

Development of content for a new RLO, based on a qualitative and quantitative analysis of students' writing

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Abstract

This pilot-study used new methods to identify specific areas of weakness in students' writing, in the Mathematics Statistics and Operational Research (MSOR) subject areas. The results produced clear recommendations for specific content for reusable learning objects (RLOs) to improve students' writing.

Many students have poor skills in writing; the initial question was to identify which areas were poor. A new mechanism for analysis derived from Halliday's 1973 text-context-functions model allowed students' written work to be tested at the ideas function, the interpersonal function and the signpost functions. Specific instruments tested each function: the use of definitions tested ideas, the audience awareness scale tested the interpersonal and a text function scale tested signposting.

Significance at $p < 0.01$ for using or not-using definitions was revealed using Chi Squared X^2 statistical analysis; 73% of participants used interpersonal language but no significance was found for audience awareness. Significance at $p < 0.025\%$ was found for text signposting. Thus this original study resulted in clear recommendations for content for RLOs which is responsive, i.e., based on specific students' needs, that is pedagogically meaningful and empirically derived. Additionally new qualitative and quantitative methods were devised that were capable of disentangling the key areas of weakness in students' writing.

Key words: RLO, Ecology, writing, mathematics, statistics, reusable learning object, objects, Pedagogy, Higher Education Academy, MSOR, CETL

Introduction

This pilot-project analysed students' written work in the Mathematics Statistics and Operational Research (MSOR) subject areas to identify gaps in their understanding. These gaps were used to inform the development of content for reusable-learning objects (RLOs) to help students improve their writing. This study focused on international students who all used English as a second language.

This pilot-study was funded by the Higher Education Academy Mathematics Statistics and Operational Research (MSOR) subject group network (2006). The aim of this mini-project was to help students' writing in MSOR subjects. This work was conducted in the spirit of the UK's Higher Education Academy's priorities for research that "enhances student success" (HE Academy HEA 2005).

This study also aimed to highlight current practices of content development for RLOs simply as an "add on" to existing teaching material with, it is argued here, little thought given to a pedagogic role in terms of addressing specific students' needs.

Issues facing post-1992 universities are briefly considered in order to situate this research in its environment. A short summary is presented of issues affecting international students together with students' learning and writing, in the area of "mathematics, statistics and operational research" (Mathstore 2005).

This project aims to provide coherent, pedagogically meaningful methods for developing content for RLOs that is student-specific, based on empirical recognition of what is needed to support student learning in the area of writing.

London Metropolitan University

London Metropolitan University heads up a Higher Education Academy Centre of Excellence in Teaching and Learning CETL for reusable e-learning objects (RLO) with partners the University of Cambridge Wolfson Institute, and Northampton University. RLOs are multimedia-learning objects, e-learning freely accessed over the Web that can be integrated into teaching (<http://www.rlo-cetl.ac.uk/index.htm>), (see Boyle 2003).

The context - widening participation

Morgan *et al.* (2003) says that students' writing is weak, particularly in the mathematics, statistics and operational research MSOR disciplines. UK government policy has resulted in many more participants in higher education, both through widening participation among non-traditional students and in increased numbers overall. For post-1992 institutions such as London Metropolitan University, this brings more students from the UK and from overseas arriving with lower achievements in exams who are not well prepared for university (Dearing 1997).

Dochy, De Rijdt and Dyck (2002) recommends that teaching and learning strategies be designed to provide additional help, since students arriving with less prior knowledge may experience difficulty acquiring and applying new knowledge and problem-solving skills.

This paper suggests new ways of analysing students' writing to identify what gaps exist in their learning and understanding. As a result new content for RLOs can be developed to address specific gaps and support students' progression.

Student learning and writing

It could be argued that policy changes have altered the processes of student learning. Modern teaching strategies are now based on prioritising student learning (see, for example, the Dearing Report 1997). Ramsden (1989) sees a shift from individual responsibility to institutionalised quality control, together with a shift in learning in university and employers' requirements. Knowles and Hensher (2005) suggest that universities now operate in a supply and demand culture, with students no longer as passive learners but customers.

