Teaching mathematics for search using a Tutorial style of delivery

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Understanding of mathematics is needed to underpin the process of search, either explicitly with Exact Match (Boolean logic, adjacency) or implicitly with Best match natural language search. In this paper we outline some pedagogical challenges in teaching mathematics for information retrieval (IR) to postgraduate information science students. The aim is to take these challenges either found by experience or in the literature, to identify both theoretical and practical ideas in order to improve the delivery of the material and positively affect the learning of the target audience by using a tutorial style of teaching. Results show that there is evidence to support the notion that a more pro-active style of teaching using tutorials yield benefits both in terms of assessment results and student satisfaction.

Keywords: information retrieval, information science, teaching, Boolean logic.

1. INTRODUCTION

The author teaches IR to a variety of postgraduate MSc students at City University London. These courses include both Library and Information Science and Information Systems and Technology courses. The purpose of the module is to teach formal ideas and practical search methods to information scientists/managers who will act as *search intermediaries* between information users (such as lawyers, doctors, etc) and a given resource (in the case of the module, this means resources held on IT systems). Search intermediaries are needed, because many information users do not have the requisite search skills in order to specify a query that will obtain documents they require to fulfil their information need e.g. a lawyer who needs documents on case law for a particular client. Various mathematical skills are needed for this role such as knowledge of Boolean logic used for Exact Match search, or and understanding of precision and recall when carrying out evaluations. This requires and understanding of mathematics including numeracy, discrete mathematics and probability/statistics to a greater or lesser extent. In this paper we outline some pedagogical challenges in teaching mathematics to information science students, and propose a method to resolve them using tutorials inspired by the transaction model of teaching (Ahmed et al, 2002). The paper is structured as follows. In section 2 we describe the generic background and knowledge of students studying IR at City University and following on from this the requisite mathematical knowledge needed for study. In section 4 we give an outline on the problem of teaching mathematics in higher education in the U.K., in the context of our student body. We then motivate our use of tutorials for teaching maths for search etc in section 5. We describe the sources of evidence for our study in section 6, outlining the results from this data in section 7. The implications of the results and limitations of the study are discussed in section 8. We give a conclusion and pointers to further research at the end.

2. STUDENT BACKGROUND AND KNOWLEDGE

Given the categories of students' characteristics described in D'Andrea (1999); the attributes of the students who take the IR module are as follows:

- Many (but not all) have one years experience in the information profession (either as a search intermediary or as a librarian). [Knowledge on entry/Personal characteristics].
- A first degree in a subject other than information science or information studies/management. This includes courses with little or no requirement for mathematical knowledge e.g. in areas such as the arts and humanities. [Demographic information].
- A wide variety of learning styles (Fry et al, 1999): some are *deep learners* who expect to work independently, while others are only prepared to do the minimum possible in order to pass the course and are therefore *surface learners*. [Learning style].

There are therefore a wide variety of students who have vastly different levels of experience and expectations from the course. Some students may become search intermediaries when they leave the University and find work, others may become librarians and the skills gained on the course may only be intermittently used. Some students have not had any formal education in mathematics for many years. More importantly, the student body has a variety of mathematical skills on entry to the course. Given this, we consider the issue of teaching mathematics in higher education, and the effect this has on our student body.

3. REQUISTE KNOWLEDGE OF MATHEMATICS FOR INFORMATION RETREIVAL

The first and most fundamental issue to consider is the requirements for the outcomes of the module – what is the requisite knowledge for mathematics in search and how does this inform the learning outcomes. Before we consider the knowledge needed, we need to state the relevant learning outcomes of the module:

- MA2 - Evaluate information retrieval systems and services, by using appropriate methodologies.
- MD1 - Use a range of information retrieval systems and services to resolve information needs.

These learning outcomes are somewhat abstract, but there are three main areas of requisite knowledge in mathematics which are needed to conduct search and evaluation.

The first, and most fundamental, is numeracy. This is required for evaluation when using measures such as precision and recall in learning outcome MA2. As stated in section 2 many of the student body have completed arts or humanities degrees and have been avoiding mathematics since leaving secondary education. Duffin (2002: p132) describes the shock for many students who are confronted with their numeracy problems on finishing their undergraduate degree. Some institutional support may be useful here (see below), but it is still possible to present the students such material within the context of IR. Duffin (2002: p133) points out that numeracy teaching, even at a basic level, must be targeted at a University trained mind. It is the impact of the numbers therefore which is more important e.g. the inverse relationship between precision and recall.

