. It is envisaged, but not required, that the deputy chairman for the public appreciation activities will be responsible for communication in general. Consequent on this proposal there would be a considerable lightening of the duties of the chairman, who will have time to consider the wider aspects of the CCE’s strategies and duties.

31. There remains the question of the composition of the groups constituting the CCE and supporting the two deputy chairmen. The committee certainly does not wish to be prescriptive at this stage, as it expects the CCE to evolve, but it considered that groups of about 10, including the deputy chairman, is probably appropriate for commitment and to act as a pool for coordinating projects. There is no reason why a member of the CCE should not be a member of more than one group, but it is thought that an overall membership of about 20 people is about right. It is envisaged that the membership should consist of 10 Titular members (including the

² The term chairman, when used generically throughout this document, is of course to be regarded as a gender-independent term.

five members of the executive) and representatives of the seven Divisions who, the committee considers, should have an interest in chemical education. The additional presence of NRs with a keen interest in chemical education, including the public appreciation of chemistry and especially those from technologically developing countries, would continue to be welcome, and the committee hopes that they will participate in projects. The committee also considered that it may be appropriate to achieve a well-balanced committee by selecting its members from its stake-holders; particularly experts drawn from industry, government agencies, etc.

R20. *The CCE should consist of a chairman, two deputy chairmen with responsibilities for educational activities and the public appreciation of chemistry, respectively, overseeing the activities of two groups. Each group within the CCE should consist of about 10 members. Overall there should be 10 Titular Members, 7 Divisional Representatives with an interest in chemical education, and the balance made up of National Representatives.*

32. The duties of the CCE should be to fulfil its terms of reference. However, that charge must be construed to mean the initiation of projects and the monitoring of their progress and effectiveness, as set out in Paragraph 10. The Divisional Representatives would have a special responsibility to bring to the attention of the CCE any educational projects their Divisions considered appropriate or intended to initiate. The National Representatives would have a special responsibility to disseminate the activities of the CCE to their home nations and to bring forward suggestions to the CCE from their home nations. The committee hopes that National Representatives would be sufficiently interested in the general activities of the CCE to participate in and initiate projects.

33. The committee is fully aware of the demands that the enhanced activities of the CCE will put on its members and its officers. Indeed, it is of the opinion that the education agenda, now including public outreach as well as its traditional roles in chemical education, is too large and too much in need of regular attention to be a reasonable assignment for a volunteer chairman even with the added help of the two deputy chairmen that we propose (indeed, the multiplication of officers may result in ever greater demands). Someone needs to keep track of the International and Regional Conferences on Education. The education outreach of the IUPAC through a web page or other means needs continuous attention. Coordination between CCE and the various divisions of IUPAC requires keeping informed and doing considerable negotiation. The proposers of projects may need help to negotiate effective contracts for dissemination. Perhaps various countries will have an interest in setting up an accreditation process similar to one run by the Committee on Professional Training (CPT) for the ACS. Doing so would require expert assistance. Coordination with educational arms of national societies is desirable. This is not a full list of activities. To make the proposals in this report, and the activities they spawn, realistic, the committee considers that it will be essential for IUPAC to add a Director of Education to the Secretariat. If such a Director has among his or her duties the requirement to raise funds for activities, the activities of the CCE will be enhanced and the post might become fiscally neutral. In making this recommendation, we are influenced by the extent to which the ACS has paid staff to support educational activities. Having such an officer within the Secretariat should also give the education activities of IUPAC the visibility that at present is lacking. If IUPAC is to have an effective presence in education, including the public appreciation of chemistry, the committee

has no doubt that a dedicated staff member is needed. We therefore present as our most important recommendation:

R21. *A full-time Director of Education should be added to the Secretariat, whose function, in collaboration with the CCE, will be to implement and maintain the activities of IUPAC in the field of chemical education and the public appreciation of chemistry.*

Summary of recommendations

34. The committee has identified a number of deficiencies in the composition and working practices of the CTC and has suggested ways in which the global expertise of members of IUPAC and the broader world community of chemists can contribute to a more effective programme. The committee recognizes the extraordinary debt that IUPAC (and its stake-holders) owes to the present chairman of the CTC, his predecessors, and their hard working volunteer members. The aim of its recommendations is to lighten the load on the chairman, to structure the successor to the CTC, the CCE, into a more efficient organism, and to ensure that it expends effort on worthwhile tasks. At the same time, the committee considers that the CCE has an important role to play in the extension of its duties to include the public appreciation of chemistry, and has suggested how this extension may be achieved, particularly by the addition of an officer to the secretariat. Its specific recommendations are summarized below:

R1. No project should be accepted unless the proposal includes a plausible, costed, and detailed business plan for the distribution of the resulting material.

R2. IUPAC should accept distribution costs in developing countries and countries in transition as a valid budget item in all new chemical education project proposals.

