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Patterns of Student Difficulty with Science Text in Undergraduate Biology Courses

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Abstract: Equality of access to tertiary education, especially biology, requires access to the language of science. Our analysis of the patterns in student responses to an authentic science passage in university biology classes may reveal an important reason why many students experience difficulty. An existing test of student control of the specialist language of English characteristic of science was administered to 285 students in undergraduate biology classes at the University of Guam, USA. The assessment uses traditional and modern grammar categories to analyse student responses to a gap filling exercise. The results indicate that entry-level students were having more difficulty than those who were further advanced in their study of biology and that, in general, students indicating that their families spoke Chamorro or other Micronesian languages at home had more difficulty than those specifying Philippine languages who, in turn, had more difficulty than those indicating that only English was spoken in their homes. The data were further analysed to indicate the specific features of the language of science that were problematic for particular groups of students. 'Cohesive devices', prepositions and nouns presented noticeable challenges for these undergraduate Biology students. Difficulty with the language of science may seriously impede the learning of science in the study population, even though they seemed more capable than the secondary students and other undergraduates in previous studies. The levels of difficulty for all groups compared thus far have been large enough to be of concern. In many science classes, a language-conscious approach could markedly increase the understanding of those groups of students experiencing most difficulty while supporting the conceptual development of students for whom language activities would serve a predominantly review function.

Keywords: Literacy, Discourse, Register, Diversity, EAP, ESP, EST

Introduction

UNDERGRADUATE SCIENCE STUDENTS are expected to learn a large amount of content information; introductory textbooks are typically encyclopedic and over a thousand pages in length (eg., Solomon, Berg & Martin 2005). Lecturers often require students to read the text before and after class and students are expected to self-remediate through use of such textbooks when they become confused about scientific concepts. However, the written language of science is rather different from the English that is routinely used and this unfamiliarity is even greater for non-traditional students. Such students are becoming more common with the widening of access to university-level study.

Non-traditional students include domestic language minority pupils, international students for whom English is one of a number of languages in which they are variously competent, and pupils from social groups with traditionally low access to education (Barba, 1995). Fortunately, changes in the composition of classes often lift teacher attention beyond the individual student and prompt concern for the progress of various groups of non-traditional students (Rosenthal 1996). For example, in the USA

there are many federally-funded programs to increase numbers of under-represented minorities in the science, technology, engineering, and mathematics disciplines (sometimes labelled 'STEM' studies). While this is a welcome trend, there has also been some reinforcement of negative ethnic stereotypes in a climate of rising enrolments and increasing demands upon the time of already busy academics. In this context, it is significant that previous research has indicated that difficulties with scientific language may not be restricted to non-traditional students (O'Toole 1985, 1998, Rosenthal 1996, O'Toole & O'Toole 2004). The problems of students from backgrounds with infrequent access to further study may suggest difficulties with specialist language that are being experienced much more widely. Scientific language presents challenges for most students. Student difficulties in reading scientific material are too often attributed to individual student failure in ability, interest, attention, application, time-on-task, and / or motivation.

The specialist English used in science material has been identified and described (Lemke, 1990, Halliday & Martin, 1993, Klein, 2004). While scientific English shares many features with more general English, these very similarities can obscure the existence of important differences that may impede

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learning. Each step in the teaching-learning process is called into question if the students cannot effectively access the textual material presented to them (Britton, Woodward & Binkley, 1993; Rockman, 2004). As students progress, they are increasingly required to demonstrate their control of such material through writing within that same specialist language (Ackles, 2003, Hailman & Strier, 1997). Students must use scientific language to predict, explain, speculate, and generalize (Halliday & Martin, 1993). In more advanced disciplinary writing, they must use evidence to justify conclusions and they must argue the need for their research projects (Sandoval and Millwood, 2005; Schefter & Lobban, 1997). A growing control of that same specialist language becomes crucial should they join the ranks of practicing scientists (Valiela, 2001).

Specialized forms of English have been a research focus at a variety of levels for many years. Historically, the early 20th century movement for text simplification, and the quantitative measures of readability associated with it, grew out of recognition of students' difficulties with the language of their junior secondary science books (Lively & Pressey, 1923). However, there has been less recent quantitative analysis of linguistic patterns of student difficulty. Lack of writing ability has been of apparently greater concern in recent decades (Hand, Prain, Lawrence, & Yore, 1999; Prain & Hand, 1999; Unsworth, 1997) but access to text through reading has not entirely disappeared from view (Bowen & Roth, 2002; Carnine & Carnine 2004, Engen & Høien, 2002; Humphreys, 2002; Koch & Eckstein, 1995; Paterson, 1996; Peacock, 1996; Peterson & Van Der Wege, 2002). While various specialist varieties of English have caused concern, there has been little study of student ability to read tertiary biology or of particular language characteristics that cause difficulty at this level.

