Engineering Communication (ESL) and Logical Cohesion in Student Papers

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ABSTRACT: *Professional engineering practice is undergoing profound and exciting changes. These changes are shaped by globalisation, the need for conservation of resources, growing recognition of the social and environmental consequences of engineering projects and the recognition that engineering involves far more than outstanding technical skills. Communication skills are increasingly recognised as vital to good engineering practice and increasingly communication courses are included, often as electives, in engineering degrees. In a few cases such courses are compulsory. This paper argues for the inclusion of communication courses which focus on developing skills in evidence based argument. These skills are seen as fundamental to the academic and professional life of an engineer. Further, it is proposed that the way in which the course focuses on the relationship of engineering to its social, environmental and ethical context promotes the development of holistic engineering practices.*

In communication, a common area of difficulty for students, which relates strongly to the development of an effective argument, is that of integrating evidence. In the Engineering Communication, English as a Second Language course, a number of strategies are taught to help students integrate their evidence more effectively. One such strategy shows students how to strengthen the internal links in a paragraph. The author will present her preliminary research into language links within paragraphs.

1   INTRODUCTION

My particular research interest lies in text organization and in devising strategies to assist students to organise their written work. Before exploring this, I first wish to set out the context for this research, including both the broad environment of engineering practice today as well as the particular educational context. This will be followed by an outline of the course involved and a report of the preliminary research study.

Engineering practice is undergoing rapid change in response to a number of issues and demands. These include: increasingly sophisticated technology, materials developments, globalisation and a growing awareness of the social and environmental outcomes of engineering projects as well as the need for conservation of scarce resources. These changes are associated with increasing collaboration and negotiation between the varied professions as well as the communities and other stakeholders involved in engineering projects. It is in this context that the need for more effective communication skills has emerged. As part of this, it is important for engineering lecturers teaching technical courses to be aware of the importance of language and communication. It is hoped that engineering educators involved in teaching technical subjects will also find this discussion interesting and that the material will be useful to them when marking and assisting students with their reports and essays.

Many research studies have shown that for professional success, engineering graduates need to significantly improve their skills in communication, interpersonal skills and critical thinking (Department of Education, Training and Youth Affairs 2000 and 2001, Krasniewski 2001 and Lee 2003). For over six years the Faculty of Engineering, Computer and Mathematical Sciences at the University of Adelaide has provided a variety of communication courses including the Engineering Communication English as a Second Language (ESL) course. Since 2002 this course has been compulsory for all international students. The course is also offered to local students whose first language is not English.

2 ENGINEERING COMMUNICATION ENGLISH AS A SECOND LANGUAGE

Engineering Communication English as a Second Language is a semester long course which is compulsory for international students across five schools within the Faculty of Engineering, Computer and Mathematical Sciences at the University of Adelaide. Students are encouraged to undertake the course in their first semester after arriving and, as many students are from twinning or articulation programs, this means that classes are made up of students from all four year levels. Most of the students however, are undertaking level three. Each student attends one two-hour lecture-workshop per week and must complete four assignments, two oral and one written. There are no examinations. The course is task based, both in terms of out of class assignments and of in-class tasks in which students are expected to actively engage.

The Engineering Communication ESL course is developmental in nature with the first written assignment providing the basis for the later assignments. Explicit assessment criteria are used in marking and extensive feedback is provided to the students. All assignments are individually assessed. Lecturers set aside several hours a week for student consultations. These consultations are particularly helpful as a means for students to overcome individual language difficulties. In addition to the assignments students must undertake an online grammar module.

The course objectives are as follows:

On completion of the course students should be able to:

- grasp some of the ways in which social context shapes communication
- develop and present evidence based propositions
- identify and begin to apply the language features of academic writing and speaking
- locate appropriate sources of information toward their assignments
- critically read and interpret information in the development of their own point of view
- write appropriate texts which communicate the logical development of proposition(s) and analysis of issues
- present their understanding and analysis of issues in a formal seminar presentation
- participate in class and group discussions, and present decisions made to class colleagues in informal presentations.
- Increase their awareness of social, cultural and ethical issues and be able to discuss these in relation to professional and social responsibilities

Usually one topic or theme is set for all the assignments often with additional components for the final two assignments.

