Debunking method section of tertiary electrical engineering laboratory reports

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Abstract This research investigates how electrical engineering undergraduates in a tertiary institution write the method section of laboratory reports (ELR) for academic purposes. It aims to identify specific rhetorical moves, recurrent step patterns and combination of both used in composing the report's method section. In order to identify the writing patterns and conventions among the final-year electrical engineering undergraduates, a genre analysis was conducted using a corpus of 35 student reports. This study adopted Genre Theory as the theoretical framework, Ngowu(1997) analytical framework and the BCU(2007) approach and procedures for analysis. A pilot test was conducted to determine the most suitable model that fits the best to describe move and steps of ELR in the method section. An inter-coder reliability was obtained that showed high significance. To ensure validity, the move and steps were benchmarked at 60% of occurrences for analysis. This study describes the main move in method as Move 1 as this section starts subsequently after the introduction section. The analysis of the method section of 35 ELR's indicates that this section consists of a main move describing experimental procedures (obligatory). Following Move 1 are three steps, firstly M1S1, setting up experiment (conventional), secondly, M1S2 stating precautions (optional) and finally M1S3 conducting the experiment (obligatory). The exemplification of findings was cross checked against the university guidelines to identify the lacks and the combination of move patterns show the steps are in sequence of M1S1M1S2M1S3. The apparatus and procedures are consistently integrated and conventionally used except for stating precautions were used optionally. The method employed in this study may be replicated to analyse various sections of scientific and technical reports such as introduction, result, discussion and conclusion (IRDC). The study emphasises collaboration between English for Academic Purposes (EAP) practitioners such as writing instructors and discipline-specific experts in engineering to enhance and improve genre-based writing instruction at tertiary level.

Keywords: Method section, laboratory reports, move analysis, engineering discourse.

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1 Introduction

The divergence between employer expectations and academic preparation regarding written communication skills within the field of engineering has been significantly noted [1]. This disconnection underscores a prevalent decline in students' writing capabilities across diverse domains [2]. Given the status of English as the preeminent language within the scientific and technological sphere [3] [4], proficiency in academic English composition has become a necessity. Moreover, professional communication aptitudes are held in high regard within the engineering profession. Consequently, both the academic progress and vocational outlooks of these students are contingent upon their ability to articulate their ideas in English for academic purposes. Engineering Laboratory Reports (ELRs), vital components of electrical engineering pedagogy, afford students the opportunity to exhibit their understanding and application of complex engineering tenets [5]. The reports, particularly the methods sections, serve as critical determinants of the extent of student comprehension and implementation of novel knowledge. Despite the pivotal role of ELRs in both scholastic and professional spheres, there is a paucity of academic inquiry focusing on this genre, especially regarding the method component. This research gap necessitates further, in-depth research to enhance our understanding of how students navigate this crucial aspect of their education. Laboratory reports are vital and distinctive to engineering study.

2 Literature review

Laboratory reports are assigned to engineering students as one significant component of their lab assessment. A laboratory report that consists of the purpose, methods and results of an experiment are primarily written with the objective to enable the students to demonstrate their understanding of the empirical studies that they have performed. Laboratory reports are written to present and interpret experimental data precisely and persuasively [6]. Despite its vital role in tertiary assessment, lack of exposure to the structure and convention of writing a laboratory report is one major reason for students to struggle in reporting their empirical studies. Mastering the skill of writing an effective laboratory report is a challenging task especially for beginners at tertiary level [5] [7].