The objective of our investigation is a structural understanding of difficulties with scientific English experienced by undergraduate biology students in an English-medium university that serves students from diverse language backgrounds. Relevant characteristics of the student group are provided in Table 1. The study is significant in that it uses both traditional (or dictionary) categories and modern grammar categories to analyze student responses to a gap filling exercise constructed from an authentic science text. The work could serve as a baseline against which the effectiveness of language interventions could be compared and as the basis for further comparison with language difficulties experienced by student populations from other places.

This Investigation

This paper reports an investigation of the difficulties with scientific English for students in university biology classes. The students providing the data were studying in an English-medium university that serves students from diverse language backgrounds on Guam, mid way between Japan and New Guinea. The island is geographically but not politically part of Micronesia, which is a geographic region of the western Pacific including Guam, the Commonwealth of the Northern Mariana Islands, Palau, the Federated States of Micronesia, and other countries. Guam is a territory of the United States of America, with approximately 155,000 people who speak several different varieties of English. The local Chamorro people make up about 42% of the island population, with people of Filipino ethnicity making up a further 27% (U.S. Census Bureau, 2003). Depending on the situation, some people choose to communicate in a standard form of English while others use a more marked island variety, 81% of the students speaking a language here classified as 'Micronesian' identified themselves as Chamorro.

Our investigation was designed to provide a baseline for indication of the effectiveness of language interventions and to provide the basis for comparison with the language difficulties experienced by student populations from other places. The assessment was partially funded by grants to the University of Guam from the U.S. Department of Education Minority Science and Engineering Improvement Program and the National Institutes of Health, National Institute of General Medical Science Minority Biomedical Research program.

This paper describes the pattern of difficulties that characterized students identifying different heritage languages who were taking biology courses at the University of Guam in 2006 (see Table 2). The courses included several taken primarily by biology majors, two courses taken primarily by pre-Nursing students, and two courses for other non-biology majors ("general education" courses). In most U.S. universities, students must pass at least eight credits of science as part of general education.

The data from this Guam investigation were compared with earlier investigations of difficulties with scientific English that were experienced by secondary school pupils in four nations (O'Toole 1998) and by undergraduates in the People's Republic of China (O'Toole & Absalom, 2004). The high school study provides a basis for comparison with students from language backgrounds similar to those found on Guam, while the Chinese study provides a basis for comparison with students at a similar level of education. The Chinese data also allows a contrast between 'English as a Second Language' (ESL) and 'English as a Foreign Language' (EFL) contexts.

The present discussion will focus on a more detailed analysis of the language dimension from Table 1.

Table 1 Characteristics of Guam Student Group

Dimension	Category	No. of Students
Language spoken at home	English	108
	Other	177
Program level	Year 1	86
	Year 2	112
	Year 3	63
	Year 4	24
	Baccalaureate	8
Gender	Male	116
	Female	169
Place of Birth	Continental USA	41
	Other	244
Total Number of Students		285

Nature of Instrument

The investigation made use of a valid and reliable gap-filling task that had been used in previous studies, including those of secondary school and university groups mentioned above. Such gap filling tasks are often described as 'cloze tests' (Oller & Jonz, 1994). The instrument was based on a 310-word passage, dealing with the body's defences against disease, which was adapted from a Year 9 school science text (Heffernan & Learmonth, 1990). The use of a base passage from a school textbook written for fourteen-year old students makes the investigation conservative in terms of its identification of the language difficulties being experienced by college students at least in their late teens and early twenties.

The students who are the focus of the present investigation were all enrolled in biology courses at the University of Guam (UOG). The base passage (preserved in the Appendix) might reasonably be expected to form part of the background knowledge of such students. The passage itself had a machine-generated Flesch readability grade of 11 (Flesch-Kincaid 12.2) which may well have been excessive for its original Grade 9 target group but seems appropriate for the students participating in the present study. One would not expect such a passage to be difficult for undergraduate students.

This instrument was developed by leaving the section heading and first sentence untouched and then deleting every fifth word thereafter until fifty deletions were made. The next sentence of the base passage was then left untouched to complete the instrument, which is also preserved in the Appendix.

