Engagement of ESL Students with a Science Course Delivered in English with an Emphasis on Assessment Using a Learning Management System

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***Abstract*—The use of an LMS provides the potential for a particularly rich engagement of students with material in ways which can best suit, or at least supplement, their preferred learning styles. A course in environmental science was conducted with freshman ESL students where there was a heavy emphasis on on-line assessment using an LMS. The main pedagogical strategy was to allow 24/7 access to the material and allow students to practice both their reading of complex multiple choice questions along with reading and writing the explanations to these questions. Student success was high in terms of on-line invigilated assessment. Interestingly, the frequencies of student engagement with the on-line multiple choice aspects of the course were highly skewed, coinciding with deadlines for submission. Student success in an oral defence was high and strongly correlated with multiple choice results. In contrast, despite students having access to written model answers and marking schemes, performance on written components of the exams was not strongly correlated with performance in multiple choice components. In-depth interviews with students gave insight into students' strategies in engaging with the LMS in general and the on-line tests in particular.**

***Index Terms*—ESL, English as second language, LMS, Learning Management System, assessment**

I. Introduction

Our students undertake bachelor programs in the area of resilience including integrated emergency management and continuity management. The students' first language is Arabic and the programs are delivered in English. All programs share a common first year of general education and include science courses (one of which is the focus of this study).

The teaching of a discipline to students whose second language is English (ESLs) is a complex task, in which the students are confronted with not only the discipline and its own set of unique concepts and paradigms, but with the English language itself, as well as the nuances of academic English and, more particularly, the discipline's own linguistic style and vocabulary [1], [2]. Even for native speakers, the issues of learning academic English, and its discipline-specific counterpart, present considerable difficulties in acquiring a sufficient level of literacy [3]. In a scientific discipline, that literacy requirement extends to requiring students to understand scientific texts with their own set of unique vocabulary, to interpret and apply information, and to answer and make predictions about science [3].

Thus, teachers of science to ESLs are presented with difficult questions, not the least of which arise at the points of evaluation and assessment. It is these points in particular which were of interest in this study. For example, of concern was whether students' incorrect written responses to assessment items are due to misconception, that is, they didn't really understand the concept being tested, or misrepresentation, that is, they understood the concept being tested, but misrepresented their understanding because of a lack of linguistic proficiency [4]. Moreover, where assessment items were multiple-choice or true/false in nature, concerns whether students' incorrect responses were due to misinterpretation, that is, they had difficulties comprehending the assessment items, rather than them truly having misconceptions. Issues of comprehension arise even for native English speakers, particularly in relation to multiple-choice and true/false items. This is evident in any reputable textbooks on assessment, as they routinely address the treatment of issues around designing well-worded and well-constructed items (for example, see [5]).

A pilot study was conducted in the two years preceding this study that indicated students were comfortable using multiple Learning Management (LMS) systems and were competent in accessing these systems for the syllabus, lecture notes, readings, and their regular submission of assignments. Moreover, students used a variety of devices for access to the LMS, primarily phones and tablets and, to a lesser extent, laptops and desktops. The level of comfort and ability demonstrated by students in using an LMS is consistent with a major study of first year native English speakers in Canada [6]. It would not be inconsistent or inappropriate therefore to label these students "digital natives" [7], [8]. While the use of such a term is a blunt instrument as, on one level, these students

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exhibit technological competence, this does not necessarily translate directly to the use of electronic technologies to promote higher-level academic cognitive abilities [9].

The level of ease with which students engaged with the basic functions in the LMS, their obvious need to get feedback about their progress in their studies, the requirement to track student engagement with the material, and the use of modelling written answers to assessment items, all contributed to the decision to focus on employing the LMS to allow the students prior on-line engagement with the assessment items. To this end, the course was established in the LMS with an item bank of appropriate size using multiple choice, true/false, and short answer items that allowed the students to practice reading the items before selecting the answers. All items contained written feedback about why particular answers were correct (or incorrect). The students were also informed that all summative tests would consist of either on-line invigilated assessment or written assessment where students had to explain their chosen answers, or oral assessment, thus functioning in a form of defence of their choice of answers.