R3. Reports should be submitted at six-month intervals while a project is in progress, and the CTC should reserve the right to terminate a project on the basis of inadequate progress.

R4. The CTC should try its best to exploit conferences on chemical education, the ICCE and regional meetings in particular, to encourage an environment for the generation of new ideas for projects. It should use conferences to present interim and final reports on projects, and use the information obtained at conferences to help assess the success of projects.

R5. The CTC should, within the next 12 months, initiate an exchange of letters of intent between itself (as overseer of the ICCE) and the organizers of the BCCE and the ECCE, with a view to establishing a rational timetable for the three conferences within 5 years.

R6. Divisional projects of primarily educational content should be referred to the CTC at their submission stage. Conversely, where relevant, CTC projects should be referred to the appropriate Division.

R7. *Chemistry International* should be developed as a vehicle for the discussion and dissemination of, among other things, CTC activities; it should play a role in encouraging the public appreciation of science.

R8. Chemical education should be recognized as a scholarly activity, and the CTC should use its best endeavours to ensure the worldwide dissemination of good practice and research results.

R9. IUPAC should encourage projects defining curricula development in chemistry and its branches, with particular relevance to and input from local regions.

R10. IUPAC, through its Divisions and the CTC, should be willing to provide curriculum planning expertise at the request of National Adhering Organizations or bona fide educational organizations and institutions within member states, in particular by establishing a directory of curriculum resources at national level.

R11. The provision of low-cost equipment and small-scale experiments should be limited to advice, expertise, and design; IUPAC should not normally become directly involved in the provision of equipment.

R12. IUPAC, through the CTC, should establish and facilitate regional courses and workshops on the development and use of low-cost and small-scale equipment.

R13. IUPAC should strengthen its relations with UNESCO to facilitate visits of experts to technologically developing countries, and use its good offices to encourage the establishment of stable intellectual infrastructures of these countries.

R14. IUPAC, acting through the CTC, should establish relationships with NAOs and COCI with the intention of setting up a web site that would have the following functions: (a) a resource of regionally originating commentaries on developing news, (b) an archive of information on current issues, (c) a bulletin board for flow of information on chemical matters between regional groups, (d) a vector to established educational resources on central themes in chemistry.

R15. The CTC should encourage projects that draw on conventional media to propagate the public appreciation of science.

R16. The CTC should encourage projects relating to lifetime learning and related activities.

R17. The Committee on Teaching of Chemistry (CTC) should be renamed the Committee for Chemical Education (CCE).

R18. The CCE should remain as an Operational Committee and not become an Educational Division.

R19. The revised terms of reference of the CCE should be:

- (1) To advise the President and the Executive Committee on matters relating to chemical education, including the public appreciation of chemistry.
- (2) To maintain a portfolio of educational projects and to coordinate the educational activities of IUPAC.
- (3) To monitor chemical education activities throughout the world and to disseminate information relating to chemical education, including the public appreciation of chemistry.
- (4) To develop liaisons with international organizations such as UNESCO, national and regional chemical societies, chemical education committees, and organizations concerned with the public appreciation of science.

R20. The CCE should consist of a chairman, two deputy chairmen with responsibilities for educational activities and the public appreciation of chemistry, respectively, overseeing the activities of two groups. Each group within the CCE should consist of about 10 members. Overall there should be 10 Titular Members, 7 Divisional Representatives with an interest in chemical education, and the balance made up of National Representatives.

R21. A full-time Director of Education should be added to the Secretariat, whose function, in collaboration with the CCE, will be to implement and maintain the activities of IUPAC in the field of chemical education and the public appreciation of chemistry.

APPENDIX 1: Membership of the ESDC

B.M. Abegaz (Gaborone, Botswana)	1	2*
P.W. Atkins (Oxford, UK; Chairman)	1	2
D. Balasubramanian (Hyderabad, India)	1	2
J. Bradley (Johannesburg, South Africa; Chairman of CTC)	1	2
N.C. Craig (Oberlin, USA)	1	2
J. de Paula (Haverford, USA; Brazil)	1	2
A. Monge-Vega (Navarra, Spain)	-	2
J. Poë (Toronto, Canada)	1	2
K.J. Powell (Canterbury, New Zealand)	1	2
L. Sydnes (Bergen, Norway)	1	2
N.P. Tarasova (Moscow, Russia)	1	2
F. Meyers (IUPAC Secretariat)	1	2

In attendance for part of meeting 1: J. Jortner (Tel Aviv, Israel; Past President of IUPAC).

In attendance for part of meeting 2: E. D. Becker (NIH, Secretary General of IUPAC).

* Denotes the meetings attended.

The committee, and the chairman in particular, wishes to acknowledge the special and efficient contribution made by Dr Meyers throughout the compilation of this report.

APPENDIX 2: Communications with other organizations and parties

The following letter was sent to about 270 organizations and interested parties (see list that follows) in April 2000.

