

Bilingual Scientific Literacy? The Use of English in Swedish University Science Courses

John Airey, Kalmar University College

Cedric Linder, Uppsala University

Abstract.

A direct consequence of the Bologna declaration on harmonisation of European education has been an increase in the number of courses taught in English at Swedish universities. A worrying aspect of this development is the lack of research into the effects on disciplinary learning that may be related to changing the teaching language to English in this way. In fact, little is known at all about the complex inter-relationship between language and learning. In this article we attempt to map out the types of parameters that our research indicates would determine an appropriate language mix in one section of Swedish higher education—natural science degree courses. We do this from the perspective of the overall goal of science education, which we suggest is the production of *scientifically literate* graduates. Here we introduce a new term, *bilingual scientific literacy* to describe the particular set of language-specific science skills that we hope to foster within a given degree course. As an illustration of our constructs, we carry out a simple language audit of thirty Swedish undergraduate physics syllabuses, listing the types of input provided for students and the types of production expected from students in both languages. We use this information to map out an ‘implied student’ for the courses with respect to bilingual scientific literacy. The article finishes by identifying issues for further research in this area.

1. Background and aims

European higher education institutions are currently preparing for a major influx of exchange students. The reason for this is the recently signed Bologna declaration on harmonisation of European education, which promises freedom of movement for students from the 46 countries now involved in the process by 2010 (Bologna Process, 2007). At the same time, higher education institutions are also interested in attracting other cohorts of foreign students from, for example, Africa, India and Asia, for both financial and academic reasons. In many cases, one aspect of this preparation has involved adopting English as the default teaching language in a wide selection of courses. In this respect, the Nordic countries feature strongly, with recent surveys of European programmes taught through the medium of English showing only the Netherlands

offering more student places on this type of course (Maiworm and Wächter, 2002; Wächter and Maiworm, 2008). At postgraduate level, for example, approximately half of the masters courses offered by Swedish higher education establishments in autumn 2007 were expected to be taught in English (Swedish National Agency for Higher Education, 2007). Even at undergraduate level many courses in Sweden are now taught exclusively in English. This is particularly true in natural sciences, engineering and medicine, where the majority of course literature has long been published in English, and where English is playing an increasingly dominant role as the *de facto* language of science (Ammon, 2001; Falk, 2001; Gunnarsson and Öhman, 1997).

Although the shift to teaching in English has often been welcomed by teachers and students, the research community is only beginning to understand the dynamics of these changes within the learning environment. One of the reasons for this is that there is very little research available into the effects on disciplinary learning in higher education when the language used to teach a course is changed in this way. Both Met and Lorenz (1997) and Duff (1997) have suggested that limitations in a second language may inhibit students' ability to explore abstract concepts in non-language subjects. However, even without the added complication of a second language, the language aspect of disciplinary learning is particularly problematic and complex. As Östman (1998) points out, a disciplinary language is abstract and represents special communicative traditions and assumptions. On a similar theme, Säljö (2000) argues that difficulties in student learning are in fact difficulties in handling and understanding highly specialised forms of communication which are not found to any great extent in everyday situations. Lemke (1990) has thus concluded that learning depends on the ability to understand the disciplinary language in which the knowledge is construed. In this respect Halliday and Martin (1993) have claimed that language itself is much more than a simple representation of disciplinary knowledge, it is actively engaged in bringing such knowledge into being. With so many writers pointing out the complex, non-trivial nature of the relationship between language and disciplinary learning, one might expect to find an extensive body of research into the subject—particularly with respect to changing the teaching language to English. Unfortunately, there is very little Nordic research that can inform the current language shift occurring in higher education.