This semester the assignment topic is (taken from the student booklet, 2004, p10):

Health, Medicine and Engineering

Engineering has benefited both patients and the public health. However at times engineering has contributed to ill-health and even death. Discuss the relationship between engineering and health with reference to up to three specific examples.

Note:

The focus is on the benefit or damage to the health of individuals or the public not on the technical details of the engineering involved. Students may choose current or past engineering developments.

For the first two assignments students use only the evidence provided in the booklet and for the final two assignments are required to search for and use additional academically appropriate sources. Many international students have had little experience undertaking independent research using databases nor in integrating research evidence. The latter is often seen as quite difficult by the students many of whom have not previously had to cite sources for their evidence nor provide reference lists.

An important feature of the topics is that they address issues of a social and, or, environmental nature. This helps to promote a more holistic view of engineering. Students are explicitly asked focus on these issues, on the link between engineering and society and not on highly technical aspects of engineering. Students are also asked to develop an objective evidence based argument and to avoid emotionally charged points of view.

3 THE PRELIMINARY STUDY

In Engineering Communication ESL our students often experience difficulties in structuring ideas logically in academic texts. This area is also emphasised is in findings by both Krasniewski (2001) in Poland and Lee (2003) in Malaysia.

We observed that our students had major problems with the development of the argument, i.e. with the organizing (structuring) complex information in a logical way. Some papers looked like a collection of loosely related thoughts – without any clear line of reasoning. Krasniewki (2001, p. 17)

The results consistently reveal that interpersonal-communication skills remain a major concern of many employers today. …This ranged from failure in both written and oral communication skills to presentational and other work-specific communication skills such as informal discussions, publication of papers, public speeches and interviews, etc. For example, reports are poorly written, rife with misspellings, redundancies, grammatical errors, illogical sequencing and imprecise expressions. Lee (2003 P.5)

In the Engineering Communication ESL course several strategies for strengthening text organization are taught to students. These include staging devices such as the use of topic sentences and the movement from general to specific. More unusual in courses of this nature, is the explicit use of strategies developed using principles of Halliday's functional grammar, itself part of a larger theory of language, Systemic Functional Linguistics (SFL) (1994). My research interest lies in one particular aspect of this: logical cohesion between sentences in a paragraph. By logical cohesion I mean the links in meaning between parts of a text and in terms of this research between meanings within a paragraph. Barbara Wake of the Learning Teaching Development Unit introduced several tasks to do with logical cohesion into the Engineering Communication ESL curriculum several years ago and sparked my interest in researching the area. The aim of this research is to test the strategies and depending on the findings, to use the findings to refine existing strategies and develop further strategies that students can use to improve the cohesion within a paragraph.

The immediate aim is to examine student texts to observe how students structure their texts using analytical tools, particularly the constructs of Theme-Rheme, developed by Halliday (1975 and 1994) and others. If we can identify language features which students can recognise and use to strengthen the links, the cohesion within paragraphs, students will have a valuable resource for improving their writing. To be useful as a student tool the identifiers need to be recognisable to non-linguists and with language features this is not always straightforward. Finding identifiable features which are reliably observeable and comprehensible to students whose first language is not English is a major challenge in this research. There is significant research which suggests that Theme and Rheme may be the basis for developing useful teaching strategies. However this agreement is not universal (see for example Crompton, 2002)

