AN OVERVIEW OF ASPECTS TO PROMOTE GOOD PRACTICE OF WRITING OF LABORATORY REPORTS

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ABSTRACT
This paper presents an overview of aspects that can contribute to promote good practice of writing of laboratory reports and hence result in students producing better reports. The aspects presented include peer evaluation, informed assessment and formative feedback. Students should be made aware of the required structure, content, assessment criteria with corresponding weightings, common errors, software publishing aspects and other auxiliary information relevant to making a good report such as formatting.

INTRODUCTION
Engineering courses usually include the writing of reports based on experimental work. The incidence of these poorly written laboratory reports is common especially in reports of students in their earlier years. This indicates that a sizeable number of engineering students experience problems in writing good technical reports. Indeed inadequacies are also apparent from reports of students in their later years of study.

One notes that their reports improved with experience. Clearly good report writing is acquired over time. Good report writing skills are important in engineering. An inability to write good reports may result in even brilliant ideas or results being overlooked and ignored [1]. It is therefore important that engineering programs incorporate some development of technical writing skills especially that most engineering disciplines are analytical in nature students lack opportunities to practice writing. Writing is important and has been shown to encourage critical thinking, improve the ability to communicate and raise technical competency [2]. It has also been positively linked with individual engineering creativity.

Implementing technical writing courses requires time, effort and manpower. It is costly and suffers from implementation issues. For example ideally specialists in the English department would have to be consulted and enlisted. However it is not always possible to introduce such courses in today's demanding education environment. In addition the work covered in these courses tends to be broad, not providing students enough experience in some specific subject areas. The effectiveness of these courses may be further diminished because students think writing is not a valuable component of their field of study. It is in this light that this paper looks at other aspects that should improve the ability to write laboratory reports.

METHODS
A contributing factor to poor technical writing skills of students is that they are mostly novices in their course of study. They are thus wanting in factual (syntactic), semantic, schematic and strategic knowledge in these areas [2]. As a result they suffer from reasoning error or fallacy [3]. They tend to focus on less important features of problems. They ignore relational structure and

apply little logic in making arguments but instead rely on superficial features, such as content and believability. Novice writers when given a composing task rarely plan, rather they simply begin writing, in the hope that the structure of their composition will some how be realized on the cuff.

A mistake that is often made by course instructors is to presume that students must have acquired good technical writing skills and are proficient in electronic publishing by the time they reach college. This may further be aggravated by assuming that they know the appropriate format of the reports required for their course in particular, as report structure and requirements may differ significantly even for topics within the same course.

An effective way to improve the quality of reports is by providing students with guidelines and making them aware of the assessment criteria and aspects that will be penalized [4]. This includes providing report outline structure, aspects to be evaluated as well as their weighting. The use of formative feedback in improving learning is a well documented. Peer evaluations have been shown to be effective methods in improving writing abilities [5], [6]. Further knowledge and information of software publishing tools is an essential component in producing quality reports.

STRUCTURE AND CONTENT

To improve the report writing skills students should be informed what to include in their report. The required content and structure is an essential component. Some of the required sections apply to technical papers in general [6]. A typical laboratory report usually comprises of some of the following sections and corresponding information:

- *Cover/title page*—This should have a title, name of the author, names of co-investigators (all those who participated in the experiment need to be acknowledged) and date the experiment was conducted. The title should be concise and to the point, while conveying as unambiguously as possible the subject of the experiment. It is good practice to include the captions “Experiment on”, “ Experiment report” or “Laboratory report”.
- *Table of contents*—This should list the different sections (and subsections where appropriate) in the report and the page number on which they begin. The listing should be sequential in the order in which they occur starting from the first page. Page 1 is usually taken to be the first page after the list of contents.
- *Summary*—A concise statement on the purpose and description of the experiment, the findings and conclusion. This should be no more than a couple of hundred words. There ought to be no citations to references in this section.
- *Introduction*—An overview of the topic being covered that is relevant to the experiment. Only formulae essential in explaining the concept should be included.
- *Theory*—Theory on the concept of the experiment. Relationships and formulae utilized in the experiment should be given.
- *Method*—The procedure followed in carrying out the experiment. A list of apparatus, including make and model should be given. Circuit diagrams and/or apparatus setup schematics should also be provided.
- *Results*—Measurements and observations represented in an appropriate form, such as tables and graphs.

- *Answers to questions*—This section is included where answers to specific questions and or specific observations are required. In some instances this may be incorporated under results, discussion or in the appendices.
- *Discussion*—Analysis, interpretation and explanation of results and observations. Any discrepancies that may have been observed should be pointed out and explained. In the case where the experiment was unsuccessful recommendations for solutions should be given. Reference to some real world examples may also be provided.
- *Conclusion*—Summarizes the experiment and the findings and the conclusion arrived from these. Applications and uses of the finding may also be given.
- *References*—Contains a list of sources referenced. The quality and sources of references should be considered carefully. References should where possible be readily available sources (preferably internationally available) and from reputable institutes or publications. They should also be as current as possible. Normally they are indicated by numbers in superscript form or enclosed in square or normal brackets. They are necessary to show that the information is verified and not conjured, and to allow interested readers to pursue the referenced topics. The referencing style should be consistent and complete (title, author, publisher, year).
- *Appendices*—material that need not be placed in the main body because it is involving or is in large quantities or may distract focus of the reader. Mathematical proofs are an example.