In line with the shift in teaching, educational research now focuses on what students do. When students are, for example, engaged in academic writing tasks, Bazerman *et al.* (2000) recognise the key role played by the student in finding their "self" in writing. Crème (2002) acknowledges the issue of personal knowledge while Lea and Street (1998) consider student identity and personality are key and that students change their style to fit in with whatever assessment they are completing, while Scott (2000)

considers students' writing as performance. This study therefore attempts to identify students' needs in order to develop responsive learning materials.

Barnett and Hallam (1999) argue that the role of university is now a supercomplex environment: trying to address different stakeholders' demands, students, academics and employers who demand graduates with high levels of "Techno mathematical literacy" (Hoyles *et al.* 2003) able to problem solve in new environments. It is in this complex environment that this paper aims to disentangle students' writing to reveal meaning, which can inform strategy.

Teaching and Student learning in the subject area of "mathematics, statistics and operational research" (MSOR)

This practical pilot-study focused on identifying what is weak in students' writing then building content to help them to improve their writing.

Nardi, Iannone and Cooker (2003) found mathematics teaching in schools was limited in range, focused on calculation and was geared for students with perceived abilities of C/D or B/C levels at GCSE. This, they argue, has undermined the image of mathematics as an intellectually attractive subject. The 2006 Ofsted report supports this and found teachers were teaching students to pass exams not to gain knowledge (Ofsted 2006). Thus it is argued here that some teaching simply aims to pass on the knowledge that is needed to pass.

Mathematical writing is defined as abstract, formal and impersonal and symbolic; students' experiences of mathematics may be impersonal (see, for example, Solomon and O'Neill 1998). This contrasts with the arts and humanities, "soft disciplines", where writing incorporates the author's voice and beliefs. It was found that students may learn maths using a surface and repetitive approach (Biggs 1999) frequently mediated by e-literacy (see, for example, Holley 2002 and Singh, O'Donoghue and Whorton 2005). Johnstone (2005) undertook a large metastudy of student learning in science, particularly in chemistry, which found that what students already know may determine what they learn. This taken together with (Morgan 2006) who says students don't simply

“pick up” and understand the “less explicit rules” of mathematics (p.178), will be investigated here in terms of identifying what students do know.

This detailed analysis of the content of students’ writing will bring a better understanding that can inform the development of responsive learning and teaching strategies that are able to improve students’ understanding.

Methodology and methods

This project is situated in the ecology of learning, and used an eclectic approach based in the enactivist paradigm, to ensure the learners were situated in their environment. This contrasts with, for example, constructivism, which Fenwick and Tara (2000) describes as a “cut universe” where the learner is separated from their “environment and experiences”(p.7).

Quantitative and qualitative methods of analysis were used. Kershaw, (1964) suggests Ecology as a model of investigation was developed from the realisation that the environment was a “complex living, dynamic entity, that required sensitive mechanisms to extract meaning from the mass of data (Ibid p.6). To deal with this complex environment the Ecology approach was adopted.

Nardi (1996) comments that scientific validity should be widened to include vertical studies with small samples sizes and that these microanalysis receive parity of acceptance with large-scale trials. While this study notes those comments, this study used empirical inference and analysis methods that are specifically designed to cope with small sample sizes, commonly used in Ecology research.

Scripts were obtained with proper consent in line with appropriate ethical considerations from students undertaking the International Foundation Programme, Quantitative Analysis and Finance modules. The samples were taken during the eight-week summer term of 2005, (n=31). This was a homogenous sample since all students were international and all were studying the same subject.

Instruments

Halliday (1973) analysed text in terms of context and proposed that text has three functions: to convey meaning and ideas, to mediate between the writer and reader and to act as a signpost. Halliday's method was selected as the overarching aim for the analysis and this informed the selection of instruments capable of identifying each of the three functions.

Barwell *et al.* (2002) devised methods to enable analysis of the key features of texts by examining writing to determine the meaning/ ideas and the interpersonal or audience awareness function and the use of the text itself as a signpost, for example a paragraph break, an italic or bullet point, or in the case of statistics, a table or chart.