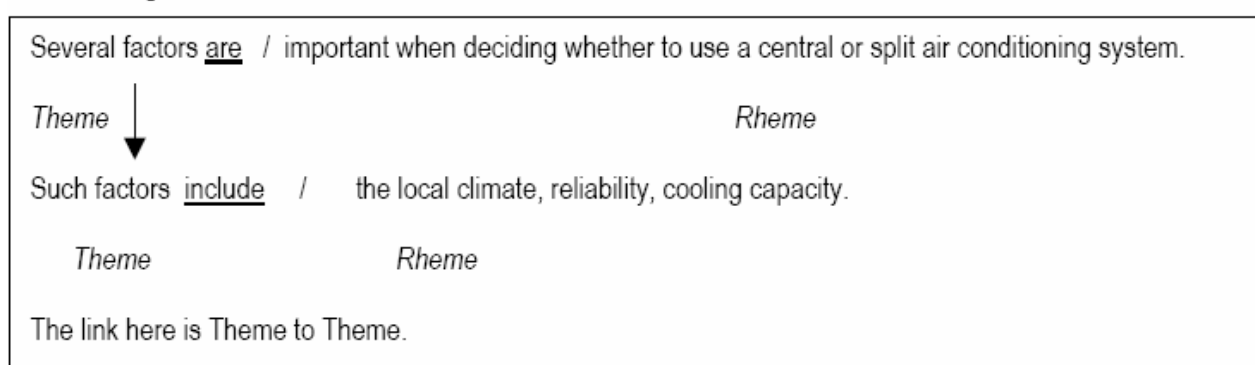# 4 THE CONCEPTUAL FRAMEWORK AND ANALYTICAL TOOLS

Several key assumptions of SFL are relevant to this study. Firstly, grammar (and all language) is viewed as functional, observations and analyses focus on how people use grammar, not on the formal rules of grammar. Secondly, language is, in an important sense, how we construct the world, not a tool for reflecting the "real world". For example, light can be viewed as particles or as waves but not as both simultaneously. Experimental observations of the wave properties of light preclude the possibility of observation of light as particles. Thirdly, language is shaped in profound and fundamental ways by the culture and immediate social context in which it occurs. Language is "doing a job in some context of situation" (Halliday and Hasan, 1985,p. 52). In relation to this work, the immediate social context is academic study and more specifically that of engineering.

Cohesion refers to the, the meaningful links within a text. Cohesion refers to the extent to which a message, oral or written "sticks together", has unity of meaning. Cohesion is a matter of degree, a continuum rather than an "on off" quality. Links between sentences, links between paragraphs and the introduction and the conclusion, all contribute to this. Generally highly cohesive texts are much easier to read and thus cohesion is a key factor that contributes to overall readability. The limited capacity of short term memory is important here since we can only store around eight to ten pieces of new information in our short term memory. Compare for example the greater difficulty of learning an eight digit telephone number with that of mastering a ten digit mobile number.

Theme-Rheme relations are one factor in cohesion. Others include conjunction, reference, substitution, ellipsis and lexical cohesion (Halliday and Hasan 1976). To illustrate what is meant by Theme, Rheme and cohesion here, a brief explanation of the concept of Theme and Rheme and an overview of some recent linguistic research findings will be followed by analyses of an example paragraph from an engineering research journal and two example student texts. This will be followed by a summary of my preliminary findings.

According to Halliday (1994, p. 37), in English, the initial position in a clause has a special function "…we signal that an item has thematic status by putting it first." [and] "The theme is the element which serves as the point of departure of the message; it is that with which the clause is concerned." Thus, the positioning of elements in the clause as Theme has textual significance in that Theme orients the reader or listener to the development of the text. Theme here, refers to everything up to the first finite verb in the clause, everything else is the Rheme or rest of the clause. Patterns of connections between clauses are one important way in which cohesion can be developed.

For example:

Several factors <u>are</u> / important when deciding whether to use a central or split air conditioning system.

Theme ↓   *Rheme*

Such factors <u>include</u> /   the local climate, reliability, cooling capacity.

    Theme   *Rheme*

The link here is Theme to Theme.

Theme in the Hallidayan sense is a complex concept which can be analysed at various levels in the language from complete texts to the clause level. In addition several types of Theme can be identified, for example, textual, topical and interpersonal. In relation to teaching students such distinctions are unnecessary and students are expected to identify and apply only Theme and Rheme. For simplicity, Rheme is referred to as "Rest" in the course.

