Imitation, Copying, and the Use of Models: Report Writing in an Introductory Physics Course

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***Abstract*—*The following article focuses on the use and misuse of models—both appropriate and inappropriate—in the report-writing practices of first year physics students, especially those from non-English speaking backgrounds. It analyzes the students' propensity to use any available text on a given topic as a source of model sentences. Examples of "copying" are provided and analyzed. It is argued that many forms of copying are legitimate learning strategies of novice writers, for the production of certain kinds of texts, but that this can become a problem when inappropriate models are used or when appropriate models are used inappropriately. Copying is discussed in relation to imitative learning and modeling as well as plagiarism, and some suggestions to improve teaching practice are made.*

***Index Terms*—*Copying, ESL instruction, modeling, plagiarism, report writing, writing pedagogy.*

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Students with no background in writing for science and, more particularly, those for whom English is not a first language, frequently find it difficult to produce laboratory reports written to an acceptable standard. Meanwhile, many students, particularly those with weak language skills, assume that the descriptions of experiments, and discussions of theoretical aims to be found in manuals, course notes, textbooks, and other written materials, can be used as models; therefore, they copy the kinds of sentences and linguistic structures they come across in these texts, often with unfortunate consequences.

Copying of any sort is condemned in academic settings and, as plagiarism, is treated as a grave manifestation of intellectual dishonesty. It is represented simply as an ethical and a legal issue, not as a pedagogical one. Its grave consequences are usually dwelt upon for the edification (read: intimidation) of students. In this paper, on the other hand, modeling and copying are seen as integral components of the teaching and learning cycle. Copying is viewed as a natural process, with cognitive roots in imitative learning; it is a valuable learning strategy and a first step toward the autonomous production of complex text-types that conform to and perpetuate unspoken sets of discipline-specific rules and values. Text production of this nature, and the intellectual and sociocultural skills (along with the writing skills) that are involved in this process, can only be mastered very gradually, and the process requires as much practice and as much scaffolding on the part of educators as is realistically possible. The danger for us is not that students imitate or copy per

se, but that they frequently copy from inappropriate models and that this interferes with learning.

Three kinds of copying are recognized here: COPYING THE FORMAT (i.e. the structure of a text-type or genre), COPYING TEXT SEGMENTS (often whole sentences, usually corresponding to text functions), and COPYING TEXT FRAGMENTS (i.e. phrases). We regard all three as potentially benign, that is, as potentially able to scaffold learning. However, when large and/or poorly understood chunks of text are copied without understanding the meanings to be expressed or the textual functions to be fulfilled, this is a matter for serious concern. This kind of copying often indicates a serious language deficiency, such that learning simply cannot take place. It may represent an institutional issue, linked to the level of English language proficiency required for entry to the institution. This can only be addressed at an institutional level, either with provision of targeted and intensive language support, or the raising of entry standards.

LITERATURE REVIEW

There is little doubt that modeling and imitation represent teaching and learning strategies that are as old as the human race, but which have traditionally been more characteristic of informal, or social, learning than formal classroom instruction (see [2]–[6], [7]). Imitation is a process that appears to be, if not unique to humans, developed to a qualitatively higher level in humans than in even the higher primates [5], [8]. Even in humans, the development of imitative behavior progresses through identifiable stages, from purely reflexive, to deliberate, and finally to delayed imitation, as the infant becomes a child, somewhere between the ages of 18 and 24 months [9], [10]. In Stage 6 of Piaget's developmental schema, we are able to recognize both the beginnings of representational or symbolic thought, along with the ability to solve certain kinds of problems mentally and to store representations in the memory. These may then be used as models for delayed imitative behavior [9], [10].

Behavioral scientists and cognitive psychologists have begun to distinguish between ACTION-LEVEL IMITATION and PROGRAM-LEVEL IMITATION [8]. The former involves reproduction of fairly complex sequences of actions, while the latter can be defined as imitated learning of higher-order goal-directed behaviors, including some problem solving. These forms of imitation usually support INSIGHTFUL PROBLEM SOLVING, which is not related to imitative behavior and does not presuppose a model [11].

Modeling presupposes imitation and is almost certainly unique to humans. Adults model (or scaffold) important activities for children [12], from peeling an orange to reading a book. Modeling and imitation between them probably constitute the only known way for someone to become a composer. One cannot write music until after one has spent years studying pieces other people have written. In other words, one learns by imitating good models.

Vygotsky [13] and his followers (such as [14]) have made us familiar with the notion that much if not all human language is copied, in the sense that the "inner speech" of a child mirrors the social talk that goes on around it. When children begin to talk, they have already been primed, not only with the patterns of dialogic human communication but also to a large extent with accepted topics and attitudes. Thanks to this theory of intellectual and linguistic development, and the movement that began there, the importance of modeling has been recognized and modeling-based pedagogies have been taken up in the primary school classroom with great vigor in some quarters in the United States.

Modeling in the classroom is complemented by a number of other teaching strategies (see [14] for a good overview). But modeling, scaffolding, and giving feedback on performance, often purely imitative, are still core teaching strategies in the early years of schooling. Gallimore and Tharp put it this way:

> Modeling is a powerful means of assisting performance, one that continues its effectiveness into adult years and into the higher reaches of intellectual complexity. In the educational setting, both expert teachers and peer models are highly important sources of assisted performance, for children and adults alike. [14, p. 179]

J. R. Martin, the founder of the Australian genre school, has done extensive work on primary and secondary schooling, and the teaching of functional, or social, literacy (see [15, pp. 9–12], and [16]). Martin advocates a teaching method based on the premise that written models (of conventional text types, or GENRES) have a central place in the teaching of a socially empowering literacy. He and numerous adherents of this approach have developed a SCAFFOLDED approach to writing instruction. Martin explained his approach in a recent interview with Nathan Edwards:

> I also favor what's called front-loading in the curriculum. You make very clear to the students what the goals and objectives are and provide very good models of what you expect the students to be doing. I find a lot of teachers are reluctant to provide models and the students are left continually searching for what it is they are supposed to be doing. There is also an important stage where the students do joint writing with the teacher, who uses an

> OHP for example. They also craft a text together with the teacher before they write on their own. It is important for the teacher to first work with and guide the students in their production of a certain text genre such as an exposition. Given models and scaffolding, it is amazing what students of all ages are capable of doing! [17]

In genre-based teaching, teachers present students with texts and then, with the class, deconstruct these texts in terms of their social purpose(s) and function(s), and (more importantly here) in terms of the rhetorical functions of different sections of the text (e.g., the general function of an introduction, and then the more specific functions of different sections of an introduction). Students then imitate these models, in terms of structure and linguistic register, but using different content. This method has had some remarkable successes, leading to an understanding of the differing purposes of different text types and the social functions of writing conventions and linguistic forms, as well as gradual mastery of appropriate registers and styles.

