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journal or publication title	Scientific approaches to language
volume	2
page range	171-188
year	2003-03-25
URL	http://id.nii.ac.jp/1092/00000078/

Diversifying Instructional Contexts: An Evaluation of the *Science Across Europe* Programme¹

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Science Across Europe is an international science education programme with the aim of bringing a global dimension to science education. Its materials were developed to encourage secondary school pupils across Europe to work on everyday issues such as 'food' and 'domestic waste' and to exchange ideas and findings with pupils in other countries. The programme aims to promote the use of a foreign language both through working on the materials and through exchange with other schools. This paper presents some of the findings from an evaluation of the programme, undertaken by the University of Warwick, UK, by means of a questionnaire survey with approximately 60 teachers and 600 learners in 13 countries. The findings suggest that the programme has had a positive impact on learner motivation, with some evidence for enhanced learner achievement. The research also has some interesting implications for classroom activities related to foreign language learning in a cross-curricular context.

1. Introduction

Communicative language teaching is often narrowly interpreted as simply conducting activities such as role plays and information gap activities in the language classroom. However, the underlying principle of the communicative approach is to provide learners with genuine purposes and contexts for using the target language. As early as the late 1970s, Widdowson suggested that providing learners with authentic tasks was a key to the communicative approach, and that teaching other subjects in a foreign language could be one way of achieving this (Widdowson 1978).

¹ The programme is now called *Science across the World* as it has expanded beyond Europe, but

In that respect, programmes such as *Science Across Europe* (SAE) can be regarded as a way of promoting communicative language teaching.

The SAE programme was started back in 1990 by an international group of science teachers as a new way of teaching science; it is sponsored by British Petroleum and managed by the Association for Science Education.² The programme was designed to encourage secondary school learners in different countries in Europe to work on common projects relating to everyday issues such as ‘food’ and ‘domestic waste’. The materials mainly consist of worksheets which promote investigation into a topic and group discussions. They were also designed to encourage students in different countries to exchange their findings with each other, especially by e-mail, and possibly in a foreign language.

The declared aims of the SAE programme are to:

- bring an international dimension to education by enabling students in different countries to exchange knowledge and ideas about their varying perspectives and ways of life;
- raise awareness of the ways science and technology affect society, industry and the environment in different countries;
- provide opportunities for teachers and students to collaborate with their counterparts in other countries and to develop communication skills, especially in languages other than their own.

Recently the emphasis on foreign language (FL) learning has become more prominent in the programme. It is hoped that SAE will provide good opportunities to learn a foreign language as well as science. With the FL element emphasised, the SAE team suggests a variety of ways of using the SAE materials for FL teaching. They include:

- using SAE to extend an existing unit of work, solely within the Modern Languages department;
- using SAE as a vehicle to incorporate Information Technology

this paper uses its original name when the evaluation was conducted.

² For details contact Marianne Cutler, Association for Science Education, science@bp.com

- into Modern Languages learning across the whole department;
- a Modern Language Teacher working collaboratively with a science teacher within the school to jointly deliver a SAE unit of work;
- using SAE to add content and focus to an existing exchange with other schools;
- a whole-school event, based on an SAE unit;
- older learners working independently on a unit of work to extend their language skills;
- using SAE to enhance the content of an existing Modern Languages topic;
- encouraging collaboration between classes of different ages;
- using SAE for a focus at an after-school language club;
- moving towards delivering part of the science curriculum through the medium of the foreign language.

Of interest to language educators is the dual aim of SAE to promote the use of a foreign language both through working on the science-oriented materials and through the exchange of information with schools in other countries. The programme itself is premised on a number of assumptions from areas in applied linguistics such as: bilingual education or immersion; content-based language teaching; collaborative teaching; self-directed learning; and the use of information technology. The relevant literature is discussed in the following section.