Dear Colleague,

Educational strategy of IUPAC

The International Union of Pure and Applied Chemistry (IUPAC) has set up a committee to explore how best it may fulfil its aims in respect of chemical education, interpreted broadly to include the public appreciation of chemistry. The principal terms of reference of the committee are as follows:

1. Review IUPAC's current and immediately planned activities in the field of chemical education, including programs of the Committee on Teaching of Chemistry, the other Operational Committees, and the Scientific Divisions.
2. Recommend areas in which IUPAC should and realistically can make meaningful contributions toward worldwide chemical education. Provide advice as to areas where IUPAC should not be involved.
3. Recommend ways by which IUPAC can realistically contribute toward the public understanding of chemistry and the scientific method.
4. Recommend any organizational and/or operational changes within IUPAC to facilitate the implementation of the recommendations proposed by the Committee.

The committee has a broad membership (see attached) and has had a preliminary meeting. At that meeting it was decided that so compact a committee could not possibly infer the views of all the potentially interested parties, let alone identify all the national interests. I was therefore asked, as chairman of the committee, to write to as broad a range of people as was reasonable, taking particular care to identify countries or regions not represented on the committee, and solicit from them views that would be helpful to the committee. I am therefore writing to national adhering organizations of IUPAC, to chemical societies (when different), to a variety of organizations active in chemical education and the public understanding of science, and to institutions in countries who are not members of the Union. I am also writing a short article for a number of chemical journals, a copy of which I attach.

The committee would be most grateful if you would consider the items listed in our terms of reference, and let us have your views. We appreciate that IUPAC's activities, particularly in the field of education and public understanding, cannot be done in isolation, without reference to its end-users and members, and without taking note of the vigorous programmes already established by national organizations, ministries, and enthusiastic groups in many countries. In particular, it does not wish to duplicate their efforts; it does, however, want to find ways for being constructive and helpful.

We shall be meeting again in July. As a great deal of analysis of replies will need to be performed before that meeting, I would be grateful if your responses could be sent to me by the end of May. You may prefer to communicate directly with local members of the committee.

Thank you for your contribution to this important initiative.

Yours sincerely

(Professor) P.W. Atkins (Chairman, Educational Strategy Development Committee)

This letter was sent to:

By mail:

CTC members (31); NAO mailing (45); ANAO mailing (18); AMP contacts (46); Olympiad99, mentors list (93)

By e-mail:

National Centers (20); Press group (about 20, including: AAAS, ACCN, C&EN, *Chemical Week*, *Chemistry and Industry*, *Chemistry in Australia*, *Chemistry in Britain*, *Chemistry in New Zealand*, *ChemWorld*, *Chimica Oggi*, *Environmental Science & Technology*, *ETH-Zentrum*, *Kemia – Kemi*, *Nachrichten aus Chemie*, *New Scientist*, *Quimica*, *Quimica Nova*, *UNESCO Courier*, *Bulletin of the Chemical Society of Ethiopia*, *NAPRECA Newsletter* (Tanzania).

The following are highlights from the responses. Only comments relating to strategic issues are summarized below. Most contributions have been summarized/edited; original documents are available via the Chairman of ESDC.

Organizations, Institutions, and Societies

UK: The Royal Society of Chemistry

The Education Division of the RSC has considered the document, and has voiced general support for the initiative. However, it awaits explicit proposals before committing itself to a specific view. It is relevant to note that the RSC has set up an RSC-IUPAC committee to consider its relations in general with IUPAC (in a strongly positive light), not just on educational matters; PWA is a member (as representative of the Education Division of the RSC), and presented the work (but not the current recommendations) of ESDC to the committee at its first meeting (26 June 2000). The President of IUPAC was present. One point made at the meeting was that the ASE's publication on nomenclature in schools had proved particularly valuable, not only in the UK, and that is was perhaps a model for dispersing IUPAC standards throughout the world.

Ecuador: Pontificie Universidad Católica de Ecuador

IUPAC should provide information on experimental teaching of chemistry on a microscale, chemistry education through distance learning, teams for experimental work at low cost, textbooks at low cost. It should consider the economic characteristics of developing countries, and concern itself with matters relating to pollution and health. The *School of Chemical Engineering* makes, among more general proposals relating to the good of humanity and activities that are already in place, the following suggestions:

- 1 Organize visits of IUPAC representatives to universities (conferences, short seminars).
- 2 Facilitate the participation of IUPAC members from Universities in developed countries in the developing countries (during sabbatical years).
- 3 Promote scholarships, etc. for professors, postgraduate students, etc. in exchange programs.
- 4 Facilitate the participation in joint research projects between developed countries and countries in search of development.
- 5 Design correspondence courses through internet, videos, mail.
- 6 Prepare easy reading material for first and intermediate instruction levels regarding the understanding of daily phenomena.