Copying is clearly an important and ubiquitous learning strategy, one that is explicitly encouraged in genre-based teaching and one upon which students with weak language skills instinctively rely. It is not necessarily an attempt at deliberate deception or an indication of intellectual laziness. Sometimes, of course, it is simply fraudulent and then counts as plagiarism, which is pedagogically without value, morally deplorable, and subject to legal consequences. However, in a controlled learning situation, copying allows students, especially those with poor language skills, to BOOTSTRAP their own learning, and in this manner helps them approach an extremely difficult level of technical expertise in manageable stages. We hypothesize that, with the right kind of feedback from markers, the segments of a text copied will become gradually smaller and increasingly interwoven with pieces of the student's own writing, until finally, only the generic structure of the model text is imitated (see examples below). The student ideally progresses from plain copying to CALQUING—relexifying phrases and constructions—to paraphrasing; to reorganization of the information; and, finally, to autonomous, fluent, and creative writing.

The general idea is not new. In the 1970s, British researchers presented an empirically based model of GRADUATED COPYING [18], and the gradual incorporation of textual sources in students' own writing was the subject of a 1990 study by Campbell that was called, appropriately, "Writing with others' words" [19]. These kinds of empirical approaches and the graduated models that they yield promise to cast important new light on the "problem" of plagiarism and to suggest new ways of dealing with this complex phenomenon.

Buranen recently noted that "plagiarism is a vastly more complex issue than we as teachers may recognize and certainly far more complex than we customarily suggest to students" [20, pp. 64–65]. Let us consider some of the reasons students copy. Yore et al. [21] quote Anthony, Johnson, and Yore [22] to the following effect:

> The reason that students copy from their resource books is threefold: (1) the resource material is already in required form; (2) students are reading text written by experts and writing to an informed audience; and (3) the writing is not focused on authentic questions requiring synthesis of ideas into unifying concepts.

We would comment here that, while the deference to experts is a powerful belief for all students, it is the perceived expertise of authors and appropriateness of their written work that apply most readily to the present case. In writing a lab report, there is little need to modify the actual content, which is obtained from open sources, or to synthesize ideas in novel ways.

> Writing a science 'report' usually means an informative, factual expository report. The research information for the science report is normally obtained from one or more resources, most frequently books. The resource books consulted by the students are already framed as informative, factual expositions and a single source contains far more information on the topic than needed or expected. Thus *students are faced with a transportation and edit-to-length problem rather and* [sic] *a transformation, interpretative, and synthesis problem*. (Our italics.) [21]

The distinction made here resembles that made some years back by Bereiter and Scardamalia [23] between KNOWLEDGE TELLING and KNOWLEDGE TRANSFORMING. Knowledge telling is a type of composition in which information is retrieved from the memory or from some textual source and is relayed in the writer's own text. Knowledge transforming, on the other hand, implies reflection, problem solving, and planning; it involves associative thinking while critically analyzing the information available, in the light of clear goals, in order to create new understandings. While most teachers and professors are concerned that the students develop the latter, which is seen as a necessary criterion of, and evidence for, the kind of higher order thinking expected of tertiary-level students, there is little acceptance that certain useful and necessary activities demand no more than the former. We argue here (with Yore et al.) that information selection and transfer are the main functions in certain types of writing and learning [21].

Meanwhile, other aspects of the situation can easily be enumerated:

> The problem is compounded by the fact that both the author of the text and the audience (the teacher) knows more about the topic than the student writers. Thus, students read and write beyond their level of expertise. Novice writers are called upon (a) to read in an area about which they have little concrete experience and know little, (b) to develop expertise, and (c) to write in a form that is used to "inform" someone who may well know more about the topic. [21]

Introductory report-writing exercises are "topic centered and fact focused" [21]. The teacher or professor usually decides on the experiment, and the students need only report on a standard procedure, the actual results and contingent uncertainties of their experiment being the only new thing in their report. These writing resources are not meant to be transformed, at least beyond a certain point at this stage, but rather to be merely reported. Yore et al. sum this up nicely: "The students arrive at the resource material lacking a strategic question that requires them to analyze, synthesize or verify the isolated text-explicit information (knowledge transforming)" [21].

CONTEXT, DATA, AND METHODS

This paper is based on qualitative data collected while evaluating a writing skills intervention. In late 2000 and early 2001, the authors trialed a pilot adjunct course to teach laboratory report writing for physics. The course dovetailed into an introductory physics course for first-year students. Approximately 240 students enrolled for this course at the beginning of 2001. More than 50% of these were fee-paying international students, the majority coming from countries in East Asia. Many of the remainder were Australians with language backgrounds other than English (i.e. their dominant home language was not English); this is to say that they were first or second generation immigrants. In Australia, these two large categories are officially referred to as non-English-speaking background (or NESB) students. The rest were Australians with English as their first language. The students also came with a wide variety of academic backgrounds. High school physics was not a prerequisite for this unit, though mathematics was. This was not a mainstream physics course (see below). The majority of the students planned to graduate with a degree in computing science.

It was the large size of the NESB cohort and the problems they experienced in writing laboratory reports that first prompted the two authors to plan this intervention, for which funding was fairly easily obtained from the university. The problems experienced by students were reflected in the difficulties of markers in grading the reports. Grading was often impossible without substantial leaps of faith, inferring the writer's intent from inadequate evidence. Moreover, it soon became clear that most of the students who spoke English as a first language needed a degree of help in many of the same areas as the nonnative speakers. Two main needs were identified on the basis of an inspection of samples of student writing. These needs were for: (1) explicit guidelines about the structure of a report and (2) advice about the kinds of language appropriate to each section of the report (covering issues such as voice, tense, and word choice).

Context of Learning: PHYS149 Physics 149 is called *Physics for Technology* and is available only to students enrolled in certain degree programs. According to the Undergraduate Handbook (2002), the PHYS 149 unit is made up of topics chosen to be of use to students working toward degrees in computing, computing science, and information science. This unit is in fact only available to students enrolled in the B.A. in computing and information systems or the B.Sc. in computing and information systems, and to certain Bachelor in Technology (B.Tech.) students, as well as to some other students who plan to enter the above courses. Indeed, the unit may not be used toward a degree in physics. On the other hand, it has become a prerequisite for Optoelectronics (OPTO 200) and the Signals Analysis and Processing strand of Information Science (INFO 240). The unit presently covers the following topics: mechanics, heat and thermodynamics, oscillation and waves, electricity, optics, and atomic and nuclear physics. The unit webpage (16/06/01) noted: "the theory side of this unit places a significant emphasis on problem solving."