II. Literature Review

There is often a perceptual gap between students' conversational abilities, which are often viewed as fluent and referred to as basic interpersonal communication skills [10] and their abilities to function in the domain of academic English, in which students may have great difficulty reading, writing and talking about concepts [3]. This makes some sense, since the demands of conversational English rarely extend to those of its academic counterpart, namely, requiring students to speculate, hypothesize and, arguably most importantly, display a level of rigour of thought not normally required in everyday conversation. Moreover, academic language can have different meanings to that of everyday usage and requires a rigorous specificity of its usage. For example, the use of "element" and "compound" in chemistry, which have very specific conceptual meanings, when misapplied by students, tend to be interpreted as being due to a lack of understanding of the concept rather than its conflation with problems of linguistic fluency. It is that difference between the requirements of fluency in conversational English and those of its more rigorous counterpart, academic English, that were exemplified in a study that attempted to quantify the burden of writing research articles in English by professional scientists whose first language was Spanish [11]. The subjects of the study were all first-language Spanish-speakers from a major research institute and a state university and who published at least half of their research in English. The data clearly pointed to these scientists' main difficulty being linguistic, rather than disciplinary in nature, and is consistent with other studies indicating greater difficulty in writing in second-language English (for example, see [12], [13]). The difference in the literacy skills of ESLs and native English speakers can be referred to as a literacy gap [14].

Whilst there are clear and obvious difficulties and challenges in teaching discipline-specific content such as science to ESL students, the process could be viewed more as opportunity than challenge. This notion of opportunity has been recently expressed in curriculums of teaching English for specific purposes. Indeed, the concept of English for Specific Purposes (ESP) has had a bridging effect across various disciplines allowing students to learn English in authentic discipline-specific contexts [15]–[17]. Thus, one could conceptualise the teaching of science as a specialised brand of teaching English for Specific Purposes (ESP), that is, English for Scientific Purposes (ESP) [17].

In summary then, the teaching of ESL students produces the proverbial coin with two very different sides. On one side, significant challenges exist because the students are required to punch well above their linguistic weight, raising practical questions about the validity of assessment instruments, and philosophical questions about student learning outcomes. On the other side, opportunities arise to give students an authentic, contextualised learning experience. Whilst it could be viewed that the teaching of science to ESL students is an opportunity to teach ESP, this of course is tempered by the real-world in-class experience of dealing with students who may apparently exhibit a level of competence that is clearly not reflected in their written test scores.

Of particular interest in this study were the following questions:

1. How do our students engage with the elements of the course accessible in the learning management system (Moodle)?
2. How frequently and to what extent do students engage with the on-line quizzes?
3. What is the relationship between the students' results in on-line multiple choice quizzes and written and oral assessment items?
4. What are the students' attitudes in relation to written, verbal and on-line multiple choice testing?

III. Methods

This study was designed as a mixed methods study, adopting a consecutive (quantitative and qualitative) mixed method approach to data collection [18]–[20]. Quantitative data was generated via the "report" and "grade" functions in Moodle and informed the core qualitative data from focus group interviews. Raw data as XML files were exported from Moodle, curated and initially analysed by employing pivot tables. Descriptive and inferential statistical analyses used Excel functions directly. Interviews (focus groups) were transcribed and axial coding applied using Excel, to determine principal themes and patterns. Of particular interest in the focus groups were how students were engaging with the quiz questions in preparation for their exams as well as questions about their difficulties with the language.

A. Student Assessment and Course Delivery

The introductory environmental science course was delivered face-to-face as three hours contact per week over 16 weeks. The course was set up on-line in Moodle (LMS) and students had unfettered access to all course materials including all the possible assessment items (referred to as the item bank). All items in the item bank (130 items covering the whole semester's work, including a problem set) were multiple choice or multiple true/false (for simplicity, both item types are referred to hereafter as "multiple choice"). Students had access to the correct answers to all items after they attempted the items for the first time as well as detailed explanations about why particular answers were correct or incorrect. The item bank was also split into ten parts and called "quizzes". The students had 24/7 access to the quizzes and were based on material delivered in the face-to-face lecture sessions.