A number of Nordic studies have examined the *extent* to which English is used in higher education and there are also studies of the effects of such teaching on *language learning* (e.g. Brandt and Schwach, 2005; Carroll-Boegh, 2005; Falk, 2001; Gunnarsson and Öhman, 1997; Hellekjaer and Westergaard, 2002; Höglin, 2002; Melander, 2005; Teleman, 1992; Tella, Räsänen and Vähäpassi, 1999; Wilson, 2002). However, studies relating to *disciplinary learning* in a second language are few in number—in fact, apart from our own work, we could only find two Swedish studies that could be said to have any bearing on the questions posed in this article. These two studies have examined the understanding of written text, both concluding that the ability to judge broad relevance is greatly reduced when text is in a second language (Karlsgren and Hansen, 2003; Söderlundh, 2004).

Even internationally there are only a small number of studies that have examined the effects of the teaching language on disciplinary learning in higher education. These international studies point to negative correlations between disciplinary learning and changing the teaching language to English (Gerber, Engelbrecht, Harding and Rogan, 2005; Klaassen, 2001; Neville-Barton and Barton, 2005; Vinke, 1995). However, in the most comprehensive of these studies Klaassen (2001) found that the negative effects on disciplinary learning disappeared over the period of a year. Klaassen concluded that the students in her study had adapted to the language switch, and suggested follow-up work to identify the mechanisms by which this adaptation may occur.

Until recently no Nordic research had been carried out into the relationship between the teaching language and disciplinary learning at tertiary level. This situation changed with the publication of the results of a Swedish study which examined the disciplinary learning of undergraduate physics students who were taught in both Swedish and English (Airey, 2006a, 2006b; Airey and Linder, 2006; 2007). Building on Klaassen's earlier experiences in the Netherlands, this study showed that, whilst on the whole students believed that the teaching language had little effect on their learning, the same students could witness to a number of significant differences in their learning when commenting on video footage of teaching situations. The differences found involved the amount of interaction in lectures (students asked and answered fewer questions when taught in English) and a greater focus on the process of note-taking in English-medium teaching at the expense of following the

lecturer's line of reasoning. Importantly, the students in the study changed their learning strategies to cope with the language shift in a number of ways: some students read sections of work before lectures, whilst others no longer took notes in class. However, in some extreme cases lectures had simply become sessions for mechanical note taking with extra work needed to make sense of these notes later.

Valuable though the above research is for teachers faced with the day-to-day reality of teaching Swedish students through the medium of English, we would argue that the changes brought about by the push to internationalise Swedish higher education require much more than increased awareness of the ways such teaching can be experienced by students. The decision to use a particular language must also be justified from a pedagogical perspective. Unfortunately, in the present situation the decision to change the teaching language to English often has little to do with achieving specific disciplinary learning objectives. Writing in 2002, Carlson voiced the concerns still held by many in Swedish higher education about the effects of language shift on disciplinary learning:

At present there has been no systematic research into the way in which student learning is affected by the language used, but my gut feeling and that of many of my colleagues is that students gain less robust knowledge and poorer understanding if the language used is not their mother tongue. (Carlson, 2002: 15) (our translation)

In an attempt to improve the disciplinary language of their students, teachers at Uppsala University started a project named DiaNa (Dialogue for Natural Scientists). Here, the academic departments of chemistry, biology and earth science emphasise communication training as an integrated part of their programme courses (Uppsala universitet, 2001, 2007). Moreover, in an attempt to redress what was seen as an imbalance between English and Swedish, Carlson and her colleagues also reduced the percentage of courses offered in English to third and fourth year biology students from approximately 70% to approximately 40%. All students now read at least one advanced course in Swedish. Although a movement back towards disciplinary Swedish seems to be a reasonable objective, Airey suggests that we would be well-advised pedagogically to focus on disciplinary learning objectives rather than the creation of general language policies:

[...] decisions [about the language of instruction] should be taken in order to better fulfil the aims of the syllabus, and not in order to solve temporary problems about what to do with a particular exchange student. This demands a structured approach, where the language of instruction is an integrated part of the overall strategy to produce well-educated graduates. (Airey, 2004: 104)

What we are suggesting, then, is a comprehensive rethink of the fundamental aims of undergraduate degree courses in order to acknowledge the language aspects involved in appropriate disciplinary learning.