The instruments used to assess students' written work to determine specific components in students' writing for: ideas, the framework for definition-related activity (Morgan 1996); the interpersonal, the Audience Awareness Scale (Berrill 1992) and the signposting, the text function scale (Wylde 2005 and Wylde in press). These are discussed more fully in individual statistical analysis sections: the Text Function Scale, the Use of definitions and finally the Audience Awareness Scale.

Participant script writing analysis

Individual scripts were analysed according to the text analysis instruments, scores based on the instrument's parameters were recorded in a simple Likert scale (1-n). A binary score was used to code the raw responses. Elbow (1993) argues the usefulness of the binary system, and suggests it simply records presence or absence and gives "equal affirmation to both sides"(p.51).

Statistical Analysis

This project used a systematic approach to attempt to understand what was present, in light of the complex nature of data in educational research. Other considerations included the use of nominal and ordinal scales of measurement and the small sample sizes. Given these constraints a non-parametric statistical analysis using Chi Squared

χ^2 test for goodness of fit was conducted, this method is recognised for its ability to interpret this type of data (see, for example, Mathstore 2005).

Finally, as Chi Squared χ^2 tests may be biased by small sample sizes of less than 5, many of the scales were collapsed to increase the number of the data points to ensure the minimum frequencies were achieved (Waters 2001).

However it is cautioned that this was a pilot study and there were a small number of samples ($n=31$). The results reported here must reflect the uncertainty that is present in these findings. Finally as Johnstone (2005) says, models are only useful if they reveal information (p.61).

Use of definitions

Analysis of the scripts for use of ideas, expressed as definitions was through the Framework of Definitions (Morgan 1996) categorisation. Scripts were scored based on the categories ranging from A to D (high).

Table 1. Frequency of participants using definitions in assignment scripts ($n=26$)

Number of definitions used			
Definition	1	2	Total (%)
A. Pre-existing	4 (11%)	11 (30%)	15 (41%)
B. Used for logical argument	5 (14%)	10 (27%)	15 (41%)
C. Student construct			
D. New construct			
No definition used			7 (19%)
Total	9 (25%)	21 (57%)	37
Note Percentage values are rounded, so totals do not necessarily = 100%.			

It was found that participants were clustered in three categories: those who did not use definitions, those who used one definition and those who used two definitions.

Participant [16] demonstrates the use of definitions, “The mean is the sum of items divided by the total...in other words, sum of claimants divided by the total number of boroughs”, and later develops the use of the definition to form the basis of a logical argument, “In fact the standard deviation is almost the same but the mean is...hence Hackney’s sd is smaller than Greenwich”, (sd refers to standard deviation).

Participant [14] develops the idea further by suggesting, “the definition of mean is...total ...by the complete number...” and later, “The standard deviation is useful to represent distorted data...” and later [14] uses the following statement to present a pre-existing definition of an index number: “Index values are used to find the percentage change in the data from a specific base data”, and follows with “It would be interesting to find out the level of percentage increase in the number of visits...” which indicates the application of the definition for logical argument. This last statement, also demonstrates an awareness of the audience, see the next section, Table 4, the Audience Awareness scale.

Thus participants [14] and [16] use pre-existing definitions, for example, for the arithmetic mean and index numbers, and also use definitions in relation to the specific data in the assignment, which indicates the application of the definition for logical argument. It was found that 57% of participants used two definitions (A and B), 25% of participants used one definition and 19% used no definitions; this is equivalent to 82% of participants using definitions.

Statistical analysis of the definitions data

Table 2. Chi-squared, X^2 analysis of the use of definition categories

Definition	Frequency of definition	Chi-squared X^2	Significant
No definition	7	2.0833	
One definition	8	1.3333	
Two definitions	21	6.75	*
Degrees of freedom = 2			
P ≤ 0.05% 5.99			*
P ≤ 0.01% 9.21			**

Chi-squared, X^2 analysis was conducted for the use of definitions in the framework. The use of two definitions was found to be moderately significant at $p \leq 0.05\%$ level and very strong evidence of significance was found for the collapsed scales, using or not using a definition $p \leq 0.01\%$ level.