Students traditionally received instruction and information in the following ways:

- lectures—three one-hour lecture each week throughout the semester;
- "prac sessions"—weekly three-hour hands-on practical sessions held in the physics lab, furnished in the usual way with workbenches and laboratory equipment;
- online—weekly assignments posted online (solutions available by email, on request);
- tutorials—one one-hour tutorial each week (dealing mainly with the online assignments).

The following components were added in 2001 as part of a pilot course. We took advantage of a number of unused lecture slots and "prac sessions" to provide:

- three additional lectures on laboratory report writing;
- three report writing workshops (interspersed with the regular practical sessions; i.e. three three-hour

sessions spread out over the semester).

The lecture content was taken from the set textbook *College Physics, Ninth Edition*, by F. J. Bueche and E. Hecht [24]. Students were warned: "Be aware that this course depends critically on the problems in the set textbook." The previous textbook (*Principles of Physics* by R. Serway [25]), as well as the textbook for PHYS 140, the first mainstream physics unit (*University Physics*, by H. D. Young and R. A. Freedman [26]), were given as useful references for the course. Students were told that other reference books for first-year physics were to be found in the university library—for example, *Fundamentals of Physics* by Halliday and Resnick [27]. Students were also told that, if in doubt, they could approach one of the course lecturers (there were two lecturers, each one responsible for giving a fixed number of lectures; one of these was the second author).

Available Models Since this paper focuses on copying from textual sources (both appropriate and inappropriate), a full listing of the texts available to students is provided in Table I. These can be regarded as constituting a set of genres [28], [29]. These were all available to the students, for potential use as writing models, and any of these may have influenced students' conception of writing, and especially writing for physics. Much investigation will be required to ascertain the facts.

Sources H and I represent innovations designed to improve student report writing. In the modeling workshop, the two authors interactively composed a report on overhead transparencies, which was projected onto a screen so that the students could follow the detail of the process, including disagreements, negotiations, erasures, and corrections. Students could, of course, overhear all the talk which accompanied the composing process, in which language and content rarely appeared as separate issues. However, it is important to stress that, in this first adjunct course (2001), the potential use and misuse of models was not discussed; a schematic model of the required sections was provided, but full model reports ("graded" reports) were only provided in the second intervention (in 2002).

Other sources of information and possibly guidance (as opposed to textual ones) were the lectures, consultations with lecturers in their offices, and conversations with demonstrators (mostly Ph.D. students or high school physics teachers) in the course of the prac sessions.

Student Writing Students kept records of their laboratory work in science notebooks that were kept in the laboratory until the end of the semester (the stated purpose of this was to prevent students from reworking their notes at home, something not seen to be either necessary or good practice; an unstated purpose was to prevent cheating). Students were encouraged from the beginning of the semester to keep to the recommended format (i.e. the sequence of sections) of a standard Physics Laboratory Report, as outlined in the special Report Writing handouts and also in the modeling workshop. The other model report available was in Kirkup's *Experimental Methods*

TABLE I
THE SET OF TEXTUAL SOURCES AVAILABLE TO STUDENTS

Source	Description	Comments
A	Course Guide	Containing administrative and other information about the course (e.g., assessment procedures).
B	Course Notes	Available for optional access via the web.
C	*Laboratory Notes*	In effect a lab manual, prepared over a number of years and regularly revised by staff of the Physics Department. Privately printed.
D	*College Physics* [23]	A textbook chosen for selected problems; few students appear to have consulted this source.
E	Weekly Assignments	Sets of problems with minimal wording (i.e., a set of facts and figures accompanied by one to four sentences, followed by a number of questions in point form).
F	*Experimental Methods* [29]	A recommended textbook, containing a model report in an appendix.
G	Additional Textbooks [24], [25], and [26]	Available in the university library.
H	Report Writing Handouts & Worksheets	Up to 12 pages per session of (limited) explanation, instructions, and (especially) short tasks designed to activate new knowledge.
I	Modeling Workshop	Successive drafts of a 'model report' were produced and projected on an overhead. (Both the process of writing and the product were modeled by the authors working in tandem, and dialogically voicing the mental processes—the hesitations, the doubts, the compromises—normally involved in the writing process.)

[30]. This latter is a useful book that, though listed in the course outline, few students actually referred to. (Indeed, most students in PHYS149 were not motivated to go beyond the basic requirements of the course. As already noted, they intended to specialize in another discipline or subject. They worked with what they were given in the lectures and "practicals," and depended disproportionately on the laboratory manual.)

Students were told that a small amount of prose would initially suffice for their notebooks. It was explained that the notetaking process was the important thing at this stage and that they needed to add just a few sentences, or phrases, to connect up their equations and calculations in a logical way, and perhaps to remind themselves, the writers, of any important circumstances or complicating factors. However, at the end of the semester students were required to write a three-page "Special Laboratory Report" in prose. They were allowed to base this report on any one experiment they had conducted in the laboratory and recorded in their science notebooks over the course of the semester. Before the introduction of the Report Writing course, they were given little guidance in this task.

Laboratory Manual The single text that students copied from most—indeed, almost exclusively—was the laboratory manual. This is entitled *Laboratory Notes* and is a work of composite authorship. It took on its present shape gradually, as different lecturers refined and added to the instructions, notes, and explanations of their predecessors. In fact, it has developed over some thirty years, and it is still frequently revised, when typographical errors or (occasionally) errors of fact are identified or when a lecturer-in-charge decides to reword a sentence or add some comment. In terms of a common if somewhat crude dichotomy [31], one would have to say that the manual is written half in the "investigative" mode, while half is in the "cookbook" mode. That is, much of the text is in the form of instructions. This is balanced by long descriptive sections, and each procedure is followed by questions designed to stimulate the students' curiosity. Students who copy from the manual, and in particular NESB students, run a grave risk of inadvertently "reporting" in the language of instructions.

The style of this manual is uniformly cryptic. Information is packed densely into complex sentences, with subordinate clause piled up on subordinate clause. Dense nominal groups add to the reader's task in unpacking this prose. Whether or not the cause is the composite and incremental nature of the authorship, the kind of writing exemplified in this book goes well beyond the expected density and complexity of scientific writing [32], [33]. These were not issues that could be broached easily with staff or students at the time of our intervention.

Traditional standards of first year student writing in this physics department are revealed in the words of the second author, a physics lecturer there for many years:

> Students are expected to work from, and follow, the manual. Obviously a degree of copying must be involved and this should be encouraged; students are not expected to cite the manual as a reference text; in other circumstances they would be obliged to do this. [However,] As well as follow good forms and examples, students need to be encouraged to interpret and evaluate [data], and synthesize their own reports. (In conversation.)