In addition to the report structure it is beneficial to add formatting requirements, which do not necessarily affect writing ability but improve the quality of the report, such as those pertaining to page numbering and headers and footers.

Pages should be numbered preferably using a notation that indicates the page number and the total number of pages of the report. For instance use “1 of 7” or “1/7”. Pages are conventionally numbered starting on the page after the list of contents. The practice of including headers or footers with the title of the experiment and the names of the authors is a useful addition for instances where pages get dislodged or are kept as references.

FIGURES, TABLES AND EQUATIONS

Figures, tables and equations should be uniquely numbered. Separate numbering should be maintained for figures, tables and equations respectively. Multipliers should be included in units, i.e. one would write “kV/m” instead of say “V/m x 1000”. The abbreviation and full form of quantities should not be mixed. You can write “kV” or “kilo Volt” but not “kVolt” or “kiloV”.

Each figure and table should have a caption that describes it in sufficient detail. Any symbols used defined within the caption (when they are not defined within the figure) for figures. For tables any symbols not defined within the table should be defined at the bottom of the table. The quantities represented by axes of graphs should be written in full followed by the units in square or normal brackets (e.g. Electric field [V/m]). A table should only continue on to another page when it can not fit on an entire page.

Equations are usually referred to within text by their reference number only, except when beginning a sentence the reference number is preceded by the word “Equation”. All symbols used in equations should have been defined before the equation otherwise they should be defined immediately after it.

ASSESSMENT

In addition to informing students what they are expected to include in their reports, informing them of the assessment scheme also contributes to improved reports. As a result the guidelines for reports should include the assessment criteria and respective weighting. Students should know that they are required to produce as professional quality of reports as possible.

Usually the bulk of the marks are allocated to technical content and analysis. However allocating significant marks to auxiliary aspects that are never the less important in the making of a good report such as general presentation, organization and layout, including spelling and grammar errors, help students write better reports.

The use of constraints such as the minimum number and type of references, setting upper and lower limits to the number of words for the different sections will enable them to develop better writing skills and produce better reports. This usually circumvents writing tactics that result in poor reports such as unstructured long rumbling discussions where the information from many sources is reproduced with the aim of covering as many essential points as possible. Constraints therefore enable students to be critical, analyze information and be concise, encouraging quality over quantity.

An effective way of reducing bad practice is by penalizing it. Students need to be made aware of bad practices. Common bad practice [7] include long rambling reports; illogically ordered and confused sentences; excessive use of jargon; spelling and grammar mistakes; unclear meaning due to confused grammar (at times deliberate when a student does not know an answer); lack of evaluation (avoiding to discuss or conclude); distorted and fabricated information.

FEEDBACK

Formative feedback is essential in learning [9]. By reflecting on feedback students are able to take remedial action and improve their report writing skills. It is therefore important that feedback includes comments on the writing and shortfalls of a report. Commenting on strengths as well, adds value to feedback. It is important that the feedback is formative and suggestions provided when ever possible.

COMMON ERRORS

Common errors can make an otherwise good report appear unprofessional. These errors appear obvious to the experienced writer but are however oblivious to the novice. In addition to informing students of the required report structure and assessment aspects they should therefore be made aware of common errors. A common mistake made by students when they write reports is to write as a student writing for a professor. Such an approach can easily result in a report lacking a professional tone. Rather considering themselves as scientists or working professionals writing for an institution helps attain a professional tone in their reports [4]. Some selected common errors are presented here:

- Personal feelings and experiences should not be expressed. For example, “the lab went well”, ” it took long because I was tired”, “ I was very happy to obtain results”.
- Use incorrect or lay terminology. For instance “a stretched cosine wave” to imply “a cosine wave at a lower frequency” or “shifted cosine wave” to describe a phase shift. Students should familiarize themselves with topic terminology and concepts. Correct terminology is essential if a report is to be deemed professional.

- Merely concluding that the experiment was a success. Instead the verified theory should be stated. For example, "it was verified that the relationship between current, voltage and resistance is given by Ohm's Law", as opposed to "the experiment was a success".
- Acronyms and abbreviations that are not common should be defined on their first occurrence in a report. Conventional abbreviations should not be defined (e.g. ac and dc).
- Numbers less then ten are normally written in words especially where they begin a sentence.
- When unconventional symbols are used or where ambiguity of what they represent arise they must be defined.
- The article "an" should be used before symbols when their pronunciation starts with a vowel, otherwise the article "a" should be used. As a result we write and say "an M30" not "a M30" as this is pronounced "em-thirty", while we would write "a C90".
- Multiple superlatives or qualified superlatives should not be used. For instance write "least" and not "most least."
- The subscript of the permeability and permittivity of free space is the number zero and not the letter "o".
- The abbreviations for "for example" (e.g.) and "that is" (i.e.) have periods after each letter.
- Always proofread the completed report!

