Estimating Undergraduate Bilingual Scientific Literacy in Sweden

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Abstract

This paper reports ongoing research results from the first Swedish study to be carried out into the relationship between the teaching language and disciplinary learning at university level. The study explores the ability of Swedish science students to spontaneously describe and explain, in both Swedish and English, the concepts they met in their course lectures.

The work reported here is a first attempt to evaluate a number of techniques that together may be used to estimate spoken bilingual scientific literacy. Transcripts of students using both English and Swedish to describe a science concept are analysed using three categories: fluency, involuntary codeswitching, and disciplinarity. These categories are then cross-referenced with the language in which the disciplinary concept was originally taught (Swedish, English, or both languages).

The study finds that for some students, spoken scientific literacy in English is indeed a problem. Here, it has been suggested that these problems may be transitory, and more work is needed to ascertain whether this is indeed the case.

Keywords: Bilingual scientific literacy, Fluency, Undergraduate science, involuntary codeswitching, Language choice

Introduction

In Sweden, science undergraduates meet two languages in their education: English and Swedish. The most common division between these languages is to have lectures in Swedish with course texts in English. However, the presence of a single exchange student on an undergraduate course can change the lecture language to English (Airey, 2004). With the number of exchange students predicted to rise as a result of implementation of the Bologna declaration, the role played by English in Swedish higher education seems set to increase. This recently prompted one vice-chancellor to predict that all their programmes would be delivered in English within 10-15 years (Flodström, 2006).

Disciplinary learning in a second language

Met and Lorenz (1997) and Duff (1997) have suggested that when taught in English, limitations in this second language may inhibit students’ ability to explore abstract concepts in their area of study. This suggestion appears to be supported to some extent in the literature (Vinke, 1995; Klaassen, 2001; Gerber et al. 2005; Neville-Barton and Barton, 2005). 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. Building on Klaassen’s work, Airey and Linder (2006; 2007) found that students change their learning strategies to adapt to English-medium instruction in a number of ways, with some students reading sections of work before lectures, whilst others no longer take notes in class. However, in some cases lectures simply become sessions for mechanical notetaking with extra work needed to make sense of these notes later. This is useful information for lecturers who already teach their students in English, but leaves the question of an appropriate balance between languages unanswered.
**Bilingual scientific literacy**

Airey and Linder (in press) claim that the goal of natural science degree courses is the production of scientifically literate graduates. For the situation where two languages are involved, they introduce the term, *bilingual scientific literacy*, which they define simply as scientific literacy in two languages. They find that Swedish course syllabuses appear to imply low levels of practice in spoken forms of bilingual scientific literacy. In response to this finding, this paper reports the first results of an ongoing study of students’ spoken bilingual scientific literacy.

**Assessing levels of spoken bilingual scientific literacy**

The main question that presents itself when contemplating the assessment of spoken bilingual scientific literacy is one of validity. What constitutes a legitimate measure of a student’s ability to speak about science? In linguistics, syllables per second (SPS) is often used to measure spoken ability—this is because higher speech rate is seen as an indicator that knowledge has become proceduralised (Anderson, 1982). Another related linguistic method involves documenting pauses. Chambers (1997) discusses the types of pauses that exist in speech dividing them into natural and unnatural pauses:

- Natural pauses, allowing breathing space, usually occur at some clause junctures or after groups of words forming a semantic unit. Pauses appearing at places other than these are judged as hesitations, revealing either lexical or morphological uncertainty. These hesitations may be either simply a silent gap or marked by non-lexical fillers (“uh”, “um”), sound stretches (or drawls on words) or lexical fillers with no semantic information (such as “you know”, “I mean”).

Chambers (1997:539)

We can thus expect the difference between first and second-language speech to be in the frequency of unnatural pauses, indicating lexical gaps in the second language. However, a number of studies have claimed that the most statistically significant measure of speaking ability is the amount of speech uttered between pauses (Towell et al. 1996; Kormos and Dénes, 2004). Here, the average phrase length in syllables is calculated. In the literature, this value is termed mean length of runs (MLR).