Table 3. Chi-squared, X^2 analysis for use of, or no use of a definition

Definition	Frequency of non-use or use of definition	Chi-squared X^2	Significant
Non use of definition	7	6.772	**
Use of definition	29	6.772	**
Degrees of freedom = 1			
$P \leq 0.05\%$ 3.84			*
$P \leq 0.01\%$ 6.63			**

The Audience Awareness Scale

Analysis of the scripts text for interpersonal function was undertaken using the Audience Awareness Scale; scripts were scored based on the categories ranging from 1 to 5 (high).

Table 4. Frequency of participants' scripts categorised according to the Audience Awareness Scale (n=26)

Level of audience awareness	Number of scripts
1. Egocentric	7 (27%)
2. Cursory awareness of alternative view	10 (38%)
3. Acknowledges alternative point of view	9 (35%)
4. Appreciates alternative point of view	0
5. Accommodates alternative point of view	0

An example of an egocentric viewpoint is demonstrated by participant [1001] who says, "I have chosen Norway..." and later says, "Now the mode means..." It is suggested that the first statement shows no audience awareness and the latter, it is suggested, sounds didactic.

Participant [16] demonstrates the use of a non-egocentric viewpoint, "We can see interesting..." (in reference to a chart) and later "As you can see...". These statements invite the audience to participate in the investigation and arguably demonstrate AAS level 3, an acknowledgement of alternative points of view.

It was found that 27% of scripts showed the use of an "egocentric" point of view; the majority 38% demonstrated a "cursory awareness of an alternate viewpoint" and 35% demonstrated the higher awareness and "acknowledged an alternate point of view". The scales are collapsed to consider egocentric or non-egocentric levels of awareness; this resulted in 73% of scripts demonstrating non-egocentric viewpoints.

Statistical Analysis of the audience awareness data

Chi-squared, X^2 analysis was conducted for participants' scores for their level of audience awareness. No significance was found at the $p \leq 0.05\%$ level, a second analysis was conducted after the scales had been collapsed to either non-egocentric or egocentric and no significance was found at the $p \leq 0.05\%$.

Text Function Scale

Analysis of the scripts for text function the scripts was undertaken using the Text Function Scale (TFS); scripts were scored based on presence or absence of text the parameters, on a binary scale of one (present) or zero absent. Table 5 shows that highest frequency of participants used readable font sizes, consistent margins and aligned the text consistently. At the other, lower end of the scale, one participant used a bibliography and bullet points.

Table 5. Text function scale; parameters including the sub scales for mathematical layout, page layout design and organisation (n=31)

Text function parameters			Sub scales		
Parameter code	Text Function	Frequency of use in scripts	Mathematical layout (ML)	Page Layout Design (PD)	Organised (OG)
1	Footnotes	0		PD	
2	Quotations	0		PD	
3	Tables – layout	0	ML	PD	
4	Bibliographies/References	1		PD	
5	Lists – bullets	1		PD	
6	Lists – title	1		PD	
7	Page Numbers	7		PD	
8	Sub-headings	7		PD	
9	Formatted text	11			
10	Tables – title	16	ML	PD	
11	Clear layout	18			OG
12	Graphs– layout	18	ML	PD	
13	Section Titles	20		PD	
14	Graphs– title	22	ML	PD	
15	Body Text alignment – consistent	25			OG
16	Font size/ readable	26			OG
17	Margins – consistent	26			OG
	Total	204	4	12	4

No scripts were found to have tables laid out accurately or correctly. This may be an indication of the participants' weakness in terms of understanding basic elements of mathematical layout. The results appeared clustered and sub scales, focusing on elements of design; mathematical layout, page layout or organisational layout, were devised to attempt to disentangle the parameters, see Table 5. It was found that the

scripts were scored with 15% displaying appropriate page layout design, 53% for mathematical layout and 91% for organisation.