Other Texts The students were exposed to a large number of short reports (or, rather, sections of reports) provided in handouts for the new report writing workshops. These contained excerpts, and often whole sections, from reports on a wide variety of experiments. In retrospect, it can be seen that the use of these was inherently dangerous. Some students borrowed whole sentences from these, often from the appropriate section but from the wrong report. Students also borrowed inappropriate sentences from the overheads shown in the modeling workshop (even though the futility of this had been explained). The course textbook appears not to have been consulted to any great extent; the authors found no clear examples of copying from this source.

The Special Laboratory Reports Almost all of the students made obvious efforts to follow the guidelines for the special reports. One marker (second author) evaluated all the reports on the basis of four marks for writing skills and four marks for physics comprehension. There was considerable evidence that students needed more specific guidance in understanding the physics concepts that they were expected to apply in the laboratory.

The special reports that provided the input for this study were produced in the following way. Students were asked to choose one particular experiment that they had done well, and produce a Special Laboratory Report of about two pages of text. Only 10% of the reports met these basic criteria. The rest were too long and showed no selectivity of the topics chosen, often to the disadvantage of the students. About 40% of students included verbatim instructions (i.e., instruction words) in their reports although they had been specifically and repeatedly asked not to do so (in the report writing workshops). When the laboratory notes provided a clear "Introduction" and "Aim," these were usually copied directly into the report (see below).

Analysis of Results By marking special reports under the two categories of writing skills and physics comprehension, it was found that students were weaker overall in their comprehension of physics than in their English expression. (There may be some bias here as all the marking was done by the physics lecturer). There was no discernible correlation between the writing skills of students and their ability in the formal examination, nor was there a discernible correlation between the physics comprehension of students and their ability in the formal examination. Table II shows the marks for language compared to those for physics.

Observations In general, we observed that a significant number of the students (it is not clear exactly how many) had little or no physics background. A significant number of students (more than 10%, mostly international students) were observed to walk out of lectures whenever enrichment, revision or report-writing skills were presented [34]. Nonetheless, a survey following the final workshop on report writing skills was predominantly positive and comments constructive. From this survey, it emerged that students want more input and earlier instruction on writing skills and more feedback while they worked. A keen demand for good examples, or models, of physics laboratory reports was also noted.

TABLE II
PERCENTAGES OF RAW SCORES

Language	Marks /4	Physics
37%	4	29%
34%	3	33%
20%	2	27%
9%	1	11%

Marking emerged as the major logistical problem, and the person–hours needed to correct 240 papers in any detail was an important constraint even on the kinds of tasks devised in such a course. Specific funding was required to train markers to implement even this relatively simple marking scheme.

Salient Features of Student Reports The two most salient features of the language of the reports produced by students, both in the workshop and at home, were inappropriate or ineffectual copying and inadequate English expression. The students had been exposed to numerous (albeit fragmentary) examples of the approved writing style, and they had studied model paragraphs and analyzed sections of reports. They had been given detailed handouts, with more examples, and had received emphatic oral instruction (to reinforce the written instructions). They had also seen an entire report built up on overheads. The anomalies that we found in their own reports, post-intervention, are doubly interesting because of this exposure to (as we believed) high-quality input, and the intense and focused nature of the instruction.

Issues connected with inadequate levels of English language proficiency in second-language writing, and, more specifically, in laboratory report writing, have been analyzed and discussed in many places (see [35]). We confirmed that what students seemed to lack most was an understanding of the grammar and lexis of the scientific register, an appropriate level of complexity [32], [33], and familiarity with procedural expressions common to scientific and academic writing [34]. This applied most clearly to the international students, but these are also the areas in which many Australian students, whether first or second generation immigrants, with or without English as their home language, were also experiencing some difficulty. These issues are not pursued further here.

COPYING

Copying is looked at here on three levels: copying the format (the structure of the text) from an appropriate or an inappropriate model; copying segments of text (often corresponding to specific text functions, like the statement of aims, for instance, and, thus, to complete sentences); and copying fragments (i.e., phrases or, grammatically speaking, constructions). Since success in the imitation of the structure of a report was the main aim of our intervention, we were able to view lower level copying as either effective or ineffective in helping students to replicate the overall structure of a (simple) laboratory report, with a minimum of five (well organized) sections. What we found in the special reports can be summarized as follows.

Copying Format or Imitation This is viewed as the imitation of a model, rather than the kind of detailed and more or less word-for-word reproduction of content or text which we would call copying. The five sections modeled were: Introduction, Methods, Results, Discussion and Conclusion.

The majority of students used the correct subheadings, i.e., those used in the models provided, and, particularly, the one jointly composed by the two authors on overhead transparencies during the modeling workshop. Students took notes, or copied the subheadings from either the overheads or schematic handouts that were afterwards made available. However, nearly half of the students used *Procedure* (imitating the style of the laboratory manual) instead of the recommended subheading *Equipment & Methods* when writing their special reports.

Copying Segments Some copying of this nature occurred in the modeling workshop, as was to be expected. This was regarded benignly, as a learning process. Copying from the modeled report (produced interactively and incrementally by the authors on overhead transparencies) was fairly common and may have reinforced the report structure to be learnt. Indeed, in the reports written at home—the Special Reports—most students replicated the correct functional structure of the Introduction (minimally including a sentence about the importance, or significance, of the topic, and another giving the aim, or objective, of the particular experiment).

The instances of MISCOPYING, or copying from the wrong model, that were referred to above, did not account for all of the structural anomalies in the reports written by students. Some left out important functions from the appropriate sections, others added irrelevant sentences. But on the whole, miscopying accounted for the largest proportion of the generic errors and is associated in ways that have yet to be determined with levels of language proficiency.

Copying Fragments This kind of copying is different from the two categories of copying dealt with further above. This kind is, in fact, hard to differentiate from real learning. It is now commonly accepted that vocabulary teaching must take account of lexical clusters and lexical formulas. The former are generally fixed, as in "on account of," "a number of," and "on a related point"; the latter are subject to some modification, as in "x depends on y" or "x is a function of y" or even "the x of the/this experiment is/was to ...". Essentially, linguists are now telling us that a language is largely acquired or learned in terms of CONSTRUCTIONS (i.e., more less fixed patterns of words), and not simply item by item (see [36]–[39]).

Next, we provide the results of a quantitative survey that focused on kinds of copying (along with other strategies) that were found in introductions; we then adduce some examples of miscopied sentences in the Methods or Equipment & Methods section.

Coping With Introductions Table III below represents the results of a survey of student introductions (the basic structure of an adequate introduction had been explained in great detail in handouts, in informal sessions with groups of students in the labs, and in the modeling workshops).

It can be seen that the inappropriately worded models contained in the manual were, in fact, successfully adapted by just over half the students. Another twelve percent (9% plus 3%) attempted to use these models, but were—to varying degrees—unsuccessful. It is noteworthy that a mere 3% of students resorted to direct copying. One quarter of the students demonstrated a deeper level of understanding by writing their own introductions, often using original sources, and a small proportion failed in this attempt.