Hincks (2005, 2008) compared presentations on the same topic given by the same students in English and Swedish using the SPS and MLR measures. Her main finding is that when Swedish students speak English they pause more often, use shorter phrase lengths and speak on average 23% slower. However, Hincks advises caution when comparing speaking ability between students based on SPS and MLR, pointing out that there is a strong effect of individual speaking style which carries over to second-language speaking from a student’s first language.

Where two languages are involved, lexical gaps may also be filled by *codeswitching* (i.e. inserting a word or phrase from another language). The benefits of codeswitching in the learning environment have been widely documented, with researchers from a range of backgrounds acknowledging that the use of two languages offers better opportunities for representing and accessing knowledge (See for example Moreno et al. 2002; Üstünel and Seedhouse, 2005; Liebscher and Dailey-O’Caine, 2005; Fakudze and Rollnick, 2008). However, for this paper, the term *involuntary codeswitching* is introduced to describe a situation where codeswitching occurs in a monolingual setting. In the interviews conducted for this paper, students were instructed to use one language exclusively for a given description. Any codeswitching that occurred was thus deemed involuntary and indicative of a lexical gap in the language being spoken.

Finally, in order to be deemed scientifically literate, what is said needs to make sense from a disciplinary perspective. For example, the SPS and MLR values for a fluent meta-description of a lack of understanding do not provide much information about scientific literacy.

To summarise then, it may be possible to triangulate bilingual scientific literacy by considering; SPS, MLR, involuntary codeswitching and a judgement about the disciplinarity of what has been said. The remainder of this paper applies these four approaches to actual student interviews.
Assessing bilingual scientific literacy through interviews

In this section, illustrative examples from three student interviews are presented. The raw transcripts were prepared for analysis in four stages. First, all speech by the interviewer was deleted and marked by a double return in the transcript. Next, all noticeable pauses—both filled and unfilled—were marked by entering a single return. This created a transcript of phrases of various lengths, each on a separate line. Then, all utterances in filled pauses—where the student uses sounds such as aah, um, er, etc.—were deleted. Finally, each word in the transcript was divided up into syllables. The SPS value was calculated by dividing the total number of syllables in the transcript by the total student speaking time (interviewer speaking time was first subtracted from the total time). MLR was calculated by dividing the total number of syllables in the transcript by the number of text lines (excluding empty lines). Instances of codeswitching were highlighted in bold and a subjective judgement about the disciplinarity of the description was made, using the following criteria:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Label</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Weak:</td>
<td>Student clearly has major problems when talking about disciplinary concepts in this language.</td>
</tr>
<tr>
<td>2.</td>
<td>Intermediate:</td>
<td>Student uses some disciplinary terms appropriately, but either has clear disciplinary lexical gaps or uses other terms inappropriately.</td>
</tr>
<tr>
<td>3.</td>
<td>Good:</td>
<td>Student uses disciplinary terms appropriately in the sequence, but does not develop ideas fully.</td>
</tr>
</tbody>
</table>

The first excerpts are from interviews with two students, Andy and Hope (pseudonyms). The students are from different universities, but were both reading two physics courses simultaneously, one taught in Swedish and another taught in English. Video footage from lectures was used in a process of stimulated recall in order to initiate spontaneous descriptions of science concepts in both English and Swedish.

Andy

Andy is a second-year student in a larger, research oriented department. He has experienced physics lectures in English in earlier courses. Below are his descriptions of the content from a course that was taught in Swedish:

**Translated Swedish description**

1. No, you know
2. uniform convergence wasn’t intuitively clear
3. why you can’t choose
4. then choose one—if there’s
5. one n for all x, why can’t you take the largest first?