Recent research by Mirahayuni (2001) studied the textual structure of academic research papers, using several methods including Halliday's Theme, Rheme framework. Her work is particulary relevant to my research as she studied very similar kind of writing, that is writing that is putting forward propositions based on evidence. In her research two groups of published research papers were analysed and compared: papers by native English speakers published internationally and research papers in English published in Indonesia and written by Indonesian writers. In terms of Theme Rheme at the clause level Mirahayuni identifies two significant differences: native writer clause Themes generally had more complex nominal groups and more regular Theme progression patterns compared with those of non-native English writers. Mirahayuni considers these differences may contribute to making the native English speakers articles more "reader-oriented" (2001, p. 308) and more acceptable to international journals.

One of Mirahayuni's concerns is that research by Indonesian, non-native English speakers is less often published in international journals than that by native speakers of English and therefore has restricted readership and recognition (Mirahayuni 2001, pp. 3-4). She recommends that teaching of academic discourse needs to include strategies for improving text organization. Included in the implications of her study is the recommendation that learners are shown "specific linguistic features" (p. 315) associated with different kinds of writing and more specifically:

First, this study urges the importance of exposing learners to the nature of scientific writing in English to communicate scientific information. Learners may need to be introduced to various aspects of scientific language, such as abstraction from everyday experiences into scientific information, utilization of linguistic devices for packages information and presentation of scienitifc knowledge in scientific language. Learners may need to be introduced to linguistic resources in English that play significant roles

in scientific writing, such as grammatical metaphor, devices indicating logico-semantic relations within the clause constructions and elements of grammar and vocabulary exposing various genres (2001, pp. 315).

Mirahayuni also argues for teaching how science writing involves integrating two contrasting strategies of text organization, that of the development of deductive (predictive) and inductive (building up of information) arguments (2001, p. 315-316). A further observation Mirahayuni makes is that the non-native English texts were weak in references to other research (2001, p. 316). In terms of SFL theory, Mirahayuni's work provides many interesting examples of how social context and culture may affect language features. In this case Indonesian writers of English writing within their Indonesian research context and international academic readers expectations may differ regarding cohesion and other language features.

Others too have encouraged the use of Theme – Rheme in teaching, even at school level. See for example Butt, Fahey, Feez, Spinks and Yallop (2001), p. 157: "Checking for effective thematic progression and drift in their own texts can be one of the earliest editing skills student writers are taught."

Next, to illustrate the kinds of analyses carried out in the research, three texts will be analysed for cohesion between clauses. The following excerpt was taken from the introduction in a journal article entitled: Evaluation Of Drinking Water Biostability Using Biofilm Methods.

Microbiological growth in potable water distribution systems is a growing public health concern and quality of service issue. Regrowth can lead to numerous problems in a distribution system including microbial-induced corrosion, accumulation and proliferation of indicator or problem organisms, accumulation of nongrowing pathogens, and the general decline in water quality (i.e., color, odor, taste) (Geldreich et al. 1972; Ford 1999). These problems may be minimized/controlled by various treatment processes that are designed to remove biodegradable organic material from the water and optimize disinfectant stability. Processes that control bacteria-escaping treatment, as well as those present in the distribution system, are also important. (Sharp, Camper, Crippen, Schneider, and Leggiero, 2001, p. 403)

INTRODUCTION

1. Microbiological growth in potable water distribution systems is a growing public health concern and quality of service issue.

2. Regrowth can lead to numerous problems in a distribution system including microbial-induced corrosion, accumulation and proliferation of indicator or problem organisms, accumulation of nongrowing pathogens, and the general decline in water quality (i.e., color, odor, taste) (Geldreich et al. 1972; Ford 1999).

3. These problems may be minimized/controlled by various treatment processes that are designed to remove biodegradable organic material from the water and optimize disinfectant stability.

