Globalisation in Chemistry Education Research and Practice: Necessity or Utopian Dream?

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Abstract: Chemistry and chemistry education are closely related, and so is research in the two fields. While, a major goal of education research is the improvement of chemistry education, its impact on the practice of chemistry education has remained relatively low. The vehicles for publishing results of research are international and national journals. Publishing in established peer-reviewed international journals is a very hard job. This is a necessity for a young field which needs its academic reputation to be enhanced, and not to be accused as easy research. For the non-native English authors, the language barrier is very serious. On the other hand, concern should cause the fact that even the most prestigious international journals are of a narrow national character. In this paper, we survey the subject of practical (laboratory) work in chemistry in two journals: '*The Journal of Chemical Education*' and '*University Chemistry Education*'. While most non-American authors cite in considerable proportion American sources, the American authors cite as a rule only American sources. Another issue which is examined in this paper is that of the nationality of the participants of the *ECRICE* Conferences. The paper concludes by stressing the need to support, expand, and spread new electronic, freely distributed through the Internet European journals, such as '*Chemistry Education: Research and Practice in Europe*' and '*University Chemistry Education*'. A more ambitious target is to set up a major Europe-centred international journal of chemistry education.

1. Empirical Research into Chemistry Education

According to Bunce & Robinson (1997), research in chemical education is the third branch of our profession at university. Consequently, there is an increasing number of universities all over the world at which researchers in chemistry education are working. These researchers belong either to a chemistry department or to an education department. In a chemistry department, they work side by side with chemists, while in education departments, the staff are from various disciplines, with educators being the majority.

There are certain advantages and drawbacks in both environments. In a chemistry department, the educationist may be working alone or in a small group, while in an education department the presence of other chemists among the staff may be questionable. The standards of research may also be different (in terms of publications) which are set by the two kinds of departments. In chemistry departments, publications in international journals with high impact factors are demanded, and this becomes a necessity too for researchers in chemistry education. On the other hand, education departments attach importance to research of a local character, which is published in national journals, in the language of the country.

Chemistry and chemistry education are closely related, and so is research in the two fields (Bunce & Robinson, 1997). There is however a fundamental difference: chemistry education research is a field belonging to the social sciences; it focuses on understanding and improving chemistry learning by studying variables relating to chemistry content or to what the teacher or student does in a learning environment (Herron & Nurrenburn, 1999). It involves "a complex interplay between the more global perspective of the social sciences (i.e., the process of learning) and the analytical perspective of the physical sciences (i.e., the content). As such, it has to be conducted by chemists alone or in collaboration with psychologists and/or educationists. According to Moore (1997), "our ability to carry out experiments in chemical education is far less developed than our ability to carry out experiments in chemistry, but that ought not be an argument against chemical education research - just the opposite".

Scholarship (research) in chemistry education has been the subject of reports by leading chemistry organisations. The *Task Force on Chemical Education Research* (1994) of the American Chemical Society has defined the elements of scholarship in chemistry education. The following areas of scholarship were considered: scholarship of teaching (that is, excellence in teaching); scholarship of discovery; scholarship of application. Characteristics of research are that it: is theory based; is data based; produces generalisable results. According to Johnstone (1997), "research papers are copiously referenced to theories, held beliefs, hypotheses, and objective measurement and seek to build on and extend what has been done before". Of central importance is the support of research with suitable theory or theories, … otherwise it would not be different from journalism (Caliendo & Keele 1996; Tsaparlis, 2001). The *Division of Chemical Education* of FECS has also worked out a position paper on empirical research into chemical education (de Jong *et al.*, 1999).

J.J. Lagowski, the former editor of the *Journal of Chemical Education*, has reviewed the past, and considered the present and future of chemical education (Lagowski, 1998): 'the 21st century will supply many challenges for chemical education". Chemistry education researchers are "challenged to incorporate the best aspects of quantitative and qualitative methods into carefully planned research projects" (Herron & Nurrenburn, 1999). Further, an increased knowledge of new information technology will be required, while "as the population becomes more heterogeneous and researchers learn more about how students of diverse backgrounds, learning styles, and ability acquire knowledge, the way chemistry content is structured will become increasingly important" (Gabel, 1999). Finally, Johnstone (2000a, b) argues that research has provided us with the tools "to harmonise a logical approach to our subject with a psychological approach to the teaching of our subject so that young people will catch our enthusiasm and enjoy the intellectual stimulus which our subject can, and should, offer."