Laboratory reports, like many other types of genres, are written in a particular convention and the structure is influenced by the nature of the course and governed by the institutional requirement. In many ways, laboratory reports are like research articles or published scientific papers with similar IMRD format: Introduction, Methodology, Results and Discussion [8]. Previous studies on laboratory reports have highlighted the similarities and differences between laboratory reports and research articles. [7] compared laboratory reports with research articles and concluded that while both genres share some similar microstructure, there are significant differences in the realization of moves. While there have been extensive studies on research articles using move analysis, little attention has been given to engineering laboratory reports. According to Jung (2013) [9], despite laboratory reports playing vital roles in the work of many engineers, less focus has been given to this genre. Since genre is characterized by the communicative purposes that it is intended to fulfil different purposes for writing lead to different text types with distinct text structure and linguistic features [10]. Hence, there is a need for studies to focus on the structure of Engineering lab reports.

Genre analysis, a study of situated linguistic behavior in an institutionalized academic or

professional context, focuses on detailed study of texts to gain understanding of the structure of the texts. Swales (1990) [11] argues that a particular genre is similar in its "structure, style, content and intended audience. This rationale, hence, shapes the schematic structure of discourse and influences the choices of pattern and style. There are three popular schools of genre analysis: English for Specific Purposes Theory, Australian educational linguistic theory, and North American new rhetoric theory [9] [12]. Swales' (1990) [11] move analysis focuses on the IMRD framework (Introduction, Method, Result and Discussion), and Bhatia (1993) [10] divided the moves into four different categories: introduction purpose, description of methodology, summary of results, and presentation of conclusion*s.* Ngowu (1997) [13], analysing medical research, established a model different from Swales. Ngowu's model is adapted in this study as it provides a comprehensive analytical framework to subjects under study.

In the field of genre analysis, research articles of various disciplines have been one of the most extensively analyzed genres. A host of studies have been conducted on the abstract, introduction and discussion of research articles [14][15][16][17] [18] [19] [20] [21]. Recent progress in genre analysis has led to interest in professional practices (Jung, 2013). There are several studies that are specific to the science and engineering disciplines conducted in the past [13] [22] [23] [24] [25]. Manzoor, Majeed, and Munaf (2020) [26] analyzed structures of civil engineering research articles' introduction and concluded that the introduction genre in the field does not have the proposed sequence given in the model. In another study, [27] analyzed engineering research articles to address the need for discipline-specific writing for beginners of the English language. The study combined corpus-based and genre-based approaches to identify rhetorical structures of research articles. Besides, in recent years, researchers have also focused on the genre analysis of engineering laboratory reports, an essential academic writing pedagogy [7] [9] [28]. Jung's (2013) [9], analysis of undergraduate engineering laboratory reports led to a conclusion that the linguistic moves and steps in the reports have identical patterns. Parkinson (2017) [7] on the other hand, compared laboratory report moves to research articles and highlighted their similarities and differences. Due to the complex nature of laboratory reports and their importance in the academic world, it is important to offer technical faculties strategies to train engineering students to communicate effectively in an academic setting [24]. This calls for further exploration of the structure and pattern of this discourse.

Many studies have focused on analyzing the genre of research articles from various disciplines and languages [29] [30] [31]. However, there are a limited number of studies on Engineering lab reports [9]. Despite studies highlighting the visible similarities and differences between research articles and engineering reports [7] [8], there seems to be a gap in the studies on laboratory reports. Besides, the number of recent studies is also limited, especially in the methodology section of laboratory reports. Hence, this study has attempted to fill this gap by unravelling the structure of the methodology section of engineering lab reports.

The purpose of this study is to identify the rhetorical strategies and recurrent move patterns that students utilized to compose the method section. The research questions that we intend to investigate, and answer are what the rhetorical moves are and what are the combinations of move patterns used by electrical engineering students in writing the method section of ELRs. By identifying these rhetorical moves and steps, the lack in writing can be determined after a cross check of the findings against the institution's ELR writing guidelines. The outcome of

the cross check may shed light on the need for language instructors who teach English for Academic Purposes (EAP) and engineering laboratory instructors to improvise their instruction to address areas of writing deficiency in the method section. Hyland (2018) [32] mentioned that the findings of genre analysis will be immensely helpful to educators and academics, especially those who teach English for Academic Purposes (EAP) to modify their curricula to better suit their students' writing lacks.