To summarise 46% of the scripts were found to have used the text function parameters this demonstrates their understanding of the functions of text.

Statistical analysis of the text function scale data

Chi-squared, X^2 analysis was conducted on the sub scales, page layout design, organisation and mathematical layout. Table xx shows the parameters associated with each of the sub scales. It was found that the sub scales parameter page layout design, no14, contains significance at $p \leq 0.025\%$.

Table 6. Chi-squared, X^2 analysis of the TFP subscale, page layout design

Text Function Parameter Sub scale	Text Function Parameter	Chi-squared X^2	Significance
Page Layout Design (PLD)	14	23.43	**
Degrees of Freedom =8			
P $\leq 0.05\%$ 19.7			*
P $\leq 0.025\%$ 21.9			**
P $\leq 0.01\%$ 24.7			***

International Students

De Vita (2001) suggests that overseas students may suffer in terms of adopting the academic literacy necessary for success in UK universities. This is beyond the scope of this paper, however recommendations for learning and teaching strategies in the conclusion suggest mechanisms to assist participants interrogate and improve their written work and understand what is required of them. This will also help students' practice and, it is suggested, this will have the added value of helping participants to achieve greater grades.

Discussion and Conclusion

This success of the pilot study in terms of achieving its aims, together with a consideration of international students are briefly discussed.

The methods developed enabled specific areas of weakness to be identified. These results can guide the development of specific teaching and learning strategies, to help students' writing.

Specifically students' writing was found to be weak in terms of, signposting; in design of tables, graphs and basic page layout for example using bullet points, sub headings. It was further found that the consistency was variable, lay out or font size would change mid-document.

Significance at the $P \leq 0.025\%$ level was found for text layout at the sub scale, page layout design for the parameter graph title layout. The key findings and their implications will be discussed in more detail in terms of how this helps understand student writing.

More than 82% of participants used definitions, of which 41% were used to support logical arguments. The use of two definitions was moderately significant at $p \leq 0.05\%$ level; strong evidence of significance was found for the collapsed scales, of using or not using a definition $p \leq 0.01\%$. It was found that 73% of participants demonstrated awareness of their audience through the use of non-egocentric text.

Overseas students' experience their most serious problems progressing from the first year to the second (De Vita 2005). It is questioned if this was always the case or if this is a result of widening participation. Pokorny and Pokorny (2001) suggest that a key factor affecting adjustment to the demands of university study is students' entry grades and it is acknowledged this is one of the realities of widening participation. In any case, it is argued here that the findings revealed here can be translated into learning and teaching strategies to address specific student learning needs.

These findings show the direction for future work; a larger study, an examination of home students and comparative analysis with international students and refining of the statistical methods.

The future

The use of new research methods and the development of responsive content are briefly discussed in terms of implications for the future.

This combined approach of using qualitative and quantitative methods worked well to identify specific areas of weakness in students' writing. It is suggested this new approach, based methods traditionally used in Linguistics and Ecology helped disentangle key factors from the "mass of data", in this case students' writing (Kershaw 1964 p.6). Once we know what is present, or in this case absent, we can develop strategies to help students' understanding of what is required. It is suggested that this work be developed to further refine the methods.

Morgan (2006) findings that students don't simply "pick up" and understand the "less explicit rules" of mathematics (p.178) is backed up here by the findings of no correctly formatted tables. It is argued the development of student-specific content for RLOs will help students address the gaps in their skills.

To further help entry-level students understand what is expected and how to present work, it is proposed to show them examples of work written by good mathematicians or statisticians. Barwell et al (2002) says students are often unsure as to how to present written work and unable to recognise writing that is considered "appropriate" or "mathematical" (p.178). These examples can also be used to align assessment criteria (see Elander et al 2004).

Thus this project resulted in recommendations for the development of responsive content for RLOs. Content that is pedagogically meaningful based on specific student needs and empirically derived in terms of what was needed to support student learning.

Finally it is suggested that this timely new approach may shed light on basic learning and teaching "issues" previously unrecognised due to their complexity.

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