Publishing education research results in established peer-reviewed international journals (in English) is a very hard job. Both journal editors and reviewers are very demanding, having set high standards for both research methodologies and form of presentation. This is a necessity for a young research field which needs its academic reputation to be enhanced, if it is not to be accused of being easy research (Johnstone, private communication). On the other hand, there is skepticism about the long review processes, with one or more revisions, so that papers take more than one year and up to two years to appear in print; this should be compared with chemistry journals for which the turn-around time between submission and acceptance (and often publication) is often three to five months.

If there is a kind of educational research which is easy, it is poor (vague, ill-focused) research. This is mainly the case with secondary-school teachers, and occasionally with university teachers, who design and conduct on their own amateurish educational studies. Such research cannot be accepted of course by quality journals, but it finds its way of publication in national and international conference proceedings and/or in not peer-reviewed national magazines and journals. The authors of such papers get the credit they require for job tenure or promotion and for making their names. At the same time, they contribute to the accusation of chemistry education as inferior research. Has it ever crossed the mind of such 'researchers' to do on their own (e.g. in their school) research in organic chemistry? To do acceptable educational research, one needs almost the same means as for doing research in science: ideas, a good library, an experienced supervisor, hard work, and in certain cases (not expensive) equipment. Otherwise, the results are already tried ideas, lack of knowledge of the relevant literature, poor methodology, and poor bibliography (often restricted to self-references). As one distinguished reviewer of CERAPIE commented criticising a particular manuscript, *'We want to encourage people to get interested in chemistry education research, but they must learn the methodologies of the discipline.'*

Chemistry education research, like research in many other domains (including chemistry), should be "viewed and accepted as a self-standing activity whose primary function is that of analysis, diagnosis and knowledge generation, regardless of whether such knowledge is of immediate usefulness and applicability" (Kempa, 2001). On the other hand, science education research (including chemistry education research) has or should have as one of its major goals, the improvement of science/chemistry education. According to Hurd de Hart (1991): *There is little reason to do research in science education unless there is a pay-off in the classroom.* Kempa (1992) expressed a similar view: "*Chemical education research should (seek to generate) insights and information on the basis of which informed decisions can be taken about major aspects of the teaching of chemistry. Chemistry education research should have then an impact on the practice of chemistry education.*"

2. The Practice of Chemistry Education

Learning chemistry is a demanding task. Its abstract nature (structural concepts, symbolic language, quantitative/mathematical character) not only causes difficulties to many students, but also contributes to making it an unpopular subject. Despite the enthusiasm of chemical educators, as well as several big projects (Chem. Study and ChemBond in the U.S., Nuffield and Salters in England, and Alternative Chemistry in Scotland), chemistry continues to be problematic (Johnstone, 2000a).

Dedicated teachers, both in schools and universities, abound in every country. This is seen in their massive attendance at national teachers' conferences (e.g. those by ASE in UK or by the American Chemical Society in the U.S.), as well as in the publication of teachers' ideas and thoughts about improving chemistry teaching (e.g. in the *Journal of Chemical Education, Education in Chemistry, School Science Review,* and numerous national magazines such as *La Chimica nella Scuolla* in Italy).