3 Method

The research was conducted using the genre analysis approach. In earlier studies assessing academic writing in many domains, this method, which is based on genre theory [10], has shown potential and has thus been adapted to current study. A sample of 35 ELRs written by electrical engineering students who are in their third and fourth years of study were selected from a compilation of 79 ELRs based on richness and comprehensiveness to reduce data saturation. These samples have obtained a minimum score of 4 out of 5 awarded by laboratory supervisors and instructors. The Genre Theory, Ngowu's (1997) [13] analytical framework, and the Biber, Connor and Upton (2007) [33] BCU analysis procedures were adapted to uncover the underlying rhetorical motions and patterns in the method sections. In addition, a pilot test was carried out to establish a baseline for identifying the presence of a move or step, and it was benchmarked that 60% of the reports had such information. Hence, the results will give a thorough understanding of the format of the method section and how students applied the tools and techniques in writing this genre both. Inter-rater reliability was obtained from 3 coders, namely 1 from the language department, another 1 from the engineering department and by the researcher himself. 2 hours of training session was conducted to familiarise coders with the text and on how to code based on the coding scheme given. Cohen Kappa was chosen to assess the inter-rater reliability of the Method section for the articles that showed high consistency (96.3%) among coders.

4 Result and Discussion

Lim (2006) [34] posits that the method section is an important part used by researchers to strengthen the credibility of their findings to dispel possible doubts and criticism on results and its interpretation. This study describes the main move in the method section as Move 2 as this section starts subsequently after the introduction section. The analysis of the method section of 35 ELRs indicates that this section consists of a main Move, which is called Move 1, Describing Experimental Procedures. Following Move 1 are three steps, firstly M1S1, (Setting up experiment), secondly, M1S2, (Stating Precautions) and finally, M1S3, (Conducting the Experiment). The details of the analysis of this move and the steps are presented and discussed in the next section.

Move 1: Describing experimental procedures.

Electrical engineering is a well-known field of discipline that follows strict procedures in conducting experiments, such as the use of proper methods and techniques. The overall aim of conducting laboratory experiments is to enable undergraduates to use technology, energy, materials, and information, making laboratory experiments the best start-off point to their career. The engineering laboratory experiments use materials to construct an experiment. Usually, ELR reports show how an experiment is built or generated, as this is seen as a prominent step in ELR corpus. In this section, information on how laboratory materials are set

up, prepared, and used to conduct an experiment is discussed. Hence, move 1, which describes the experimental procedures, provides information on procedures in setting up materials in an experiment, stating precautions and conducting the experiment. To show how the analysis of this section is conducted, a sample from ELR 21 is exemplified below. The extracts taken from the ELR corpus are italicized.

Move 1: Describing experimental procedures.

- *Set the impedance of the transmission line to 200 W and connect the meters as shown in Fig. 2. The circuit should be connected to the three-phase variable supply. Note that watt/var meters and phase meter need 24V AC supply provided in the power supply unit.*

Move 1 Step 1: Setting up experiment.

- *Adjust the sending-end voltage E1 to 300 V and keep it constant for the reminder part of the experiment (CAL'D) positions.*

Move 1 Step 2: Stating precaution.

- *Don't remove any other connections shown in Fig.2. Verify your connections with the lab supervisor before switching on the power supply.*

Move 1 Step 3: Conducting the experiment.

- *Take readings of E1, Q1, P1, E2, Q2, and P2. Record your results in Table 1Take readings of E1, Q1, P1, E2, Q2, and P2 for different loadings. Record your results in Table 3.*

Move 1 Step 1: Setting up the experiment.