2. Literature Review

2.1. The teaching of subjects through a foreign language

The main studies on bilingual education have been conducted within the framework of ‘immersion’ teaching in the USA and especially in Canada. Many immersion studies highlight the potential for success in teaching the school curriculum wholly or partly in a second language (e.g. Cummins and Swain 1986; also see Baker 1996; Genesee 1987; Johnson and Swain 1997). With regard to pedagogy, a key finding of these studies is that students are generally able to achieve good grades in subject-matter knowledge. However, it seems that fluency is sometimes gained at the

expense of formal accuracy.

Bilingual education is currently gaining ground in Europe as well, where students study one or more subjects partly or wholly through a foreign/second language. Studies suggest that this kind of teaching is taking place increasingly widely in continental Europe, mainly in secondary schools; that its proponents expect students, under given circumstances, to be able to improve their subject-matter knowledge; and that the approach can arouse considerable enthusiasm amongst teachers and students (see Baetens Beardsmore 1993; Marsh and Langé 1999; Masih 1999).

2.2. Content-based foreign language teaching

Content-based language teaching is a form of language teaching which imports subject contents. The literature on content-based FL teaching includes what FL teachers call ‘project-work’, which can involve longer investigations into subject topics, but within the framework of FL teaching (see Brown and Brown 1998; Fried-Booth 1986; Legutke and Thomas 1991). According to Fried-Booth (1986), the advantages of ‘project work’ are:

- it is student-centred;
- it promotes personal involvement;
- it encourages co-operation/collaboration among learners;
- it bridges the gap between the classroom and the outside world;
- it integrates the four language skills.

Fried-Booth further lists issues relevant to the current thinking in FL teaching: emphasis on authentic tasks; learner autonomy; and motivation. Fried-Booth emphasises the need for planning the learning of both subject matter and language use in this kind of work, as well as making a careful choice of the types of activity.

2.3. Collaborative teaching

Collaborative teaching is not very common in FL teaching in many parts of the world, but Nunan (1992) sets out some of the conditions which must be fulfilled if innovations in education – of which collaboration is one – are going to work. These include, for instance, that teachers need to possess

the skills which the innovation requires; that they are given time to implement the innovation and that appropriate administrative and managerial arrangements are developed in tandem with the innovation.

Collaboration between subject teachers and specialists in English as an additional/second language is common in the education of language minority users in mainstream classrooms in Western industrialised societies (e.g. the UK, USA, Australia). There is a fair amount of discussion of collaboration of this kind (e.g. Clegg 1996; Mohan 1986). The emphasis is mainly on issues such as those raised by Nunan, that is, on the planning and sharing of roles and on the managerial support on which teachers can rely.

2.4. Self-directed learning

It is now widely accepted that giving learners responsibility for their own learning promotes their learning, and makes it more effective. The literature is abundant in this area (e.g. Benson 2001; Ellis and Sinclair 1989; Hammond and Collins 1991; Nunan 1992; Pica and Doughty 1985; Wenden 1991). Among others, Pica and Doughty (1985) empirically investigated the effectiveness of group work for language learning as opposed to teacher-fronted lessons. While there was no difference in the level of grammaticality of the learners' output in the two situations, the amount of their output and input directed at them was greater in the group work. Completions and corrections were also found to be more common in the group interaction than in the teacher-fronted lesson. These findings suggest that learners will have more opportunities to talk and to be exposed to the language in use in group work, and that learners are capable of complementing and correcting each other when left to their own devices.

2.5. Information Communication Technology (ICT) and language development

Studies on the use of ICT are becoming more common in education in general (see DfEE 1997; Grey 1999; Mercer 1995; Thompson 1993) and FL teaching and learning in particular (see Chesters and Gardner 1987; Hewer 1997; Pennington 1989; Warschauer 1997). The Department for Education and Employment (DfEE) in Britain recently conducted nationwide research on the use of ICT, and the following is a list of advantages

emerging from its survey (1997: 7):

- improved subject learning;
- the development of network literacy;
- improved vocational training;
- improved motivation and attitudes to learning;
- development of independent learning and research skills;
- social development.