The situation is more problematic when the issue of discrete mathematics is considered. Knowledge of Boolean logic and set theory is required for learning outcome MD1. Students need to create Boolean queries from given information needs. Burn (2002: p32-33) points out that students who have had no prior experience of thinking abstractly will find problems with this type of mathematics and therefore with formulating Boolean queries. Just delivering set theory without some context will not work with the student body. It is best to take a number of specific examples, show how these examples work in practice, and then move to the general case. With this understanding they will be able to think more clearly.

Discrete mathematics is not the most problematic of all the mathematical ideas applied to IR. Many of the theories in IR and evaluation methods require the knowledge of probability and statistics. Some of these ideas can be very difficult to master. So while there is a requirement to deliver this material to postgraduate IR students (for both learning outcomes stated above), there is a real worry that students will not want to actively engage with the material. The author does deliver this material, but only scratches the surface and teaches it at a very simplified level. Davies (2002) suggests that the use of real data in order to deliver statistics is a good strategy: the author does this with some simple example of how term weighting works. We do not address this particular issue in the paper.

4. THE ISSUE OF MATHEMATICS IN HIGHER EDUCATION

In this section the issue of teaching mathematics in higher education is examined and the impact these various issues have on our area of teaching are discussed. In this context the following themes are addressed: the effect of mathematics teaching in secondary education, the role of the institution in teaching mathematics, the issue of who should teach mathematics to IR students, the attitude of the students and the effect this has on their knowledge, and finally we describe an approach to teaching mathematics in search.

4.1 Effect of mathematics teaching in Secondary Education

There is clear evidence that there is a decline in mathematical skills in students entering University: Croft (2002: p151) states that the performance in U.K. university entry tests of students with grade N A-level maths taken in 1991 is equivalent to that of students who obtain grade C today[1]. This grade inflation is a worrying trend, and while it does not effect postgraduate courses directly it will have a considerable knock on effect, as students who have less skills in maths, gradually filter through the higher education system to Masters level. A further problem is that many of the students will not have studied maths since doing their GCSE (General Certificate of Secondary Education – taken by students mostly between the ages of 14 to 16) and many subjects such as calculus are no longer taught at that level (Appleby and Cox, 2002: p6). Because the gap between the mathematical skills of students and the requirements placed upon them is growing wider, there is an increasing need to take steps to

[1] Grading: A=70%+, B=60-69%, C=50-59%, D=40-49%, any other grade is > 40%.

address the issue. Another important aspect is one of attitude – this gap alluded to above causes real fear in the student body and they may develop avoidance strategies (Appleby and Cox, 2002). Many of the students who undertake our IR module have completed Arts or Humanities degrees and are not comfortable with mathematics – Croft (2002: p145) calls this type of students the 'maths anxious'. The effect of the transition of the teaching of mathematics in secondary education is that reliance cannot be placed on certain subjects having been taught to the students, and/or at the level required. This has a significant impact on all the areas of requisite knowledge mentioned above.

4.2 Institutional factors

Given the problem described in section 4.1, many higher education institutions now offer support services for students who have problems in mathematics. How much support can a teacher depend on from the University? There is conflicting evidence as to the usefulness of mathematical support centres. Croft (2002: p155) points out that there is a danger that departments and schools will rely on these support centres and not develop their course material. This may fail to address the problems students have as resources for such support centres are limited – the wrong strategy chosen by the institution could lead to these support centres being overwhelmed. However it has been shown that such centres are useful (Lawson, 2003): students at Coventry University are very happy with a centre providing drop in support for maths problems and use it heavily. The question to answer here is when should the department offer the support needed and when should the services of a University mathematical support centre be called upon – this will be dealt with in the next section.

4.3 Who should teach mathematics to IR students?

Croft (2002: p147) poses the question of who should teach mathematics to students e.g. when it is appropriate for either a mathematics support centre or mathematics department to teach maths and when is it appropriate to be done in house? Croft (2002: p148) outlines the problems with both strategies. If a mathematics department teaches information science students, they will not have the same background in IR as the author, and will therefore not be able to give the students' context. Mathematics lecturers may not understand the often negative feelings the students have for mathematics and that they are not mathematics students. These lecturers may feel that they have been dumped in a support role and are taken away from the advanced mathematics teaching they would like to do. However as the author does not teach mathematics full time, he is unaware of the precise details of the mathematics taught in secondary education. Because of the lag between students leaving secondary education and taking the authors courses, it may be difficult for non-specialists to develop strategies to deal with student problems over the course of time. There is potential for a turf war between departments over who should do this kind of teaching. Croft (2002: p149) argues that mathematics as a discipline is unique within each subject. There is a considerable advantage in having an expert in one particular field of mathematics who also has knowledge of LIS issues. For example, the teaching of maths in IR is very context driven; the author teaches the student body set theory within the context of searching, how to form search sets and manipulate them with various strategies. The use of guest lecturers to deliver some specialist knowledge in the area of probability and statistics might be useful for part of a lecture however.