A similar conclusion was reached at a recent symposium on language policy in higher education held at Södertörn University, Sweden in 2006. The symposium brought together representatives from the Swedish National Agency for Higher Education, the Swedish Language Council, the Swedish Academy, the Swedish Student Union, the Swedish Research Council and the Parliamentary Working Group that drafted the 2002 report on language *Mål i mun* (Utbildningsdepartementet, 2002) and its 2005 follow-up report. At the symposium, concern was expressed about issues of diglossia (Ferguson, 1959)—a division of functions between languages—where English is the academic ‘high’ language and Swedish is the everyday ‘low’ language and domain losses¹ to English (Fishman, 1967) with the fear being that certain subject areas in society might become impossible to discuss in Swedish. There was also general agreement that *both* English and Swedish are needed in Swedish higher education, with the term *parallel language use* being adopted to describe the desired situation (see Josephson, 2005). However, questions about what the term parallel language use actually means and how it might be implemented remained largely unanswered.

We suggest that the first point to note when examining the term parallel language use is that its focus appears to be primarily on the educational system itself, i.e. the language *used* when educating students

¹ The concept of domains was first presented by Fishman (1967). Examples of domains are the family, school, the workplace, etc. The idea is that domains can dictate language choice.

rather than the language *competencies* that we would like graduates to attain with respect to their subject of study. Clearly, the former is intended to imply the latter; however, we believe it is dangerous to assume that there is a one-to-one relationship between teaching and learning in this way. Thus, we prefer to reformulate the parallel language requirement, suggesting that each degree course should be analysed in terms of the *desired combination of language-specific disciplinary skills that we would like to be attained within that course*. Once this has been decided, the next step would then be to determine the appropriate combination of input and output that we hope would lead to these aims being achieved.

For this article then, our overarching goal is to map out the parameters which we see as important when deciding on the language combination to be offered within one section of Swedish higher education—namely the case of natural science degree courses. Here we suggest that the answers to two questions are important for informing future research in this area:

- *What kind of input and output with respect to language can be argued to be typical in natural science degree courses—i.e. what does the educational system seem to be offering students at the moment?*
- *What kind of language-specific student science-competencies does this combination of input and output imply?*

In an attempt to illustrate the answers to these questions, we take as our starting point the overall goal of science education, which we argue is the production of *scientifically literate graduates*.

2. The goal of science education: scientific literacy

Why do our students spend three or four years learning undergraduate science? One answer to this question—the one subscribed to by the authors of this article—is that we want to produce *scientifically literate graduates*. The term science literacy was first coined by Hurd (1958), but since then there has been little agreement as to its precise meaning (Laugksch, 2000). So, for the purposes of this article, what exactly do we mean by the term scientifically literate? Usually when we talk about literacy we mean being able to read and write. In this respect, Norris and

Phillips (2003) have suggested that literacy takes two forms; *fundamental* and *derived*. Fundamental literacy is the ability to extract meaning from text (i.e. in its widest sense), whilst derived literacy refers to the use of knowledge in a particular context. Clearly, then, from this point of view, the fundamental form of *scientific* literacy involves being able to extract appropriate meaning from a science text, but when one comes to derived scientific literacy there are questions of context that need to be answered. Here, Roberts (2007) has aided our thinking by introducing the notion of two *visions* of scientific literacy: Vision I—coming to understand the content of science itself, and Vision II—coming to understand the implications and applications of science, particularly in relation to everyday situations. He suggests that when we think about derived scientific literacy we are in fact referring to a combination of Vision I and Vision II. Thus, Roberts argues that the type of derived scientific literacy fostered by a given undergraduate science course will place itself somewhere on the continuum between these two complementary visions. Following this division we define scientific literacy for the purposes of this article as both the ability to *work within science* and the ability to *apply science* to everyday life.