More recently, e-mail communication has been regarded as a particularly promising avenue for FL learning and for enhancing learners' motivation because it provides learners with opportunities to use a foreign language to communicate across national boundaries (see Liaw 1998).

3. Research

Premised on these assumptions, the SAE programme seems to offer significant benefits in FL teaching and learning. The programme has been increasingly popular since its launch and has now expanded beyond Europe. However, until recently the SAE team had not had its impact on FL learning formally evaluated and the University of Warwick was therefore invited to conduct the evaluation project.

3.1. Objectives

The evaluation investigated the perceptions of teachers and students. The following are the objectives of the evaluation:

- to evaluate the SAE materials (by way of teachers' and students' perceptions);
- to evaluate learner language development (by way of students' self-rating);
- to identify 'new directions' for SAE.

To investigate the above, the following variables were selected:

- teachers' and students' experience in SAE;
- gender;
- teaching approaches to SAE;
- comparison of the new users' perceptions and language ability

before and after using the SAE materials.

3.2. Planned research design

It was planned to have sufficient and comparable numbers of samples from each variable group (e.g. teachers experienced in SAE vs. teachers new to SAE). Then six countries were identified, and data were to be collected from approximately 40-50 schools from each country, at least 5 of which were new to SAE, and with a comparable ratio between FL and science teachers. However, as will be explained below the project did not work out entirely as had been planned.

3.3. Instruments

Questionnaires were the main instruments for data collection. Six versions of the questionnaires were prepared: four versions for teachers (new FL, experienced FL, new science, and experienced science teachers) and two versions for students (new and experienced). The questionnaires consisted of questions seeking general information about the respondents; their opinions about science and FL learning; self-assessment of their language skills; and their opinions about the SAE materials. For new users, similar questions were asked about the SAE materials and their language skills before and after using the materials. Case studies, including interviews and classroom observations, were planned, but eventually abandoned due to lack of funds.

3.4. Respondents

The data were collected from both teachers and their students. The questionnaires were sent out to 146 secondary school teachers in 21 countries, but only 65 teachers from 15 countries responded. Out of these, six responses were excluded from the analysis due to their inadequacy. The students in the classes of the 146 teachers were requested to answer the questionnaires, and 758 students from 14 countries responded, but 21.5% of the responses had to be excluded from the analysis due either to their inadequacy or to late arrival. In total, the responses of 59 teachers and 595 students were analysed.

The ages of the students ranged from 13 to 17, with the majority being 14-15. The majority of the respondents were from countries in Eastern

Europe and the Former Soviet Union (e.g. Georgia, Latvia). The vast majority (73% of the teachers and 95% of the students) were first-time users of SAE materials, and for just over half of those students, SAE lessons were run by FL teachers only.

It must be pointed out that this sampling was uneven and was not as had originally been planned. The balance between the categories was not comparable. However, sampling was unfortunately beyond our control. This is one of the difficulties of commissioned research (see 5.2 below).

3.5. Procedures

The evaluation project started in the spring of 1999, followed by the preparation of questionnaires. The main data collection was carried out in the autumn of 1999, and data analysis was conducted in the early part of 2000. Two interim reports were compiled and the final report was completed at the end of the year.

3.6. Analysis

Questionnaire results were analysed both quantitatively and qualitatively. Comments and responses to open-ended questions were analysed qualitatively. Responses to multiple-choice questions and rating were analysed with the SPSS/PC statistical package, producing descriptive statistics. *T*-tests were also conducted to compare the students' rating of their language ability before and after using the SAE materials and to compare boys' and girls' perceptions.

4. Main findings

Many interesting and wide-ranging issues emerged, but due to the limitation of space, only points of particular interest are shown here as examples (see Kobayashi et al. 2000 for more details).