4.4 Students attitude and knowledge

It is important to consider what the effect the students attitude and characteristics (specified in section 2) has on the knowledge they bring with them and what they are required to do with our IR material. One particular problem is that many of the students may adopt strategies that try to avoid genuine engagement with the mathematical material provided to them. There is a real tension here between supporting students and encouraging them to learn independently (Appleby and Cox, 2002: p15). The student body (who are all at postgraduate level) are particularly encouraged to be independent. In order to match the knowledge of the student body with what they will need for an IR course and their future career it is important to consider the learning in mathematics required the students. Table 1 shows the 'Mathematical Assessment Task Hierarchy' or MATH taxonomy, defined by Smith et al (1996) and based on Bloom's Taxonomy.

Group A	Group B	Group C
Factual Knowledge Comprehension Routine use of procedures	Information transfer Application in new situations	Justifying & interpreting Implications, conjectures and comparisons Evaluation

TABLE 1 – THE MATHEMATICAL ASSESSMENT TASK HIERARCHY (MATH) TAXONOMY

Each of the groups in table one is a building block (Croft, 2002: p144) e.g. Group B depends on knowledge gained in Group A, which in turn depends on Group C. The student body will need at least Group B knowledge and will certainly need most of Group C (advanced understanding of conjectures and theorems are not necessary). The problem is that students may not have the requisite skills in Group A (see section 3). We apply this building block method to the teaching of mathematics in IR in the next section.

4.5 An Approach to delivering mathematics for search

Rather than expecting the students to have Group C knowledge in the MATH taxonomy, it must be accepted that some remedial material needs to be delivered at the Group A and B levels. Table 2 shows the building blocks for mathematics required for teaching search skills:

Group A	Group B	Group C
Numeracy. Set theory. Transformation rules e.g. commutativity, associativity. Statistics and probability.	Forming Boolean queries analysed from a users information need.	Search strategies (different uses of Boolean and Adjacency operators and terms). Evaluation of results.

TABLE 2 – BUILDING BLOCKS FOR MATHEMATICS REQUIRED FOR IR

The mathematics required for IR was introduced in section 3 above: numeracy, discrete mathematics and probability & statistics. Numeracy is helpful in building the other two areas. It is important for the sake of those who require it, that confidence is built up on numeracy material first. Even then, the student body may resist for reasons given above. But it is important that the underlying theories and axioms are delivered (Ahmed et al, 2002), rather than just the procedures – these skills are required as a *search intermediary*. The use of additional and unassessed modules to help students could be considered (Appleby and Cox, 2002), but is this a realistic option in an already tight curriculum? And will students attend these extra courses?

What is the best way to deliver mathematical material to the student body? Ahmed et al (2002: p38) outline a choice of two models for delivering maths to learners. The first of these is a *transmitting model*: facts and ideas are transmitted to the student, who is just a passive recipient. This is the traditional mode of delivery in higher education, largely through the lecture format. Ahmed at al (2002) asserts that this type of teaching for maths is inadequate and has damaged learning in higher education. As the students in this study are postgraduates, this model is completely inappropriate – students must be actively engaged with the material presented to them. The other model Ahmed et al (2002) describes is the *transaction model*. This model goes beyond the didactic model, and its purpose is to set up a two-way communication between the teacher and learner, the student being involved in solving real problems and encouraged to engage in active learning with the material. Teachers give feedback on the work the student does on exercises to solve the given problem in order to create a beneficial feedback loop. This material may sometimes be basic, for example with numeracy problems, but it is still possible to encourage active learning e.g. using a tutorial style of delivery. It is this transaction model we advocate in this paper.