The analysis of 35 ELR's shows that Move 1 Step 1, Setting up experiment occurred in 32 laboratory reports or 91% of the total report making it a conventional step in writing the method section. This figure is significant as most undergraduates include this step in their method section. Equipment such as voltmeter, transformer, and attenuator are common terms used in this step. This step is frequently used to provide information on procedures undertaken before conducting an experiment and the preparations that are involved and to be done. An optional step that co-exist in this part of the report is precaution steps. The information on setting up laboratory equipment is crucial, especially for the future experiments. This step is written carefully by following a step-by-step guideline to ensure the experiment is error free and the same method can be replicated by others in future.

The following extracts below exemplified Move 1 Step 1 that shows setting up an experiment.

- *ELR 32 Set a multi-meter in "diode test" mode (note that some multi-meters need to push two buttons in together to set "diode test" mode).*
- *ELR 25 Establish the connections for power measurement in DC circuit according to the circuit diagram shown in Fig. 2.1 and select the ranges on the wattmeter as indicated.*
- *ELR 16 In the code shown above, we are going to modulate the signal of message signal which we store in array "b" with bits of [1 0 1 0 1] at line 4. while setting the frequency of message signal to 5 at line 5.*
- *ELR 6 In the 1st procedure we are going to use the function wavered for reading the wave file.*
- *ELR 4 Launch cable is connected. FC adapter is used to connect the FC connector.*

Move 1 Step 2: Stating Precaution

The safety precautions are written as a reminder to laboratory users who conduct experiments. There are two different precautions. Firstly, the safety precaution for the safety of laboratory users from hazards such as acids and fire. Secondly, the one relevant to this study is the precaution on handling the experiment. This precaution serves as a reminder or a warning to those involved in hands-on experiments. The reasons for these precautions are the safety of the experimenter, the careful use of laboratory apparatus, and to achieve desired outcome from the experiment without causing any damages which could deter the results. Based on the analysis from 35 ELR' s it was observed that there were 14 ELR's or 40% of the overall reports stating precautions. This number is below the benchmark of 60% for making this move an optional step in the method section based on its low rate of occurrence.

The extracts below exemplified Move 1 Step 2 that shows stating precautions.

- *ELR 1 Before enabling SPr, the motor jolts after turning it ON swiftly after turning it OFF. After enabling SPr, does not jolt. The system would be damaged if SPr is not enabled, due to inertia.*
- *ELR 12 Do not make any changes in wiring connection as long as the power supply is turned on.Make sure the connections are tight and not loose.Ensure that the voltage is '0' before power supply is turned on.*

Move 1 Step 3: Conducting experiment.

The analysis of 35 ELR's show that Move 1 Step 3, indicating experimental steps occurred in all 35 ELR's or 100% of the total reports making it an obligatory step. This is a significant finding as students found this step as an important element that must be included in their report. This step states the procedures in conducting the experiment after they have explained the steps in setting up the experiment in the method section. The differences between Move 1 Step 1 and Move 1 Step 3 can be noted as the prior is written as a prerequisite to the later, and it is also written in sequence in all ELR's although Move 1 Step 1 was omitted from 2 ELR's of the corpus. In this step, students are required to conduct the experiment hands on by manipulating the laboratory equipment to achieve desired outcome. In this step, students follow certain pre-determined protocols as outlined by laboratory instructors or by manufacturers of the products and materials being used for experiments, employ techniques that were previously used successfully, and draw on strategies such as drawing graphs, controlling the current flow in circuits, and repeating the same procedures if there are errors.

The following extracts below exemplified Move 1 Step 3 that shows conducting experiment.