3. Bilingual scientific literacy

If one accepts that the goal of natural science degree courses is the production of scientifically literate graduates, in line with our definition, then, what is the nature of this scientific literacy with respect to language? At this point we introduce a new term, *bilingual scientific literacy*, which we define as scientific literacy in two languages. We use this notion to characterise the particular collection of language-specific science skills fostered within a given degree course with respect to Roberts' two visions.

We suggested above that everyday literacy is often couched in terms of reading and writing. Here, we note that reading is an interpretive skill whilst writing is a generative skill. Thus, from an analytical perspective, we argue that bilingual scientific literacy should similarly be divided into interpretive and generative components. Thus, we suggest that it is important that any science degree course syllabus clearly identify the particular blend of bilingual scientific literacy that is intended in terms of

a combination of three factors: the vision (I and II), the language (L1 and L2), and the form of literacy (interpretive and generative) see figure 1.

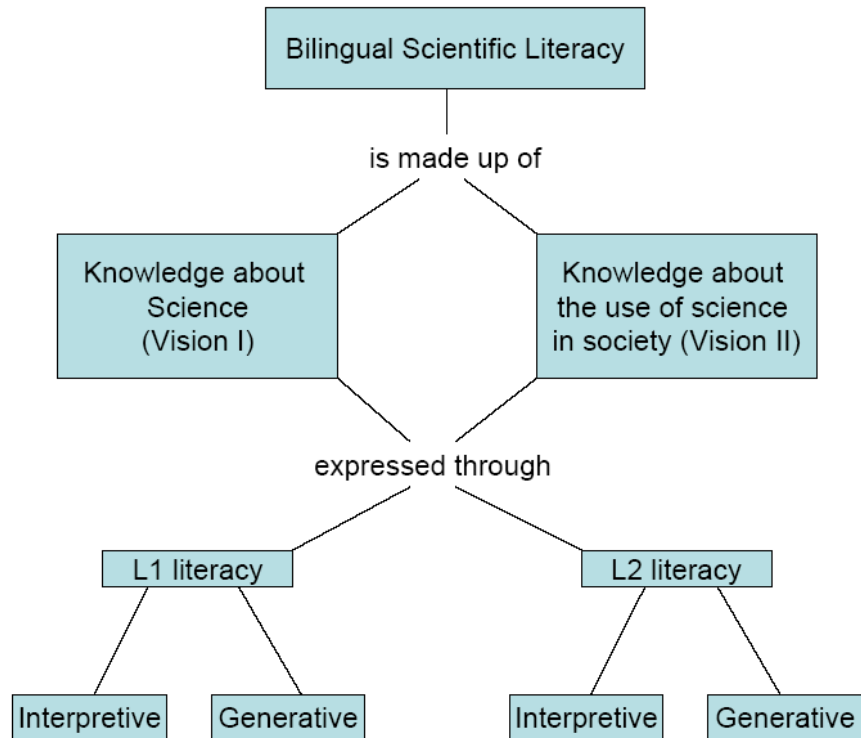


Figure 1 Bilingual scientific literacy in a degree course syllabus.

To our knowledge, no Swedish degree syllabuses specify educational outcomes for all these components of bilingual scientific literacy in an explicit manner at this time. What, then, we wonder, are the *implied* goals with respect to our suggested components of bilingual scientific literacy that form the ‘hidden curriculum’ of these courses? In an attempt to answer this question we audited a sample of thirty syllabuses from undergraduate courses in physics offered in spring term 2008 at one of Sweden’s foremost universities in science and engineering.

4. Syllabus analysis with respect to bilingual scientific literacy

Using a Vision I perspective, Airey and Linder (2008) have divided disciplinary semiotic resources into three categories; *representations, tools and activities*. They suggest that for natural science the category of representations includes; oral and written language, mathematics, tables, graphs and diagrams. The tools category refers to any physical objects used within science, whilst activities refers to the methods and praxis of the discipline. They suggest that students will need to become fluent in a critical constellation of these semiotic resources. Clearly, from this perspective, each of these semiotic resources will require both interpretive and generative fluency. We draw on this description to analyse the types of formal learning activities used on the thirty courses. Initially we focussed on two course features that could be readily collated from the thirty syllabuses: course literature and teaching language.