4. Processes that control bacteria-escaping treatment, as well as those present in the distribution system, are also important.
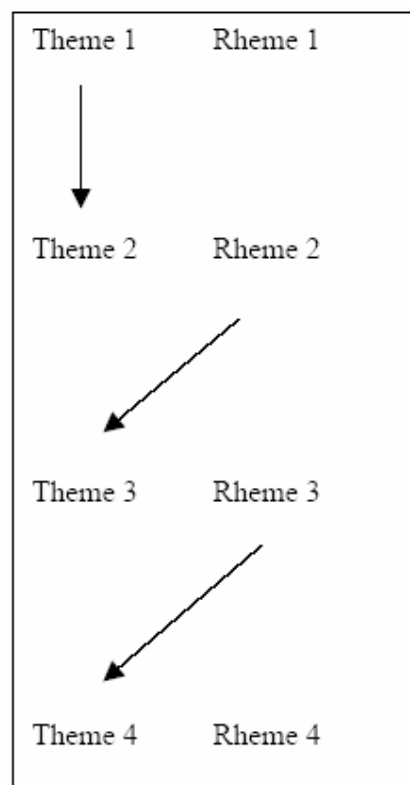
Theme 1   Rheme 1

Theme 2   Rheme 2

Theme 3   Rheme 3

Theme 4   Rheme 4

Figure 1   Analysis Of Theme – Rheme Links In An Engineering Journal Text.

Here there is a clear pattern of links in that each sentence is linked to the one before. Cohesive paragraphs can have a variety of links but in principle if there is too much unlinked material, say a

sentence or more depending on the length of the paragraph, the paragraph will become increasingly difficult to read. Common patterns of links are T->T, R->T, and various combinations. Where there are links between R->R or no links, there is little or no cohesion. A more detailed illustration of patterns of cohesive links is provided in the Findings and Discussion section 5 below.

To illustrate that cohesion is more than links between words, consider the following group of sentences.

The cat sat hungrily eating its fish.

Hungry animals are often violent.

T.V. crime series frequently show a lot of violence.

The latest music video clips are frequently shown on television.

Here there are a lot of words shared between sentences, but little or no cohesion. Several factors are at work here, the over-generalisation from one hungry cat to a suggestion that as an animal, a cat is likely to be violent, the leap from one context to an entirely different one and a similar move between the next two sentences.

The two student papers below were written for Assignment 2:   Discuss the possible effects of environmental tobacco smoke on the health of passive smokers. The students concerned gave written permission for use of their work.

Example Showing Little Cohesion

Table 1   Analysis of Theme - Rheme links in Student Text   Key: T = Theme, R = Rheme, X = no link

1	Data Id. ESL/S2/02/A1p/20	Paragraph No: 1	1/ESL/S2/02/A1p/20
	Theme	**Rheme**	**Link**
1	Many people	had become unhealthy because of passive smoking.	
2	These	show that non-smokers are living in an unhealthy environment	X
3	and the smokers	had threatened their health.	X
4	One of the research	shows that a smoker has approximately 10 times the risks of developing the lung cancer then a non-smoker (The National Health and Medical Research Council, 2001).	X
5	Additionally, passive smoking not only	will affect our human heart	R1 – T5
6	and	which will lead us to a critical step in heart disease (Emmons, K.M., Thompson, B Feng, Z., Herbert, J.R., Heimendinger, J., Linnan, L., 1995).	X
7	These consequences of passive smoking	need all of us to concentrate and solve it in an unrelenting way.	Very weak R1 – T7

Many people had become unhealthy because of passive smoking. These show that non-smokers are living in an unhealthy environment and the smokers had threatened their health. One of the research shows that a smoker has approximately 10 times the risks of developing the lung cancer then a non-smoker (The National Health and Medical Research Council, 2001). Additionally, passive smoking not

only will affect our human heart and which will lead us to a critical step in heart disease (Emmons, K.M., Thompson, B Feng, Z., Herbert, J.R., Heimendinger, J., Linnan, L., 1995). These consequences of passive smoking need all of us to concentrate and solve it in an unrelenting way.   Data ID. ESL/S2/02/A1p/20

Note: Although the cohesive links are represented as moving "forwards" the meaning links often work in both directions. In addition, in the research analyses both topical and textual themes are distinguished but for the purposes of this paper these fine distinctions have been ignored.