Teachers' ideas and experiences can be very useful to other teachers, and as such they are worth being publicised. They are of course open to criticism in terms of subjectivity: they "are full of assertions, homespun wisdom, and ingenuity, and lack measurement" (Johnstone, 1997). What is worse however is that, as a rule, the authors of such papers (as well as the authors of textbooks) are not aware of the findings of chemistry education research - they are even hostile to chemistry education research. According to Kempa (2001), "*despite the enormous growth of science education research during recent decades, its impact on the practice of science education has remained relatively low.*" This observation is also supported by Gabel (1999), who noted that "*the changes that have occurred in textbooks during the past four decades have not been driven to any great extent by research findings*". Kempa goes on to cite a number of reasons for this lack of impact. Most of them are esoteric to the research 'business' (for instance, the conduct of studies focusing on 'diagnostic' aspects, for example, of learning and learning behaviour, rather that on genuine 'application studies'). But what is more relevant here is the ignorance on the part of practitioners of *"the findings from science education research and/or their willingness to take cognisance of them in the design and organization of their teaching strategies and procedures. In making decisions about professional practices in the classroom, they tend to rely largely on the 'personal knowledge' derived from their practice of science teaching or on what they regard as self-evident ('common sense' knowledge) (Costa et al. 2000a, 2000b]). If the impact of science education research on the practice of chemistry education is to be increased, the various factors responsible for the current low level of research utilization need to be addressed. The key to achieving the foregoing is to bring researcher and practitioner closer together and, wherever possible, remove the traditional divide between the two." (see also, De Jong, 2000).*

3. The International and National Character of Chemistry Education Research

Educational studies of course are, as a rule, conducted within a local context. They may be influenced by a number of restrictions, so their results are not generalisable. Notwithstanding the necessity and usefulness of contextually bound studies, to be truly a

scientific discipline, chemistry education research must have a global character and impact, and as such be published in international journals (in English). To what extent is this however a reality?

3a. The Journals

Science education (including chemistry education) has exhibited a large growth during the past twenty years. Research journals are often international and written in English. It is noteworthy that national journals also publish research studies which may have a global character, but their authors neglect to publish them in international journals. For a more thorough study and comparison of national and international science and physics (but not chemistry) education journals see the survey by Viglietta (1996).

What is of particular importance is that even the most prestigious international journals (especially the American ones - see below) are of a narrow national (i.e. American) character. They have an international audience, although the majority of their authors (American) are aware only or mainly of American publications. According to Jimenez Aleixandre (1995), *"when reading articles published in the prominent American journals, and comparing them to articles published in Europe or Australia, one gets the impression - through comparison of the articles' bibliography - that there is a significant qualitative difference between them: Articles published in European and Australian journals include references from a variety of origins, while a significant number of articles published in American journals seem to cite a proportionally high number of references from North American journals and even from themselves"*

The author has conducted a limited survey to demonstrate this point. Table 1 reproduces the main findings. The proportion of the North American references is high, including the UK-Based IJSE. On the other hand, the number of non-North American references in both the American journals is low.

TABLE 1. Results of survey of one issue (July 1994) of three leading science education journals (Jimenez Aleixandre, 1995).

JOURNAL	No. of articles in Issue	References to same journal	References to other N. Amer. journals	References to other Non N. Amer. journals
Sci. Educ. 78(4)	4	11	15	9
JRST 31(4)	6	32	24	3
IJSE 16(3)	9	13	25	18

Practical or Laboratory Work in Chemistry

To reinforce the above assertion, I will do a similar survey with chemistry education research. I have chosen to survey the subject of practical or laboratory work in chemistry.

There are significant problems associated with experiments and practical work. As early as 1982 it was concluded that laboratory instruction is not effective in enhancing conceptual understanding (Hofstein & Lunetta, 1982). Johnstone (1991) has pointed out one reason why students find chemistry difficult is that in the laboratory they make observations at the macroscopic level, while they are expected to interpret the observations at (sub)microscopic level. Johnstone and Al-Shuaili (2001) have reviewed the relevant literature and discussed the problems. Note that the findings are in contrast to the fact that many students when asked declare the laboratory activities that they like best about school chemistry (70% of the students in the study by Gabel, 1993).