The *School of Chemical Sciences* makes, among others, the following suggestions:

- 7 Apply long-term policies and activities in order to incorporate scientific methods in the daily duties and tasks of all human beings.
- 8 Design training policies for teachers and technology by means of specialized committees.

Brazil (informal response from Brazilian Chemistry Committee for IUPAC)

For developed countries the urgent matter is to direct efforts to disseminate scientific knowledge to the general public efficiently, particularly showing the real benefits of chemistry. The focus should be changed when dealing with Chemical Education in the developing countries. Most of IUPAC's efforts for this sector have been directed to the development of "low cost" experiments and equipment, with the accompanying descriptive material in English, a language which many teachers do not comprehend, even at the university level. A giant step toward improving Chemical Education for many countries would be providing texts in *local teaching languages* by way of the Internet.

South Africa: South African National Committee for IUPAC

The following is verbatim from a detailed document

1. Your committee to carefully assess all the projects relative to available project members, their ability to deliver and mechanisms to distribute the information, and in addition, to guide the implementation thereof. Much attention was previously directed by CTC at the teaching of chemistry at secondary level, within IUPAC a concerted effort should now also be directed at tertiary education in chemistry; and to the interface between chemical research and chemical education.
2.
 - a) The committee should define recommendations for the criteria for the completion of master's and doctoral studies in chemistry. The IUBMB set criteria for the doctoral dissertation in the biological sciences—an admirable example to evaluate.
 - b) IUPAC in collaboration with grant giving bodies such as the IMF, World Bank, UNESCO and funding agencies should explore ways to enable postgraduate from developing countries to undertake advanced studies in internationally renown laboratories, as well as to enable lecturers from developing countries to undertake sabbatical studies abroad. The studies should be in chemical research and/or chemical education.
 - c) Efforts should be explored to supply young graduates from developing countries with essential chemicals and access to equipment and information upon completion of their studies in top international laboratories. The grants should be made available in the countries of origin of the said scientists. [In many developing countries newly qualified researchers frequently fail to reach their potential as scientists or as teachers.]
 - d) Information is of cardinal importance to education and research in the chemical sciences. IUPAC and granting bodies (e.g. World Bank) should invest in an electronic scientific highway to be deployed in developing countries such as Africa. The rapid development of electronic communication networks and the availability of electronic text (journals and textbooks) should make the great difference in teaching and chemical research. Of particular importance is access to IUPAC recommendations, etc. in a form suited to different audiences, e.g. school teachers, university students.
 - e) Your committee could consider defining the topics for the holding of a few world-class conferences (e.g. two per year) of general appeal. Contact should be established with IUPAC Divisions and specifically its CHEMRAWN and COCI.
 - f) IUPAC should NOT be involved in the compilation or publication of textbooks or in the provision of equipment. However it should be involved in the promotion and dissemination of new ideas and trends in chemical education.
3.
 - a) IUPAC and its Committee of Chemical Education should be pro-active in its statements on e.g. global warming and climatic change; the hole in the ozone layer; HIV-AIDS; environmental estrogens; mycotoxins; genetically modified organisms; irradiation of food; the chlorine issue; etc. The Committee on Chemical Education should be involved in the development of related educational materials for school and university levels.

- b) IUPAC should employ a consultant/lobbyist to work on behalf of the Union to promote the excellent work of the Union professionally and to create a better image for chemistry. Much publicity should be given to IUPAC Congresses and GA's.
 - c) The Committee on Chemical Education in conjunction with CHEMRAWN and/or COCI should arrange world-class conferences, however, with a more general public appeal.
 - d) IUPAC's website should be extended to contain information on scholarships (postgraduate) and postdoctoral fellowships (faculty members).
 - e) Regular articles on chemical education in CI, rather than an under financed newsletter.
 - f) IUPAC should encourage members to publish articles on understanding scientific issues (e.g. ethics in science) in local newspapers and other media which get to the people.
4. The chairman of CTC is currently a member of the IUPAC Bureau, therefore having a high status in the Union: A new chemical education committee should consider having subgroups giving attention to:
- Secondary chemical education
 - Tertiary chemical education
 - Public understanding of chemistry
 - Interaction with all the Divisions and Standing Committees of IUPAC

The teaching of chemistry is (or it should be) a top priority in Africa. [The correspondent] presumes [the committee] is familiar with the UNESCO/IUPAC Report: Chemistry in Africa's least developed countries—an overview of capacity building and research support by CF Garbers (1998). May [the correspondent] also refer [the committee] to *Chemistry International* 1999; **21**(1): 1 for a report on the IUPAC-sponsored meeting on the role of chemistry in the development of Africa. Active use could be made of the International Chemistry Council – Executive Committee as a vehicle for promoting a number of educational objectives in cooperation with UNESCO.