PUBLICATION TOOLS

Reports now have to be written using electronic media. As a result a lack of adequate software publishing skills and knowledge can adversely affect the quality of a report. This information should include publishing tools for different platforms, and more specialized tools such as equation editors, statistics, image and graph plotting applications. The limitations of these applications are an aspect that should not be overlooked. Portability and conversion between software applications are areas that need to be addressed as they concern compatibility issues. Another important area that should not be ignored is the transferring of material into electronic form.

COMMUNICATING REQUIREMENTS

The form in which the above aspects that make for better report writing are imparted to students has some bearing on the effectiveness of the entire process. The students can be informed by several means. This can be in the form of handouts, online web resource, classroom session or a combination of these.

Handouts suffer from the disadvantage of not being read at all. Having an obligatory exercise or questionnaire based on the handout may ensure that students have gone through the resource material. However, on their own they may not be very effective and would be of better use as supplements to some classroom based session and activity. Online writing resources are similar to a handouts but have the advantage that they can be referred to whenever necessary and easily updated. When used as the sole source of information they also suffer from the possibility of poor utilization and here too having an obligatory online exercise or questionnaire may be beneficial.

A commonly used approach that is particularly effective is peer evaluation, where students evaluate each other's reports [10]. This is a good method as it supports different learning types and has been shown to develop technical communication skills [11]. Students find peer evaluation valuable [12]. Peer evaluation requires thinking at high levels such as evaluation (the highest level on Bloom's taxonomy) and therefore also helps develop critiquing abilities, which are rather poor in the novice student. Explaining a topic to others results in better understanding and improves the ability to express things clearly.

CONCLUSION

This paper has presented methods, which have been found to improve writing that can be applied to the writing of laboratory reports. Improved writing can be achieved through informing students on the structure, assessment, common errors, software publishing and by use of formative feedback. The means of informing students of the requirements affects the effectiveness of the methods. Peer evaluation has been found to be an effective means to teach students. However, the use of a combination of handouts, web resources and peer evaluation would naturally be more effective than using a single medium of dissemination. Many aspects that have been presented here may also be applied to improve writing in other types of reports.

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CASE STUDIES IN PROBLEM BASED LEARNING IN ENGINEERING

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ABSTRACT
An overview of the Problem Based Learning - PBL concept in the third level education was presented and the implementation of PBL into Engineering and its implications were investigated. The significance of this relatively new educational concept, how it can be used, its strength and limitations were explored. The impact of the PBL method on the efficiency of Engineering educational process was also assessed. PBL in Engineering was found to address many of the labour market demands - working and learning in teams, presentation skills, negotiation abilities, research skills and critical thinking. However, PBL in Engineering did seem to limit the possibility of offering the students a more comprehensive image of the Engineering concepts. The use of a Hybrid model (PBL and Traditional method) was found to answer the problems associated with implementing PBL into the traditional Third level educational structure and to increase the efficiency of the learning and teaching process in Engineering. The findings also suggested that the Hybrid model provided students with a sound knowledge base along with problem solving, independent and critical thinking – essential features for a future Engineer.

1. INTRODUCTION

1.1 Problem Based Learning - Overview
Problem Based Learning – PBL as it is generally known today evolved from an innovative health sciences curricula introduced in North America over 40 years ago and has since spread across the globe and across most disciplines. It is a new method of teaching used mainly in the Third Level education based on the 'learn to learn'concept.
PBL was first developed as a small group, student-centred learning curriculum at the Mc Master Medical University in Canada (1960). The university introduced the tutorial process as central to their philosophy for structuring an entire curriculum reform promoting student centred multidisciplinary education as a basis for lifelong learning in professional practice [1].
PBL emerged as a concept in 1980 when Barrows [2], discovered through investigations into medical education that: 'Medical students and residents for the most part did not seem to think at all', which was a worrying finding. The traditional curriculum suffered from overloading students with an excessive emphasis on memorization.
Barrows together with another famous researcher Tamblyn (1980) [2] concluded that:

- Learning through problem situations -much more effective than memory based learning
- The medical skills that were most important for treating patients were problem solving skills rather than memorization

One of the most important points about problems in problem-based learning is that it is not a question that first the students receive inputs of knowledge e.g. lectures, practicals, handouts etc. and then "apply" this knowledge to a problem they are presented with later in the learning process. Problem-based learning is problem-based learning not problem-based teaching [3].A lecturer using a PBL approach is not concerned with what and how they are teaching. Rather