Problems With the Equipment & Methods Section Despite repeated warnings not to use the imperative mood (along with a promised penalty in terms of marks), and in-class exercises in paraphrasing instructions as descriptions of past events, 18% of the students were unable to avoid this. Students used sentences like: *Connect the circuit as shown in* Fig. 1. The cause for this is almost certainly low levels of proficiency in English.

In Table IV, we give two examples from students who successfully avoided copying sets of instructions, but were unable to reword the text in an appropriate form for the "Equipment & Methods" section (compare category D in Table III above). Both were modeled on, or drew on, sentences in the manual.

The second example in Table IV would have been better explained using a sketch. Although the students were strongly encouraged to use sketches of apparatus and circuit diagrams, 23% did not take this option.

These examples illustrate the kinds of difficulty students can experience in trying to exploit textual models. In the next section, we concentrate on the textual analysis of selected examples of student writing that contain clear

TABLE III
CONSTRUCTING AN INTRODUCTION

Grade	Grading Criteria	% of students
A	Production of a successful introduction independently of the text in the manual	25%
B	Unsuccessful introductions constructed independently of text in the manual	12%
C	Successful rewording of text from the manual	51%
D	Unsuccessful rewording of text from the manual	9%
E	Direct copying of text from the manual (penalized)	3%

examples of more or less functional copying.

EXAMPLES OF COPYING

We here introduce some examples of student texts (i.e., texts produced by students) to illustrate the value of a close textual analysis in identifying just what is going on when a student copies.

Example 1 (Student A) Student A wrote an introduction to the Special Report shown in Fig. 1. Let us compare what the student wrote with the introductory sections of the corresponding chapter in the manual, also shown in Fig. 1. It is easy to identify the copied portions in the text that the student produced (these appear in italics). We can also identify portions of the text that the student thought might be omitted.

Clearly, most of this short text has been "plagiarized," and one can well envisage the indignation of many teachers if confronted by the evidence above. Yet, the student has, nonetheless, managed to produce—if not "write"—a functionally complete introduction to a Physics Laboratory Report. That is, it contains a statement of the value of the experiment plus a statement of its aim. The omission of the prepositional phrase "with the angle of the upper arm" is the most serious problem with the student's text in that it interferes with the meaning of the original and, in fact, makes the aim hard if not impossible to understand. It would be necessary to say more here, rather than less, to make the objective really clear. However, in an unmistakable sense, this student has learnt something from this intervention.

Example 2 (Student B) Student B wrote the introduction to the Special Report shown in Fig. 2. The italics indicate, as before, copied text, while the student's additions or changes (*combining* for *containing*) have been bolded. Underlining indicates a simple production error of the kind all writers make from time to time.

Let us compare this text with the original text (given in Fig. 1), and also with Student A's text. In this case, the student has neglected to say anything about

Fig. 1. Example from Student A's introduction to the Special Report compared with the introductory sections of the corresponding chapter in the manual.

PHYSICS OF THE HUMAN ARM

INTRODUCTION

The value of this experiment is that it illustrates the very essence of physics, in that data from measurement [-s] *on a physical system is first collected, and is* [then] *compared with prediction* [-s from a mathematical description of the physical arrangement]. [As explained below,] *The aim is to determine both theoretically and experimentally how the load carried by the hand varies* [with the angle of the upper arm] *and then to repeat the experiment with* ***the real*** *arm.*

Student A's Introduction

Introductory section in manual

Italics = text copied from manual
bold = text that has been changed or added
[ ] = parts of words or sentences that the student has omitted
(Where whole sentences are skipped, this is not indicated.)

PHYSICS OF THE HUMAN ARM

INTRODUCTION

The value of this experiment is that it illustrates the very essence of physics, in that data from measurements on a physical system is first collected, and is then compared with predictions from a mathematical description of the physical arrangement.

This experiment examines how the basic and simple rules describing equilibrium can be applied to a complicated biological system, containing muscles and bones, in order to develop a convenient model of the system, which can then be tested by collecting data.

AIM

A mechanical model of the human arm, shown in the figure, is provided for you to take measurements. As explained below, the aim is to determine *both* theoretically and experimentally how the load carried by the hand varies with the angle of the upper arm, and then to repeat the experiment with your own real arm.

the value of the experiment (an important grounding function),

TABLE IV
EXAMPLES OF UNSUCCESSFUL REWORDING OF TEXT FROM THE MANUAL

Student Text	Manual Text
First, in order to obtain a clear focus for seeing a distant object a completely relaxed eye was placed in front of the telescope.	With the eye completely relaxed, as for viewing a distant object, move the eyepiece in its draw tube until the cross-wires come into clear focus. (Experiment L12)
The transducer and the detector were mounted on an apparatus which allowed the detector to move freely towards or away from the transducer and also supplied a means by which to fix the distance between the two.	Set one source transducer in the centre of its mount and connect it to the oscillator. Set the pivoted rule to the 0 (degree) mark, and place the detector on the rule. (Experiment W12)

Fig. 2. Example from Student B's introduction to the Special Report.

PHYSICS OF THE HUMAN ARM

INTRODUCTION

The aim of this experiment is to examine *how the basic and simple rules describing equilibrium can be applied to a complicated biological system,* c**ombining** *muscles and bones, in order to develop a convenient model of the system, which can* [then] *be tested by* **doing experiment.** [. .] **Taking** *a mechanical model of* [the] *human arm,* [. . . .] **for example** *the erotically and experimentally how the load carried by the hand varies will the angle of the upper arm and* **second** [to] *repeat the experiment with* **a real biological arm that is human arm.**

Italics = text copied from manual
bold = text changed or added
[ ] = parts of words or sentences that the student has omitted
(Where whole sentences are skipped, this is not indicated.)
__ = production errors

while elaborating on the aim of the experiment. The first phrase in bold has almost certainly been copied from models provided in the writing workshop, and again it demonstrates learning has taken place. The student feels confident enough to replace the wording of the manual (*this experiment examines*) with a newly learnt and very functional phrase. Replacing *containing* with *combining* was unnecessary, but again indicates a desire on the student's part to make the text their own. It should be remembered that international students are often taught and encouraged to use some very simple paraphrasing techniques in academic preparation courses. This can often have unfortunate results.

Student B's phrase *by doing experiment* replaces *by collecting data* and works well in the context. Of course, we could complain that *do* is not as academic as "perform" or "conduct," but these stylistic refinements will come in due course. Also, the student will need to try and improve his/her control of the English articles—but this is widely regarded as an impossible task for most nonnative speakers of English. The only serious solecism in this text is caused by the lack of finite verbs in the last sentence.