The largest formative assessment pieces in the course were the mid-term and final exams, each of which were weighted at 30% and an oral defence of a problem set (available to students in the item bank), which was weighted at 20%. The mid-term exam consisted of two parts. The first part was an on-line invigilated exam of 40 items drawn at random from the item bank for each student. The second part was an invigilated written exam which served to test students' ability to write about the same conceptual material, and was derived from the same item bank as the multiple choice items. Marks for the mid-term (written) were allocated to items solely on the basis of student's explanations and reasoning, not on whether their answers were correct and were marked against a marking scheme derived from the model answers accessible to the students in the LMS. The final exam was an on-line invigilated exam of 50 items drawn at random from the item bank for each student. The oral defence required students to explain their reasoning and answers to the problem set item bank of 15 questions. An analysis of student engagement and success with the large formative assessment instruments form the basis of the results and discussion sections of this paper.

IV. Results

The number of times students engaged with the on-line quizzes (segments of the item bank) or a practice exam, which was designed to emulate the mid-term multi-choice exam is shown in Table I. These results are also indicative of the final exam. That is, for both final and mid-term multi-choice exams, the average number of quiz attempts for each student was approximately 2/student, whereas, it was approximately 4 attempts/student for the practice exams (for the mid-term and final). All students attempted each quiz at least once.

Even though they had the option, once each quiz was completed in a particular week of offer, students did not retake the quizzes (data not presented), but preferred to attempt the practice exams to study for both the mid-term and final multi-choice exams. This study strategy was surprising, since the practice exams contained a randomized subset of items, and students could not be certain that they would cover all possible items for the mid-term and final multi-choice exams.

TABLE I. Summary of Students' Attempts at Quizzes and the Practice Mid-Term Multi-Choice Exam

Quiz number/type	Total Quiz attempts	Mean attempts/student	Standard Dev.
1	245	2.63	1.35
2	194	2.09	1.31
3	192	2.02	1.17
4	245	2.66	1.23
5	179	1.95	0.96
Practice Mid-Term Multi-Choice Exam	380	4.22	3.27

The number of attempts over time at the practice mid-term multi-choice exam (see Fig. 1) shows most students attempted the practice exam just before the mid-term exam on the 12th of October (week 10). Similar results were observed for the practice final multi-choice exam (data not presented). However, it should be kept in mind that the data shows only the number of practice exam attempts and does not take into account students downloading and/or printing the assessment items for study. Indeed, the course instructor did notice some students with paper copies of the assessment items, and some students had comprehensive screen-shots on their devices.

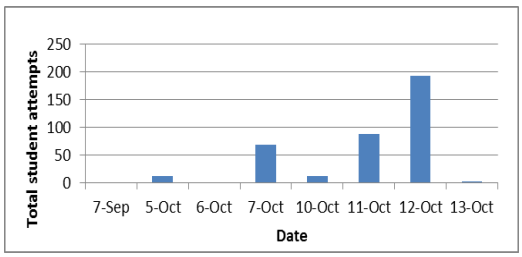

Figure 1. Total student attempts at the practice mid-term exam.

Students' results in all large formative assessment items (Table II) shows that performance was most variable in the oral defence and the mid-term written.

TABLE II. Summary of Student Results

Assessment Instrument	Student Marks Mean%	Coefficient of Variation
Mid-Term Multi-Choice	89	0.14
Oral defence	86	0.30
Final Multi-Choice	84	0.15
Mid-Term Written	60	0.44

Pair-wise T-tests of results of these assessment instruments revealed that student performance on the mid-term written was significantly different to each of the other assessment instruments ($p < 0.0001$). There was also a significant difference between the mid-term multi-choice and final multi-choice ($p < 0.0001$). A comparison of the grade distribution of the mid-term written compared to the mid-term multi-choice is shown below in Fig. 2.

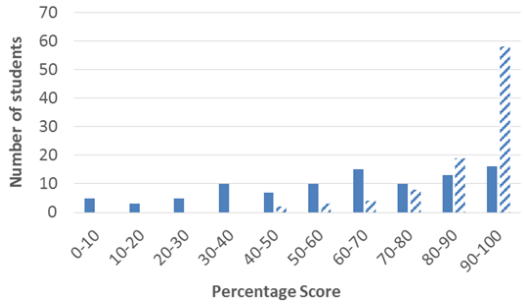

Figure 2. Comparison of mid-term grade results, written (solid) vs multiple-choice (hatched).