Netherlands: The 34th Chemistry Olympiad

The International Chemistry Olympiad (IChO) is becoming more and more important, with 60 countries participating in the 32nd (Copenhagen, 2000). The Olympiad helps in getting attention for chemistry and encourages pupils to put an extra effort into studying chemistry; it strengthens the position of chemistry as a school subject. For example, the participation of Denmark in the IChO has led to the inclusion of chemistry as a separate subject in the secondary school curriculum. Furthermore, the IChO shows that it is also fun to study chemistry. On the other hand, the increase in the number of participating countries makes organizing the Olympiad more and more difficult, with budgets at about US\$1M. The correspondent considers that one certain way for IUPAC to fulfill its aims to increase the public understanding of chemistry would be for the Union to provide some kind of support, in the sense of seeking IUPAC's sponsorship for

IChO, the name, but not necessarily financial support, because sponsorship by IUPAC opens the door to more fruitful fundraising from elsewhere. He asks the ESDC to consider whether a recommendation along these lines is possible. [Note in passing: this request has been passed on to the President of IUPAC directly, and received unanimous support of the members of the ESDC acting as individuals.]

Ukraine: The National Committee for Chemistry

The Ukraine considers that IUPAC's role should be to:

1. To create standard curricula for chemistry for secondary and tertiary education, which will provide a base for creation of appropriate national programs.
2. To organize under IUPAC's guidance international meetings to discuss the place of chemistry in general education, the standard curriculum of chemistry courses, and problems connected with creation of textbooks.
3. To establish IUPAC awards for best textbooks in chemistry for secondary and tertiary education.
4. To participate actively in International Chemistry Olympiads. In future, these Olympiads should proceed under IUPAC's guidance.
5. To organize IUPAC Internet conferences devoted to chemical education strategy.

Individuals (identified by country)

Viet Nam

IUPAC should continue speeding up using chemical nomenclature all over the world by, for example, supplying the book *Principles of chemical Nomenclature* free for the poor countries and permitting translations free into local languages IUPAC should consider funding (or at least advising on) a "laboratory in a bus" that would be used to train chemists in experimental procedures.

Japan

Correspondents from Japan drew attention to a number of activities originating in Japan. They include:

- (i) CTC web page, opened in 1997. This is an extension of the work to open the Asian Chemical

Education Network (ACEN) within the framework of the Federation of Asian Chemical Societies. In the same spirit, the World-wide Chemical Education Network (WCEN) as been opened. Both are linked with IUPAC CTC web page, the intention being to make the CTC the world centre of information on chemical education. The correspondents consider that this kind of activity will be helpful in making CTC (and hence IUPAC) visible in society at large.

(ii) Virtual Chemical Education

The VCE project is another attempt to make CTC the centre of teaching (chemistry) materials for use of the Internet. Many such materials have been prepared, but most are used only locally. The correspondents suggest that IUPAC/CTC can be a hub of exchange of such materials. A grant has been obtained from the Ministry of Education, Japan, and the work has been started as an international project authorized by the CTC. The intention is to organize symposia on this subject: [details were given]

(iii) New Electronic Journal for CTC

For many years CTC has published a pamphlet *International Newsletter on Chemical Education*. For financial reasons, the publication has stopped for three years. Professors Takeuchi and Ito were asked to revive this as an electronic journal at Berlin CTC meeting (1999). The intention is to make this journal for teachers and young people, the aim being to promote chemistry among young people and to make IUPAC more visible in society.

In conclusion, the correspondents believe that CTC has acted and will be very active in making IUPAC and CTC visible in society. If IUPAC feels education is important, then the most effective help to CTC is not a change of the structure, etc, but simply some money by which they can prepare new electronic journals.

Turkey

The correspondent expresses agreement that the CTC's contribution in Chemistry Education is very valuable and that it can do even more. It is important, though, to obtain information about different programs in different countries and should cover both secondary and tertiary levels. The correspondent goes on to stress the importance of Chemistry Olympiad, and remarks that from his experience, the Olympiad contributes in many ways to both national and international improvement in chemistry education. He considers that IUPAC could make many contributions, such as topics to be included in program, the level of examination, etc. He goes on to remark that the CTC and in general IUPAC can bring different ideas and experience into people attention by opening an Internet web site or holding symposia on the subject.

Phillipines

The correspondent suggests that because it is now very difficult to separate the practice of chemistry from biotechnology, materials science, and modern medicine, this link should be emphasized. Instead of pushing chemistry itself, we should emphasize these other facets of

chemistry. In particular, the link between chemistry and chemical engineering should be strengthened. He goes on to remark that we should show how chemistry is an essential part of the solution of environmental pollution and sustainable development.

Korea

The correspondent remarks that he is a firm believer in changing the way chemistry is taught to make it more enjoyable and effective. He appreciates the committee's 'noble efforts' trying to bring chemistry to the students and the public in more effective ways.

USA

The correspondent believes that the scope of the CTC should be broadened to encompass elementary industrial, medicinal, and process chemistry, regulatory issues etc.