SPS 3.7  MLR 8.7  Disciplinarity 3

**English description** (Codeswitching to Swedish in bold)

1. All the part about this supremum, well, that was clear to me.
2. This last
3. part about uniform convergence it’s well, it's not in
4. intuit
intuitiv. [intuitive]

And here are Andy's descriptions from a course taught in English:

**Translated Swedish description** (Codeswitching to English in bold)

1. Yes, yes it means
2. that
3. the curl of E there is
4. is minus the derivative of the B field but
5. then exactly what a curl is I've still not really got a, you know
6. direct in intuitive picture of it

**English description**

1. Yeah,
2. well what he says right now is
3. basically is that the E field is a conservative field
4. even though a mathematician wouldn't say that
5. but
6. which allows us to
7. to create a potential and
8. also it says that
9. a line integral
10. describing the work for example is
11. independent of, independent of time
12. in this, when you've got the zero there

Andy shows the anticipated pattern of reduced SPS and MLR values when talking about concepts in English that has been found in previous studies. There is one lexical gap in his English description of a concept taught in Swedish, although the word 'intuitive' that he is searching for has no real bearing on scientific literacy. Here we see an interesting result, when taught in English, Andy codeswitches in his first language—Swedish—using the word ‘curl’ (line 3) and the phrase ‘curl of E’ (line 5) instead of the standard Swedish term 'rotation'.
Hope
Hope is a first-year student in a smaller teaching department. She has not been taught in English before. Below are her descriptions of the content from a course that was taught in Swedish:

**Translated Swedish description**

1. I don’t think so much about b times v, you know—b times the velocity that’s a constant—b times v what is that really but
2. aha he says
3. that, you know
4. the total force is the force of the spring minus
5. the force from this damping system
6. which is the same as the total force, which is equal to the mass times acceleration
7. I understand that, but I don’t think so much about
8. where does, what is this b times
9. times the velocity

**English description** (codeswitching in bold, translations in square brackets)

1. the mass which is
2. ska jag prata på...? [should I speak in...?]
3. massan [the mass]
4. the mass which is
5. det är svårt alltså [it’s difficult you know]
6. which is
7. fast? [stuck?]
8. connected to, to a
9. spring
10. and on here we have
11. dämpnings system [damping system] which also is connected to the mass.
12. this is the velocity
13. of the mass
14. this is the fjä fjäder kraften som verkar i motsatt riktning [spring force which acts in the opposite direction]
15. som [which]
16. which
17. acts in the opposite side
18. to the displacement
19. this is
20. the spring constant
21. which deter
22. mines the spring
23. and this is
24. dämp dämpnings konstant [damping constant] which determs the
25. dämpnings system [damping system]

*Note: actual values will fact much lower due to the high amount of Swedish in the transcript.
And here are Hope's descriptions from a course taught in English:

**Translated Swedish description** (Codeswitching to English in bold)

1. this **torque** thing
2. that's a bit strange and that too
3. but otherwise that
4. the **torque** is analogous to the force in one dimension
5. I understand that

SPS 3.7  MLR 8.7  Disciplinarity 2

**English description**

1. this equation
2. **jag alltså jag** [I well I]
3. the
4. the torque
5. alltså [well]
6. **jag kan läsa ut vad det vad det** [I can read out what it what it]

7. okay the torque
8. **kraf** [for(ce)]
9. the tangential
10. the tangential force times the distance
11. to the point P
12. from the
13. axis

SPS 1.6  MLR 3.8  Disciplinarity 1-2

Clearly, Hope has extreme difficulty talking about science concepts in English—so much so that the SPS and MLR values from both of her English descriptions become effectively unusable due to the high proportion of Swedish. Interestingly, she had few problems using English to talk about her background and the organisation of the courses, giving reasonably fluent descriptions of these in the introductory part of the interview. We can thus conclude that it is precisely scientific literacy in English which is absent. Although we cannot draw conclusions from such limited material, it is interesting to note that this interview took place in the early stages of the first course Hope had read in English. In comparison, Andy's more fluent descriptions came well into that particular course, and after previous experience of reading courses in English. Taken together then, the interviews with these two students may give some anecdotal support for Klaassen's (2001) finding that the negative effects of a language shift to English disappear over time. Despite her problems with English, Hope, like Andy, codeswitches to English in her Swedish description of concept that was taught in English.
Mia attended a single course taught in both English and Swedish. The course was offered in the first year of study and thus represents her first experience of being taught in English.