Unfortunately, ten of the course syllabuses failed to detail the required literature, thus effectively reducing the number of useable syllabuses to twenty for this aspect. Of the twenty undergraduate course syllabuses that did specify texts, only four appear to have exclusively Swedish course literature. Sixteen courses had at least some literature in English, with six of these having only English texts. When it comes to the teaching language, things were somewhat different. Of the thirty courses, only two were taught exclusively in English; the majority, twenty-three were taught in Swedish. This information is summarised in Table 1.

It is interesting to note that five syllabuses indicated that “*If so required, the course will be given in English.*” One can wonder about the type of bilingual scientific literacy that course developers have in mind when a course can spontaneously change teaching language in this way.

Table 1 Language use in 30 undergraduate physics courses as specified in the syllabus.

English texts only	Mixed texts	Swedish texts only	Taught in English	Taught in English or Swedish	Taught in Swedish
6	10	4	2	5	23

Note: Of the 30 syllabuses, 10 gave no guidance on literature, these have therefore been excluded from the left hand column detailing the language of course texts.

Following our initial analysis, informal discussions were held with lecturers to ascertain typical types of course activities and the languages used in these. We then used this information to build up a picture of the types of student competencies that the course activities implied.

5. The implied student

From our analysis of the thirty syllabuses and our discussions with course lecturers about course activities we have generated a profile of an implied student with respect to bilingual scientific literacy. In Table 2 below, we first analyse the implied fluency in semiotic resources other than language.

Here we see that the course activities imply high levels of interpretive and generative fluency within the discipline (Vision I), but the implication is that there is little use of these semiotic resources with respect to the problems of everyday life (Vision II). We suggest that either lecturers do not see it as their job to encourage societal scientific literacy, or they assume that disciplinary literacy automatically leads to an ability to use the semiotic resources of science in an everyday context.

Table 2 Implied fluency in semiotic resources other than language

	VISION I		VISION II	
	Interpretive	Generative	Interpretive	Generative
Mathematics	High	High	Low	Low
Graphs	High	High	Low	Low
Diagrams	High	High	Low	Low
Tables	High	High	Low	Low
Tools	High	High	Low	Low
Activities	High	High	Low	Low

A similar division can be seen when we examine the use of linguistic semiotic resources in the thirty courses (Table 3).

Table 3 Implied fluency in linguistic semiotic resources

	VISION I		VISION II	
	English	Swedish	English	Swedish
Reading	High	Medium	Low	Low
Listening	Medium	High	Low	Low
Writing	Medium	Medium	Low	Low
Speaking	Low	Low	Low	Low

Once again, the implication is that a Vision II perspective may be absent. However, a new pattern emerges. Within the discipline (Vision I), there is now no longer a uniformly high level of practice. Fluency in spoken disciplinary English and Swedish does not appear to be encouraged. This is, in fact, a common finding in science—even without a dual-language approach (Lemke, 1990). Second, we would like to point out that the higher levels of implied fluency appear to be in *interpretive* rather than *generative* forms, i.e. reading in English and listening in Swedish. This might suggest that students become less able to use language themselves when a dual-language approach is adopted. Finally, the analysis raises questions for reading, listening and writing. In these forms there is only *some practice* in one or both languages. It could be argued that this is a result of a dual-language approach—i.e. if learning had been limited to one language alone, extensive practice might have been recorded for these forms.

6. *Discussion and implications*

We believe we are now in a position to make some tentative observations about the kind of implied attitudes to bilingual scientific literacy and scientific literacy in general that university science courses appear to represent. The first point is that in comparison to the other disciplinary semiotic resources, linguistic resources would seem to be less well developed—with the least developed of these being oral skills in both English and Swedish. In this respect, Lemke (1990) has suggested that students should be given the chance to “talk science”, whilst Tobias (1986) believes that science learning would be enhanced if students were encouraged to “kick the ideas around” as they typically are in the social sciences and humanities. Here we extend these assertions by suggesting that development of oral skills in both languages may be an important factor in becoming scientifically literate.