4.1. Why teachers used *Science Across Europe*

FL and science teachers used SAE for a variety of reasons to do with pedagogy, culture and professional development. A large number of teachers hoped to improve their students' language skills. They valued the impact of exchange activities on cultural awareness, and hoped that the materials would enhance their learners' motivation for learning and awareness of the topical issues.

4.2. Approach to using *Science Across Europe*

SAE-experienced teachers collaborated more than teachers new to SAE. In most (77.8%) of SAE-experienced schools, science and FL teachers collaborated, whereas this happened in only 26.4% of schools new to SAE. This may suggest that collaboration is not straightforward, and takes time to establish. This seems to support Nunan (1992), who emphasises the importance of careful planning and preparation for successful collaboration. It is worth pointing out that experienced teachers seem to have established collaboration successfully, and it would be useful to investigate their practice in detail to understand what works best (see 4.6 below).

4.3. Impact on learning and motivation

Most interestingly, the SAE materials were perceived by almost all teachers to be useful for promoting FL learning and motivation for learning. Experienced teachers' perceptions were particularly encouraging because their opinion must be based on their long-term use and therefore should be more reliable.

Students' perceptions also supported this. More than 90% of the students who responded to the questionnaire were positive about SAE; students experienced with SAE were more positive than first-time users.

A large proportion of students (especially experienced users and those in schools where SAE was led by a FL teacher) liked learning a foreign language through SAE more than other FL lessons, and learning science through SAE more than other science lessons. The majority of new students (56.9%) and experienced students (74.1%) liked learning science through the SAE materials more than other science lessons. With regard to FL learning, 50% of new students and 63% of experienced students liked learning a foreign language through the SAE materials more than in other FL lessons. In both cases, experienced students were more positive than new students. This is a promising sign if we can treat their views as more credible, given that they had more experience with SAE.

Although SAE lessons seemed to be slightly more popular as science lessons than as FL lessons, students reported that their FL abilities improved after using SAE materials, according to their self-assessments. In all language areas students rated their language ability higher after using

the SAE than before, even though the improvement was small, and the differences were statistically significant in all but one area (i.e. spelling) (see Table 1). Of course, the measurement was based on their self-rating, and the findings only show they thought that they were more able than before: it is another matter whether their language ability really had improved. Nevertheless, we can at least say that the students felt more confident.

4.4. Classroom practice

In terms of classroom practice, the SAE programme seems to promote a wide range of classroom activities. A greater number of activities were regularly conducted in SAE lessons than in non-SAE lessons. In particular, the range of activities conducted in schools familiar with SAE is worth noting. All or nearly all experienced teachers reported that their lessons involved exchange activities, discussions, surveys, interviews with people,

Table 1: New students' self-rating of their language ability before and after using SAE materials

Language abilities	Before	After	df	T-value
Listening (N=541)	3.882	4.006	540	-4.98**
Speaking (N=542)	3.768	3.847	541	-3.04**
Reading (N=542)	4.135	4.203	541	-2.81**
Writing (N=540)	3.759	3.841	539	-3.07**
Grammar (N=543)	3.466	3.543	542	-3.02**
Vocabulary (N=542)	3.714	3.784	541	-2.65*
Pronunciation (N=528)	3.833	3.939	527	-3.92**
Spelling (N=535)	3.832	3.871	534	-1.49
Paragraph writing (N=494)	3.715	3.804	493	-2.99**

* $p < .05$, ** $p < .005$

New FL teachers (N=26)	Experienced FL teachers (N=5)
Discussing topics etc. (50%)	Writing letters etc (80%)
Looking for information in books etc. (46.2%)	Reading letters etc (60%)
Looking for information on the internet (42.3%)	Writing short texts (40%)
Writing letters etc. (38.5%) Reading letters etc. (38.5%)	

Table 3: Three most useful activities for FL learning rated by students

New students (N=523)	Experienced students (N=27)
Discussing topics etc (46.9%)	Reading letters etc (63%)
Reading letters etc (43.4%)	Writing letters etc (59.3%)
Writing letters etc (41.6%)	Writing short texts (51.9%)

constructing and interpreting graphs and charts.