For the purpose of this presentation, I have chosen to survey the publications on laboratory work in chemistry (including demonstrations) during the last five years of two leading chemistry education journals, one American (*The Journal of Chemical Education*) and one British (*University Chemistry Education*). Tables 2 and 3 contain the results of this survey, together with the nationality of the authors, the number of references, and the distinction of references into American and British. It is obvious that while most non-American (in our case British) authors cite to some extent (an average of 26.3% in the data of Table 3, excluding papers # 5 and 7, versus 65.3% to British papers) American sources, the American authors cite as a rule only American sources (an average of 92.6% in the data of Table 2, versus 4.1% to British papers). It is true of course that American scholars dominate the field of science education research, but that should not be an excuse for them to ignore work which is being carried out and published outside America.

TABLE 2. Publications on practical work since 1997 in the *Journal of Chemistry Education*.*, **

	Title	Year	# Ref.	# U.S. Ref.	# UK Ref.
1	The nature and state of general chemistry laboratory courses offered by colleges and universities in the United States	1997	5	5 (100%)	0 (0%)
2	The organic lab: A status quo report and a two-semesters-in-one approach	1997	28	28 (100.0%)	0 (0.0%)
3	Is laboratory-based instruction in beginning college-level chemistry worth the effort and expense?	1998	11	11 (100.0%)	0 (0.0%)
4	Problem-solving teaching in the chemistry laboratory: Leaving the cooks ...	1998	17	11 (64.7%)	1 (5.9%)
5	Constructivism: The implications for laboratory work	1999	42	35 (83.3%)	6 (14.3%)
6	A content analysis of general chemistry laboratory manuals for evidence of higher-order cognitive skills	1999	22	20 (90.9%)	2 (9.1%)
7	A review of laboratory instruction styles.	1999	68	60 (88.2%)	4 (5.9%)
8	Problem-based learning in undergraduate education	1999	21	21 (100.0%)	0 (0.0%)
9	Effects of context-based laboratory experiments on attitudes of analytical chemistry students	1999	22	20 (90.9%)	1 (4.5%)
10	Using demonstration assessments to improve learning	2000	16	16 (100.0%)	0 (0.0%)
11	Using the science writing heuristic to move toward an inquiry-based laboratory curriculum: An example from physical equilibrium	2001	35	30 (85.7%)	5 (14.3%)
12	Deaf students, teachers, and interpreters in the chemistry lab	2002	18	18 (100.0%)	0 (0.0%)
13	The influence of collaborative learning on student attitudes and performance in an introductory chemistry laboratory.	2002	11	11 (100.0%)	0 (0.0%)

*Except paper # 4 (of which the author is Canadian), in all other papers the authors are from the U.S.

** Because of uncertainty with respect to the nationality of certain literature sources, the data on the last two columns of this and the following table may contain some (small) error.

TABLE 3. Publications on practical work since 1997 in the journal *University Chemistry Education*.* **

	Title	Year	# Ref.	# U.S. Ref.	# UK Ref.
1	Virtual investigations: Ways to accelerate experience	1997	23	5 (21.7%)	10 (43.5%)
2	Skills development and practical work in chemistry	1998	13	1 (7.7%)	10 (76.9%)
3	Changing the nature of physical chemistry practical work	1999	12	2 (16.7%)	9 (75.0%)
4	Introducing first-year students to some skills of investigatory laboratory work	2000	8	1 (12.5%)	7 (87.5%)
5	Preparing for the chemistry laboratory: An Internet presentation and assessment tool	2000	15	6 (40.0%)	7 (46.7%)
6	Experience with a random questionnaire generator in the chemistry laboratory and for other continuous assessment	2001	9	0 (0%)	9 (100.0%)
7	Why lecture demonstrations are 'exocharmic' for both students and their instructors	2001	17	16 (94.1%)	1 (5.9%)
8	Learning in the laboratory: Some thoughts from the literature	2001	44	8 (18.2%)	33 (75.0%)
9	On the use of chemical demonstrations in lectures	2002	7	6[&] (85.7%)	1 (14.3%)
10	Promoting active learning through small group laboratory classes	2002	44	21 (47.7%)	22 (50.0%)

* From the first issue of this journal. References to Internet cites are not counted.
** Except papers # 5 and 7, of which the authors are from the U.S., in all other cases the authors are British.
[&] Including one Canadian reference.