The cloze procedure was invented as a way of directly measuring text against reader in an attempt to produce a reliable indication of readability (Gilliland, 1972). It has been widely used, in a wide variety of forms, since it was proposed in the 1950s

(Taylor, 1953) and popularized in the 1970s (Oller, 1979). Several considerations contribute to making versions of the cloze technique attractive to instructors and researchers. The procedure for preparing a cloze measure is potentially objective. As indicated by the description above, cloze tests can be relatively easily made from authentic text without having to create potentially subjective or confusing questions as in open-ended tests, or questions and potential responses as in multiple-choice tests. Various versions of cloze have been used to investigate interactions between bilingualism and critical thinking in nursing students (Albert, Albert & Radsma, 2002), adult learner access to instructional material (Allison et al., 1995), reading competence of young children with language and phonological disorders (Bellon-Harn, Hoffman & Harn, 2004), brain activity underlying linguistic processing (Duarte-Exposito et al., 2004) and hemisphere involvement in language function (Faust & Kravetz, 1998), convergence of sound and meaning in word choice (Ferreira & Griffin, 2003), readability of public health (Gemoets et al., 2004) and hospital (Wilson, 2000) information, language development among the deaf (Kelly, 1996) and communication difficulties induced by psychosis (Newby, 1998) and autism (O'Connor & Klien, 2004). There has been some controversy surrounding cloze (see, for example, Kobayashi, 2002a, 2002b; Chen, 2004; Kobayashi, 2004) but the purpose, form and coding of the instrument used in this study differ substantially from the cloze tests that have attracted most criticism. The analysis of student group conceptually scored response to deletions representing particular language classes seems defensible.

The reliabilities of the particular instrument and its sub-scales are conventionally acceptable and discussed in more detail below. The instrument possesses considerable face validity (conceptually correct replacement would seem to indicate control of the deleted language class), content validity (the base

text seems appropriate in terms of content and readability), construct validity (those students who could be expected to be most linguistically adept do exhibit lower levels of difficulty) and criterion-related validity (cloze tests have consistently produced acceptable levels of correlation with other tests of readability and student language competence).

The questions regarding student background that appeared on the back of the answer sheet allowed the establishment of various groups within the population (see Tables 1 & 2). This means that details such as heritage language or familiarity with content rest on student disclosure and are subject to the strengths and weaknesses of all such data. For example, it is possible that the 'Micronesian' group under-represents the local population, as some students from Chamorro-speaking homes may have chosen to associate with the dominant culture by specifying U.S. English as their home language. The University of Guam registrar confirmed this tendency. Data leakage, from the group that might be expected to have the greatest degree of difficulty to that which might be expected to have the least, may narrow the gap between the apparent performances of the two groups. The survival of a statistically significant gap may therefore be more practically significant than it might otherwise have been.

Coding of Cloze Items

Student replacements of the words deleted to form the particular cloze test preserved in the Appendix were analysed in detail. Deletions that were filled with exactly the same word as that in the original passage were coded as instances of '*exact replacement*'. Suggestions of words that are clearly wrong were coded as '*error replacement*'. A response was coded as '*conceptually correct*' if it differed from the 'exact' term but its use maintained meaning in the passage. Summing the exact and conceptually correct replacements yielded the *conceptually correct total*, while the sum of the clear mistakes yielded the *error total*. Omissions were coded as errors when they preceded an entry attempt but were not so coded when they followed a student's last attempt at inserting a deleted word, thus not directly penalizing students who did not complete the test.

Grading cloze tests by counting the number of exact replacements yields distributions with lower means than would be generated by counting the number of conceptually correct replacements. A mean exact total of 57% or more indicates that students from the group that completed the cloze test should be able to read the text independently (Robinson, 1981). To put that another way, adept readers may incorrectly replace 21 of the 50 deletions based on text that they could actually read quite ef-

fectively. Analysis of only exactly correct student deletion replacements would therefore overstate student difficulty, if the nature of difficulty represented by each individual deletion is the focus of attention. Accepting conceptually correct replacements should increase the validity of analysis of patterns of individual deletion replacement.

Drawing on earlier work by Bormuth, Robinson (1981) suggested that Cloze scores of less than 37% would be associated with reader frustration. Such a score indicates incorrect replacement of 31 fifth-word deletions from a 250 word passage. Such a score based on acceptance of conceptually correct replacements would seem even more worrying.

The alternatives coded as conceptually correct might not always appear appropriate when the replacements are considered in isolation but when the context of the passage as a whole is considered, it becomes clear that different pupils are reconstructing different passages while maintaining the original meaning. The relatively generous procedure (summing exact and conceptually correct replacements) is more likely to underestimate pupil difficulty with particular stylistic features than it is to produce an inflated estimate of difficulty.