Tables 2 and 3 show the responses about the most useful activities for FL learning. Teachers' and students' responses generally coincide. Approximately half of the teachers and students new to SAE chose discussion as the most useful activity. However, SAE-experienced users did not value discussion to anything like the same degree.

Teachers and students familiar with SAE assigned more importance to exchange activities than first-time users and they rated these activities as the most useful for FL learning. Although exchange activities were highly rated, the mode of communication (i.e. whether e-mail or conventional mail) was not clear from the results. The use of internet does not seem very frequent either in new or experienced schools. It seems that IT facilities were unavailable in many schools, and this may have limited the range of activities carried out in both non-SAE and SAE classrooms.

4.5. Comparison between boys and girls

Teachers claimed that SAE materials equally benefitted both boys and girls in their motivation for learning and improvement of FL proficiency and science knowledge.

In the students' data, however, there are indications that girls may have benefitted more from using SAE than boys. Girls were more positive about learning SAE than boys, especially when SAE was used for science learning. This may be explained by the combination of science and foreign language encouraged in SAE lessons. Girls may have found this 'soft' science more attractive than 'harder' topics in science lessons proper.

When boys' and girls' performance before and after using SAE is examined separately, girls reported improvement in more skill categories after using SAE than boys (see Tables 4 and 5). However, it must be noted that the girls' sample size was larger than boys. This may have affected the statistical significance and it is important to compare equal numbers of boys and girls in future research to draw more definite conclusions.

4.6. Comparison between approaches to SAE

SAE lessons were preferred more by students in classes led by FL teachers than those in science-led classes or in 'combined' approach classes (where more than one teacher collaborates).

Table 4: New students' self-rating of their language ability before and after using SAE materials (Boys)

Language skills	Before (Q12)	After (Q24)	df	T-value
Listening (N=186)	3.903	4.022	185	-2.40*
Speaking (N=186)	3.833	3.823	185	.23
Reading (N=185)	4.135	4.195	184	-1.29
Writing (N=186)	3.720	3.839	185	-2.27*
Grammar (N=185)	3.438	3.497	184	-1.13
Vocabulary (N=185)	3.665	3.778	184	-2.20*
Pronunciation (N=183)	3.792	3.967	182	-3.56**
Spelling (N=185)	3.789	3.854	184	-1.27
Paragraph writing (N=178)	3.607	3.730	177	-2.10

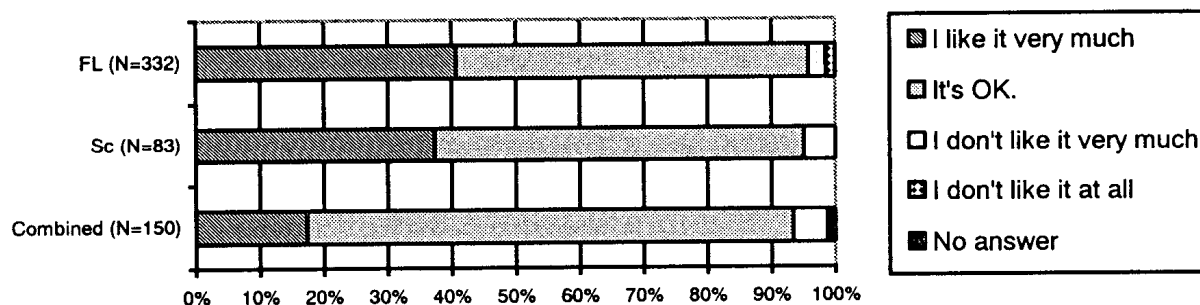
* $p < .05$, ** $p < .005$

Table 5: New students' self-rating of their language ability before and after using SAE materials (Girls)

