CHEMISTRY EDUCATION: RESEARCH AND PRACTICE IN EUROPE
2000, Vol. 1, No. 1, pp. 31-36

RESEARCH COMMUNICATION (INVITED CONTRIBUTION)
General issues in science education

Nilza COSTA, [1] **Luis MARQUES** [1] **and Richard KEMPA** [2]
[1] *University of Aveiro, Department of Didactics and Educational Technology*
[2] *Keele University, Department of Education*

SCIENCE TEACHERS' AWARENESS OF FINDINGS FROM EDUCATION RESEARCH

Received: 22 November 1999

ABSTRACT: In this paper, we report on a small-scale study designed to estimate science teachers' awareness of findings derived from research in science education and other branches of educational research. The study was conducted among experienced science teachers in Portugal who were following advanced professional training programmes, usually leading to Masters' degrees in science education. The results indicate that science teachers' knowledge of education research findings is generally very limited. What teachers regard as sound pedagogical knowledge is usually derived from personal experience and 'common sense' and does tend not to be questioned by them as to its compatibility with the results of research. The outcome of the study provides evidence of the existence of a serious gap between research and the practice of science education. In the light of these findings, the authors propose that to narrow this gap should be a major task to be addressed by researchers and practitioners. [*Chem. Educ. Res. Pract. Eur.*: 2000, *1*, 31-36]

KEY WORDS: *research utilisation; theory and practice of science teaching; teachers' pedagogical knowledge*

INTRODUCTION

The issue of research utilisation by science (and other) teachers has repeatedly been raised in the literature for same years now. The background to this is that science education research has been a major activity for more than 30 years now, often for the purpose of generating a data and information base upon which the practitioners of science education can draw in order to make science teaching and science learning more effective. Yet, the extent to which the findings from science education research have found application in actual science teaching has, by and large, been rather limited.

It may be argued that an important precondition for the application of research findings in the practice of science education is that teachers, as practitioners, have an adequate awareness and appreciation of such findings. This paper describes the results of a small-scale study that was undertaken in order to establish the extent to which practising science teachers are knowledgeable of some results from science education research.

EXPERIMENTAL

The study involved a total of 42 practising science teachers with between 2 and 12 years' experience of school teaching. All had recently enrolled on a two-year university programme leading to Master's degrees in science education at two Portuguese universities (Aveiro and Évora).

In the course of an early session during their course, students were given a questionnaire containing 12 items of commonly held pedagogical 'wisdom' (though disputable on the grounds of reported research findings) and asked whether or not they endorsed these statements (a neutral 'I am uncertain response' was also allowed).

The 12 statements are given in Table 1 in the 'results and discussion' section. It should be noted that two of the statements are outside the province of science education research *per se*, since they represent either an *a priori* value judgement about school science education (Statement 2) or a position that derives from the history of science, rather than from science education (Statement 11).

Following the completion of their ratings of the statements themselves, the teachers were asked to indicate the basis on which they had provided their answers to the statements. (Statements about which 'uncertainty' had been expressed were excluded from this part of the enquiry.) To help respondents with this, the following five response categories were suggested, but teachers were invited to supplement these with their own comments.

A. The content of the statement reflects 'common sense' (or - in case of disagreement - is contrary to common sense).
B. The view expressed by me about the statement is based on my personal experience.
C. The content of the statement is in line (or - in case of disagreement - is in conflict) with the ideas presented to me by my tutor(s) and/or mentor.
D. The statement is in keeping (or - in case of disagreement - is in conflict) with what I have read in books or relevant literature.
E. I am aware of studies or investigations which support (or negate) the validity of the statement.

RESULTS AND DISCUSSION

The results of the teachers' ratings of the validity of the twelve statements in the questionnaire are listed in Table 1. The figures are given to the nearest 2.5 per cent, for ease of presentation.

It is seen from the data that five of the statements found endorsement by a large majority of teachers (in excess of 85%). They were Statements 1, 2, 6 and 8. The remaining statements gave rise to considerable divergence of views. In these cases, 'I am uncertain' responses accounted for a significant proportion of the answers received, varying between 35 and 55 per cent of all answers. Three of the statements also attracted 'disagreement' responses from a relatively high proportion of the teachers (45 per cent or more). These were Statements 5, 9 and 10.