Cohesive example
Environmental Tobacco Smoke has well documented adverse effects on the health of passive smokers, particularly asthmatic children and infants, including lung cancer, aggravated asthma, respiratory problems and heart disease. The risk of lung cancer in a passive smoker is increased by 30%(NHMRC, 2001). In asthmatic children passive smoking is probably linked to increased frequency and severity of symptoms (ASH, 2001) and clearly to heart disease (Chilmonczyk et al, 1993). Finally, risks of infant respiratory problems and deaths have been associated with mothers smoking (Hoo et al, 1998). Passive smokers, specifically infants and asthmatic children, can potentially suffer lung cancer, aggravated asthma, respiratory problems and heart disease. ESL/S2/02/A1/8

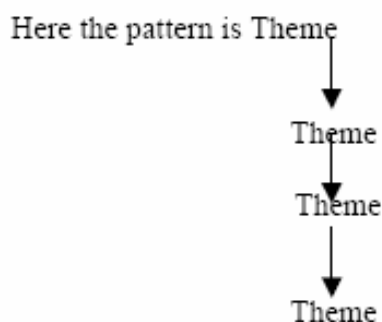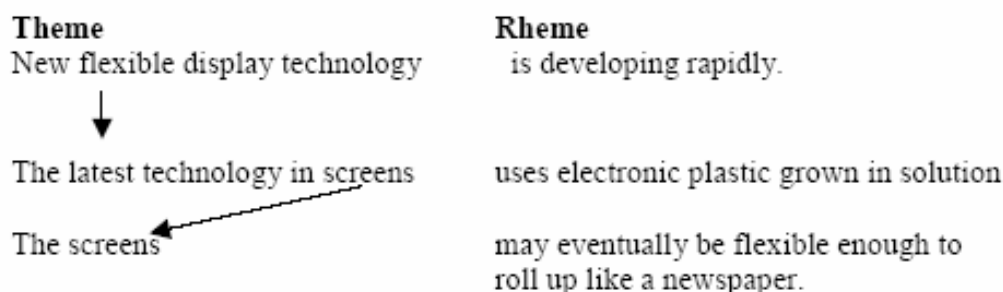Table 2   Analysis of Theme - Rheme links in Student Text   Key: T = Theme, R = Rheme.

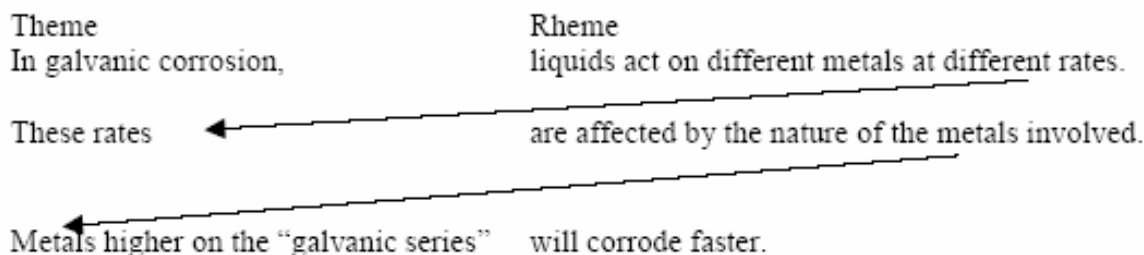| 2	Data Id. ESL/S2/02/A1/8	Paragraph No: 1	2/ESL/S2/02/A1/8
	Theme	**Rheme**	**Link**
1	Environmental Tobacco Smoke	has well documented adverse effects on the health of passive smokers, particularly asthmatic children and infants, including lung cancer, aggravated asthma, respiratory problems and heart disease.	
2	The risk of lung cancer in a passive smoker	is increased by 30%(NHMRC, 2001).	R1 – T2
3	In asthmatic children passive smoking	is probably linked to increased frequency and severity of symptoms (ASH, 2001) and clearly to heart disease (Chilmonczyk et al, 1993).	R1 – T3
4	Finally, risks of infant respiratory problems and deaths	have been associated with mothers smoking (Hoo et al, 1998).	R1 – T4
5	Passive smokers, specifically infants and asthmatic children,	can potentially suffer lung cancer, aggravated asthma, respiratory problems and heart disease.	R1 – T5 R1- R5