3b. The ECRICE Conferences

The European Conference on Research in Chemical Education (ECRICE) is a biennial Conference that was launched in 1992 in Montpellier, France, by the Division of Chemical Education of the Federation of European Chemical Societies (FECS) in collaboration with the Chemical Society of the host country. The subsequent ECRICE Conferences were held in Pisa Italy (1993), Lublin and Kazimierz, Poland (1995), York, UK (1997), Ioannina, Greece (1999), and Aveiro, Portugal, 2001. Although these Conferences are dedicated to Research in Chemical Education, a considerable number (balanced in the first five Conferences) of contributions deal with the practice of Chemistry Education, that is with *Journal of Chemical Education* type of work. Note that 6th ECRICE was combined with 2nd ECCE, and this explains the considerably higher proportion of non-research papers.

Table 4 provides data about the papers, the languages, the distinction of papers into research and practice, and the number and the nationalities of the authors. The number of papers remained almost constant in the first four
Conferences, while a considerable increase occurred in the 5th and the 6th ECRICE. With respect to the language, French and Italian dominated in the first two Conferences (with English being the language of the rest of the papers); from 3rd ECRICE on, English has

become the almost exclusive language. It is remarkable that while French was accepted in the 5th and the 6th ECRICE, with the hope to draw more French speaking participants, the number of presentations in French was very limited. Finally, with respect to the nationality of authors, it appears that the host country has as a rule a large share, a reasonable fact. Table 5 gives data about the distribution of papers according to country of origin in the six ECRICE Conferences.

TABLE 4. Data for papers and authors of the six ECRICE Conferences.

ECRICE	Place	No. of papers*	Language	R	P	No. of authors**	Nationality of authors
1st	Montpellier, France	66	43 Fr 23 E	37	29	121	51 French 70 Foreign
2nd	Pisa, Italy	70	21 E 49 I	34	36	118	70 Italian 48 Foreign
3rd	Lublin, Poland	64	E	30	34	117	17 Polish 100 Foreign
4th	York, UK	62	E	30	32	107	14 British 93 Foreign
5th	Ioannina, Greece	90	87 E 3 Fr	48	42	135	40 Greek 95 Foreign
6th	Aveiro, Portugal	88	87 E 1 Fr	33	55	185	56 Portuguese 129 Foreign

* Excluding plenaries and workshops

** Including plenary speakers and workshop organisers.

TABLE 5. Distribution of papers according to country in the six ECRICE Conferences.

ECRICE	1st	2nd	3rd	4th	5th	6th
France	25	9	0	1	6	2
Italy	9	32	8	7	6	3
Poland	3	2	12	0	0	7
UK	1	3	7	12	15	17
Greece	1	11	12	5	28	5
Portugal	0	1	0	0	2	18
Germany	4	3	2	7	3	1
Spain	5	2	4	2	3	3
Slovenia	0	2	6	7	3	7

4. The Language Barrier

One major reason for the unsatisfactory international character of chemistry education research and practice is the need to communicate through journals and conferences in English. Unfortunately, many European chemistry educators experience difficulty in written English. Of course, many can communicate in English. But when it comes to writing in English, it becomes a formidable task. As one author of a paper submitted to CERAPIE wrote to me, *"You see, the English language is so easy to speak, but difficult to write"*. A distinguished chemistry education researcher, with publications in international journals in English, wrote to me: *"As a non-native English speaker I cannot publish very much in international journals"*.