Consequently, the difficulties which are exposed by the conceptual coding technique are more likely to be of practical significance than might be the case if a less conservative approach to error identification were adopted. These conservative coding practices make it more likely that this investigation will reveal both the levels and nature of difficulties thus yielding both practical and statistical significance.

Describing Item Language Features

Each cloze item was classified both by its traditional (or dictionary) category and its modern grammar category. This two-stage model allowed the formation of language feature sub-tests whose results could be discussed separately, in turn allowing the comparison of levels of pupil difficulty with particular characteristic features of the scientific English.

The dictionary categories are the traditional parts of speech: *Noun*, *Pronoun*, *Adjective*, *Article*, *Verb*, *Adverb*, *Conjunction* and *Preposition* (Crystal, 2000). The modern grammar categories used in this study were *Technicality*, words with special meanings in the target style or unique to it (Herbert, 1965; Martin, 1993); *Grammatical Metaphor*, where a word of one dictionary category functions as a member of another (Halliday & Martin, 1993, p. 13); *Word Stacks*, where a final noun is modified by a string of adjectives or 'metaphorical adjectives' (Stevens, 1977; Trimble, 1985); *Voice*, where the actor in an action is concealed (Cooray, 1965; Kess, 1993; Trimble, 1985) and *Cohesion*, which refers to the patterns of

repetition and referral that hold paragraphs together (Connor & Johns, 1990; Halliday & Hasan, 1967).

The particular passage used as the basis for the existing work on undergraduate language difficulties was drawn from a much larger study of language difficulties at the secondary school level (O'Toole, 1998, 2000). The set of language features sampled by this cloze test based on that passage was not comprehensive; the larger secondary study indicated that the language feature sub-tests extracted from it were not equally reliable. Features which were either not sampled or yielded sub-tests with Cronbach's ALPHA less than 0.5 do not appear in the results that follow.

Framework for a Guam Baseline and Comparison with Existing Data

As is apparent from the background detail sheet preserved in the Appendix, Guam students were presented with a number of alternatives regarding their heritage languages. This generated numerous categories containing few members and so heritage language data was recoded into language groups. Application of SPSS14 to the data yielded information regarding the comparative language performance of students from different language backgrounds (Table 2).

Table 2 Language performance of Guam students of differing language background

Language Group	Mean Conceptual Total (/50) ^A	Number of Students	Standard Deviation
English	35.5	108	7.25
Korean	36.0	4	4.55
Micronesian ^B	29.9	43	11.35
Filipino	33.6	124	8.16
Other	34.5	6	7.72
Total	33.8	285	8.48

NOTES:

^A The 'Mean Conceptual Total' is the average number of deletions from the relatively simple base passage which undergraduate students claiming the specified heritage language filled with a word that maintained the meaning of that passage.

^B The great majority of those speaking a Micronesian language were Chamorro (81%).

The apparent differences between the conceptual total scores on Table 2 are statistically significant at the conventional level ($p < 0.05$, $F = 2.516$, $Sig = 0.022$), implying that they merit further discussion. Students claiming English as the language spoken in their homes were unable to suggest words for almost one deletion in three. This is of concern given the relatively simple passage (for a college audience) on which the test was based. It is even more concerning that students specifying Chamorro or other Micronesian languages were unable to suggest conceptually adequate replacements for more than two words in three. There may well be information of practical significance here.

The relative numbers of students in each group suggests that results from students specifying English, Micronesian and Filipino languages as their heritage might be of most use. The recognition that

students specifying English as their home language perform better on tests of scientific language than those specifying Micronesian or Filipino confirms common assumptions, but it is not of great practical importance at that level of specificity. It would be more useful to know *which* features of the scientific style are difficult. Table 3 provides that information. Table 3 reports difficulty levels, based on error total calculations, for groups of Guam students claiming specific heritage languages (Rows A to D) and comparable data from earlier studies (Rows E to G). Any apparent small inconsistencies between the results on Row D (overall Guam sample) and those on Rows A to C (language groups based on heritage languages specified by Guam students) and between the 'Overall Difficulty' column and the language feature columns result from reduction of data to integer values.