It may be argued that the statements which are overwhelmingly endorsed by the teachers (Nos. 1, 2, 6, 8 and 12) express 'truisms' about aspects of science education that are widely held throughout the teaching profession. They reflect positions that are frequently transmitted through teacher education programmes; also, tend to come within the purview of

TABLE 1. *Science teachers' ratings of the validity of statements expressing pedagogical 'wisdom'.*

Statement		Agree	Uncertain	Disagree
1.	Laboratory work has a motivating effect on students.	92.5	5.0	2.5
2.	Practical work forms an integral part of any science education programme.	97.5	-	2.5
3.	Students have a general dislike of being tested and assessed.	50.0	37.5	12.5
4.	Learning by 'discovery' is more effective than expository teaching.	52.5	40.0	7.5
5.	Girls out-perform boys in tasks requiring verbal communication.	5.0	40.0	55.0
6.	Praise is an essential means of enhancing students' learning effort.	90.0	10.0	-
7.	When pupils work in groups, they usually learn from each other.	65.0	35.0	-
8.	The more motivated students are, the better they learn.	90.0	10.0	-
9.	Teacher demonstrations of scientific phenomena are just as effective as is pupil-based practical work.	7.5	42.5	50.0
10.	Science subjects are intrinsically more difficult than non-science subjects.	17.5	37.5	45.0
11.	The process of scientific discovery is based on the logic of the 'scientific method'.	15.0	55.0	30.0
12.	There is a strong link between class-size and teaching effectiveness.	85.0	12.5	2.5

teachers' personal experience. This is borne out by teachers' indications of the nature of the knowledge on which they based their judgements about the validity of these statements. These are given in Table 2. It is evident from the data relating to the foregoing statements that, in the main, this knowledge was claimed to have been derived either from personal experience or from what had been transmitted to them by mentors and tutors or from what was regarded as self-evident 'common sense' (Answer categories B, C and A in Table 1, respectively). Only for Item 2 did a significant proportion of the teachers refer to books or other literature as their source of information. When asked about this, these teachers pointed to official teaching and curriculum guides issued by their education authorities: these state categorically that practical work should be viewed as an essential and integral part of school science education.

It is not the purpose of this paper to review the extent to which the individual statements used in the questionnaire are supported by research-based evidence. Suffice it to say that this evidence is generally not strong, not even in cases where teachers appear to be largely convinced of the validity of a statement. For example, research results concerning the link between motivation and learning, as reported in the research literature, point to correlation coefficients of only moderate magnitude (r is usually in the region of 0.3), which suggests that other factors influence learning and effort as strongly as do motivational aspects. Similarly, the evidence that praise is a stimulus to enhance learning and learning effort is only moderate (Fraser *et al*. 1987). Indeed, as a study by Munn, Johnstone, M., and Holligan

TABLE 2. *Knowledge types used by teachers for assessing the validity of statements presented.*

Statement		*Percentage of teachers choosing*				
		A	*B*	*C*	*D*	*E*
1.	Laboratory work has a motivating effect on students.	2.5	90.0	-	5.0	2.5
2.	Practical work forms an integral part of any science education programme.	17.5	25.0	17.5	40.0	-
3.	Students have a general dislike of being tested and assessed.	25.0	70.0	-	5.0	-
4.	Learning by 'discovery' is more effective than expository teaching.	-	40.0	15.0	25.0	20.0
5.	Girls out-perform boys in tasks requiring verbal communication.	25.0	62.5	-	7.5	5.0
6.	Praise is an essential means of enhancing students' learning effort.	20.0	45.0	10.0	15.0	5.0
7.	When pupils work in groups, they usually learn from each other.	2.5	62.5	7.5	10.0	17.5
8.	The more motivated students are, the better they learn.	10.0	50.0	10.0	27.5	2.5
9.	Teacher demonstrations of scientific phenomena are just as effective as is pupil-based practical work.	-	57.5	17.5	17.5	7.5
10.	Science subjects are intrinsically more difficult than non-science subjects	35.0	25.0	25.0	7.5	5.0
11.	The process of scientific discovery is based on the logic of the 'scientific method'.	-	15.0	25.0	30.0	30.0
12.	There is a strong link between class-size and teaching effectiveness.	10.0	75.0	5.0	5.0	5.0
MEAN		13.4	51.9	11.5	13.9	9.3

(1990) demonstrated, pupils themselves rate praise and encouragement rather lowly among the methods whereby teachers get classes to work well.

As already indicated above, for more than half of the statements teachers were divided in their opinion of the statements' validity. The 'uncertain' responses may be interpreted in two ways: either that the teachers' experience or knowledge had not provided them with any clear evidence in the one or other direction, or that their knowledge or experience did not extend to these aspects B in which case the 'uncertain' response would have been the appropriate one to choose. Without additional information, which was not sought in this enquiry, it is not possible to distinguish between these alternatives.

In cases where teachers who gave a clear 'agree' or 'disagree' response to particular statements, they were probably convinced that their verdict was 'correct'. However, in view of the divergence of opinion, it is self-evident that they cannot all be right at the same time. It is thus of interest to examine more closely the nature of the knowledge upon which teachers based their judgements. The relevant information is given in Table 2. In this, A to E correspond to the response categories given above. The response profiles for the different statements indicate that there are some variations in the type of knowledge base on which teachers relied for their judgements. However, the mean values for the various response categories clearly point to teachers' 'personal experience' as the most important basis of their judgements: it applied to over 50 % of all definite judgements that were made. 'Common sense' formed the basis of about 13 % of the ratings, but it is noteworthy that for four of the statements (Nos. 3, 5, 6 and 10) twenty or more per cent of the teachers had relied on it for their judgements.