The delivery of mathematics for IR is crucial for developing search skills. Ahmed et al (2002: p40) describe three key aspects of developing active learners when delivering such material. The first of these is the mechanisms for mathematics e.g. manipulation of sets using operators such as AND. The next key aspect is the communication between the student and the lecturer. The last key aspect is the student working on his or her own without interference from a lecturer. Each of these aspects is built on each other in the order stated. We use each of these aspects to design our tutorial style of teaching, within the context of the transaction model for teaching as follows. The use of group work in conjunction with lectures to work on material is put forward as one particular way of solving these problems – this forces the student to engage with the material. For example, each group is given an information need: tutorial tasks require them to complete facet analyses of this need and to write a Boolean query from this analysis, evaluating the results using standard IR measures e.g. precision. A tutorial task is associated with all the lectures. The results of these tasks are then discussed in seminars, with material posted on an e-learning system beforehand together with oral presentations in the seminars. The material posted is constantly monitored with feedback and advice given on how to improve student work. We divide the assessment into two constituent parts: Boolean knowledge and numeracy for evaluation.

5. MOTIVATION AND RESEARCH QUESTIONS

5.1 Motivation

In section 3, three separate areas of concern for teaching mathematics in IR were identified namely, numeracy, discrete mathematics and probability/statistics. The focus in this paper is on the first two of these. In section 4.4 the problem of the tension between support and encouraging independent learning was outlined, particularly given that the student body (all postgraduate) are encouraged to be independent (Appleby and Cox, 2002). Given this background we wish to develop active learners using the transaction model briefly described in section 4.5 using a tutorial style of delivery. Our purpose is to actively help students with their problems when learning mathematics for search, using the knowledge identified in the pedagogical literature identified above.

5.2 Research questions

Given our motivation, we wish to formally examine the success of the tutorial style of delivery using two main sources of evidence. The first of these is an evaluation of the assessment results: does this style of teaching have a positive effect on the students' understanding of the material i.e. does it improve the students' understanding of mathematics and can they apply these ideas in search. The second is student feedback: how did students feel about their learning in the presence and absence of a structured tutorial delivery style.

6. SOURCES OF EVIDENCE FOR STUDY

We use two sources of evidence for our study from two years of the delivery of our IR module. In one year (labelled *Year1*) the tutorial style of teaching was used, while in the other (labelled *Year2*) just used lectures, demonstrations and talks with very little interaction or support given to the student body. Students in both years were put into groups, but no specific tasks were given to the students in *Year2*. We examine the assessment results for the coursework and student feedback results (both quantitative and qualitative) of this module. These two sources are described in more detail below. We split each cohort into two main groups i.e. 'Information Systems & Technology' (**IST**) students and 'Library and Information Science' (**LIS**) students (see table 3).

Student Cohort	*Year1*	*Year2*
Information Systems & Technology (**IST**)	24	20
Library and Information Science (**LIS**)	49	54
Total	**73**	**74**

Table 3 – Breakdown of cohort for two years under scrutiny

We report on these cohorts separately in order to examine the possible effect of background between them (they are sufficiently different to potentially make a difference in the data). In our view an attempt to examine the data holistically without breaking down these into two separate groups could be misleading. **LIS** students come to their course with at least one years work experience in the profession, and often have direct practical experience of IR in the workplace. **IST** students come from a wide variety of backgrounds, some with significant IT work experience while some have recently left university. Most will not have the level of experience in IR that **LIS** students have.

6.1 Brief Description of the assessment

As described in section 4.5 we assess the students on facet analysis for some information need, specification of queries using Boolean logic and natural language queries, with an evaluation of results using a methodology described in MacFarlane (2007). The tutorial directly leads therefore to the assessed work. While the tutorial work is done in groups, assessment is completed individually. A standard set of topics are used for the tutorial work (Vakkari et al, 2004), but the student is free to choose their own subject for the coursework. For *Year1* therefore, each stage of the assessment is fully supported through the tutorials both via peer group support and from the lecturer. Mathematics knowledge plays a very important part of this assessment both at all the levels given in table 2 above; at a minor level for issues such as precision, and at a major level deriving Boolean queries and search strategies. The students in *Year2* where taught using the traditional transmitting module using lectures, with some in-class tutorial support. The assessment was identical for both years.

6.2 Brief Description of the student feedback survey

The survey used for this study uses a standard set of 10 questions, and is given to all students in both cohorts for all the modules they are taking – the list of question used are detailed in appendix 1. We do not include all the questions used in the student survey – we ignored those which dealt with University Resource issues (e.g.

standard of classrooms etc). This survey is identical for both years. The questions are designed to elicit such information as the prior experience of the module and experience of learning on the module (communication, assessment etc). All questions are answered on a 6 point Likert scale, answers at the lower end of the scale being 1, at 6 being at the high end of the scale. Each answer (e.g. Very Poor…Very Good) is tailored to the question. As well as providing quantitative information on which we can perform statistical tests, we also examine qualitative information through three other questions:

1. Positive Aspects of the Module
2. Negative Aspects of the Module
3. Additional Comments

7. RESULTS OF THE STUDY

7.1 Examination of assessment results

Student Cohort	*Year1 Marks*				*Year2 Marks*				**Yr1 vs. Yr2 t-test**
Statistic	**Avg**	**Max**	**Min**	**SD**	**Avg**	**Max**	**Min**	**SD**	
IS&T	64.0	77.8	48.9	7.53	52.0	75.6	17.8	12.4	0.00*
LIS	64.2	80.0	45.6	8.18	60.5	82.2	31.1	10.5	0.048*
t-test (in Yr)	0.92	-	-	-	0.0*	-	-	-	-
All students	64.2	80.0	45.6	7.92	58.2	82.2	17.8	11.6	0.00*

Table 4 – Comparison of assessment results for both years
(*Indicates a significant difference)

Table 4 shows the comparison between years and cohorts for the assessment. There is evidence in the data that the tutorial style of delivery has a positive effect on students learning for both cohorts. Both years show a good range of marks (see table 4 and figures 1 and 2) and the averages are what you would expect for a cohort of this type (averages on other modules for this body of students are similar). There is a clear and statistically significant difference between the years - 64.2 in *Year1* compared with 58.2 in *Year2*. It is clear where most of the difference between the cohorts occurs (see tables 5 and 6 below). In looking at difference within years there is no significant difference statistically between the cohorts in *Year1*, but the difference is very significant in *Year2*. The average for **IS&T** students is 52.0 compared with 60.5 for **LIS** students. There is some effect with the **LIS** cohort, but while being statistically significant it is much less pronounced - 64.2 in *Year1* compared with 60.5 in *Year2*. It is clear that the very significant difference in assessment results is therefore mostly due to the difference in **IS&T** results in the two years under scrutiny. This indicates that the tutorial style of delivery is more likely to positively effect those students who do not necessarily have a background in search. Note that it is possible that the difference recorded here could be a difference between the abilities of the two cohorts. However the difference is so significant, particularly for **IS&T** results, it is unlikely that one factor would make the difference, and therefore there is evidence in general that the method of teaching works. The average for the assessment has remained about the same in subsequent years using the same tutorial delivery method.

Figure 1 – Distribution of Marks for Year 1

Figure 2 – Distribution of Marks for Year 2

Examining the range of marks gives us more detail on which students' are more likely to be effected by our teaching style – see figures 1 and 2. It is clear from the data presented that the marks are reasonably normally distributed and use of the t-test to test for statistical significance is therefore justified. The spread of marks is much wider and more noticeable in *Year2* – hence the higher standard deviation in marks for the latter. The marks in *Year2* tend towards the lower end of the range, which that of *Year1* tend towards the higher end. What is noticeable is that there are no marks under 40% for *Year1*, and many fewer marks under 50% than for *Year2*. This is for both **LIS** and **IS&T** students. It is clear therefore that weaker students have more to gain from the tutorials irrespective of the cohort. Those in the middle of the distribution have also something to gain, but not to the same extent. High performing students seem to do well irrespective of the style of delivery e.g. the number of students with a 80% mark or over is about the same. The data in figures 1 and 2 bring into sharp focus the benefits to be gained from tutorials for the **IS&T** cohort. The question to be asked is which area of the assessment is most likely to be positively effected by the use of our proposed teaching method. Tables 5 and 6 give the results for the two main parts of the assessment (see section 4.5 above) - Boolean knowledge and numeracy for evaluation.

Student Cohort	*Year1 Marks*				*Year2 Marks*				**Yr1 vs. Yr2 t-test**
Statistic	**Avg**	**Max**	**Min**	**SD**	**Avg**	**Max**	**Min**	**SD**	
IS&T	68.0	80.0	52.0	7.87	58.4	80.0	36.0	12.7	0.00*
LIS	69.7	86.0	50.0	8.59	62.8	84.0	28.0	13.5	0.00*
t-test (in Yr)	0.41	-	-	-	0.22	-	-	-	-
All students	69.2	86.0	50.0	8.35	61.4	84.0	28.0	13.2	0.00*

Table 5 – Comparison of Boolean Knowledge results for both years
(*Indicates a significant difference)

Student Cohort	*Year1 Marks*				*Year2 Marks*				**Yr1 vs. Yr2 t-test**
Statistic	**Avg**	**Max**	**Min**	**SD**	**Avg**	**Max**	**Min**	**SD**	
IS&T	59.1	75.0	40.0	10.6	47.6	70.0	25.0	10.6	0.00*
LIS	57.4	80.0	20.0	13.5	57.6	80.0	25.0	13.2	0.94
t-test (in Yr)	0.60	-	-	-	0.00*	-	-	-	-
All students	57.9	80.0	20.0	12.6	54.9	80.0	25.0	13.2	0.97