As editor of CERAPIE, I check the language of manuscripts written by non-native English speakers, and I usually take care that at least one reviewer is a native English speaker. CERAPIE of course does not demand a perfect use of English in the initially submitted manuscripts. But one expects manuscripts to be comprehensible, while reviewers are asked to make language corrections. It is heartening that most reviewers are quite helpful in this matter. Often however the language problems are quite serious. Example: the term 'natural sizes' was used to mean 'physical quantities'. In such cases, it may be impossible for the editor and the reviewers to follow and correct the English. A British reviewer commented for a particular manuscript: *"Unless I am missing something deeper (and I did have difficulty with the English in a number of places) this does not seem a very profound finding";* also *"there are many places where the English needs correcting. Most of these do not prevent meaning being conveyed, but the paragraph at the top of page 8 made no sense to me."*

5. Conclusions - Recommendations

Returning to the question raised in the title of this presentation, it is apparent that there is a necessity for a globalisation in chemistry education research, if it is to be regarded as a true scientific endeavour. Globalisation in the practice of chemistry education is also a must. The present state of affairs does not support that this necessity is a reality. The relatively young age of the field contributes to an instability in terms of research methodologies, and this, coupled with the widely held view that research in education is easy research, contributes to the production of many low-quality research results. Add to this the language barrier, to explain the failure of the realisation of a global character. What then should be done, if we want to turn our aim into reality?

Referring to science education in general, Viglietta (1996) accepts the necessity of journals and magazines written in the language of the country, especially for teachers, and recommends the need to bring closer together research and practice, researchers and practitioners. On the other hand, in order to bridge the gap between the various journal categories (domestic/international, teachers'/ researchers'), the building up of a widely comprehensive citation index for the subject category of science education journals is recommended.

During an international meeting entitled '*Science Education Journals'*, promoted by the Italian Association for Teaching Physics, and held in Gaeta, Italy, in 1993, many participants stressed the need to make non-English published research papers better known in English-speaking countries, as another way for improving the dissemination of the research findings. Motivated by the above fact, Rinaldo Cervellati, then editor of '*La Chimica nella Scuola*' (the bimonthly chemical education magazine of the Italian Chemical Society), suggested during the 2nd ECRICE (Cervellati, 1993), that FECS should undertake an effort to launch a European Journal of Chemical Education. According to the author, the structure of such a journal should include: (a) a 'core' containing articles of general interest and/or research reviews in English, with abstracts in French/Italian/Spanish/ German; (b) a section typical of each European country with articles written in the language of the country with abstracts in English. For example, the Italian edition of such a journal would be composed of (a) the international core, and (b) the usual contents of '*La Chimica nella Scuola*'.

Apparently, the need for such a publication derives from the English language barrier. One wonders however whether such a publication would be more than simply adding together an international journal and a national magazine. The inclusion of multi-language abstracts is a complicated process, which does not solve the language problem, since there would be many unrepresented European languages.

Following the 5th ECRICE, of which I was the organiser, motivated by a comment by Professor Richard Kempa (that the publication of Conference Proceedings is of limited value and use), and encouraged by Dr. Michael Gagan, I launched an electronic journal, entitled *Chemistry Education: Research and Practice in Europe* (CERAPIE). It is available free-of-charge at the Internet [http://www.uoi.gr/conf_sem/cerapie]. In undertaking this publication, the following targets have been set (Tsaparlis, 2000a): (1) To provide to both researchers and practitioners of chemistry education in Europe an additional means to publish their work, taking into account that … there is a need for an exclusive means for the publication of science education research in the special domain of chemistry. (2) To secure a high quality of the published work, by submitting it to peer reviewing by professional science education researchers and/or chemical educators. (3) To speed up considerably the review and publication process. (4) To make CERAPIE as widely read as possible, by distributing it free through the Internet.

Concerning the editorial policy of CERAPIE, I was guided by the January 2000 Editorial of *Science Education* (Duschl, 2000): "... A balance needs to be struck between, on the one hand, maintaining standards, and, on the other hand, providing individuals opportunities to be part of the community and to participate in the review process." Eventually, "what is published is the product of the review process … Reviewers have reviewed manuscripts in a professional and efficient way (Tsaparlis, 2000).