Consideration of Tables 2 and 3 indicates that there may also be an implicit assumption in university science education (in this case physics) with respect to Vision II scientific literacy. Either it is assumed that Vision I literacy, virtually by default, provides for Vision II literacy, or that Vision II literacy does not form part of the curriculum in any kind of specific way. In any case, the lack of focus on Vision II literacy has serious implications for the attainment of scientific literacy in general. These implications arguably become more profound in the context of the attainment of bilingual scientific literacy. It is here that we believe that a model such as the one presented in Figure 1 can be used as a powerful educational tool. When preparing to teach disciplinary knowledge, we know that information about students as learners, student-teacher perceptions of teaching and learning, and the relations between these are educationally critical. However, in contexts where consideration also needs to be given to bilingual scientific literacy, Figure 1 offers a reflective teaching-preparation instrument that could be used to bring into focus the kinds of things that we would argue are needed to make the attainment of scientific literacy possible.

At the same time we have argued elsewhere that in the Vision I domain students need to become fluent in a *critical constellation* of semiotic resources in order to appropriately experience a given disciplinary concept (Airey and Linder 2008). It is interesting to speculate whether this criterion can be applied to the Vision II domain. If

this is indeed the case, then the model given in Figure 1 also provides a way for teachers to think about the semiotic resources that they will need to draw on for the attainment of scientific literacy.

The findings of this study also have implications for the training of future science teachers. It is not unusual for trainee teachers to study natural science together with students from other programmes. However, we note that the goals of a teacher-training course with respect to bilingual scientific literacy are probably quite different than those of courses offered to the rest of the student population. We argue that trainee teachers will need to become fluent users of Swedish scientific literacy centred mainly around a Vision II perspective. Consequently, we suggest that the ways in which these students translate their English language, Vision I literacy into Swedish language, Vision II literacy in their day-to-day work in the classroom is an important area for future research.

Earlier, in our critique of the term parallel language use, we suggested that it was irresponsible to plan courses based on the assumption of a one-to-one relationship between teaching and learning. The discussion above hints at some of the kind of complexity that may be involved. We cannot go further than that here. Our interests in this article are reformist in nature and have simply been to analyse the *implicit* aims of a sample of natural science courses with respect to bilingual scientific literacy. We believe this to be an important issue for discussion regarding the wider goals of undergraduate science. Since we have identified spoken English and Swedish as potentially the most critical areas our future work concentrates on this problem. We intend to report on an analysis of *spoken* bilingual scientific literacy, where student oral descriptions of scientific concepts in both languages are analysed and related to the types of linguistic input provided within their degree courses.

References

- Airey, J. 2004. "Can you teach it in English? Aspects of the language choice debate in Swedish higher education." In R. Wilkinson (Ed.), *Integrating Content and Language: Meeting the challenge of a*