Table 3 Student difficulty with features of Scientific English

Row	Language Group	No. (% of sample)	Noun % wrong Comp. Sample D'fclty ^B	At'cle % wrong Comp. Sample D'fclty	Verb % wrong Comp. Sample D'fclty	Prp'n % wrong Comp. Sample D'fclty	Tchlty % wrong Comp. Sample D'fclty	Word Stacks % wrong Comp. Sample D'fclty	Pas've Voice % wrong Comp. Sample D'fclty	Cohsy Device % wrong Comp. Sample D'fclty	Overall D'fclty % wrong Comp. Sample D'fclty
A	English	108 (39%)	32 -3	23 -4	23 -4	29 -4	20 -3	12 -2	23 -5	35 -4	30 -2
B	Micronesian	43 (15%)	40 +5	42 +15	37 +10	41 +8	27 +4	24 +10	40 +12	47 +8	40 +8
C	Filipino	124 (43%)	36 +1	27 0	26 -1	34 +1	24 +1	13 -1	28 0	39 0	32 0
D	U/G Guam	285	35	27	27	33	23	14	28	39	32
E	U/G Chinese Sample	114	53	39	52	47	48	32	43	38	49
F	Secondary Filipino	380	49	33	48	55	37	20	46	52	47
G	Secondary English	179	45	29	39	41	37	25	36	41	42

NOTES:

^A % wrong: The data on this table is based on the error total calculation for students claiming the specified language on the appropriate language feature sub-test.

^B Comparative Sample Difficulty: Difference between the difficulty a particular group (e.g., pupils specifying English as the language spoken in their homes) experienced with a specific feature of the language of science (e.g., nouns: 32%) compared to the mean level of difficulty with this feature experienced by Guam sample as a whole (e.g., 35%, yielding a comparative difference of -3 for English specifying Guam student difficulties with nouns).

Discussion of the data in Table 3 will begin with comparison of the overall difficulty being experienced by the different groups of students and then move on to the detail permitted by the language feature sub-tests. The first and most obvious thing emerging from Table 3 is the relatively high performance of the Guam sample on this school-based instrument. In terms of overall difficulty (right hand column of Table 3), the Guam students averaged 32% clear error on this cloze test (Row D). They got roughly one deletion in three wrong. This is significantly lower than that reported from the earlier studies (Rows E to G, where the error rate approached one in two). There are probably fewer obvious or deep problems in this student group from Guam than in others. However, we might have expected them to have made fewer errors than they did. The level of difficulty indicated here may make it difficult for these students to effectively comprehend college science texts. In practical terms, they could have difficulty accessing many of the books from which their lecturers expect them to remediate.

It is not surprising that undergraduate students specifying English (Row A) and Filipino (Row C) should have less difficulty than their younger secondary school counterparts (Rows G and F). Neither is it surprising that undergraduate students in a context where English is a First or Second Language (Row D) might have less trouble than those studying where it is a Foreign Language (Row E). However, the results for different heritage language groups (Rows A to C) within the Guam sample provide some cause for concern. It appears that students claiming Chamorro and Micronesian heritage languages (Row

B) may have the greatest degree of difficulty with the language of their undergraduate science books.

Further, the results of the modern grammar language feature sub-tests expose a number of specific difficulties. It appears that these students studying biology in Guam are having greater difficulty with the dictionary category of 'noun' than they do with the related modern grammar category of 'technicality'. This may indicate gaps in the general language development of students sampled. This is supported by anecdotal reports from the testing process indicating that the biology majors were happy to replace 'biological' words but less comfortable with the less 'scientific' features of the language. It appears that those students specifying Chamorro or other Micronesian languages as their heritage language had the greatest degree of difficulty with both of these features (5 points above mean for 'noun' and 4 points above mean for 'technicality'). 'Cohesive devices' seem to be the most difficult feature for this group of undergraduates from Guam (error rate 39%). This may again reflect student inattention to 'non-scientific' aspects of this language test, as may the lower (though still worrying) difficulty experienced with 'prepositions' (33% error rate).

The levels of difficulty experienced by these undergraduate biology students are certainly lower than those experienced in other places tested. However, even this level of difficulty with scientific English is likely to impede their acquisition of scientific ideas. A difficulty level of 35% with nouns means that an 'average' undergraduate in Guam is likely to misunderstand one noun in three from what they read. The fact that they will comprehend most of the technical words does not mean that they will under-

stand what they read or hear. This results in student answers that involve throwing technical words at the page, once the student recognizes one or two technical words in a question. Missing the impact of almost half of the articles in a passage (as appears to be the case for Guam undergraduates from Chamorro or other Micronesian backgrounds) can lead to misinterpreting the specificity of potentially key information. Similarly, inability to recognize the relationships communicated by more than a third of the prepositions in a passage may well leave a reader with a faulty conception of what the writer intended to say. Difficulties with one cohesive device in three (or up to half in the case of Chamorro and Micronesian-background students) are very likely to compound this confusion, as readers lose their grip on the conceptual flow through a passage.