5   FINDINGS AND DISCUSSION
Theme – Rheme analysis of 12 student texts written in the same semester, in response to the same assignment task were carried out. The analyses certainly support the view that a simplified version of Theme – Rheme analysis may be useful as a student tool for increasing cohesion in their writing. For example, students could undertake an anlysis of their work and recognise that where there are many links between Rhemes and few links to Themes and, or, where links extend several sentences back and are mainly between Rheme and Rheme; that they could improve their cohesion.   However, no definitive findings are possible on the basis of a small number of texts. The analyses raised several issues. One of the issues was that when the texts were difficult to understand, for example because of a low level of grammar and, or, there were difficulties with basic word meanings; the analysis worked less well. This

may be an argument for introducing this tool only when students have quite good control of their grammar. The findings of the analyses are presented in Table 1 below.
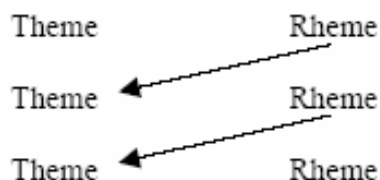
As is noted above there are common patterns of Theme – Rheme associated with cohesive writing (Fries, 1995 p. 320 – 321 citing Danes, 1974). These include Theme-Theme, Rheme to Theme, and a single Rheme, (for example the first Rheme in a paragraph) then linking to subsequent successive themes. After illustrating these, the patterns observed in the student texts will be discussed in terms of the levels of cohesion displayed., Each of these patterns is illustrated in more detail below.

Theme	Rheme
New flexible display technology	is developing rapidly.
The latest technology in screens	uses electronic plastic grown in solution
The screens	may eventually be flexible enough to roll up like a newspaper.

Here the pattern is Theme

Theme
↓
Theme
↓
Theme

Another pattern is where the Rheme (very often new information) becomes all or part of the next Theme as in the example below.

Theme	Rheme
In galvanic corrosion,	liquids act on different metals at different rates.
These rates	are affected by the nature of the metals involved.
Metals higher on the "galvanic series"	will corrode faster.

Here we have:

Theme   Rheme
Theme   Rheme
Theme   Rheme

Yet another pattern is where part or all of the Rheme is picked up and becomes the Theme in successive clauses.

Theme	Rheme
Environmental tobacco smoke	has led to ill health amongst passive smokers exposed to it.
Lung cancer	is higher among passive-smokers than among non-smokers
Heart disease in non-smoking women	is also greater for those living with a smoker than for those living in smoke-free circumstances.

Here the pattern is
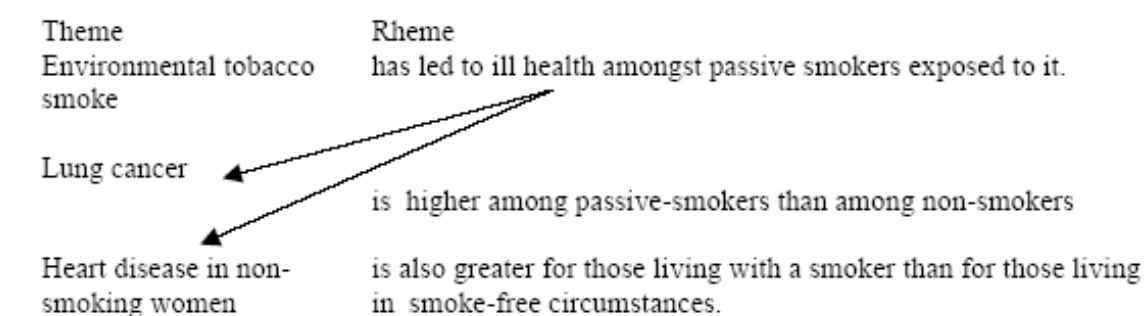
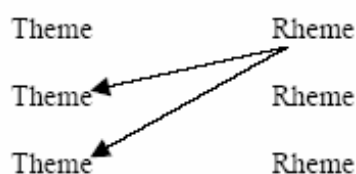| Theme	Rheme
Theme	Rheme
Theme	Rheme