USA

The correspondent plans to research some of the common elements in the strategies for education and science outreach in Britain and make comparisons with those in the US, and remarks that it might be possible to take a more global look at these issues in collaboration with the ESDC. A particular concern is the manner in which publishing companies/media conglomerates are influencing the state of chemical education. She goes on to ask what are the fundamental concepts that IUPAC agrees that all students of chemistry should learn? Does IUPAC plan to put a stamp of approval on some textbook products? How will the issues with regional differences be resolved? (The periodic table double labelling, differences in nomenclature, and so on.) What is IUPAC's position on chemistry courses in distance learning? How can laboratory components of these courses be handled? Is distance learning a better way to teach chemistry in more remote third world countries? What about examinations? To measure the success of distance learning or any program, assessment tools are needed. Does IUPAC have its own examination plan? Do chemical societies other than the ACS have these examinations? Are the instruments comparable?

Thailand

The correspondent used to help organizing the ICSU workshop for the production of simple equipment for analytical chemistry held in Thailand several years ago. This workshop created some ideas among Thai educators for producing cheap and workable equipment in Thailand. But it seems to the correspondent that there is no continuation for the support to help further workshop. Developing countries like Thailand still need this kind of workshop as it will save money to buy them from overseas. IUPAC's policy should be maintained to help poor countries. The other activities include distance learning either by the Internet or circulation of a newsletter. New methods of teaching should be introduced to members of IUPAC so as to catch up with new ideas and cheaper investment on equipment.

UK

IUPAC carries great authority as a result of the care and quality control imposed on its activities and, through being global, provides a stable international base for chemistry. Through its global nature, IUPAC can identify, prioritise, and tackle matters of global concern. IUPAC's educational effort should be directed at the promotion of the use of SI units (the correspondent suspects that there is a large hidden cost in the lack of SI universality in the USA). IUPAC can best reach its target audiences through national societies with targeted communication to relevant subgroups and through international bodies with common interfacial interests, such as ICSU, ILO, IUTOX, IUPHARM, IPCS, UNEP Chemicals, UNDP, etc. There is a need for better chemical education in many areas that depend on and impinge upon chemistry, such as toxicology, occupational hygiene, pharmacology, and regulation of activities involving chemicals. Interactive digital TV and radio should permit more student-centred delivery of education of all sorts and reach households where conventional computers are not available. As to the various stakeholders, the correspondent identifies health as an overriding global issue. The general public is our main stakeholder, and must be made aware that health, good nutrition, and a good quality of life are the results of the proper use of chemicals and that good chemistry is the basis of a good life.

Argentina

The correspondent considers it of the utmost importance for IUPAC to be involved in national activities all around the world, and outlines a number of initiatives in Argentina. These include a program for the Promotion and Diffusion of Science run by the Research Council of the Buenos Aires Province; one of its activities has been to identify leaders in different regions of the country to form Local Advisory Boards. Another outcome of this program is the establishment by two national universities of a Master of Didactics of Experimental Sciences course, the principal aim being to prepare people to teach at all levels of chemical education; the correspondent considers that IUPAC's cooperation with these courses would be very beneficial. Periodic meetings have also been established in which university professors discuss teaching-learning issues at all levels of education: the next meeting will be in Uruguay in 2001, and the correspondent hopes for CTC sponsorship. In an editorial in *Industria y Quimica*, the correspondent urges that steps be taken to ensure that professors and teachers be capable of teaching up-to-date material at all stages of education and that it is important to educate people in the use of scientific language and the deployment of scientific attitudes.

USA

The correspondent drew attention to Project Kaleidoscope (www.pkal.org), an informal national (USA) alliance of individuals, institutions, and organizations committed to strengthening undergraduate science, mathematics, engineering, and technology education. The correspondent went on to describe the use they hoped to make of IUPAC nomenclature recommendations at a forthcoming summer school on *The future of plant biology*.

Canada

The correspondent urges that the educational mandate for IUPAC be given a higher profile and that the organizational structure is appropriate. He wonders about a change of name for the CTC and the possibility that it become a Division. The correspondent makes the following suggestions for the focus of IUPAC's educational activities:

- 1 Continue to deal with global issues but explore ways to strengthen links between CHEMRAWN and CTC.
- 2 Continue to provide high quality materials to deal with global issues. Excellent examples are PAC special issues on chlorine and endocrine disrupters as well as the CTC work with the Commission on Toxicology. Can IUPAC take advantage of opportunities to produce educational materials at the secondary and tertiary levels that evolve from these materials?
- 3 Continue to bring together the global chemical education community. Conferences like the ICCE have paid an important role but participation is limited by cost. The current emphasis seems to be on North-South dialogues: there may be scope for more South-South dialogue using regional conferences, satellite, Internet.
- 4 Address the brain drain for countries of the South. This particular brain drain has a huge impact on the pool of gifted scholars and teachers available to provide the educational infrastructure. Can IUPAC find a mechanism to enable recently retired chemists to spend extended periods in development contexts (mentoring, curriculum review, obtaining funding and instrumentation, etc)?
- 5 Facilitate communication between chemical societies about chemical education initiatives and resources. The correspondent welcomes the CTC initiative to provide the newsletter electronically.
- 6 Continue to address educational issues at secondary and tertiary levels and at the interface between the two. The correspondent considers that much of the success of the CTC has been in producing resources for the production of low-cost equipment, etc. IUPAC should assist chemists and chemistry teachers to play a substantial role in sustainable development education initiatives.
- 7 Find new ways to open formal channels of communication with national chemical societies that have an educational mandate. In North America, the ACS Division of Chemical Education and the CIC's Chemical Education Division should be formal stakeholders in IUPAC's educational initiatives.

Israel

The correspondent forwarded the letter to the Chemistry Committee of the Ministry of Education, but no response has been received. The correspondent considers that virtual demonstrations of experiments would be very helpful.

Northern Ireland

Syllabus developments of the generic format "Chemistry and..." are useful but should be

coordinated to produce a core syllabus. IUPAC should act as a clearing house for the material produced by other agencies, facilitate cooperation, and avoid the duplication of effort and the waste of scarce resources. The division of domains suggested in this report seems sensible, and it is important to produce domain-relevant material.

Turkey

The correspondent remarks that IUPAC should take steps to stimulate teachers in high schools and universities in *experimental* chemistry. He makes the following specific suggestions:

1. Helping developing and underdeveloped countries by supplying chemistry books, simple laboratory experiments, and chemicals to primary and secondary schools. This could be done with a project.
2. Encourage, through NAOs, the establishment of chemistry teachers associations and use CTC to help arrange summer schools to improve their knowledge.
3. To urge NAOs to make contact with chemical industry to give support for the establishment of research and development laboratories in contact with universities.
4. To encourage the establishment of open universities.
5. To make people believe, via the media, that chemistry is the central science and the basis of nature, environment, health, and industry.

Greece

From a dozen suggestions, the following are identified as being more appropriately “strategic” and appropriate for our committee’s consideration:

1. The establishment of a permanent committee of IUPAC in the European Union, charged with the confrontation of problems of chemical education.
2. Chemical education programs in secondary schools and universities should be coordinated in the countries of Europe.
3. The teaching of chemistry should make use of internet facilities.

.....
One further communication is worth recording

UK

The chairman of the ESDC had a meeting with the Director of the Human Resource Development Division (Education and Health Departments), himself a former chemist, of the Commonwealth Secretariat (CS; in London), and discussed a number of issues in this report and explored the kind of information to which the Commonwealth Secretariat has access. In agreement with a number of remarks made above, the CS takes the view that to disseminate chemical information successfully to a not always willing public it is essential to tie it to personal issues, such as health (in particular but not exclusively HIV-AIDS). The spread of information must always be in context, and textbooks and other sources of information should, wherever possible, be regionalized. The CS also sees the Internet as a primary channel of dissemination, but there are parts of the world where it is much more successful (India, South Africa, Botswana) than others (island nations, such as those of the South Pacific and the Caribbean). In the more dispersed communities, the high cost of network access was a considerable barrier to widespread use. Moreover, the CS realizes that it is insufficient simply to supply hardware, software, and connectivity: instruction must be given to the users on best practice. Despite these reservations, the CS considers Internet provision to be an essential component of its future strategy. The Director suggested that a useful contact might be the Commonwealth of Learning, based in Vancouver, and he provided information relating to the Department for International Development in London.

APPENDIX 3: Comments on the current educational activities of IUPAC

The committee notes the following remarks on the current activities of the CTC and the Divisions.

CTC 025/27/85 International Newsletter on Chemical Education

The printed version of this Newsletter has been terminated. The electronic version is far weaker and barely conveys enough interesting information to make referring to it worthwhile. Valuable in principle as a vehicle for propagating ideas and views, it needs to be refreshed and enhanced if it is to be worthwhile in practice.

CTC 025/33/89 Distance education in chemistry

The project depends on well-meaning but sporadic initiatives that is more opportunistic than strategically planned. This is an example where spurts of progress depend on the enthusiasm of committed individuals.

CTC 025/34/89 International network for locally produced low-cost equipment

The paradigm example of the unhappy conflict of personal enthusiasm and commercial pressure. The considerable impact of this project (which involved local social engineering as well as a broader picture of supplying low-cost equipment) was blighted by the difficulties associated with distribution. This project is also an example of one in which momentum was achieved by the commitment of a single individual, and which appears to have been lost on the retirement of that individual from the project. Low-cost equipment is not necessarily the pinnacle of achievement: there is an aura of condescension about the approach, a built-in probability of obsolescence, and perhaps a distraction, by focussing on infrastructure, from the aims of a chemical education.