Language skills	Before (Q12)	After (Q24)	Df	T-value
Listening (N=348)	3.868	3.997	347	-4.56**
Speaking (N=349)	3.728	3.857	348	-4.12**
Reading (N=350)	4.131	4.203	349	-2.51*
Writing (N=347)	3.781	3.839	346	-1.91
Grammar (N=351)	3.482	3.561	350	-2.86**
Vocabulary (N=350)	3.734	3.786	349	-1.69
Pronunciation (N=338)	3.849	3.920	337	-2.17*
Spelling (N=343)	3.866	3.889	342	-.77
Paragraph writing (N=310)	3.774	3.848	309	-2.24*

* $p < .05$, ** $p < .005$

Figure 1: What do you think of Science Across Europe lessons in general?



The 'combined' approach seems less effective than other approaches. The students in these classes were least positive about SAE in general (see Figure 1); they also rated their FL ability after using SAE lower than FL-led and science-led students.

Table 6: New students' self-rating of their language ability before and after using SAE materials (Three approaches)

	FL-led		Sc-led		Combined	
	df	T-value	df	T-value	df	T-value
Listening	321	-4.43**	73	-3.68**	141	-.45
Speaking	323	-3.03**	73	-2.08*	140	.15
Reading	322	-1.54	73	-1.88	141	-1.72
Writing	321	-2.64*	73	-1.69	140	-1.07
Grammar	323	-2.38*	73	-1.74	141	-.73
Vocabulary	323	-2.05*	73	-1.30	140	-.93
Pronunciation	315	-2.62*	71	-2.92**	136	-1.24
Spelling	319	-2.60*	72	.60	138	.29
Paragraph writing	306	-1.98*	71	-2.98**	111	-.64

* $p < .05$, ** $p < .005$

The *t*-test results confirm significant improvement for FL-led and science-led groups between 'before' and 'after' using SAE (see Table 6). When the three groups are compared in terms of the statistical significance of the perceived improvement, the greatest improvement in ability is observed in FL-led classes. This is understandable because it is expected that SAE lessons led by FL teachers lay more emphasis on FL learning. However, it is difficult to understand why there was no statistically significant improvement in combined classes where both FL and science teachers conducted SAE teaching. We might speculate that it has something to do with how they worked as a team. The teachers may have been new to the practice and the team-work may not have functioned as effectively as it could have. However, nothing is known about what forms of collaboration took place. Many different ways of planning, teaching and evaluating could be operating. It would be useful to know more about the way teachers collaborated and to give guidance as to what might work best.

5. Discussion

5.1. For Foreign Language teaching

The findings point to useful directions for SAE practice. They include: the need for more guidance for teachers in FL teaching methodology, especially in the area of SAE specific activities (e.g. exchange) and collaboration between teachers. It is certainly necessary to provide teachers with more training and guidance in collaboration.

The findings of this evaluation further present insight for FL teaching in general. Amongst others, exchange activities are particularly frequent in experienced schools, and perceived to be helpful in promoting learners' motivation and learning of a foreign language. This corresponds to the accepted view of FL teaching: the use of a foreign language for genuine communication should enhance learning, and thus this main focus of the SAE project should be encouraged as a useful means of language learning.

Discussions were also a common activity, but their effectiveness remains uncertain. While the majority of new users perceived discussions as useful for learning, experienced users were of a different opinion. Conventional FL thinking might agree with new teachers that a discussion in the foreign language is good for promoting FL ability, but much more so if done in pairs or in small groups, where students get more opportunities to talk, than in the plenary classroom, where talking opportunities for students are scarce (see Pica and Doughty 1985). In addition, it has to be said that when students work in pairs, especially in the non-FL classroom, it is possible that a significant amount of talk took place in the mother tongue. Unfortunately the survey has not provided the information which we would like to have here: for instance, did the discussion happen in the plenary classroom? If it happened in small-groups, did it happen in the FL? This certainly needs further investigation.