It is clear from Table 3 that Guam students need assistance to develop their command of scientific English; the language problems are widespread and

potentially damaging to student learning. Different groups of undergraduate students experience different degrees of difficulty with a range of language features. Even though the extent of difficulty being experienced by these undergraduate students is less than that experienced by other students in other places, the problems are important enough and broad enough to deal with in a comprehensive manner. Information such as that provided by Table 3 allows people responsible for teaching science to such students to begin with the areas of scientific English that are most likely to be difficult for particular groups, confident that students from other groups who share the classroom will be experiencing enough difficulty to make direct treatment of the language features useful to them as well.

The study data is amenable to similar analysis on a course-by-course basis. Table 4 summarizes the data gathered from the different biology classes.

Table 4 Language performance of Guam students from different biology courses.

Class ^A	Mean Conceptual Total (/50)	Standard Deviation	Numbers of Students ^B	
BIO 100	32.8	7.88	E=23 F=25	M=20 T=68
BIO 124	32.2	8.80	E=39 F=2	M=125 T=108
BIO 157	36.7	6.65	E=20 F=12	M=5 T=38
BIO 225	31.7	8.43	E=13 F=21	M=0 T=38
BIO 315	43.6	4.09	E=5 F=4	M=1 T=10
BIO 410	39.9	4.58	E=6 F=4	M=4 T=14
BIO 416	37.8	10.76	E=5 F=4	M=0 T=9
Total	33.8	8.48	285	

NOTES:

^A **Course type:** BIO 100 General Education option (majors other than biology); BIO 124 first year pre-nursing students; BIO 225 second year pre-nursing students & biology majors; the other BIO courses are for biology majors.

^B **Student language background:**

E=English, M= Chamorro or other Micronesian, F=Filipino, T=Total

The apparent differences between the conceptual total scores on Table 4 are statistically significant at a more rigorous conventional level ($p < 0.01$, $F = 5.449$, $\text{Sig} = 0.000$). In general, students in the larger, entry level courses (BIO100 and BIO124) are having more difficulty than those in later courses, although the lowest mean came out of the second year course (BIO225).

In summary, the results of our investigation indicate that university students specifying Chamorro or another Micronesian language as being spoken in their homes are likely to experience more difficulty than their classmates who specify Philippine languages who, in turn, can be expected to experience more difficulty than their classmates who indicated that they were monolingual in English. Students at

the beginning of their undergraduate study are likely to experience more difficulty with the language of their biology courses than students who have progressed further through university. Biology majors are likely to experience less difficulty than other students. The results showing that more experienced students have less difficulty with specialist language is perhaps unsurprising, but a possible interaction with language background is more worrying. The differences between the heritage language groups are statistically significant and of practical interest, but it is their similarity that points towards a response to any possible differential attrition.

Pedagogical Implications - Response to Language Difficulties in Biology Classes

The pattern of features that is most difficult for particular groups of students could guide the preparation of material that will assist most students. In other words, for Guam university students and for many other students, most science texts and many other college texts are likely to be at frustration level. It seems sensible to suggest that students who comprehend less than half of what they read experience frustration. Such students would need considerable linguistic coaching to lift their reading to their instructional level. The results of this investigation of language difficulties in a relatively high performing population included levels of difficulty approaching that level on a text that might be expected to be significantly easier than those from which these students are asked to learn.

One strategy for responding to these difficulties includes developing language-conscious exercises that communicate key biology concepts. Let us assume that entry-level undergraduate students are using a textbook such as Solomon, Berg and Martin (2005). Books such as this are often accompanied by purpose-written study guides (such as Daniel, Daniel & Taylor, 2005). These workbooks often contain completion and editing exercises focussed on technical terms. These formats or frames could be used to focus directly on other features of the specialist English that characterises science, for example, patterns of cohesion, word stacks, and passive voice. O'Toole (2000) contains a collection of language exercise frames that can be used to develop other exercises (in any content area). Such frames could be fruitfully used to generate language development exercises that reinforce the textbook content.

The results of the present investigation suggest that many students in university and community colleges, in fact, in many biology classes, could usefully complete and discuss such exercises. Previous research at the secondary school level indicates

that such use would assist those students having most difficulty with the specialist language while serving as language-conscious review for those who are already adept in the use of general English. As noted by Rosenthal (1996) and O'Toole & O'Toole (2004), everybody benefits from language-conscious instruction.