CTC 025/43/91 Small-scale chemistry

This project struck the committee as one of the more successful ones stemming from the CTC. It is still highly active and of world-wide interest. A critical factor in its success has been the support of UNESCO, which has provided substantial funds and contacts in a wide range of countries. A lesson to learn is the importance of collaboration with other agencies, which has helped the dissemination of the project, and a clear appreciation of the needs of particular countries.

CTC 025/44/91 Source books for teaching of chemistry

A noble effort thwarted by uncommercial distribution. Here there was no UNESCO support, which is thought critical for projects requiring dissemination, and no commercially viable plans for the distribution of the books produced. Indeed, it appears that the only major sale was to an

eagle-eyed purchaser in a relatively rich Western nation. It is possible to ascribe the failure of this project to the impossibility of marketing where professional publishers fear to tread.

CTC 025/45/93 Education in chemistry and industry

The committee did not have sufficient information to comment on the success of this project, which was developed in collaboration with COCI.

CTC 025/46/96 Education in chemistry and the environment

Still being developed. The committee is suspicious that project funds did not allow for distribution.

CTC 025/47/96 Education in chemistry and human health

The committee notes that the original coordinator is no longer active in IUPAC, and is concerned that no mechanism exists for spotting this problem and, having spotted it, acting quickly to find a replacement. Apparently none of the promised workshops have been organized and the project appears to be more moribund than healthy.

CTC 025/49/98 International curriculum development

There was considerable doubt that this project now exists; it appears never to have made any progress.

Chemrawn 021/13/93 X Chemical education

The committee notes that little progress has been made and regrets that this opportunity has been let slip.

Division V (Analytical) 560/9/83

A research database; not strictly relevant to chemical education except in specialist courses; but see Soleq below.

COCI 022/17/98 The assessment of DIDAC as an aid for the teaching of chemistry around the world

This is, appropriately, a COCI/CTC collaboration. However, there was never really any direct involvement of the CTC, and the project emerged more by serendipity from Agfa-Gevaert. It

seems essential to follow up the use of the material now that English versions are available. However, the committee expressed severe doubts about the cost of the material and therefore its availability to financially hard-pressed institutions. It wondered whether electronic media would be a better medium of distribution than actual transparencies. An ambitious but perhaps impractical resource.

Inorganic Chemistry Division II 230/29/95 Teaching experiments in solid state chemistry

A collaboration with CTC and ACS. Ostensibly an interesting project but it was not clear to the committee that IUPAC should contribute in the area of the provision of practical laboratory experiments. Is IUPAC fully covered for insurance in connection with any experiment it suggests?

Analytical Chemistry Division V 560/39/95 Development of materials for teaching solution equilibria

Soleq is an elaborate software package developed in collaboration with a commercial software house. The committee found the development model attractive as commercial pressures were accommodated by the presence of the commercial developers. However, it was unable to ascertain whether the project was commercially viable, and awaits developments with interest. It noted that collaboration with CTC was minimal as a result of a breakdown in communication at an early stage of the project. It understood that the commercial arrangements with IUPAC were satisfactory from both parties' point of view.

Chemistry and Human Health Division VII 720/11/97 Teaching text: Fundamentals of toxicology

The development of this text seems to have been handled well by CTC in the sense that it was brought at an early stage to the CTC, interested parties were circulated with the material, comments were invited, an education graduate assessed the text, and a draft is to be considered at a special meeting during the Budapest ICCE. However, the committee expressed severe doubts about the viability of the project, in terms of the content, variable level, and proposals (none) for distribution of the final project.

Chemistry and Human Health Division VII 761/1/90 Medicinal chemistry curriculum

It is not at all clear to the committee that this example of curriculum development would have been supported by the CTC in its new format.

Committee on Publications: Principles of nomenclature

The committee does not know where this project currently stands, but believes it has run into difficulties.

APPENDIX 4: List of abbreviations

ACS	American Chemical Society (USA)
ASE	Association for Science Education (UK)
BCCE	Biennial Conference on Chemical Education (North America)
CCE	Committee for Chemical Education [proposed]
CHEMRAWN	Chemical Research Applied to World Needs
CI	<i>Chemistry International</i>
COCI	Committee on Chemistry and Industry
CPT	Committee on Professional Training (of ACS)
CTC	Committee on the Teaching of Chemistry
ECCE	European Conference on Chemical Education
ICCE	International Conference on Chemical Education
IUPAC	International Union of Pure and Applied Chemistry
NAO	National Adhering Organization
NR	National Representative
OC	Operational Committee
PAC	<i>Pure and Applied Chemistry</i>
RSC	Royal Society of Chemistry (UK)
TWAS	Third-World Academy of Sciences (Trieste)
UNESCO	United Nations Educational, Scientific, and Cultural Organization