Example 3 (Student C) Certain students exhibited enormous flair for BRICOLAGE, putting together quite good reports while using fragments and even chunks from the manual. This skill depends on the student having read the manual closely as, instead of presenting an experiment in report form, it usually describes parts of experiments, in piecemeal fashion, as suits the conversation with the reader, and intermingles discussion with instructions, advice, and description. Copying from others for a report on one's own experiment is not only challenging but has inherent pitfalls.

Student C reported on an experiment entitled *Determination of γ for air using the method of Rüchart*. (The umlaut bespeaks a fastidious mind, betrayed alas by the omission of a second -h-; Rüchhart is the correct spelling). Such was the skill and selectiveness shown in cutting and pasting that the operation slipped past the marker (in the initial marking), and the student received a high score for "expression" (including structure and grammar). In contrast, this student scored a much lower mark for physics comprehension.

As the manual neglected to list the equipment needed before discussing the experiment, this student put aside the approved models and simply copied two paragraphs of method (retaining the present tense of the manual, as opposed to the past tense of the models) along with the diagram. This feat of very accurate copying was followed by some quite good calculations, taken from the right places in the manual. Again, the fact that the student copied only the correct formulas and equations from amongst quite a collection of workings demonstrates an admirable understanding of the experiment, and its purpose. However, a "bad misunderstanding" of the physics further down (to quote in full the marker's comment) was what cost the student a high mark here. Otherwise, the Results and Uncertainties, the Discussion, and the Conclusion, though brief, are competently written in good English (earning a summative tick).

The introduction is particularly interesting. We show it in full in Fig. 3. This is a good introduction. Instead of explaining the importance of γ (as recommended by the instructors), the writer describes the Rüchhart method and explains its usefulness for measuring γ. But the sources for this paragraph are varied. The

introductory section of the relevant chapter from the laboratory manual appears in Fig. 3.

The fragment *involves the dynamics of pressure oscillations in a column of air set into vibration in a suitable way* in the student's first sentence has clearly been calqued upon the second sentence of the introductory section of the manual chapter. The source of the remainder is less clear. Examine the first sentence in the final section of the relevant chapter from the manual, also shown in Fig. 3.

Student C has clearly obtained an expression from the manual: *the accepted value of* γ. The phrase *the constant* γ occurred in the first sentence of the introductory section (further above). It would not normally be claimed that these two expressions have been copied, rather that they have been learnt. Moreover, the fact that the student has used these expressions in the correct part of the report, and used them appropriately in a well-formed sentence to express the aim of the experiment (more explicitly in fact than in the Aims section of the manual itself) can be interpreted to indicate the kind of deep learning or conceptual understanding that lecturers look for. Student C has clearly sought and found the accepted value of the constant in an appropriate text (or on the internet), as instructed.

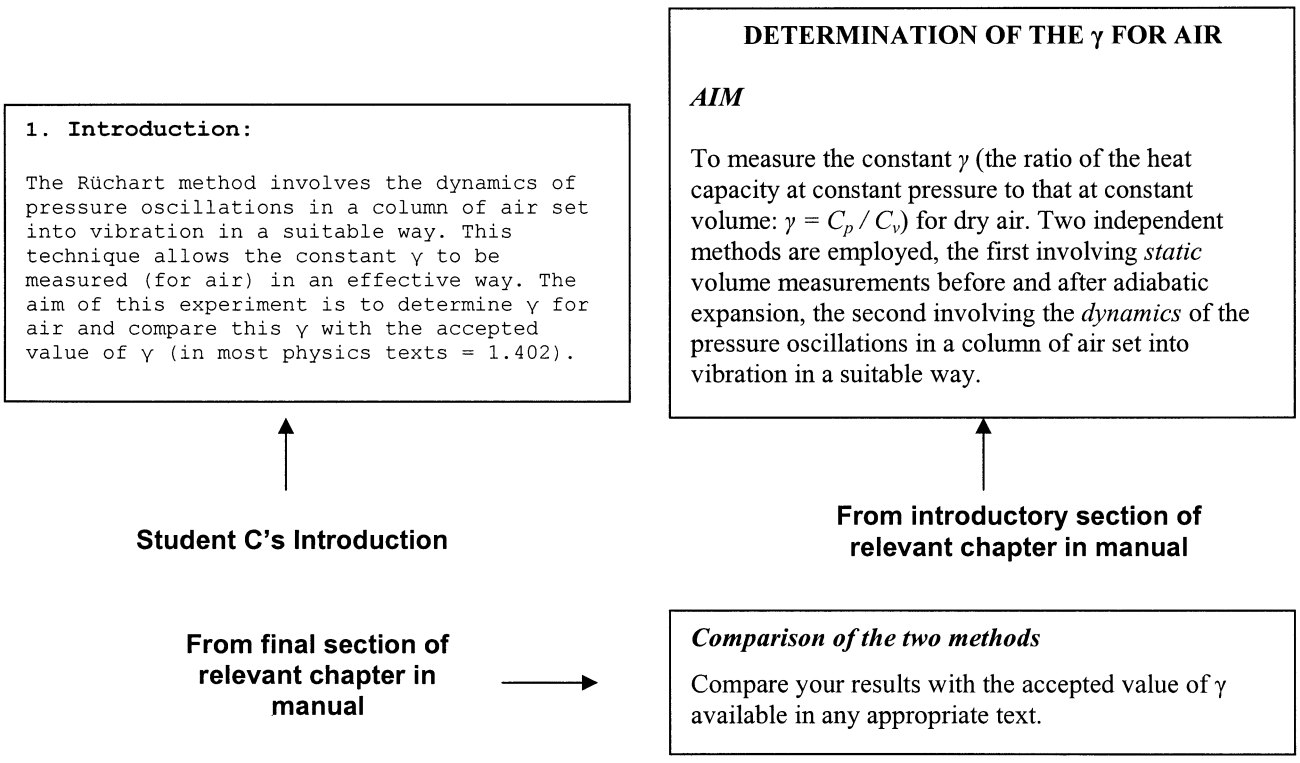
In sum, Student C has made good use of the available models in the Introduction but overrelied heavily on these, and to ill effect, in the Equipment & Methods section.

DISCUSSION

A number of useful findings emerged from the pilot report writing course described above, and these have been incorporated in a rather more successful intervention carried out in 2002 (reported in [1]). Enlisting the tutors, or demonstrators, and briefing them on clearly functional writing criteria had a major effect on improving student report writing skills over one semester. The interactive modeling workshop continues to receive very positive student evaluations. However, the very strong propensity of all students to copy from the laboratory manual (or other inappropriate models) in the course of the pilot intervention (2001) made a lasting impression on both authors. It was the most prevalent and, at the same time, the most poorly understood strategy used by novice student writers in producing their reports. This led us to look more closely at the mechanisms involved, and to look at the role of copying and imitation in learning more generally. The present article is a prelude to the systematic research in this area, combining physics content knowledge and applied linguistic skills, that is so urgently needed.