The difference in student performance between the two components is striking, with many students doing very well on the mid-term multi-choice, with more than half the students scoring over 90%. In comparison, there was a much more even distribution of student results for the written component of the mid-term exam.

Despite the difference between the written and multi-choice components of the mid-term, there was, nevertheless an obvious positive correlation between an individual student's written and multi-choice mid-term assessment results when analysed as a scatter-gram (Fig. 3, R^2=0.192).

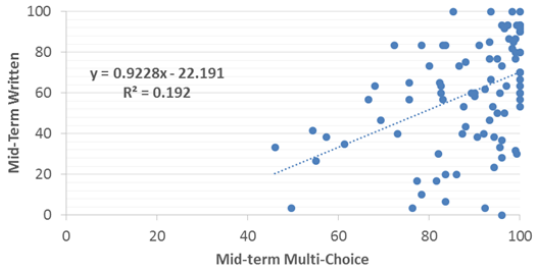

Figure 3. Scattergram of individual student's results: written versus multi-choice for the mid-term exam

For the final exam, the students were required to complete an on-line invigilated exam of 50 items drawn from the total semester's item bank of 130 items. Comparing the frequencies of grades in the mid-term multi-choice and final (n=95) showed only minor differences between them, despite there being more than twice the number of items in the final compared to the mid-term (Fig. 4).

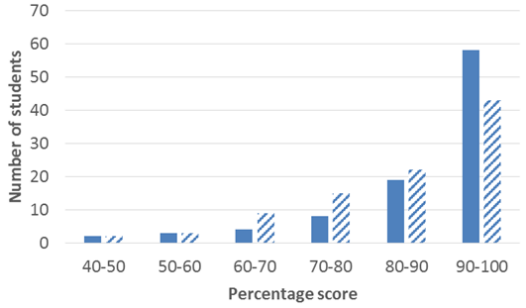

Figure 4. Comparison of mid-term multi-choice students' marks (solid) versus final exam multi-choice (hatched).

The similarity in overall student performance in the mid-term multiple-choice and final exams was consistent with a positive correlation between an individual student's on-line mid-term and final exam results when analysed as a scatter-gram (Fig. 5).

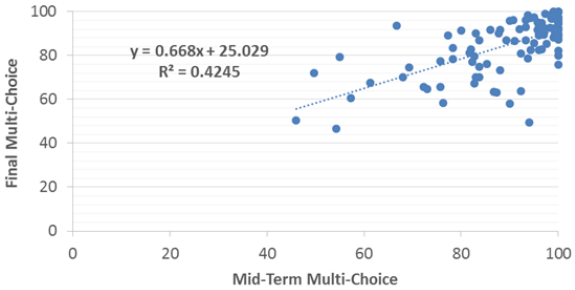

Figure 5. Scattergram of individual student's results: mid-term multi-choice versus final exam multi-choice.

The oral defence was structured in a manner whereby students had to verbally defend the answers to three randomly-chosen items from a pool of 15 questions. The worked answers to these questions were demonstrated in class and were also available in the LMS. In the oral defence, students were given the opportunity to explain how a particular problem was solved, and were asked for clarification if part of their explanation was unclear. On the whole, the students performed very well in this assessment task. There was a weak positive correlation between students' performance on the final multi-choice, mid-term written and mid-term multi-choice and the oral defence (data not presented, R^2=0.2421, 0.1933 and 0.1709 respectively). However, it is interesting to note that 13 of the students (almost 15% of the class) declined attending the oral defence.

Interviews (focus group sessions) with students revealed a number of consistent comments. In particular:

1. Students commented positively on the availability of course materials via the LMS.
2. Consistent with the quantitative data, students spent considerable time practicing the on-line quizzes as multiple-choice items, either on-line or as downloaded notes.
3. Students did not appear to spend much time using the written explanations in the LMS to practice writing their answers for the mid-term written.

V. Discussion

In this study, we delivered a science course to ESLs and were concerned about minimizing our students' misinterpretation of multi-choice assessment items and misrepresentation of written and orally-defended assessment items. That ESL students have challenges in written expression in particular is well established in the literature (for example, see [11]–[13]).