- multilingual higher education* (pp. 97-108). Maastricht, Netherlands: Maastricht University Press.
- Airey, J. 2006a. "När undervisningspråket blir engelska [When the teaching language is changed to English]." *Språkvård*, 2006 (4), 20-25.
- Airey, J. 2006b. *Physics students' experiences of the disciplinary discourse encountered in lectures in English and Swedish*. Licentiate Thesis. Uppsala, Sweden: Department of Physics, Uppsala University.
- Airey, J. and C. Linder. 2006. "Language and the experience of learning university physics in Sweden." *European Journal of Physics*, 27(3), 553-560.
- Airey, J. and C. Linder. 2007. "Disciplinary learning in a second language: A case study from university physics." In R. Wilkinson and V. Zegers (Eds.), *Researching content and language integration in higher education* (pp. 161-171). Maastricht: Maastricht University Language Centre.
- Airey, J. and C. Linder. 2008. "A disciplinary discourse perspective on university science learning: Achieving fluency in a critical constellation of modes." Accepted for publication in *Journal of Research in Science Teaching*.
- Ammon, U. (Ed.). 2001. *The dominance of English as a language of science: Effects on other languages and language communities*. Berlin, New York: Mouton de Gruyter.
- Bologna Process. 2007. *Bologna Process. Towards the European higher education area*. Retrieved 31 May 2008, from <http://www.ond.vlaanderen.be/hogeronderwijs/bologna/>
- Brandt, S. S. and V. Schwach. 2005. *Norsk, engelsk og tospråkighet i høyere utdanning En pilotstudie om bruk av engelsk i fem fagtilbud ved fire læresteder [Norwegian, English and bilingualism in higher education. A pilot study of the use of English in five courses at four institutions]*. NIFU STEP Norsk institutt for studier av forskning og utdanning / Senter for innovasjonsforskning.
- Carlson, K. 2002. "Tvåspråkiga naturvetare [Bilingual natural scientists]." *Språkvård*, 2002(2), 14-19.
- Carroll-Boegh, A. 2005. "Internationalisation and teaching through English: A Danish perspective." *Educate*, 5(2), 19-30.

- Duff, P. A. 1997. "Immersion in Hungary: an ELF experiment." In R. K. Johnson and M. Swain (Eds.), *Immersion education: International perspectives* (pp. 19-43). Cambridge, UK: CUP.
- Falk, M. L. 2001. *Domänförluster i svenskan [Domain losses in Swedish]*: Nordic Council of Ministers.
- Ferguson, C. 1959. "Diglossia." *Word: Journal of the Linguistic Circle of New York*, 15, 325-340.
- Fishman, J. A. 1967. "Bilingualism with and without diglossia; diglossia with and without bilingualism." *Journal of Social Issues*, 23, 29-38.
- Gerber, A., J. Engelbrecht, A. Harding and J. Rogan. 2005. *The influence of second language teaching on undergraduate mathematics Performance*. Retrieved 23 September 2005, from <http://ridcully.up.ac.za/muti/language.pdf>
- Gunnarsson, B.-L. and K. Öhman. 1997. Det internationaliserade universitetet. En studie av bruket av engelska och andra främmande språk vid Uppsala universitet [The Internationalized University. A study of the use of English and other foreign languages at Uppsala university]. *TeFa No.16*. Uppsala: Institutionen för nordiska språk, Uppsala universitet.
- Halliday, M. A. K. and J. R. Martin. 1993. *Writing science: Literacy and discursive power*. London: The Falmer Press.
- Hellekjaer, G. O. and M. R. Westergaard. 2002. "An exploratory survey of content learning through English at Scandinavian universities." In A. M. Simensen (Ed.), *Teaching and learning foreign languages issues and ideas* (pp. 47-61). Oslo: Unipub.
- Hurd, P. d. H. 1958. "Science literacy: Its meaning for American schools." *Educational Leadership*, 16, 13-16.
- Höglin, R. 2002. *Engelska språket som hot och tillgång i Norden [the English language as threat and resource in the Nordic countries.]* (Vol. 561). Köpenhamn: Nordiska ministerrådet.
- Josephson, O. 2005. "Parallellspråkighet [parallel language use]." *Språkvård*, 2005(1), 3.
- Karlgren, J. and P. Hansen. 2003. *Cross-Language relevance assessment and task context*. Paper presented at the Advances in Cross-Language Information Retrieval. Third Workshop of the Cross-Language Evaluation Forum, CLEF 2002, Rome, Italy.