'Europe' features in the title of CERAPIE to emphasise the links of the journal with the ECRICE conferences. However, the European authors and readers of CERAPIE extend now far beyond the ECRICEs. In addition, CERAPIE has become an international journal with authors and readers from all over the world. For this reason, from Volume 4 (with Issue 1 scheduled to appear in February 2003), the journal is planning to drop Europe from its title. The new name will be: '*Chemistry Education: Research And Practice'* (CERP). It is clear that CERP will continue to serve European chemistry education in the same way as CERAPIE did. On the other hand, the new title is expected to make authors from further afield feel equally welcome.

It would be a mistake in this presentation if specific mention was not made of another important development in electronic publications on chemistry education in Europe: *'University Chemistry Education'* (UChemEd) is published by the Royal Society of Chemistry (RSC), and covers the teaching of chemistry in higher education. From Volume 5, UChemEd is an electronic only journal, and is accessible free of charge online, providing full text articles in both HTML and PDF: [http://www.rsc.org/uchemed/uchemed.htm]

Last but not least, it would be a great advancement if a new *major* international, Europe-centred journal was launched. Such a journal would place the emphasis on publishing research papers about chemistry education at all levels. It could also contain a section with papers on the practice of chemistry education. This section would include largely or solely papers reprinted (translated if needed) from practitioner's periodicals from around Europe. Such a journal needs to: (a) have a European flavour; (b) be international - to attract research from around the world; (b) be refereed by an international body of recognised scholars. It appears that many people in Europe are willing to work toward this end. An end that is hoped to bring a global (and inevitably a Pan-European) character to chemistry education research and practice.

Papers surveyed from *The Journal of Chemistry Education* (Table 2):

1. Abraham, M.R., Craolice, M.S., Graves, A.P., Aldhamash, A.H., Kihega, J.G., Gil, J.G.P., & Vavghese, V.: **1997**, *74*, 591-594.
2. Moody, A.E. & Foster, K.A.: **1997**, *74*, 587-591.
3. Hilosky, A., Sutman, F., & Schmuckler, J.: **1998**, *75*, 100-104.
4. Gullet, C.: **1998**, *75*, 72-77.
5. Shilandd, T.W.: **1999**, *76*, 107-109.
6. Domin, D.S.: **1999**, *76*, 109-112.
7. Domin, D.S.: **1999**, *76*, 543-547.
8. Ram, P.A.: **1999**, *76*, 1122-1126.
9. Henderleiter, J. & Pringle, D.L.: **1999**, *76*, 100-106.
10. Deese, W.C., Ramsey, L.L., Walczyk, J., & Eddy, D.: **2000**, *77*, 1511-1516.
11. Rudd, J.A. II, Greenbowe, T.J., Hand, B.M., & Legg, M.J.: **2001**, *78*, 1680-686.
12. Seal, B.C., Wynne, D., & MacDonaldd, G.: **2002**, *79*, 239-243.
13. Shitbley, Jr. I.A. & Zimmaro, D.M.: **2002**, *79*, 745-748.

Papers surveyed from *University Chemistry Education* (Table 3):

1. Garrat, J.: **1997**, *1*, 19-27.
2. Bennett, S.W. & O'Neale, K.O. **1998**: *2*, 58-62.
3. Brattan, D., Mason, D., & Rest, A.J. **1999**: *3*, 59-63.
4. Hunter, C., Wardell, S., & Wilkins, H.: **2000**, *4*, 14-17.
5. McKelvy, G.M.: **2000**, *4*, 46-49.
6. Masson, M.R.: **2001**, *5*, 9-15.
7. Bodner, G.M.: **2001**, *5*, 31-35.
8. Johnstone, A.H. & Al-Shuaili, A.: **2001**,*5* 42-51.
9. Walton, P.H.: **2002**, *6*, 22-27.
10. Byers, W.: **2002**, *6*, 28-34.

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Costa, N., Marques, L., & Kempa, R.F. (2000b). Science teachers' awareness of findings from educational research. *Chemistry Education: Research and Practice in Europe, 1*, 31-36.

Duschl, R.A. (2000). Building community while raising standards (editorial). *Science Education, 84*, 1-4.

de Jong, O. (2000). Crossing the borders: Chemical education research and teaching practice. *University Chemistry Education, 4*, 31-34.

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