In an effort to allow our students ready access to assessment items and potentially circumvent issues that arise because of misinterpretation and misrepresentation, we decided to allow our students access to a large potential pool of assessment items and their answers using a Learning Management System (LMS). A large enough pool of items would, at least in theory, encourage students to engage in deep learning [21].

Our prior pilot studies indicated that students would have the necessary proficiency to effectively use the LMS. There was no evidence in this study that indicated anything contrary to this idea. Indeed, the impression we had, feedback from the focus groups, and data from student engagement in the reports generated by the LMS, consistently indicated that students appreciated the 24/7 nature of access to the course, and the convenience in accessing all course materials including the on-line item bank.

On the whole, students performed exceedingly well in this course. It was very clear when analysing the times taken to complete the on-line invigilated assessment items, and the high level of success, that students were highly proficient in completing these assessment instruments. In the case of the final exam, students had to complete 50 randomly-chosen items from a bank of 130 items, written in academic English, and do so within one hour. This in itself was quite an accomplishment.

Statistical differences and relatively weak positive correlation coefficients notwithstanding, in terms of mean scores, there was very little difference in students' scores between the three assessment instruments mid-term multi-choice, final exam multi-choice and oral defence. There was however a striking difference in overall student performance in terms of the mid-term written, both in terms of a statistically significant different mean and this assessment item having the largest coefficient of variation. This result was consistent with the literature (see above) indicating that ESLs have particular difficulties with written expression.

Whilst student's marks in the written assessment and multiple-choice instruments were positively correlated, the correlation was not nearly as strong as that observed between the multiple-choice mid-term and final exams. This is most likely reflects some students possessing differing abilities in representation (writing) versus interpretation (answering multiple-choice items). Similarly, students, on the whole, performed very well in the oral defence. This performance was consistent with our observations of the students' abilities in conversational English and is consistent with other reports in the literature in which students are often perceived to have conversational fluency [10].

Interestingly, some students declined to attend the oral defence. There is little chance that these students did not attend the defence because of a lack of awareness of the requirement to attend, since they all made an appointment to do so and the oral defence was the only assessment task whose deadline had passed and for which none of the students pleaded a case for an extension. We therefore conclude that these "no-show" students did not want to do the defence, presumably because they found it confrontational.

In this course, since the only component of assessment requiring written answers was the mid-term written and it was worth 15% of the assessment of the course, we suspect that, at least to some extent, the students in this course used this minor weighting as a rationale to spend less time studying for this component. Of course this is not unusual: we all perform cost/benefit analyses, trading off the potential gains we may get versus the amount of work we invest in a particular project. The students' generally weaker performance in the mid-term written may, in part, be due to a cost/benefit strategy.

One issue that did strike us when reading the literature is that there seems to be little work investigating the effects of differences in non-English speaking backgrounds may have on learning scientific vocabulary. For example, we wondered if our students, whose native tongue is Arabic (a Semitic language) find learning scientific vocabulary more problematic than native Indo-European speakers, since scientific language often uses words whose etymology is based in Latin and Greek. We would have thought, *a priori*, that those speakers whose native language is Indo-European in general and is a romance language, or heavily-influenced by a romance language, such as English, in particular, afford those speakers a natural advantage in learning scientific vocabulary. Interestingly, there seems to be a paucity of information in the literature in relation to this issue.

Quite fundamental and philosophical questions arise when considering the design of learning outcomes for ESL students undertaking content-based courses. In particular, whether the learning outcomes for students should emphasise their conceptual understanding of the material (based on the content) or, as would be the case for native English speakers, conflating the outcomes of written fluency and interpretative ability in combination with conceptual understanding. We attempted to circumvent these issues to some extent by allowing our students unfettered access to a large bank of potential assessment items. Questions in our minds still linger about whether the multi-choice assessment items we used, and which our students were so successful in completing, truly reflect deep learning and conceptual understanding, or show our students' uncanny ability to memorise the details of a very large number of assessment items. On the basis of our student's success in the oral defence, we suspect the former, rather than the latter, but further work has to be done.

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