Our results and suggestions are also of potential interest to academics who offer courses in other contexts that attract international students from diverse backgrounds to study in English-speaking contexts. Our work may be particularly relevant to those who draw significant numbers of students from more clearly non-English speaking contexts than those prevailing in Guam, USA. Difficulties such as those reported here for Guam may suggest areas for fruitful investigation in other locales. Successful strategies, including development of materials for Guam undergraduates, may be useful elsewhere. Analysis of the specific difficulties being experienced by students from differing language backgrounds in particular classes could guide the creation of suites of exercises whose precise focus should enhance their effectiveness. The analysis of patterns of difficulty and effectiveness of precisely focused exercises could be a fruitful direction for further research.

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Appendix

Test Administration script
A TEST OF LANGUAGE IN SCIENCE

Thank you for participating in this study.

Please distribute the sheets in this envelope. Each student should get a **cloze test** (a passage with every fifth word replaced by a numbered blank) and an **answer sheet** (which is printed on both sides of the sheet).

Please read the following statement to the class.

"Science books are sometimes hard to read. These sheets are part of an attempt to find out what parts of the writing are hard to understand. Please listen carefully before you fill in the sheets. People are doing this test in three different countries.

You should have a question sheet and an answer sheet. The question sheet is printed on one side of the paper and the answer sheet is printed on both sides. Put up your hand if you don't have both sheets.

The writing on the question sheet is taken from a science book, but some words have been taken out and replaced by numbered blanks.

One side of the answer sheet has numbered lines on it. You should read the writing on the question sheet, and put the words which you think belong in each space onto the answer sheet. Put each word onto the line with the same number as the gap which you think it fills.

The other side of the answer sheet has a number of questions on it. Please answer these questions first.

You have the rest of the period (around 45 minutes) to fill in the answer sheet.

This test is designed to show up the features of the science writing which are difficult for students from different language backgrounds. Your responses and answers will not be used to grade you, nor will your information be individually identified. Please do your best and answer the questions truthfully."

Text on which cloze test was based.***“Natural defenses against infectious diseases***

When disease-causing microbes try to invade our bodies, we have a number of natural defences, many of which will fight *any* infection.

1 *Skin, mucus and tears*

When unbroken, the skin on the outside of the body and the moist layers of the skin that line the mouth, nose and lungs help keep out unwanted microbes. Hairs to keep out disease-carrying dust particles are contained in the nose, and any that get past the hairs into the nose or lungs are caught by the sticky mucus, from where tiny hairs, provided that they have not been killed by tobacco and marijuana smoke, remove mucus and trapped microbes quite efficiently. Bacteria that reach the stomach are finally killed by its high acidity, although their spores can often pass through to the intestine. Chemicals in the tears can kill bacteria that try to invade the eyes.

2 *White blood cells*

If the disease-causing microbes are able to get into the body through a burn or a wound, then the second line of defence comes into play, whereby any invaders are engulfed by some types of *scavenging* white blood cells. Certain smaller white blood cells arrive in the blood and attack the invaders directly. Any leftover microbes and dead and dying cells are removed when a larger cell type arrives later. Some invaders, such as worms, are too large for white blood cells to engulf, so there is a third group of scavengers that release enzymes outside their cell body, which then attack the skin of the invading parasites.

3 *Inflammation and fevers*

If the invaders overcome this attack by the antibodies and white blood cells, they will consequently start to multiply. The body responds by sending in more white blood cells and antibodies and at the same time it also tries to block off the area invaded.”

(modified from Heffernan, D.A. & Learmonth 1990; pages 299, 300)

Cloze test**8D1**

Some words have been taken out of the passage below. The words have been replaced with numbered blanks.

Write the word which fits into each blank next to its number on the **answer sheet**.

Do not make any marks on this sheet.*Natural defenses against infectious diseases*

When disease-causing microbes try to invade our bodies, we have a number of natural defences, many of which will fight *any* infection.

1 *Skin, mucus and (...1...)*

When unbroken, the skin (...2...) the outside of the (...3...) and the moist layers (...4...) the skin that line (...5...) mouth, nose and lungs (...6...) keep out unwanted microbes. (...7...) to keep out disease-carrying (...8...) particles are contained in (...9...) nose, and any that (...10...) past the hairs into (...11...) nose or lungs are (...12...) by the sticky mucus, (...13...) where tiny hairs, provided (...14...) they have not been (...15...) by tobacco and marijuana (...16...), remove mucus and trapped (...17...) quite efficiently. Bacteria that (...18...) the stomach are finally (...19...) by its high acidity, (...20...) their spores can often (...21...) through to the intestine. (...22...) in the tears can (...23...) bacteria that try to (...24...) the eyes.