Table 3 Findings of Theme – Rheme Analysis of 14 Student Texts.
Key: L = low, M = good, H = high.

Data Id.	1/ESL /S2/02 /A1p/ 20	2/ESL/ S2/02/ A1/8	3/ESL/ S2/02/ A1/31	4/ ESL/2/ 02/A1/ 11	5/ESL/ S2/02/ A1p/3 2	6/ESL/ S2/02/ A1/37	7/ESL/ S2/02/ A1p/2 5	8/ ESL/S 2/02/A 1/39	9/ ESL/S 2/02/A 1/40	10/ ESL/S 2/02/A 1/1	11/ ESL/S 2/02/A 1p/4	12/ESL/S 2/02/A1/ 5
Text No.		2	3	4	5	6	7	8	9	10	11	12
Clause No.	Link	**Link**	**Links**	**Links**	**Links**	**Links**	**Links**	**Links**	**Links**	**Links**	Links	**Links**
1												
2	X	R1 – T2	R1 – R2	R1-T2	R1-T2	T1-T2	R1-T2	T1-T2	R1-T2	R1-T2	T1- T2	R-T
3	X	R1 – T3	R 1 – T3	T1-T3	T2-T3	R2-R3	R2-T3	R2-T3	R1-T3	R2-T3	T1-T3?	T1-T3
4	X	R1 – T4	R1 – T4 R2 - T4	R3-T4	R2-T4	R1-T4	R2-T4	T3-T4	T3-T4	R1-T4	R2 -T4	R1-T4
5	R1 – T5	R1 – T5 R1- R5	T3 – T5	T4-T5	T2-T5	R4-T5	R2-T5		T3-T5	R1-T5	T1-T5? V. weak	T1-T5
6	X		R1 – T6	R1-T5	R5-T6	R1-R5	R1-T6		T5-T6	R1-T6	R1-R7 Weak	T1-R5
7	Very weak R1 – T7		R1 – R7 weak		R1-R7	R6-T7	T1-T7		R1-T7	R1-T7		
8			R7 – R8			T1-T8			T1-T8			
Cohes-ion	L	H	M	M	H	M-H	H	H	H	H	L	M-H

In terms of the relative cohesion of the student texts in Table 1 some interesting patterns and links were observed.   Texts 1 and 11 show little of any of the three cohesive patterns and generally showed lack of clear meaning links between parts of the text.   Texts 2, 5, 7, 8, 9,and 10 showed combinations of the three patterns, had many links to Themes, fewer links between Rhemes and generally the distance between links were shorter than for the texts rated as M or L. Further, more detailed analyses are needed before further claims can be made. However, even at this stage the analyses provide promising evidence in support of developing strategies for students. There is clearly a need for further research using a much larger sample of texts.

6 CONCLUSIONS

In the context of recent developments in engineering practice, communication skills are receiving increasing recognition. Increased understanding of the language features of scientific writing may help all lecturers when marking student reports. One aspect of communication that students often find difficult is that of organising their material in a logical way. This preliminary study has targeted this area using analytical tools developed by Systemic Functional Linguistics. The findings are limited as the sample of texts analysed thus far is too small to make strong or definitive claims. However the findings do open up possibilities or developing strategies useful for students. One clear claim is made: the use of Theme – Rheme analysis and the possible development of better educational strategies for students to use certainly deserves further study using a significantly larger sample of texts.

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