Information derived from mentors and/or (senior) colleagues and from books or professional literature is on a par with 'common sense' as a basis of teachers' judgements, in terms of the frequency to which teachers referred to it. Each accounted for about 12 to 13 per cent of the judgements made and is clearly less important than teachers' personal knowledge.

The final response category concerned teachers' awareness of educational research findings as a basis for their judgements. Table 2 shows that this kind of knowledge was referred to in just over nine per cent of the judgements made, but this figure is inflated as the result of the relatively high ratings for three of the statements, viz., 4, 7 and 11.

A review of the research literature shows that neither Statement 4 nor Statement 7 is supported by clear research evidence. For example, Hermann's classical evaluation of researches about discovery learning, published in 1969, already drew attention to the fact that the case for discovery learning is far from established, with almost equal numbers of studies claiming a superiority of discovery learning and expository teaching, respectively. In the case of the assertion in Statement 7, the observation can be made that our current research-based knowledge of learning interactions and transactions in working groups in science education is still too limited for unambiguous conclusions to be drawn. Likewise, for Statement 11 the research evidence (derived from the history of science) is controversial, despite the fact that the pursuit of the 'scientific method' is strongly advocated in contemporary science teaching programmes.

It is quite possible, of course, that those teachers who claimed to have based their judgements on research findings were, in fact, aware of the outcomes of particular studies and used that knowledge for their answers. In such a case, the high rate of E responses would not come as a surprise. However, the observation has then to be made that reliance on one particular piece of research with one particular outcome can lead to highly biased knowledge and certainly does not result in a balanced picture about an issue.

The predominance of personal experience as the basis of science teachers' professional knowledge found in the present study is also referred to in a recent paper on 'Developing Science Teachers' Pedagogical Content Knowledge' by van Driel, Verloop, & de Vos (1998). On the basis of a detailed review of the literature, they concluded that "science teachers' knowledge and beliefs are explicitly related to teachers' classroom practice". Using a constructivist argument, they suggest that teachers' existing (practice- and beliefs-related) conceptions about the teaching and learning of science may prove to constitute a barrier to the innovation of science teaching, in view of the fact that these conceptions are relatively stable to change attempts.

CONCLUSION

It must be a matter of considerable regret for all concerned with science education that teachers' knowledge and awareness of the findings of science education research is still very limited, despite the fact that science education research has been a thriving activity for more than 30 years now. In our view, the present data confirm that the gap between science education research and the practice of science education remains very wide.

Our concern is to identify and implement ways in which science education research and the practice of science education can be brought closer together. Some of the strategies we are intending to pursue are based on the following recommendations.

1. I n the choice of their research problems, researchers should increasingly focus on practice-related problems to ensure that research assumes a higher degree of relevance to issues of science teaching and learning than is frequently the case.
2. Involvement of practitioners in the identification and formulation of issues for research can be an effective way of ensuring 'practice-relatedness'. Hence, the integration of practising teachers into research teams is recommended.
3. In the reporting of research findings, more emphasis should be given to the elaboration of the implications of research findings for educational practice than is frequently the case. Indeed, it is desirable that, whenever possible, 'normal' type research studies should be extended to 'application' studies in order to ensure that any 'implications for practice' claimed for research findings are appropriately tested.
4. Teachers themselves need to become more aware of the value of the professional knowledge that can be derived from research findings. Guidance, however limited, to the nature of science education research, given in the context of initial and/or inservice teacher training courses may help in this respect, provided that it leads future teachers to recognise that science education research results may not always endorse views and opinions about teaching and learning already held.
5. Science education research findings have to be made more accessible to the practitioner than is currently the case. We believe that, in order to achieve this, we need to generate publications which communicate researches and research findings in a language that science teachers can understand. Current journals generally fail to do this: they are excellent channels for researchers to communicate with one another, but not with the potential 'users' of their findings.

NOTE: A fuller version of this paper is scheduled to appear in 2000 in *Research in Science & Technological Education*.

ADDRESS FOR CORRESPONDENCE: *Richard KEMPA, Department of Education, Keele University, Staffordshire ST5 5 BG, UK; fax: +44 1782 583555; e-mail: r.f.kempa@educ.keele.ac.uk*

REFERENCES

Fraser, B J, Walberg, H J, Welch, W. W., & Hattie, J F (1987) Synthesis of educational research productivity. *International Journal of Education Research*, *11*, 145-252.

Hermann, G. (1969) Learning by discovery: A critical review. *Journal of Experimental Education*, *38*, 59-72.

Munn, P., Johnstone, M., & Holligan, C. (1990) Pupils' perceptions of 'effective disciplinarians'. *British Educational Research Journal*, *16*, 191-198.

van Driel, J. H., Verloop, N., & de Vos, W (1998) Developing science teachers' pedagogical content knowledge. *Journal of Research in Science Teaching*, *35*, 673-95.