An Analytical Schema—Kinds of Copying In this section, we present an analytical schema designed to account for the different levels of use that students

Fig. 3. Example from Student C's introduction to the Special Report compared with the introductory sections of the corresponding chapter in the manual.



have made of source texts, i.e., different kinds or levels of copying, viewed as linguistic processes. In attempting to map empirically distinct levels of copying onto the two types of composing process postulated by Bereiter and Scardamalia [23]—that is, knowledge-telling versus knowledge transforming—we found it necessary to separate out two distinct levels of knowledge-telling (numbered 1 & 2) and two levels of knowledge transforming (likewise numbered 1 & 2). In attempting to correlate these four levels (A–D in Table V) with the two kinds of imitation recognized by Byrne and Russon [8], and now others, we recognized two levels of program-level imitation (defined as the imitation of organization and functions/goals). We propose to equate the highest level of knowledge transforming with insightful problem solving (which is not tied to the imitation of models). The fourth type of linguistic process (D) is neither copying nor imitation, but a true transformation of assimilated knowledge indicative of deep understanding and implying complex cognitive processing mechanisms.

Certain linguistic phenomena recognized in language contact and translation studies lend themselves to a systematic explication of the student data. Lexical borrowing from one language into the other results in what are called LOAN-WORDS. When language learners do this we say that they are "acquiring vocabulary." However, when whole phrases or clauses (corresponding to linguistic constructions) are modeled on phrases or clauses in a source language, in a word-for-word replacement process, this is known as calquing, and more precisely, as GRAMMATICAL or SYNTACTIC CALQUING. When learners do this, it is variably called (close) paraphrasing or copying (B in Table V). It is often taught as a legitimate strategy useful in avoiding plagiarism (e.g. [40]). However, we reserve the term PARAPHRASING for a higher level operation in which significant variation in the linguistic constructions used testifies to a deeper level of learning. Thus, at level C, students are modeling their texts on patterns, structures, or constructions that they have come across (and noticed) in good scientific and/or academic writing in a range of different but comparable contexts. They are, furthermore, exploiting these to construct appropriate new meanings. In a language learning context, this can be recognized as increased proficiency.

The four levels identified in Table V are illustrated with four constructed examples, all drawing on the same textual model (see Fig. 4). In example 1, the writer is describing the same experiment as in the source and has resorted to what is virtually word-for-word copying. In examples 2, 3, and 4, the writer is describing the aim of a completely different experiment and has used, respectively, calquing, simple paraphrasing, and true paraphrasing processes.

These examples illustrate not only the range of linguistic processes, but also the dangers inherent in "borrowing" lexis, content, or grammatical structure; for instance, the danger of leaving out essential qualifications or conditions, caused by looking no further than text structure and failing to gain an understanding of the physics involved (see comments following the examples). Examples 2, 3, and 4 are somewhat inadequate in terms of the physics understanding they express and are, in fact, inadequate representations of the information given in the laboratory manual (compare Fig. 5). However, since the latter text was not framed as an "Aim," some students might understandably try to map (or calque) information from the first part of the sentence in Fig. 5 onto the grammatical structure of the model (the "source text") given in Fig. 4.

TABLE V
COMPOSITION PROCESSES, LINGUISTIC PROCESSES, AND IMITATION TYPES

Category	Composition Process	Linguistic Process	Imitation Type
A	Knowledge telling 1	Copying: word-for-word (re-telling)	Action-level imitation
B	Knowledge telling 2	Calquing: mapping new content/lexis onto fixed structures (re-lexifying)	Simplest kind of program-level imitation
C	Knowledge transforming 1	Paraphrasing: the content remains unchanged, but the lexis and structures vary	Program-level imitation
D	Knowledge transforming 2	Summarizing: the content is creatively transformed by association and synthesis	Insight through writing; problem solving

The two subtypes of the knowledge telling process correspond to simple reportage or information transfer (as it is known to language teachers). The two subtypes of the knowledge transforming process correspond to true expository writing, summarizing, and what has come to be called data commentary (which is contrasted with information transfer; see [41]).

Reasons Students Copy It is useful to look at some of the reasons students in PHYS149 (many of whom are speakers of English as a second language) copied from texts like the lab manual. What did they copy? What functions did the copied fragments, or segments serve?

We found that students frequently copied words, phrases, or passages that contained relevant facts and/or figures (values, etc.), that described relevant aspects of the experiment, and/or that contained superfluous information. The first kind of copying is, effectively, required; the second kind represents a useful strategy if successful; and the third demonstrates a poor understanding of the goals of the report and the functions of the different sections.

It is relevant here that, according to Mulligan and Kirkpatrick, only one in ten NESB students were able to say that they "understood the content and intent" of their lectures "very well," and, "more disturbingly, almost one-quarter of them reported that they had not understood much" [42]. NESB students were considerably less able to understand "key terms and concepts" than ESB students ("always/mostly" 24% versus 51%). They also had greater difficulty identifying relationships between concepts ("always/mostly" 21% versus 37%) [42].

Howard [43] notes that when she does not really understand what she is reading (giving problems she had with a text by Foucault as an example), she resorts to PATCHWRITING, a useful learning strategy, even for native speakers who are already expert writers. It almost certainly represents an important aspect of student "copying," whatever the language background of the student.

Buranen proposes that much student plagiarism can be explained by the "fear of punishment for grammatical 'mistakes'" [20]. When teachers tell students to put it in their own words, but then scrawl in red ink all over the page, they are giving students very mixed messages. It is not surprising if students then turn to copying from published authorities and other reputable sources. Unfortunately, they often do not have the wisdom to choose their sources well, as when a NESB student copies instructions from a manual in a report of an experiment he or she has carried out.

It is noteworthy that certain operations that we would call copying are overtly encouraged in some courses and textbooks aimed at NESB students. For example, operations referred to as PREPARAPHRASING (e.g., changing the order of clauses in a sentence, using different logical

Fig. 4. Examples of copying processes (see Table V) based on the lab manual.

Source text: In this experiment, you will investigate the efficiency of an electric motor under various load conditions.

Derived texts:

1. In this experiment, *we* will investigate the efficiency of an electric motor under various load conditions. [Copying: very minor changes, in italics; the tense is now inappropriate.]

2. In this experiment, we measured the acceleration due to gravity at different locations. [Syntactic calquing, relexifying the grammatical structure for new content/new experiment.]

3. The aim of this experiment was to measure the acceleration due to gravity and to show that this differs from location to location. [Simple paraphrase; same content.]