- Klaassen, R. 2001. *The international university curriculum: Challenges in English-Medium engineering education*. Delft: Department of Communication and Education, Delft University of Technology.
- Laugksch, R. C. 2000. "Scientific literacy: A conceptual overview." *Science Education*, 84, 71-94.
- Lemke, J. L. 1990. *Talking science: Language, learning and values*. Norwood, NJ: Ablex.
- Maiworm, F. and B. Wächter. (Eds.). 2002. *English-Language-Taught degree programmes in European higher education, trends and success factors*. Bonn: Lemmens Verlags and Mediengesellschaft.
- Melander, B. 2005. "Engelska och svenska vid Uppsala universitet - en uppföljning. [English and Swedish at Uppsala university - a follow-up report]." In *Text i arbete/Text at work* Festskrift till Britt-Louise Gunnarsson den 12 januari 2005 (pp. 135-143).
- Met, M. and E. B. Lorenz. 1997. "Lessons from U.S. immersion programs: Two decades of experience." In R. K. Johnson and M. Swain (Eds.), *Immersion education: International perspectives* (pp. 243-264). Cambridge, UK: CUP.
- Neville-Barton, P. and B. Barton. 2005. *The relationship between English language and mathematics learning for non-native speakers*. Retrieved 21 Sept. 2005, from <http://www.tlri.org.nz/pdfs/13909.pdf>
- Norris, S. P. and L. M. Phillips. 2003. "How literacy in its fundamental sense is central to scientific literacy." *Science Education*, 87(2), 224-240.
- Roberts, D. 2007. "Scientific literacy/science literacy: Threats and opportunities." In S. K. Abell and N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 729-780). Mahwah, New Jersey: Lawrence Erlbaum Associates.
- Swedish National Agency for Higher Education. 2007. *Stor andel utländska studenter på program på den avancerade nivån Analys av preliminära uppgifter om registrerade studenter höstterminen 2007 [Large percentage of foreign students on programmes at postgraduate level An analysis of preliminary statistics on registered students for autumn term 2007]*. Retrieved 28 May 2008, from <http://www.hsv.se/download/18.7313a03211671c020798000339/utlandska-studenter-analys-0709.pdf>

- Säljö, R. 2000. *Lärande i praktiken: ett sociokulturellt perspektiv* [Learning in practice: a sociocultural perspective]. Stockholm: Prisma.
- Söderlundh, H. 2004. "Lika bra på engelska? En undersökning av hur studenter i Sverige förstår kurslitteratur på svenska resp. engelska [Just as good in English? A study of Swedish students' understanding of course texts in Swedish and in English]." *Språk och stil*, 14, 137-165.
- Teleman, U. 1992. "Det svenska riksspråkets utsikter i ett integrerat Europa [The outlook for Swedish in an integrated Europe]." *Språkvård*, 1992(4), 7-16.
- Tella, S., A. Räsänen and A. Vähäpassi. (Eds.). 1999. *Teaching through a foreign language: From tool to empowering mediator* (Vol. 5). Helsinki: Edita.
- Tobias, S. 1986. "Peer perspectives. On the teaching of science." *Change*, March/April 1986, 36-41.
- Uppsala universitet. 2001. *Goal document for the DiaNa project*. Retrieved 20 Sept 2003, from <http://kimura.ibg.uu.se/diana/dianagoals.html>
- Uppsala universitet. 2007. *DiaNa: Kommunikationsträning i naturvetarutbildning* [DiaNa: Communication training in natural sciences education]. Retrieved 30 May 2008, from <http://www.ibg.uu.se/diana/english/index.html>
- Utbildningsdepartementet. 2002. *Mål i mun. Slutbetänkande av kommittén för svenska språket* [Languages we speak. Final report of the Swedish parliamentary committee for the Swedish language] (SOU 2002:27). Stockholm: Utbildningsdepartementet.
- Vinke, A. A. 1995. *English as the medium of instruction in Dutch engineering education*. Delft: Department of Communication and Education, Delft University of Technology.
- Wilson, D. 2002. *The englishisation of academe: A Finnish perspective*. (No. 5). Jyväskylä: University of Jyväskylä Language Centre.
- Wächter, B. and F. Maiworm. 2008. *English-Taught programmes in European higher education. The Picture in 2007*. Bonn: Lemmens.
- Östman, L. 1998. "How companion meanings are expressed by science education discourse." In D. Roberts and L. Östman (Eds.), *Problems of meaning in science education* (pp. 54-70). New York: Teachers College Press.