The next point of interest is collaborative teaching. The data suggest that collaboration was infrequent among the teachers new to SAE. This raises the issue whether collaboration is difficult to establish in a short time. Furthermore, in the classes where collaboration took place, this approach did not seem to be particularly successful either in enhancing learners' motivation or promoting their language learning. This may suggest that more guidance, more training, and more preparation are needed for successful collaboration as Nunan (1992) points out.

The SAE programme encourages the use of new information technology, but the number of schools which had ICT facilities was somewhat lower than had been expected. This may be largely due to the fact that the majority of schools surveyed were in Eastern Europe and the Former Soviet Union and new to the SAE programme. In a number of schools familiar with the programme, pupils seemed to make good use of

ICT facilities, but the number is limited at the moment. It is hoped that more schools will be equipped with the necessary facilities in the near future, and will make use of them to maximise the potential for various activities suggested by the programme.

5.2. For future research

It must be pointed out that there are a number of problems in this evaluation research. The most important is sampling. Even though the findings suggest very positive attitudes on the part of teachers and students, and beneficial impact of the SAE materials on language learning and motivation, this is in a way expected because the respondents were self-selected, i.e. they were the ones who were enthusiastic about the programme and wanted to respond in the first place. It is necessary to follow up the vast majority who did not respond. It is also important that data should be collected from comparable numbers of respondents representing sub-groups of different variables (e.g. new vs. experienced) to make fair comparison possible.

Instruments and procedures should also be improved. As mentioned earlier, the measure of language improvement was based on students' self-assessment. Self-assessment is emerging as an attractive means of assessment, but its validity and reliability must be scrutinised and its appropriateness for evaluation purposes can be questioned. Another, more reliable measure of language ability may be necessary, such as a language proficiency test, to have an accurate measure of the learners' improvement in language ability.

Furthermore, the improvement measured here was after classes had used only one unit of SAE materials (usually only about 4 - 5 lessons), and it is questionable whether the observed improvement is really sustainable or not. It is important to conduct follow-up studies or longer-term studies. Another pertinent issue is what to assess in evaluation. Many evaluation projects are conducted at a specific point in time, producing a limited profile of what is evaluated, be it learners, teachers, teaching or a programme. To obtain a fuller profile, it would be necessary to keep track of what is happening for a longer period, thus providing information on the process of learning as well as the product.

In this connection, it is also important to conduct case studies to observe classrooms and talk to students and teachers to supplement the data collected through questionnaires because what people say they do is often different from what they actually do. As we had no direct involvement in classroom teaching of SAE, it was extremely difficult to draw any definite conclusion solely from responses on paper.

It must be pointed out that research in the real educational context, especially commissioned research, may have to live with such limitations because there may be a conflict between the researchers' ideal and the practicalities imposed by funders. The problem for the researchers is that they may lack the resources to pursue investigations which are of academic interest but go beyond the limited objectives of the funders.

6. Conclusion

This paper has briefly reported the main findings of an evaluation project of an innovative educational programme which combines foreign language and science learning. Despite the drawbacks in the research methodology, especially in sampling, the evaluation project provided interesting findings in the area of cross-curricular approach to the development of foreign language learning by providing learners with a genuine purpose for using a foreign language. The findings have important implications for applied linguistics: foreign language teaching could be broadened and enriched by combining it with other subjects. The *Science Across Europe* materials seem to provide good opportunities for diversifying foreign language classrooms, with clear benefits for learners.

Acknowledgements

This paper is based on a joint project with Dr Pauline Rea-Dickins (University of Bristol) and John Clegg, whose contributions are gratefully acknowledged. Earlier versions of this paper were presented at the 34th British Association of Applied Linguistics (BAAL) Annual Meeting, Reading (2001), the 36th International Association of Teachers of English as a Foreign Language (IATEFL) Conference, York (2002), and the 13th World Congress of Applied Linguistics (AILA), Singapore (2002).

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