2 *White (...25...) cells*

If the disease-causing (...26...) are able to get (...27...) the body through a (...28...) or a wound, then (...29...) second line of defence (...30...) into play, whereby any (...31...) are engulfed by some (...32...) of *scavenging* white blood (...33...). Certain smaller white blood (...34...) arrive in the blood (...35...) attack the invaders directly. (...36...) leftover microbes, and dead (...37...) dying cells are removed (...38...) a larger cell type (...39...) later. Some invaders, such (...40...) worms, are too large (...41...) white blood cells to (...42...), so there is a (...43...) group of scavengers that (...44...) enzymes outside their cell (...45...), which then attack the (...46...) of the invading parasites.

(...47...) *Inflammation and fevers*

If (...48...) invaders overcome this attack (...49...) the antibodies and white (...50...) cells, they will consequently start to multiply. The body responds by sending in more white blood cells and antibodies and at the same time it also tries to block off the area invaded.

CLOZE ANSWER SHEET

Date: _____

Write the best word to fill the blank next to the numbers.

For example: Tokyo is a (...X...)

(X) city

(1) _____	(26) _____
(2) _____	(27) _____
(3) _____	(28) _____
(4) _____	(29) _____
(5) _____	(30) _____
(6) _____	(31) _____
(7) _____	(32) _____
(8) _____	(33) _____
(9) _____	(34) _____
(10) _____	(35) _____
(11) _____	(36) _____
(12) _____	(37) _____
(13) _____	(38) _____
(14) _____	(39) _____
(15) _____	(40) _____
(16) _____	(41) _____
(17) _____	(42) _____
(18) _____	(43) _____
(19) _____	(44) _____
(20) _____	(45) _____
(21) _____	(46) _____
(22) _____	(47) _____
(23) _____	(48) _____
(24) _____	(49) _____
(25) _____	(50) _____

PLEASE ANSWER THE FOLLOWING QUESTIONS.
PUT THE CORRECT ANSWERS ON THE LINES BELOW.
FILL THE LINES BEFORE YOU COMPLETE THE CLOZE TEST.

What is the name of your school, college or university?

What is your highest educational qualification?

How long have you been in your present course?

Are you familiar with the content of the reading passage?

Are you male or female?

Where were you born?

Where was your mother born?

What form of language do your parents speak at home? *(please tick one line)*

Arabic		.....	( )
Chinese	Standard (<i>Putonghua</i> 'Mandarin').....	.....	( )
	Cantonese.....	.....	( )
	Hokkien.....	.....	( )
	Nanjing.....	.....	( )
	Other Chinese.....	.....	( )
English	British	<i>Standard</i>	()
		<i>Scots</i>	()
		<i>Irish</i>	()
		<i>Welsh</i>	()
		<i>Other regional</i>	()
		<i>Pasva</i>	()
	American	<i>Standard</i>	()
		<i>Northern</i>	()
		<i>Southern</i>	()
		<i>Ebonic</i>	()
		<i>Islander</i>	()
	Australian	<i>Other regional</i>	()
		<i>Standard</i>	()
		<i>Aboriginal</i>	()
		<i>Regional</i>	()
Greek		.....	( )
Italian		.....	( )
Japanese		.....	( )
Korean		.....	( )
Macedonian		.....	( )
Micronesian	Chamorro.....	.....	( )
	Palauan.....	.....	( )
Philippine	Standard (<i>Tagalog</i>).....	.....	( )
	Cebuano.....	.....	( )
	Ilocano.....	.....	( )
	Other regional.....	.....	( )
Polynesian	Maori.....	.....	( )
	Tahitian.....	.....	( )
	Tongan.....	.....	( )
	Samoan.....		()
	Other regional.....		()
Serbo-Croat			()
Spanish			()
Vietnamese			()
Other (please specify)		(.....)	()

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Dr. J.M. O'Toole has long been involved in the preparation of resources for science teachers who have become conscious of the language component of their expectations of students at various levels of education. He is currently responsible for secondary science teacher preparation and post-graduate re-training at the University of Newcastle. Mitch's major research interests are in the impact of language style on science teaching and in the interaction between student and teacher understandings of the history and nature of science. He has published many articles in both national and international journals as well as textbooks and research-based teacher resource books for secondary science.

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