4. This experiment aims to test the assertion that acceleration due to gravity varies from place to place on the surface of the earth, and to compare three methods for measuring this. [More complex paraphrase, indicating real understanding of some (if not all) aspects of the topic.]

Fig. 5. Explanation from lab manual, used as source of information.

The value of the acceleration due to gravity varies from place to place on the surface of the earth according to the relationship:

$$g = g_e(1 + \beta_1 \sin^2 \varphi - \beta_2 \sin^2 2\varphi) - 3.086 \times 10^{-6} h \text{ ms}^{-2}$$

where φ is the latitude and h is the height above sea level of the place and g_e is the value of gravity at the equator.

conjunctions) and paraphrasing (the relexification of clauses) are taught systematically in one much-used textbook for academic reading and writing [40]. These operations would correspond to level B in our Table V: knowledge telling 2, or calquing.

English Language Proficiency Two main student needs were identified in the pilot course, in 2001: explicit guidelines on the general structure of a report and explicit instructions on the language features appropriate to different sections—features like voice, mood, tense, and vocabulary choices. A concerted effort was made to provide the suitable input and explicit instruction. This did not turn out to be what the students wanted and needed (as indicated by student evaluations). In our second intervention, full model reports were provided (along with schematic representations), demonstrators were equipped with simple evaluative criteria that they could share with the students, and the imitation of models was accepted as a legitimate strategy (if only a starting point). This was frankly much more successful [1]. The issue of English language proficiency was largely avoided in the second intervention, and language features were dealt with only in terms of "making sense."

Analytically, there are two important aspects of report writing: (a) good expression and (b) good physics comprehension. We would argue that the first of these depends significantly upon the latter. Good physics understanding will drive clear and accurate expression. However, a good understanding of physics concepts itself derives from clear explanation, e.g. good explanatory texts, including both manuals and textbooks [44]. Although some textbooks are of a very high standard, texts prepared by subject area specialists in collaboration with text linguists would represent a great step forward. These would be designed to scaffold the comprehension of physics concepts, while at the same time providing model texts for novice writers to imitate.

Language proficiency can only be improved very gradually from a low base, and we suggest that, for some students, there is no remedy other than full-time courses in basic language skills, separate from their tertiary studies. A number of studies suggest that grammatical accuracy improves most rapidly in the context of intensive, full-time courses, especially when a focus on form is a feature of the instructional methods used. There is a widely accepted rule of thumb among teachers and institutions that prepare student for the International English Language Testing System (IELTS) test of English language proficiency (now frequently used as an alternative to the TOEFL to assess students' readiness for tertiary-level studies): the average student should be able to increase their score by 0.5 of a "band" over 10–12 weeks of tuition. Thus, to get from 6.0 to 6.5 (now the required band for entry to many universities in Australia and the U.K.), the average student in a preentry course needs about three months. While some recent research [45] emphasizes the wide range of variability among individual success rates in such courses over this time span, it nonetheless finds that the mean improvement was indeed just over 0.5 of a band $(N = 116)$.

However, what can we do when remediation is not a viable option? As described in this paper, we have attempted to integrate language instruction with instruction in the subject, in this case physics. We have had some promising results after a false start, finding that the use of models, both in interactive mode and as soft and hard copy, combined with the efforts of a team of lightly trained demonstrators, using plain criteria to identify writing, produces good results. However, in this context we had to take a hard look at what we meant by copying.

Recommendations Freeman and Jones [1] describe the second intervention in which contrasting models (constructed reports, good, average, and poor) were provided online and in hard copy, plainly worded criteria for judging the language standard of written reports were developed, and the demonstrators were briefed on applying the criteria. Written instructions were also provided, in a preface to the laboratory manual. The demonstrators seemed to be the key to the success of the second intervention, as they repeated the messages we had given them in their briefing over and over, in casual, nonhierarchical contexts, to individual students and groups, as the need arose. The core strategies were to:

- provide a single schematic template of required report structure and headings;
- provide contrasting models of good, average, and poor reports, and assist students to critically analyze and evaluate these models;
- model the writing process itself—if possible interactively (team teaching);
- provide clear and logical criteria for acceptable writing (e.g. readability, relevance, accuracy), while avoiding grammatical terms and criteria;
- provide students with assistance in reworking text from the models to suit new topics and experiments.

We found that we could facilitate and exploit natural imitative processes, firstly, by treating elementary report writing as largely a matter of information transfer rather than exposition, i.e., as a predominantly knowledge-telling rather than a knowledge-transforming process. Secondly, copying (in the senses defined above) was tolerated in

these early stages of report writing. Our assumption is that, as writing skills improve, students can be encouraged to imitate structure and function, and to imitate phrase structure rather than copying phrases intact (though there is a place even for this—recall "the accepted value of γ").

If laboratory manuals are to be used, it would be preferable if these contained writing models in the style and format of laboratory reports. The contents of the manuals could be presented as a series of experiments, each accompanied by a model report.

CONCLUSION

A number of Australian universities offer stand-alone credit-bearing courses that focus on advanced academic skills and especially writing, to enrolled students for whom English is a second or third language. These are reasonably successful but cater to a limited numbers of students. Students are usually under pressure to choose content-based subjects. Moreover, the anticipated transfer of writing skills is rather problematic. Writing workshops, offered flexibly, along with online writing support, have also had a considerable amount of success. Intensive remedial courses for students with drastically inadequate language skills are an option we are currently exploring. These could be run during the semester breaks, and would be made more or less obligatory. However, adjunct type interventions of the kind described in this paper represent a much more sustainable and more successful model, in our view.

Academics, too, must change. Professors must take account of the fact that many undergraduates in the brave new world of the 21st century are starting off from a very low base in terms of both language skills and traditional academic and scientific literacies. It is important that this be recognized as part of the equation, so that it can be factored into a viable solution—or rather a range of mutually supportive strategies. It has never been more important to recognize that writing is an indispensable skill, more necessary than ever at all levels of one's profession, but also that most students will develop expertise in this area only very gradually, chiefly by imitating the available models, and frequently by scaffolding their own writing on the linguistic structures contained in the models.

This scaffolding can present itself either as copying, as calquing (or the relexification of grammatical structures), or as (more or less transformational) paraphrasing. It is up to the professors to see that appropriate models are made available, that effective and legitimate uses of models are made familiar to students, and that tutors and markers can distinguish between constructive copying and the futile and illegitimate misappropriation of one's models, or sources. In the light of the observations and analyzes presented in this paper, it seems clear that systematic research is urgently needed to investigate the uses students make of model texts, and to evaluate more precisely the effects of available models, both appropriate and inappropriate, on student writing—both in the laboratory report writing genre and more widely.

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