- *ELR 2 We set the code to use 11bins for each color channel to construct the histogram image descriptor. After that, we select 10 images from each category as query and we need to find the top 10 similar ones. This can be done by using the Euclidian distances of the images and the color histogram feature. Lastly, the average precision rate is calculated for all the retrieved images.*
- *ELR 17 For message transferring from board 1/1 to board 1/2, the antennas were connected using a jumper wire with crocodile clips. Then the power supply was turned on. We increased AUDIO AMPLIFIER's VOLUME preset until the sound was audible from the speaker.*

Combination of move patterns in Method section

The analysis of the method section was further extended to determine the move sequence, and it was found that all 35 ELR's or 100% of the total report observed a sequenced move and steps. It was observed that students wrote Move 1 Step 1 as a prerequisite to Move 1 Step 3. The reports were written to show the procedures for setting up an experiment prior to conducting it. This makes sense because, without the equipment being fixed, it would be impossible for them to conduct the experiment. Move 1 Step 2 is usually combined with Move 1 Step 1 as the setting up of the experiment in progress, it is also important to remind the experimenter of the safety precautions. The method section is found to be more organized as the order of steps were M1S1-M1S2-M1S3 throughout the analysis. The content is explicitly written to show the procedures observed in conducting the experiments. Move 1 step 3, introducing the laboratory apparatus found to be more suitable to be included in the method section for better transition from introducing the apparatus-stating precaution-setting up experiment-conducting experiment. The method section was built based on two components, which are the apparatus and methods, and in some reports, the list of apparatus is written in one section called equipment, whereas others combine the apparatus and method when each step of the procedure is written. The analysis of the ELR's reveal that only 3 reports, or 8.5% of the total reports, have organized the method section with the material being used separately.

The extracts below show the exemplification of this pattern.

- *ELR 12: Instrument required: AC/DC Current Sensitive, Relay, DC Power Supply, Interconnection module, Universal Fault Module, Faultable transformers, Transmission grid A, Current transformers.*
- *ELR 29: Apparatus: "Low pass filter design" experiment board, DC power supply, Dual-trace oscilloscope, Function generator, Connecting wires.*

In contrast to the above structure, 33 ELR's or 94% of the total reports have integrated the apparatus and procedures in the method section and are concurrently presented. The extracts below exemplified the apparatus and procedures integrated in this section.

- *ELR 30: The capacitor "Cf" and the resistor "Rbase" are used for phase shifting, and together with the transistor, form a voltage-controlled capacitor. This voltage-controlled capacitor is actually in parallel with the tuned circuit.The changing information signal being applied to the base has the same effect as changing the bias voltage applied to the transistor and, this would have the effect of increasing and decreasing the capacitance value of the voltage-controlled capacitor.*

- *ELR 27: Connect three capacitors of equal value of 4.2 µF each in delta as shown in Fig. 2.2(c). Adjust the three-phase supply voltage to be 150 V line-to-line. Read the corresponding values measured, I of the ammeter, V of the voltmeter and P1 and P2 of wattmeter W1 and W2. Record the measured values in table 2.1. (NOTE: One of the wattmeters is a negative reading as the pointer will shows value less than zero.) Modify the wattmeter connection to obtain the reading for the wattmeter that gave negative reading.*

5 Conclusion

In conclusion, the analysis of 35 ELR's in method section indicates that there is one frequently used move in method section, Describing Experimental Procedures and this Move is followed by two subsequent steps which are Move1 Step1 Setting up Experiment and Move 1 Step 2

Conducting Experiment. These steps are in sequence of 1-2-3 consistently throughout the analysis. The analysis also shows that in Electrical Engineering reports, the organisation of apparatus and procedures are concurrently integrated and conventionally used among undergraduates. This study is merely the first step towards fully understanding the academic writing practice of engineering students. It is recommended that future studies may also evaluate ELRs' introduction, findings, discussion, and conclusion (IRDC) using the analytical strategy as in this study. Finally, to enhance genre-based writing instruction across disciplines, continued collaboration between EAP practitioners and discipline-specific experts in the engineering field is necessary to determine and deliver the most effective writing instruction and to understand why a genre is written the way it is written by a discourse community.

Table 1

Model for ELR Method Section	
Move 1	Describing Experimental Procedures (obligatory)
by Move 1 Step 1	Setting up Experiment(conventional)
by Move 1 Step 2	Stating Precautions (Optional)
By Move 1 Step 3	Conducting the Experiment(obligatory)

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