**Translated Swedish description**

1. Psaj has to be a continuous function
2. it has to
3. well, for each x-value or equivalent—what it is on this axis
4. there can only be one y-value
5. and
6. it's not allowed to
7. go to infinity anywhere
8. and
9. and the sum of
10. of well the area under
11. under the graph
12. from plu—minus, minus infinity to plus infinity in the x-direction must be one
13. well the integral
14. when you solve the integral to plus infinity.

SPS 3.0 MLR 7.5 Disciplinarity 3

**English description**

1. draw a picture of
2. the electron or what it is
3. and
4. visualize
5. what, what forces that affect the
6. the electron and
7. what its potential energy would be like
8. and then
9. therefore
10. and thereafter make some sort of a function of the potential energy
11. depending on the where
12. where the electron
13. is
14. then
15. because you can
16. use that function in the Schrödinger equation.

SPS 2.4 MLR 5.3 Disciplinarity 3

Mia does a good job of describing the content of the lectures in both languages—this is in stark contrast to the other first-year student in the study, Hope, who was taught separate courses in English and Swedish and found it impossible to describe disciplinary concepts in English. It is also noticeable that no codeswitching occurs in Mia’s descriptions in either language.
Discussion of techniques used to assess bilingual scientific literacy

We are now in a position to evaluate the contributions of the various measures to an understanding of student scientific literacy:

- **SPS and MLR**
  The SPS and MLR values appear to provide different information about fluency. For example when comparing Andy’s two Swedish descriptions, SPS is lower for the description of concepts taught in English, but the MLR is higher. This suggests that the overall speech was slower with longer pauses, but that more was said between pauses. Clearly, much more data is required before any judgement about the appropriacy of these two measures can be made.

- **Involuntary codeswitching**
  The introduction of involuntary codeswitching appears to be a useful indicator of students’ scientific literacy. Surprisingly perhaps, codeswitching was also documented in Swedish when students had been taught in English.

- **Disciplinarity**
  The estimation of disciplinarity, though somewhat difficult to assign, does serve to pick out those students who have weak scientific literacy. This is an important point since this is something not reflected in the purely linguistic SPS and MLR values.

Tentative conclusions and future work

The analysis of the limited dataset presented in this paper is a first attempt to estimate students’ oral bilingual scientific literacy from interviews, and to relate this estimation to the teaching language used. As such the paper should be read as a discussion of the methods needed for such work and clearly cannot claim to make recommendations as to the organisation of undergraduate science programmes. However a number of issues have been raised which warrant further investigation:

- **The problem of English scientific literacy**
  It is clear from the data that some students do have problems describing science concepts in English. Klaassen (2001) suggests that this may be something that reduces over time. Whether this is indeed the case, and if so, whether this reduction in problems is simply due to student drop-out, or the adaptation strategies documented by Airey and Linder (2007) is a major question for Swedish science education. A full analysis of the data collected in this study (n = 22) may help shed some light on this important area.

- **Teaching in two languages**
  In this study two of the students were experiencing lectures in English for the first time. It is noticeable that the student who was taught using a dual-language approach performed better than the student who was taught exclusively in English. This may, of course, be pure coincidence and further work is needed to assess whether a dual-language approach may indeed be a useful method for introducing students to teaching through the medium of English and fostering bilingual scientific literacy.

- **Teaching in English**
  The one student in this study who had previous experience of courses in English exhibited high levels of English scientific literacy without major negative effects on his Swedish scientific literacy. Whether this is a common pattern, and if so, why this should be the case is an area that I intend to investigate in my future research.
Acknowledgements
The author would like to thank Rebecca Hincks and Philip Shaw for helpful discussions about the linguistic methods used in this paper.

References