Table 6 – Comparison of Numeracy for Evaluation results for both years
(*Indicates a significant difference)

Looking at the within year results it is apparent from the data that the significant difference in *Year2* is largely due to the evaluation component – while there does appear to be a difference in Boolean knowledge it is not statistically significant (58.4 for **IS&T** as against 62.8 for **LIS**). Between years however, it is clear that the main difference in terms of assessment was in Boolean knowledge – all differences in results between years are highly statistically significant. **LIS** students are stronger in the evaluation segment and seem to be able to cope better with that material than the **IS&T** students. The clear difference between these groups is prior work experience as intermediaries (see section 2), which allows them to overcome some of the problems with regard to understanding evaluation measures and their implications. However, this work experience does not appear to help **LIS** students as much with regard to Boolean knowledge.

7.2 Examination of student feedback results

Question List (see appendix 1)	**Year 1**			**Year 2**		
Respondents (% Responded)	**IST** *6 25.0%*	**LIS** *16 32.7%*	**ALL** *22 30.1%*	**IST** *10 50.0%*	**LIS** *22 40.7%*	**ALL** *32 43.2%*
1. Experience	1.83	2.38	2.23	2.60	2.68	2.66
2. Challenge	4.50	4.94	4.82	3.80	4.41	4.22
3. Enjoyment	4.67	3.56	3.86	3.90	3.86	3.88
4. Time Taken	4.33	5.00	4.82	3.80	4.64	4.38
5. Met expectations	4.83	3.75	4.05	4.00	3.82	3.88
6. Communication	5.00	4.00	4.27	4.80	3.50	3.91
7. Engagement	4.67	4.00	4.18	3.78	4.05	3.97
8. E-Learning Sys.	4.83	4.19	4.36	4.50	4.18	4.28
9. Assessment	4.50	4.31	4.36	5.10	4.27	4.53
10. Teacher Res.	5.50	4.31	4.64	5.30	4.09	4.47
Average (Q2-10)	**4.76**	**4.23**	**4.37**	**4.16**	**3.95**	**4.02**

Table 7 – Comparison of quantitative feedback results for both years (averages)

Table 7 gives a summary of the quantitative feedback for both years. There is evidence in these figures to support the notion that the tutorial mechanism of teaching promotes better student satisfaction. The averages over all the questions for all sets of cohorts are very encouraging particularly for *Year1* - the overall averages are better than year 2. **IST** students appear to be more satisfied than LIS for both years. An important factor here is the response rates – these are better in *Year2* than they are in *Year1*. The **IST** response rate doubled from *Year1* to *Year2*, increasing by around 8% for **LIS** students. The assumption here is that students are more likely to answer the feedback for the module if they feel that it has not worked for them and they want to make their grievances known, while satisfied students have less motivation to respond, unless they are extremely happy. This difference of response rates between both years is more evidence of the potential effect of the tutorial style of teaching advocated here on student satisfaction.

Looking beyond the headline figures at the averages for the individual questions, in seven out of the ten questions for *Year1*, **IST** averages are better than **LIS**. For *Year2* the split is even. Those students who have more to gain are more likely to be satisfied – this would be consistent with the better marks for **IST** in *Year1* as declared above. As for *Year1* vs. *Year2*, in seven of the questions the average is better for the former. For **IST** students this increases to eight out of ten, which reinforces our point on satisfaction above. One interesting piece of data is that students who did better overall on average in their assessments felt less experienced than their counterparts e.g. **IST** *Year1* (1.83) vs. *Year2* (2.60). This could just be an effect of the difference between the cohorts, and it is hard to read too much into the data – it is not statistically significant (see table 8 below).

Question	**Year 1**	**Year 2**	**Year 1 vs. Year 2**		
	IST vs. LIS p	***IST vs. LIS p***	***IST p***	***LIS p***	***ALL p***
1. Exp.	0.398	0.684	0.238	0.329	0.139
2. Challenge	0.338	0.597	0.664	**0.046***	**0.047***
3. Enjoy.	0.065	0.792	0.388	0.564	0.895
4. Time	0.151	0.061	0.419	**0.032***	0.173
5. Expect.	0.077	0.569	0.366	0.953	0.550
6. Comms	0.113	**0.008+**	0.868	0.160	0.231
7. Engage.	0.338	0.828	0.388	0.813	0.470
8. E-Learn.	0.285	0.264	0.930	0.584	0.751
9. Assess.	0.740	0.056	0.104	0.352	0.509
10. Res.	0.065	**0.014***	0.955	0.564	0.622

Table 8 – Comparison of quantitative feedback results for both years (t-test results)

[* difference significant p<0.05, + difference very significant p<0.01]

In table 8 we use the Wilcoxon test on individual questions to see which aspects of our feedback give statistically significant results. We use the Wilcoxon test as the underlying data is ordinal. Boxplots of the data are given for information in the appendix. In *Year1* there are no significant differences between the two cohorts. In *Year2* however there is a very significant difference ($p < 0.01$) in how the students felt about the communication of information and a significant difference ($p < 0.05$) between how students felt about teaching staff responsiveness. In both cases **LIS** averages were lower than **IST**, and there is some evidence that **LIS** students are more likely to notice the difference in communication (e.g. less of it) – however there is no direct evidence of this when we compare the two years (figures recorded for both questions are not significant). There is evidence that a transaction model of teaching improves student satisfaction in this area. When comparing years there is no evidence of any significant difference in the **IST** data. However with the **LIS** cohort there is evidence of a statistically significant difference in the level of challenge (*Year1* students found the module more challenging) and in time taken to complete the module (*Year1* students were more likely to spend more time to achieve the outcomes of the module). As the tutorial style of teaching advocated in this paper will undoubtedly engage the student and they will clearly find themselves spending more time on the subject matter and find it more challenging. Students with prior experience are more likely to notice the difference in teaching styles. Note that the statistical difference between *Year1* and *Year2* cohorts is entirely due to the difference in **LIS** data.

We looked at the qualitative feedback from both cohorts to see if this information could shed some light on these differences, together with any other trends found. Some students in *Year1* commented on the responsiveness of the teacher, whereas no mention of this is made in *Year2* – students clearly appreciate efforts made on their behalf in response to any problems they may have. There did not appear to be an explicit problem in *Year2* with communication of information – but it was noticeable that a number of students picked up the issue of the lack of organisation in the module, with some commenting on the group in terms of the class rather than their own individual groups. There is evidence therefore that students who have been given explicit tasks are more likely to identify with their own group. Identity within groups is positive and appears to assist learning. Words like 'haphazard' and 'confusing' where used in relation to the organisation of *Year2*, whereas *Year1* students commented favourably on the groups researching and presenting their findings to the rest of the class. No explicit mention is made of organisation in *Year1*, but they clearly appreciated a more hands on approach to the material. Interestingly one of the main negative comments in *Year1* was on group members not making enough effort on the allocated tasks – this was absent in *Year2* reinforcing the point above about students identity within groups. Good interaction by the teacher is mentioned in *Year1* comments, and students appear to appreciate the proactive approach taken on that cohort. Some mention in *Year2* is made of the difficulty of the coursework and explicitly asking for a more pro-active style of teaching using seminars and workshops. These comments make a good case of the style of teaching used in *Year1*. Comments on time pressures for the module were mentioned in both years, so there is very little to glean in terms of qualitative information on this issue. No direct mention in the comments is made on how challenging the module was for the students.

8. DISCUSSION

There is evidence in the data we have presented that a pro-active tutorial style of teaching based on the transaction model of teaching has a positive effect on student learning and student satisfaction. More specifically the method does appear to improve the math skills of students studying an IR module, which requires knowledge of Boolean logic for search and basic numeracy skills for an understanding of evaluation. The proactive method of teaching using tutorials does encourage deep learning, and assist the understanding of requisite skills for the module. In terms of assessment, this style of teaching appears to particularly help those students who do not necessarily have relevant work experience in the area. In section 2 we outlined the background of the students who undertake this module, and there is evidence that prior work experience as a search intermediary does help with an understanding of the numeracy in evaluation issues, but it is also clear that this does not help with regard to an understanding of Boolean knowledge, and more engagement with students in this area is a requirement. This evidence confirms the ideas of Burn (2002) prior knowledge and abstract thinking in discrete maths (see section 3). Weaker students in particular appear to have much to gain from this style of teaching, irrespective of their background. There are some caveats to this statement, and it should be noted that not all differences in quantitative student feedback are statistically significant. A further concern is the level of responses for some cohorts e.g. only 25% of **IST** students completed the survey. None the less we believe that the information gathered gives us confidence that the teaching mechanism argued for here has a positive effect. When looking at the qualitative comments, it was clear that identity within groups appears to have a positive effect, and students who are more pro-active in helping with the group work, tend to get more out of the material.

We should state the limitations of the study however. The results we provide are clearly depend on the form of assessment used in the study, and there is no guarantee that if the assessment was changed radically our results would necessarily be the same. There is always the possibility that the differences between cohorts could explain the differences in the results. We did not do a test to probe the differences between years in terms of overall results, but the difference in assessment results are very significant, any difference in cohorts could not explain all of the difference recorded above. With regard to the questionnaire (which is anonymous), we did not do any tests on individual characteristics or learning styles of students as they had already completed their course long after this study began – therefore it was not possible to collect this data. It is possible that these factors and others to do with individual students could have had an impact.

9. CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

Despite the limitations of the study, we have provided evidence that a transaction model of teaching works better than a transmission model when it comes to helping students understand the mathematics needed to conduct a search and evaluate it. We have continued to use this model of teaching with great success in subsequent years, and students continue to produce good work in their assessments and provide positive feedback when questioned about their experience. The tutorial style of teaching requires significantly more effort than the alternative, but the extra effort is worth it, both for the students and work satisfaction for the lecturer.

There are a number of issues that warrant further investigation. Would it be better to deliver the material on mathematics for IR earlier in the students study (the module described here is delivered in the second semester)? This is something of a chicken and egg situation. It is better to deliver maths material in the context of IR (we argue for this strongly above), but other modules being offered could benefit from some mathematical material being delivered earlier in the course. If this was to be done, it would need careful thought. Could this style of teaching have implications for LIS study in general? There is mixed evidence for this above. Prior work experience for core information science knowledge appears to be imparted to some extent in the prior work experience of LIS students, which implies that not all of the material delivered to them needs such intensive teaching methods – in fact it could pose a barrier to independent study needed in some areas of theoretical study. The type of teaching advocated needs to be justified fully in the light of the learning outcomes of the module. One particular area for further research is support for Boolean knowledge that appeared to be an issue with all types of students in our study. One way of providing this support is to design multiple choice questions or online tests (Beevers and Paterson, 2002) to test knowledge of Boolean logic in the context of searching and give extensive feedback to students on common mistakes errors etc. This would be a fruitful area for further research on the basis of the evidence provided in this study.

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Appendix 1 – Questions used in the Student Feedback Survey's

Title	Question	Range
1. Level of Experience	Indicate your level of experience and knowledge of this subject prior to taking the module. (consider any prior experience and indicate your capabilities as the module began)	[very low… very high] 1-6
2. Level of Challenge	How challenging have you found the content and concepts dealt with in the module?(consider the academic level of the material and how difficult you found it to achieve the outcomes)	[very easy… very challenging] 1-6
3. Enjoyment	How much did you enjoy the module? (consider the module as a whole, from start to finish)	[very little… very much] 1-6
4. Time taken	How much time has it taken you to complete the module successfully? (remember, modules are expected to take the average student 120 hours in total to achieve an average grade)	[very little… very much] 1-6
5. Met expectations	To what extent has the module met your expectations? (consider the publicized syllabus, module specification, methods of teaching used, learning outcomes and other sources of information)	[very poorly… very well] 1-6
6. Communication of Information	How well has information been communicated to you to support your learning? (this includes face-to-face lectures, lecture materials on the E-learning system and other ways in which the core concepts are explained and communicated)	[very poorly… very well] 1-6
7. Engagement and Discovery	How well have opportunities for engagement and discovery been used to supported your learning? (consider situations where you have been 'doing' rather than listening or reading, such as any face-to-face practical, laboratory or seminar sessions as well as online alternatives)	[very poorly… very well] 1-6
8. E-Learning system	How well has the E-learning system been used during the module to support your learning? (consider all features of the E-learning system that have been used in the module, rather than the E-learning software itself)	[very poorly… very well] 1-6
9. Module Assessment	To what extent have you found the module assessment useful in terms of supporting your learning? (consider the work you have done in preparing for and completing the assessment and any feedback received)	[very limited… very useful] 1-6
10. Responsiveness by Teaching Staff	How would you rate the level and quality of responses by teaching staff to students in supporting your learning? (consider both electronic and face-to-face communication where relevant, across the module as a whole)	[very poor… very good] 1-6

Appendix 2 – BoxPlot Chart for Student Feedback survey

Figure A2.1 - BoxPlot chart for student feedback results in year 1

Figure A2.2 - BoxPlot chart for student feedback results in year 2